Physiological Response of Carnation Plants to Gibberellic Acid (GA_3) and Potassium Fertilization under Greenhouse Conditions

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ABSTRACT

The present study was designed to investigate the effects of gibberellic acid (GA_3) as foliar application at four concentrations 0.0, 100, 200 or 300 ppm at 20, 40 and 60 days after planting and four rates of potassium fertilizer added with water irrigation at rates 0.0, 50, 100 or 150 ppm and their interaction on growth and flower production of *Dianthus caryophyllus* cv. "Red Sim" plants. This search was carried out during the growing seasons of 2002 and 2003 at Ornamental Plants Research Branch, Horticultural Research Institute, Antoniades Garden, Alexandria, Egypt. The results showed that spraying the plants with GA_3 separately or in combination with the different level of potassium stimulated the growth and flowering of the plant, compared to the control. The highest values of vegetative growth and flowering parameters were obtained by adding GA_3 at 200 ppm plus 100 ppm of potassium fertilizer. Moreover, the total carbohydrates and mineral contents in the leaves were significantly increased as a result of spraying the plants with GA_3 and K- fertilizer at different rates, compared to the control.

Key words: Carnation, *Caryophyllaceae*, gibberellic acid (GA_3), Fertilization, mineral content, carbohydrates, greenhouse conditions.

INTRODUCTION

The modern carnation (*Caryophyllaceae*; *Dianthus caryophyllus* L.) cultivars offer a diversity of colors, shapes and sizes available in few other flowering plants. Carnations are cultivated on a large scale in the Mediterranean area. However, it can be produced over the entire world in greenhouses.

Carnation is one of the most used flowers for florist cut flower arrangement due to its excellent keeping quality , wide range of forms, ability to withstand long distance transportation. Therefore, paying a great attention to improve both qualitative and quantitative characteristics of carnations, especially, these grown under greenhouse condition is essential.

Modern carnation growers fertilize young plants as soon as they are rooted in, which usually occurs a week or so after planting. Today, a regular supply of nutrients is applied at each irrigation. Gibberellins are biological active in stimulating cell division, elongation and encouraging the flowering in perennial herbaceous plants such as *Dianthus caryophyllus* L.

Potassium (K) is considered as an essential element of photosynthesis respiration, sugar translocation and enzyme activation, this element is also so abundant that is a major contributor to the osmotic potential of cells and therefore to their turgor pressure (Frank and Cleam 1985).

Previous researches showed that growth regulators such as Gibberellic acid and potassium fertilizer had an effective role on the production potentiality of carnations. Papadimitriou and Monios (1984), Jana and Jahangir (1987), Amitabha (1990), Saks *et al.*, (1993), Neelofar and Arora (1995), Verma *et al.*, (2000) 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 (El-Shafie *et al.*, 1980; Mazrou 1991 and Eraki *et al.*, 1993), tuberose (Biswas *et al.*, 1983; El-Naggar and Sharaf, 2002) gladioli (El-Naggar, 1999) and iris plants (Nour El-Din, 1998). On the other hand, supplying the plants with suitable rate of K- fertilizer is an essential element for photosynthesis respiration, and carbohydrates transformation, especially for those grown under greenhouse conditions. Fertilization of K is practiced and growers still did not know what, when and how much of potassium to be added. In Egypt, K-fertilization is not a general practice because it is thought that the soil contain an adequate amount of the available potassium, while there are a response to potassium application because of the intensive cropping and, the depletion in Nile loam and extensive reclamation of sandy soils were used (El-Damaty *et al* ., 1972). Potassium fertilization is recommended by several investigators to improve the growth and flowering of carnation plants (Uri *et al.*, 1990; Starck *et al.*, 1991; Hasegawa, 1992 and Hosni and El-Shoura, 1996), Chrysanthemum plants (Mostafa 1996) and gladioli (Haikal 1992 and El-Naggar 1999). Therefore, this study was conducted to determine the suitable rate of K- fertilizer and its synergistic effect with GA_3 on the growth and flowering of "Red Sim" carnation plants grown under greenhouse conditions.

MATERIALS AND METHODS

The present work was carried out during two successive seasons (2002 and 2003) in the greenhouse at Ornamental Plants Research Branch, Horticultural Research Institute, Alexandria, Egypt. *Dianthus caryophyllus* cv. "Red Sim" plants were used in this study for its popularity in the flower trade for decoration purposes.

Preparation of rooted cuttings:

The cuttings of "Red Sim" carnation were taken from certified mother plants on 23rd June, 2002 and 26th June, 2003 with an average length of 7 cm per cutting, respectively. Cuttings were directly rooted under mist propagation

for three weeks (giving 10 second mist every 5 minutes). The propagation bed composted using a mixture of peat-moss and sand (1:3, v/v).

The rooted cuttings were transplanted on 14th and 17th July for the two seasons, respectively in 10 cm diameter pots (one plant/ pot), using the same growing medium under the greenhouse conditions. Three weeks later, the pinching process (single pinch) of the growing points of all the plants was done to accelerate the basal branching on 5th August and 8th August 2002 and 2003 in the first and second seasons, respectively. When the plantes had 4 pairs of leaves and about 15 cm height (Verma *et al.*, 2000) the plants were transplanted to the final pots of 30 cm diameter on 26th and 29th August 2002 and 2003, respectively using the same medium mentioned before.

The plants were supported with plastic grids at suitable heights. Three well distributed branches were chosen on each plant on 10th and 13th September 2002 and 2003 ir. the two seasons, respectively for the experimental purposes. The lateral flower buds were removed (disbudded) as soon as they can be handled to allow one terminal bud to develop per branch. The vegetative shoots below the eight node on the selected branches not be disbudded as a succeeding flower crops develop rapidly from them.

Soil analysis:

The physical analysis of the used soil revealed that it was containing 0.39, 2.23 and 97.38% of clay, silt and sand, respectively. The chemical analysis cleared that, it was containing 0.16, 0.04 and 0.18 % of N, P_2O_5 and K_2O, respectively (sandy soil). The electric conductivity (EC) was 2.02 (dsm^{-1}) with pH of 7.68.

Experimental greenhouse treatments:

The treatments consisted of foliar sprayed of GA_3 at concentrations of 0.0, 100, 200 and 300 ppm applied at 20, 40 and 60 days till run off point under greenhouse conditions. The control plants were sprayed with distilled water. The amount of K-fertilizer as potassium sulphate (K_2SO_4 48% of K_2O) was applied at 0.0, 50, 100 and 150 ppm.

The plants requirements of N, P were added by the application of ammonium nitrate (33.5% N) calcium superphosphate (16.5% P_2O_5) at the rate of 175 and 40 ppm N and P, respectively (Farina and Lupi, 1988). The other micronutrients; iron, zinc, copper and poron were added by the addition of their sulphate salts as $FeSO_4 4H_2O$ (24.7% Fe), $ZnSO_4.7H_2O$ (21.8% Zn), $CuSO_4.5H_2O$ (25.5% Cu) and H_3BO_3 (17 % B) at 2.0, 0.5, 0.3 and 0.5 ppm Fe, Zn, Cu and B, respectively (Kirilov *et al.*, 1989).

Each concentration from the previous levels of K was dissolved with the otherwise nutrients in one liter and applied to the pot soil five times per week. The first nutrient solution application was practiced one week after the final

transplanting, and was continued until reaching the stage of flower bud showing color (Kirilov *et al.*, 1989).

Experimental design:

The experimental lay-out was designed to provide randomized complete blocks in factorial type containing three replicates. Each replicate contained sixteen treatments ($4GA_3$ x 4 K fertilization). Five plants were used as a plot for each treatment.

Growth characteristics:

The vegetative growth parameters were included; stem length (cm), stem diameter at the middle of stem (cm), fresh and dry weights of stem (g), leaves number, fresh and dry weights of leaves (g). While the flowering data included; the time taken to showing color from final transplanting (day), number of flowers, flower diameter at full opening (cm) and dry weight of flowers per plant (g).

Chemical composition:

The total chlorophyll (a and b), mineral percentage and total carbohydrate content of the leaves were determined as follows:

1- The total chlorophyll content and total carotenoides of fresh leaf samples (mg/100g F.W.L) was determined by using the method described by Greig *et al.*, (1968) in the leaves beneath of the terminal bud at showing color stage (Uri *et al.*, 1990).

2- The nitrogen content and phosphorus percentage of the dried and fine leaves were determined according to methods described by Chapman and Pratt (1961), and Bringham (1982).

3- The potassium percentage was determined by using Flame Photometer according to Brown and Lilleland (1946) and Chapman and Pratt (1961).

4- The total carbohydrate content in dried leaf samples was determined according to Herbert *et al.*, (1971).

Statistical analysis:

The data were statistically analyzed according to the methods described by Snedecor and Cochran, (1981).

RESULTS AND DISCUSSION

I-The effect of GA_3, K- fertilizer and their combination treatments on vegetative growth characteristics:

The results recorded in the two seasons Tables (1-2) show that spraying "Red Sim" carnation plants with GA_3 separately or in combination with different level of K- fertilizer had a considerable effect on the different vegetative growth

characteristics ; stem length, stem diameter, fresh and dry weights of stem , leaves number , as well as the fresh and dry weights of leaves.

In most cases, application of the different concentrations of gibberellic acid (GA_3) combined with potassium treatments promoted vegetative growth, and resulted in significant increases in the values recorded for the different growth parameters, compared to the untreated control plants.

The highest values were obtained by the application of GA_3 at 200 ppm in combination with K- fertilizer level at 100 ppm K_2O / plant for several growth characteristics, such as stem length, stem diameter, stem fresh and dry weight, as well as, fresh and dry weight of leaves/ plant (giving values of 81.30 cm, 0.71 cm, 43.15 g, 4.20 g, 36.72 g and 3.14 g, respectively in the first season, and 79.86 cm, 0.71 cm, 42.02 g, 4.21 g, 34.59 g and 3.10 g , respectively, in the second season for the above mentioned parameters.).

These results could be explained through the synergistic effect of GA_3 and K- fertilizer at their suitable and adequate combinations in promoting the vegetative growth and dry matter accumulation.

In addition, the stimulating effects of both GA_3 and/or potassium fertilization may be due to activating apical meristems beside the protoplasm formation, division and elongation of meristems cells, enhancing the biosynthesis of proteins and carbohydrates. These together led to enhancing the growth. Similar results were obtained by Hosni and El-Shoura (1996) and Verma *et al.*, (2000) on carnation plants.

II-The effect of GA_3, K- fertilizer and their combination treatments on flowering:

The obtained results revealed that the mean of flowering time, number of flowers / plant as well as their size (diameter), fresh and dry weights were markedly improved as a result of spraying " Red Sim" carnation plants with either GA_3 and/or potassium fertilizer, compared to the control (Table 3-4).

The results in table (3) indicated that the time taken to showing color in the two growing seasons were significantly decreased with the spraying of GA3 alone or in combination with K- fertilizer.

The earliest reduction in the period from planting date until appearance of color, was obtained by using 200 or 300 ppm GA_3 in combination with 100 ppm K_2O / plant, as compared with the control in the first and second seasons, respectively. the difference between the treatment namely 200 ppm GA_3+100ppm K_2O and the treatment namely 300 ppm GA_3+100ppm K_2O was not significant in most of flowering parameters This may be due to that using gibberellic acid (GA_3) at suitable concentration with adding K-fertilizer at the optimum level led to the increase and activation the formed roots. This stimulates absorption of the essential elements for flowers initiation and

development. The same trend was reported by El-Naggar (1999) on gladiolus, El-Naggar (2002) on tuberose.

The 200 ppm GA_3 plus 100 ppm K_2O treatment gave significantly higher flowers than those of other treatments. Meanwhile, a decrease tendency in this respect could be observed as a result of supplying the plant with the highest level of potassium (150ppm) combined with GA_3 at 300 ppm.

The increment in the number of flowers, size, fresh and dry weight of flowers as a result of using suitable GA_3 concentration with K- fertilizer at optimum doses may be due to the role of gibberellic acid (GA_3) and/or the nutrients such as potassium, which is necessary for the synthesis of protein and cytokinin; consequently, affects cell division (Table 3-4). These results are similar to those obtained by El-Shafie *et al.*, (1980) and Mazrou *et al.* (1988) on rose, Papadimitrio and Manios (1984), Starck *et al* ., (1991) and Ramesh *et al.*, (2002) on carnation plants.

Table 1. The effect of GA_3 concentrations, potassium application and their interaction on stem length (cm), stem diameter (cm), stem fresh and dry weight (g) of *Dianthus caryophyllus* cv. "Red Sim" during the two seasons of 2002 and 2003.

GA_3 Conc. (ppm)	K_2O Rates (ppm)	Stem length (cm)		Stem diameter (cm)		Stem fresh weight (g)		Stem dry weight (g)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd
0.0	0.0	63.40	63.57	0.53	0.51	29.98	30.02	3.16	3.15
	50	69.97	67.56	0.57	0.57	34.91	34.86	3.36	3.39
	100	71.30	70.93	0.59	0.61	37.18	36.95	3.51	3.50
	150	68.50	69.72	0.57	0.58	35.30	34.99	3.42	3.42
	$\bar{x}$	68.29	67.95	0.57	0.57	34.34	34.21	3.36	3.37
100	0.0	65.50	64.57	0.59	0.58	30.05	30.13	3.29	3.28
	50	72.49	72.59	0.63	0.51	34.81	35.09	3.42	3.41
	100	78.95	76.79	0.68	0.67	37.21	37.30	3.56	3.56
	150	76.51	76.30	0.66	0.64	36.27	36.13	3.52	3.50
	$\bar{x}$	73.36	72.56	0.64	0.60	34.59	34.66	3.45	3.44
200	0.0	68.72	66.20	0.62	0.63	35.07	35.11	3.43	3.44
	50	75.61	74.81	0.68	0.70	37.13	36.91	3.69	3.68
	100	81.30	79.86	0.71	0.71	43.15	42.02	4.20	4.21
	150	78.59	75.36	0.67	0.68	41.79	39.87	4.08	3.98
	$\bar{x}$	76.06	74.06	0.67	0.68	39.29	38.48	3.90	3.83
300	0.0	66.92	66.16	0.60	0.62	35.57	36.51	3.46	3.48
	50	72.36	73.00	0.65	0.64	38.21	38.42	3.71	3.76
	100	76.48	76.02	0.68	0.66	41.92	41.91	4.10	4.12
	150	73.20	72.40	0.64	0.64	40.17	40.10	3.91	3.90
	$\bar{x}$	72.24	71.90	0.64	0.64	38.97	39.24	3.80	3.82
LSD 0.05	GA_3	1.99	2.11	0.02	0.02	1.25	1.21	0.14	0.19
	K_2O	2.16	2.19	0.03	0.04	1.39	1.38	0.20	0.20
	Inter.	2.23	2.27	0.05	0.05	2.08	2.11	0.20	0.21

Table 2. The effect of GA_3 concentrations, potassium application and their interaction on leaves number/ branch,Leaves fresh and dry weight (g)/branch of *Dianthus caryophyllus* cv. "Red Sim" during the two seasons of 2002 and 2003.

GA_3 Conc. (ppm)	K_2O Rates (ppm)	Leaves number/ branch		Leaves fresh weight (g)		Leaves dry weight (g)	
		1st	2nd	1st	2nd	1st	2nd
0.0	0.0	18.60	18.53	21.71	21.76	2.13	2.11
	50	18.98	19.00	21.92	21.84	2.30	2.28
	100	20.19	21.86	23.20	23.22	2.39	2.39
	150	19.30	19.50	22.16	22.19	2.34	2.35
	$\bar{x}$	19.27	19.72	22.25	22.25	2.29	2.28
100	0.0	19.41	19.36	23.26	23.29	2.40	2.41
	50	21.51	21.14	23.86	23.79	2.61	2.59
	100	22.96	22.86	24.05	24.12	2.69	2.71
	150	20.52	21.90	23.82	23.79	2.63	2.62
	$\bar{x}$	21.10	21.32	23.75	23.75	2.58	2.58
200	0.0	20.16	21.51	23.41	23.50	2.59	2.63
	50	22.93	22.91	28.61	27.99	2.73	2.71
	100	24.69	24.81	36.72	34.59	3.14	3.10
	150	22.18	22.21	27.51	27.36	3.02	3.05
	$\bar{x}$	22.49	22.86	29.10	28.36	2.87	2.87
300	0.0	20.44	20.51	23.37	23.41	2.48	2.49
	50	23.10	23.08	25.19	25.16	2.65	2.66
	100	24.37	24.29	34.92	33.36	3.08	3.00
	150	21.12	21.16	28.11	28.51	2.69	2.87
	$\bar{x}$	22.26	22.26	27.90	27.61	2.73	2.76
LSD 0.05	GA_3	NS	NS	1.26	1.19	0.21	0.20
	K_2O	NS	0.37	1.42	1.37	0.09	0.11
	Inter.	0.89	0.93	1.96	1.89	0.29	0.28

Table 3. The effect of GA_3 concentrations, potassium application and their interaction on flowering time (day), flowers number/ plant and flowers size (cm) of *Dianthus caryophyllus* cv. "Red Sim" during the two seasons of 2002 and 2003.

GA_3 Conc. (ppm)	K_2O Rates (ppm)	Flowering time(day)		Flowers number/ plant		Flowers diameter (cm)	
		1st	2 nd	1st	2 nd	1st	2 nd
0.0	0.0	132.56	131.97	4.10	3.95	3.51	3.46
	50	130.64	130.52	4.22	4.16	3.96	3.99
	100	127.50	128.22	4.96	4.81	4.20	4.21
	150	129.35	129.61	4.32	4.29	4.12	4.16
	$\bar{x}$	130.01	130.08	4.40	4.30	3. 95	2.92
100	0.0	127.21	126.91	4.72	4.69	4.16	4.20
	50	124.39	125.12	6.25	6.21	5.76	5.73
	100	119.81	120.53	7.65	7.42	7.52	7.56
	150	121.36	121.29	7.10	7.00	7.36	7.39
	$\bar{x}$	123.19	123.46	6.43	6.33	6.20	6.22
200	0.0	122.59	123.19	5.20	5.18	5.69	5.59
	50	115.91	114.81	8.92	8.90	7.91	7.89
	100	111.36	110.73	10.20	10.56	9.46	9.50
	150	116.48	116.91	9.39	9.28	9.13	9.10
	$\bar{x}$	116.59	116.41	8.43	8.48	8.05	8.02
300	0.0	122.89	122.15	5.15	5.18	5.21	5.22
	50	116.24	116.85	8.73	8.71	7.18	7.30
	100	110.90	112.19	10.13	10.12	9.40	9.37
	150	118.97	119.51	9.19	9.12	8.87	8.68
	$\bar{x}$	117.25	117.68	8.30	8.28	7.67	7.64
LSD 0.05	GA_3	1.19	1.21	0.22	0.30	0.32	0.30
	K_2O	1.62	1.79	NS	NS	0.41	0.41
	Inter.	2.46	2.57	0.52	0.51	0.65	0.62

Table 4. The effect of GA_3 concentrations, potassium application and their interaction on Flower fresh weight (g) and Flower dry weight (g) of *Dianthus caryophyllus* cv. "Red Sim" during the two seasons of 2002 and 2003.

GA_3 Conc. (ppm)	K_2O Rates (ppm)	Flower fresh weight (g)		Flower dry weight (g)	
		1st	2nd	1st	2nd
0.0	0.0	17.43	17.55	2.13	2.10
	50	18.56	18.46	2.28	2.25
	100	20.32	21.00	2.39	2.36
	150	19.18	19.15	2.26	2.23
	$\bar{x}$	18.87	19.04	2.27	2.24
100	0.0	18.84	18.60	2.38	2.35
	50	21.32	21.40	2.59	2.55
	100	24.85	25.00	2.83	2.83
	150	22.93	22.34	2.68	2.64
	$\bar{x}$	21.99	21.80	2.62	2.59
200	0.0	19.38	19.30	2.48	2.47
	50	24.90	24.89	2.89	2.86
	100	30.75	29.30	3.28	3.30
	150	28.16	28.15	3.00	2.98
	$\bar{x}$	25.80	25.41	2.91	2.81
300	0.0	19.30	19.40	2.47	2.48
	50	21.22	22.13	2.76	2.74
	100	26.50	27.30	2.97	2.98
	150	25.30	25.19	2.85	2.88
	$\bar{x}$	23.08	23.51	2.76	2.77
LSD 0.05	GA_3	0.56	0.52	0.12	0.15
	K_2O	0.72	0.74	0.18	0.18
	Inter.	0.98	0.97	0.21	0.21

III- Chemical composition:-

1- effect of GA_3, K-fertilizer and their combination treatments on total carbohydrate percentages in the dried leaves:

The results of the chemical analysis indicated that the total carbohydrate percentages in the dried leaves of "Red Sim" carnation plants were significantly increased with spraying of the plants with GA_3 and potassium fertilizer application compared to the control (Table5).

The highest significant increase in the total carbohydrates (%) was obtained from spraying of GA_3 at 200 ppm combined with K- fertilizer at 100 or 200 ppm K_2O (23.96 and 22.87 % in the first and second seasons, respectively, as compared with the other treatment.

This improvement in the total carbohydrate contents as a result of foliar application with GA_3 in presence of K- fertilizer could be attributed to physiological role of GA_3 with K- fertilizer in enhancing leaf production (Table5), which probably had higher chlorophyll content and consequently more carbohydrates production, beside the mode of action of K in the activation of enzymes of carbohydrates transformation or in the regulation of the consumption sugars and the promotion of water and Co_2 absorption, which can be led to increase the capacity of plants in building metabolites.

These results agree with those reported by Hassan *et al.*, (1985) on dahlia plants, Eraki *et al.*, (1993) on rose plants and El- Naggar (1999) on gladiolus plants.

Finally, these results show that the spraying of GA_3 at suitable concentration (200 ppm) combined with the potassium fertilizer (100 ppm) had a considerably beneficial effect in improving the quantitative and the qualitative characteristics of *Dianthus caryophyllus* cv. "Red Sim" under greenhouse condition.

2- Effect of GA_3, K-fertilizer and their combination treatments on total chlorophyll (a+b) and carotenoides in leaves (mg/100 g F.W.):

Chemical analysis of fresh leaf samples has revealed that the total chlorophyll (a+b) and carotenoides content in mg/100 g L. F.W. was considerably affected by the addition of gibberellic acid (GA_3) with k-fertilization (table 5). In both seasons, untreated control plants had lower mean chlorophyll contents than plants receiving any concentration of GA_3 alone or combined with potassium fertilizer.

The highest significant increases in the total chlorophyll and carotenoides contents were obtained from plants treated with GA3at either 200 or 300 ppm in the presence of K_2O at a rate of 100 ppm, as compared with the control.

These results may be attributed to the enhancing effect of GA_3 with K-fertilizer at suitable concentrations on the absorption of the essential elements specially nitrogen (NH_4), phosphorus (P), iron (Fe^{++}), magnesium (Mg^{++}) cations, which are found in many metabolically active compounds, including chlorophylls and carotenoides and these elements are necessary for enzymes activation and formation of chloroplasts and chlorophyll (Hassouna and Madkour, 1991) Besides, using GA_3 + k led to increase the green pigments in the plants by stimulating the production of chlorophyll in leaves (Wasfy,1995) Similar trend of results was obtained by (Jhone et al, (1997) and EL-Naggar (1999) on gladiolus.

3- The effect of GA_3, K-fertilizer and their combination treatments on mineral content:

The data presented in Table (6) show the effect of gibberellic acid (GA_3), K- fertilizer and all possible combination between them on macro nutrient contents in leaves of "Red Sim" carnation plants. It is that the potassium percentages in the leaves was increased as K- fertilization dose increase up to 200 ppm separately or combined with 200 GA_3. The potassium percentages ranged between 1.52% and 3.36% for the control and the treatment of 200 ppm GA_3 plus 200 ppm K_2O, respectively in the first season and 1.53% and 3.34% for the control and the previous mentioned treatment in the second season (Table 6).

Nitrogen, phosphorus followed the same trend as potassium. These results reflect the positive relationship between the concentration of K-fertilizer with GA_3 and the mineral content of leaves.

The previous result may be related to the cation exchange capacity (CEC) of the soil and/or roots of the plant resulting in adsorption and consequently, the absorption of the needed amount for growth. In addition, GA_3 at optimum rate (200 ppm) alone or in presence of K- fertilizer increased the amount of N, P and K in leaves compared with the other GA_3 concentrations. This may be due to the role of GA_3 in promoting active roots. Similar results were obtained by Farina and Iupi (1988) on carnation.

Table 5. The effect of GA_3 concentrations, potassium application and their interaction on the total chlorophyll and carotenoides (mg/100g L.F.W.) and total carbohydrates (%) of *Dianthus caryophyllus* cv. "Red Sim" during the two seasons of 2002 and 2003.

GA_3 Conc. (ppm)	K_2O Rates (ppm)	Total chlorophyll (a+b) mg/100gL.F.W.		Total Carotenoides (mg/100g L.F.W.)		Total Carbohydrates (%)	
		1st	2nd	1st	2nd	1st	2nd
0.0	0.0	176.89	175.90	28.35	28.98	14.83	14.89
	50	189.56	188.72	30.97	31.46	17.58	17.82
	100	197.17	199.56	33.76	34.20	20.57	20.47
	150	191.58	190.93	30.55	32.56	18.62	18.29
	$\bar{x}$	188.80	188.78	30.91	31.80	17.90	17.87
100	0.0	179.62	180.52	30.82	31.00	15.89	15.51
	50	197.10	198.71	37.53	36.89	19.55	19.40
	100	223.28	222.67	49.12	47.34	21.97	21.82
	150	219.72	213.80	46.80	45.16	20.18	20.22
	$\bar{x}$	204.93	203.91	41.07	40.10	19.40	19.24
200	0.0	194.75	192.01	33.96	33.57	16.97	16.64
	50	209.82	211.51	41.70	40.72	22.58	22.30
	100	256.16	258.92	59.68	56.83	26.03	26.16
	150	242.87	244.17	56.19	54.15	23.62	23.51
	$\bar{x}$	225.90	226.69	47.88	46.32	22.33	22.15
300	0.0	192.40	190.72	31.64	30.51	15.32	15.00
	50	213.22	215.62	44.74	42.90	21.71	21.67
	100	257.80	259.38	58.86	59.67	25.92	24.81
	150	240.74	243.59	51.19	52.00	22.05	22.13
	$\bar{x}$	226.04	227.33	46.61	46.27	21.25	20.90
LSD 0.05	GA_3	2.13	1.97	1.62	1.59	NS	0.92
	K_2O	2.41	2.28	1.92	1.98	1.12	1.10
	Inter.	3.58	3.46	2.66	2.31	1.26	1.29

Table 6. The effect of GA_3 concentrations and potassium application on the mineral content [N, P and K (%)] in the dried leaves of *Dianthus caryophyllus* cv. "Red Sim" during the two seasons of 2002 and 2003

GA_3 Conc. (ppm)	K_2O Rates (ppm)	N (%)		P (%)		K (%)	
		1st	2nd	1st	2nd	1st	2nd
0.0	0.0	1.66	1.65	0.10	0.11	1.52	1.53
	50	1.94	1.94	0.18	0.17	2.08	2.12
	100	2.09	2.12	0.21	0.22	2.16	2.18
	150	1.96	1.95	0.18	0.19	2.13	2.14
	$\bar{x}$	1.91	1.92	0.168	0.17	1.97	1.99
100	0.0	1.70	1.72	0.12	0.13	1.84	1.82
	50	1.98	2.04	0.20	0.23	2.26	2.26
	100	2.30	2.35	0.24	0.25	3.11	3.09
	150	2.21	2.23	0.21	0.20	3.02	3.00
	$\bar{x}$	2.05	2.09	0.19	0.20	2.56	2.54
200	0.0	1.75	1.74	0.14	0.14	1.89	1.91
	50	2.16	2.18	0.26	0.25	2.47	2.45
	100	2.63	2.60	0.37	0.38	3.36	3.34
	150	2.58	2.56	0.33	0.34	3.27	3.24
	$\bar{x}$	2.28	2.27	0.28	0.28	2.75	2.74
300	0.0	1.72	1.70	0.13	0.14	1.86	1.88
	50	2.10	2.13	0.28	0.27	2.41	2.40
	100	2.52	2.53	0.36	0.37	3.30	3.21
	150	2.47	2.45	0.29	0.32	3.22	3.20
	$\bar{x}$	2.20	2.20	0.27	0.28	2.70	2.67
LSD 0.05	GA_3	0.09	0.09	0.03	0.02	0.05	0.04
	K_2O	0.10	0.11	0.03	0.03	0.06	0.04
	Inter.	0.12	0.14	0.06	0.06	0.07	0.06

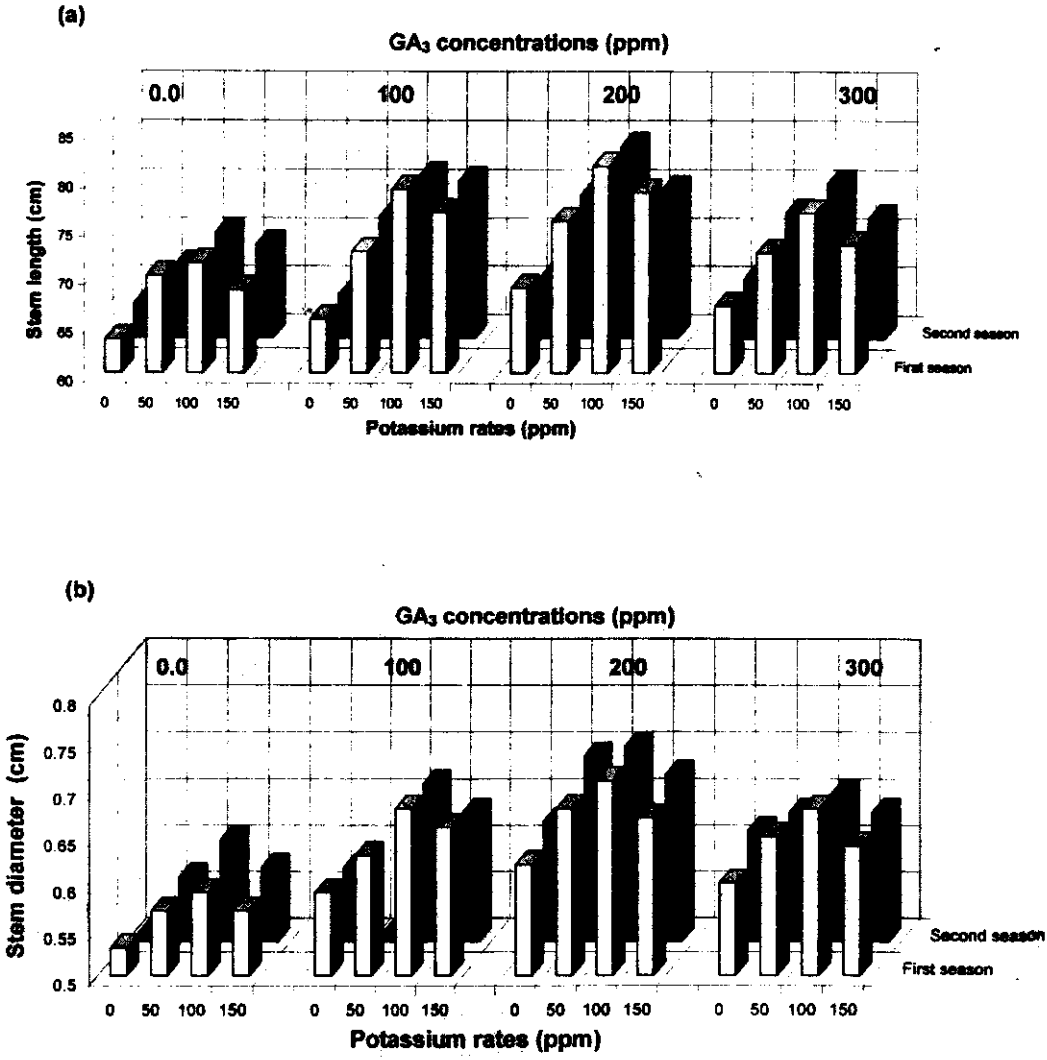

Figure (1-a & b) The effect of GA_3 concentrations and potassium application on stem length (cm) (a) and stem diameter (cm) (b) of *Dianthus caryophyllus* cv. "Red Sim" during the two seasons of 2002 and 2003 .

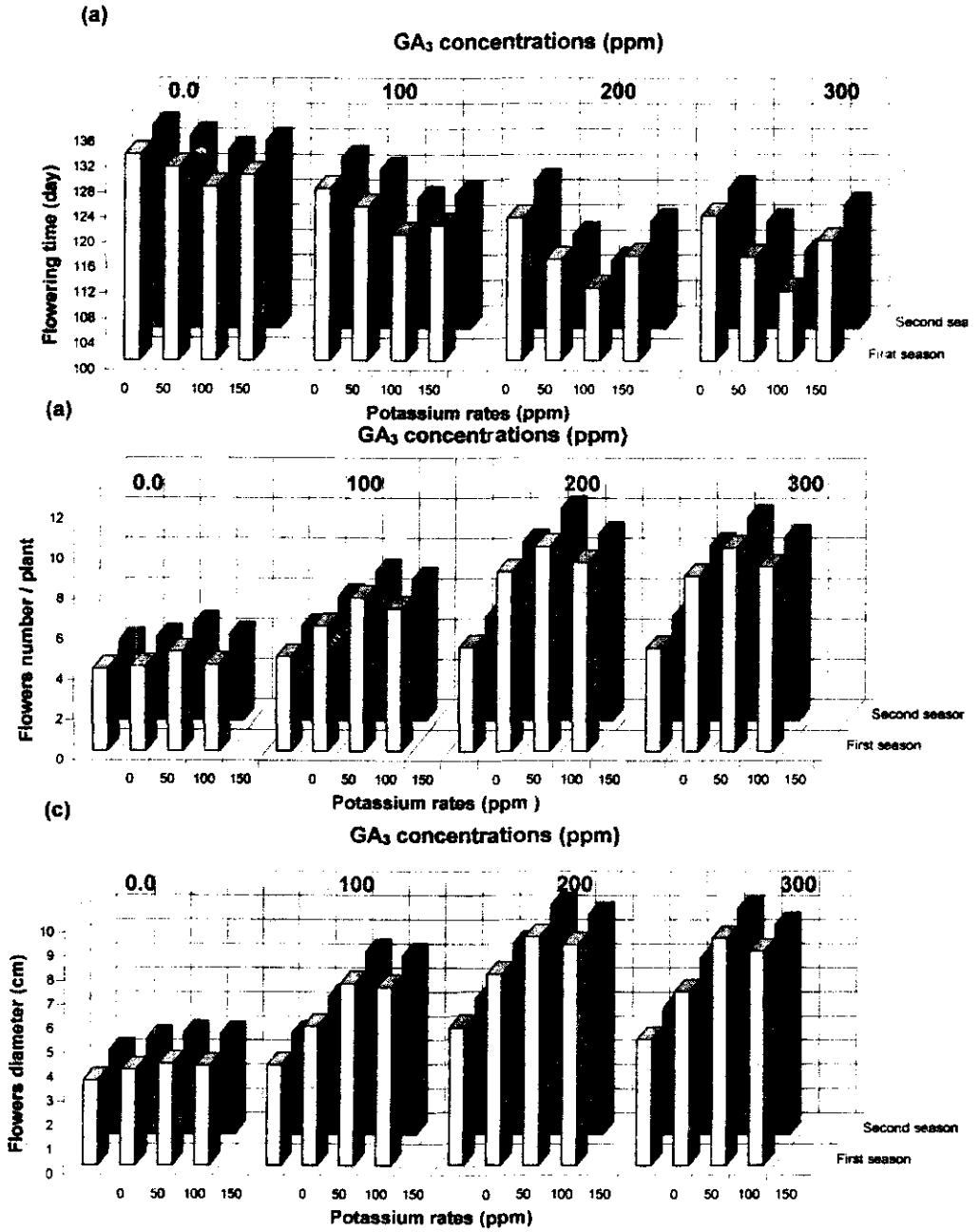

Figure (2-a,b& C). The effect of GA_3 concentrations and potassium application on flowering time(day),flowers number/ plant and flowers diameter (cm) of *Dianthus caryophyllus* cv. "Red Sim" during the tow seasons of 2002 and 2003 .

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الملخـــص العربـــــى

الاستجابة الفسيولوجية لنباتات القرنفل المجوز للمعاملة بحامض الجبريللين و السماد البوتاسى تحت ظروف الصوب

على حسن النجار ١ عاصم عباس النجار ٢

١- قسم الزهور و نباتات الزينة و تنسيق الحدائق – كلية الزراعة – جامعة الإسكندرية (الشاطبى)- الإسكندرية- مصر.

٢- فرع بحوث نباتات الزينة – معهد بحوث البساتين - حديقة أنطونيادس – الإسكندرية.

صممت الدراسة لبحث تأثير حامض الجبريللين عند أربع تركيزات صفر، ١٠٠، ٢٠٠ ، ٣٠٠ جزء فى المليون رشاً على المجموع الخضرى وذلك بعد ٢٠، ٤٠، ٦٠ يوم من الزراعة و أربع تركيزات من

البوتاسيوم صفر، ٥٠، ١٠٠، ١٥٠ جزء فى المليون و المضاف مع ماء الرى و التفاعل بينهم على نمو و إزهار نباتات القرنفل المجوز صنف " رد سيم" تحت ظروف الصوب وذلك فى فرع بحوث نباتات الزينة بحديقة أنطونيادس بالإسكندرية خلال عامى ٢٠٠٢ ، ٢٠٠٣ . أجريت جميع التوافيق الممكنة بين كل من تركيزات حامض الجبريلين و معاملات البوتاسيوم فى تصميم قطاعات عشوائية كاملة فى تجربة عاملية مكوناً ١٦ معاملة.

و أوضحت النتائج المتحصل عليها أن معاملة النباتات بحامض الجبريللين أو بسماد البوتاسيوم بتركيزاته المختلفة بصورة فردية أو متداخلة مع حامض الجبريللين قد أدت إلى زيادة معنوية فى كل من قياسات النمو الخضرى و الزهرى مقارنة بنباتات معاملة المقارنة (الكنترول) ، بالإضافة إلى ذلك كان للتأثير المتداخل لكل من حامض الجبريللين و سماد البوتاسيوم تأثيراً فعالاً فى إحداث زيادة معنوية لكل من طول و قطر الساق و أيضاً وزنها الطازج و الجاف و زيادة عدد الأوراق ووزنها الطازج و الجاف و كذلك زيادة معنوية فى الإنتاج الزهرى و انخفاض عدد الأيام اللازمة للوصول لمرحلة ظهور اللون و زيادة فى قطر الأزهار و عدد الأزهار لكل نبات و الوزن الطازج و الجاف للازهار. و أوضحت نتائج التحليل الكيماوى تحسن محتوى الأوراق من الكربوهيدرات الكلية و العناصر المعدنية (ن ، فو ، بو) نتيجة للمعاملة بكل من حامض الجبريللين و السماد البوتاسى مقارنة بنباتات معاملة الكنترول.

و يمكن القول إجمالا بأن أفضل النتائج تم التوصل إليها بعد معاملة النباتات بالرش بحامض الجبريللين بتركيز ٢٠٠ جزء فى المليون مع إضافة البوتاسيوم بتركيز ١٠٠ جزء فى المليون لماء الرى ، بينما أظهرت نباتات معاملة الكنترول أقل القياسات فى هذا الصدد.