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EFFECT OF PLANT GROWTH REGULATORS, GIBBERELLIC ACID (GA_3) AND NAPHTHALENE ACETIC ACID (NAA) ON GROWTH AND YIELD OF CARNATION (*DIANTHUS CARYOPHYLLUS* L.) UNDER NATURALLY VENTILATED POLYHOUSE

Justo C. Benny*, Devi Singh, U. Fatmi and Dona Ann Jose

Department of Horticulture, S.H.U.A.T.S., Naini Agricultural Institute, Allahabad, Naini - 211 007 (U.P.), India.

Abstract

Effect of foliar spray of plant growth regulators *viz*., Gibberellic acid (GA_3) and Naphthalene Acetic Acid (NAA) on vegetative, flowering, quality and yield parameters of three carnation varieties under naturally ventilated poly house in Allahabad agro-climatic condition was investigated. The treatment of foliar spray of NAA (100,150 and 200 ppm) and GA_3 (100,150 and 200 ppm) was given at 30, 60, 90 and 120 DAT. The results revealed that foliar application of GA_3 @ 200 ppm significantly increased plant height (84.82 cm), no. of leaves (189.37), no. of shoots (7.64), no. of internodes (17.33), intermodal length (7.37 cm), bud initiation (91.82 days), days to bud opening (17.86 days), bud length (4.55 cm), bud diameter (2.89 cm), flower length (5.38 cm), flower diameter (6.44 cm), flower stalk girth (22.89mm), flower stalk length (107.40 cm), vase life (12.02 days), no. of cut flower stalks per plat (7.11) and no. of cut flower stalks per square meter (170.66), among the varieties evaluated variety Amado was recorded with maximum no. of shoots (7.00), intermodal length (6.22 cm), minimum days to bud initiation (82.14 days), bud length (4.12 cm), bud diameter (2.45 cm), flower diameter (6.16 cm), vase life (10.31days), no. of cut flower stalks per plant(5.90), no. of cut flower stalks per square meter (141.69). The interaction of variety Amado with foliar application of GA_3 @ 200 ppm resulted in superior no. of shoots (7.73), internodal length (8.31 cm), earliness to flowering (74.93), bud length (4.76 cm), bud diameter (2.94 cm), flower diameter (6.75 cm), vase life (14.93 days).

Key words : Carnation varieties, GA_3, NAA.

Introduction

Carnation (*Dianthus caryophyllus* L.) belongs to the family Caryophyllaceae having diploid chromosome number 2n=30. It is grown in several parts of the world and is believed to be the native of Mediterranean region. The generic name Dianthus comes from the writings of Theophratus, who lived about 300 B.C. He proposed that the word "Dianthus" came from the greek words: "dios" means divine (God); "anthos" means flower, that is "the flower of the Gods". Linnaeus chose the species name "caryophyllus" after the genus of Clove, as the fragrance from Carnation is reminiscent of clove. The variety William Sim produced in 1938-39 by William Sim of North Berwick, Marine was the greatest contribution to the present Carnation industry. From that one red flowered plant, there have been mutations to several variegated forms like white, pink, orange, etc. Carnation is an important flower crop having great commercial value as a cut flower due to its excellent keeping quality, wide array of colour and forms. Carnation, apart from producing cut flowers can also become useful in gardening for bedding, edging, borders, pots and rock gardens (Dole and Wilkins, 2005). From medicinal point of view, Carnation flowers are considered to be cardiotonic, diaphoretic and alexiteric (Shiragur *et al*., 2004b).

Carnations require sufficient amount of light and proper ventilation to produce high quality flowers and therefore design and orientation of greenhouse are of greater importance. Though, there are different types of greenhouses, naturally ventilated polyhouses are preferred in mild climate in which temperature is reduced by ventilation (Ryagi *et al*., 2007). Hence, the project is conducted in a naturally ventilated polyhouse.

Carnations are highly responsive to micronutrients, fertilizers and growth regulators. Plant growth regulators

Author for correspondence: E-mail: justocbenny@gmail.com

often termed, as plant bio-regulators are generally plant hormones of different kinds that have great impact on growth, development and flowering of plants. Some of them regulate the growth of the plants, whereas some others control the flowering. Even a single plant growth regulator when applied at several doses may influence different growth phases of the plant. Exogenous application of plant growth regulators enhances the growth (El-Naggar *et al*., 2009) and flowering of ornamentals thereby yield. They may shorten the vegetative phase (Singh *et al*., 2004) or make it delayed. Plant growth regulators play a vital role for enhancing quality and yield of many commercial flowers.

IBA and NAA are most commonly used auxins (Kaviarasu and Selvaraj, 2016). Naphthalene acetic acid, commonly abbreviated NAA, is an organic compound with the formula $C_{10}H_7CH_2CO_2H$. NAA is a plant hormone in the auxin family and is an ingredient in many commercial postharvest horticultural products. It has been reported to modify plant growth and flower yield in carnation significantly increased plant height, number of leaves and nodes, internodes height, shoot and root dry weight, flower diameters and number of petals.

On the other hand, another prominent phytohormone, Gibberellic acid (GA_3), has the potential control on growth and flowering process. In addition, GA_3 application increased petiole length, leaf area and delayed petal abscission and colour fading (senescence). Gibberellic acid plays a major role in plant growth and development. It has been found to be the best for enhancing vegetative attributes along with flower initiation in many commercial flowers. The most characteristic effects of GA_3 on shoot growth are increase in inter-node extension, increase in leaf-growth, increase in diameter of plant, increase in number of flowers, induce flowering and enhanced apical dominance. In most photoperiodically sensitive plants, particularly in the form of long-day photoperiod induces increased shoot growth. It has been observed that gibberellins cause early flowering in many ornamental plants and increases the number of flowers. Spraying of GA_3 induced early flowering, increased size of the flowers, fresh weight and dry weight of flowers in Chrysanthemum Spraying of GA_3 gave maximum number of flowers per plant, flower weight and flower yield (Kumar *et al*., 2003).

Many experiments were conducted and still on progress for improving the growth and yield of carnation. Keeping in view of the above mentioned important properties of the Gibberellic acid (GA_3) and Naphthalene Acetic Acid (NAA) this experiment was designed to study the influence of various doses of GA_3 and NAA on growth yield and quality of flowers in carnation and to obtain higher yield under polyhouse conditions.

Materials and Methods

The experiment was conducted under naturally ventilated polyhouse in the Department of Horticulture, Sam Higginbottom University of Agriculture Technology and Sciences, Allahabad, during 2016-2017. Three varieties of standard carnation *viz*., Harvey, Bizet, Amado were evaluated for their growth, flowering, quality and yield attributes with respect to the application of different concentrations of growth regulators GA_3 and NAA. Treatments were given with concentrations of NAA @100,150 and 200 ppm and GA_3 @100,150 and 200 ppm at 30, 60, 90 and 120 DAT on three varieties. All the package of practices were followed as per recommendation to raise a quality crop. The experiment was laid out in factorial randomized block design with twenty one treatments and three replications. Five plants were selected randomly from each treatment per replication and the observations were recorded on various growth, flowering, quality and yield parameters on these plants. The data was statistically analyzed using analysis of variance.

Results and Discussion

Regulation of growth, flowering, quality, yield of plants using growth regulators is a major topic of experiments for the present times. Exogenous application of plant growth regulators enhances the growth (El-Naggar *et al.*, 2009) and flowering of ornamentals thereby yield. They may shorten the vegetative phase (Singh *et al.*, 2004) or make it delayed. Plant growth regulators play a vital role for enhancing quality and yield of many commercial flowers.

NAA is a plant hormone in the auxin family and is an ingredient in many commercial postharvest horticultural products. It has been reported to modify plant growth and flower yield in carnation significantly increased plant height, number of leaves and nodes, internodes height, shoot and root dry weight, flower diameters and number of petals.

GA_3 application increased petiole length, leaf area and delayed petal abscission and colour fading (senescence). Gibberellic acid plays a major role in plant growth and development. It has been found to be the best for enhancing vegetative attributes along with flower initiation in many commercial flowers.

Keeping in view of the above mentioned facts, the experiment entitled “Effect of plant growth regulators

Table 1 : Effect of plant growth regulators on plant height and number of leaves per plant in carnation varieties grown under naturally ventilated polyhouse.

Treatment	Plant height (cm)				No. of leaves per plant			
	V1	V2	V3	Mean(G)	V1	V2	V3	Mean(G)
G_0	87.31	80.27	72.16	**79.91**	179.46	160.06	154.40	**164.64**
G_1	94.12	87.89	80.26	**87.42**	189.06	169.20	162.26	**173.51**
G_2	95.08	88.04	82.46	**88.53**	190.13	170.13	163.33	**174.53**
G_3	96.76	88.72	83.10	**89.52**	191.93	171.80	164.53	**176.08**
G_4	107.93	97.75	87.84	**97.84**	194.13	181.06	172.53	**182.57**
G_5	116.64	104.78	92.98	**104.80**	196.66	182.93	179.86	**186.48**
G_6	119.66	112.24	100.56	**110.82**	196.93	186.66	184.53	**189.37**
Mean (V)	**102.50**	**94.24**	**85.62**		**191.19**	**174.55**	**168.78**	
C.D @ 5%	**V**	**G**	**V x G**		**V**	**G**	**V x G**	
	0.20	0.31	0.54		0.39	0.61	1.05	

Table 2 : Effect of plant growth regulators on no of shoots and number of internodes per plant in carnation varieties grown under naturally ventilated polyhouse.

Treatment	No. of Shoots				No. of Internodes			
	V1	V2	V3	Mean(G)	V1	V2	V3	Mean(G)
G_0	5.46	5.53	5.33	**5.44**	10.33	9.26	7.86	**9.15**
G_1	6.66	6.66	6.66	**6.66**	13.06	11.60	9.66	**11.44**
G_2	6.86	6.73	6.80	**6.88**	13.06	11.73	10.06	**11.62**
G_3	6.93	7.13	7.26	**7.11**	13.33	12.13	10.40	**11.95**
G_4	7.26	7.46	7.53	**7.42**	15.06	13.26	11.86	**13.40**
G_5	7.46	7.53	7.66	**7.55**	17.06	14.33	13.80	**15.06**
G_6	7.53	7.66	7.73	**7.64**	19.40	16.33	16.26	**17.33**
Mean (V)	**6.88**	**6.96**	**7.00**		**14.47**	**12.66**	**11.41**	
C.D @ 5%	**V**	**G**	**V x G**		**V**	**G**	**V x G**	
	0.09	0.13	0.23		0.15	0.23	0.40	

Gibberellic acid (GA_3) and Naphthalene Acetic Acid on growth and yield of carnation (*Dianthus caryophyllus* L.) under naturally ventilated polyhouse" was conducted and the results of the experiments are discussed here under the light of existing supportive literature.

Vegetative parameters

Plant height varies significantly among the varieties due to the effect of different concentrations of growth regulators applied. Among the varieties maximum plant height was recorded in variety Harvey (102.50 cm), this may be attributed to the genetical characters of the varieties. Among the different concentrations studied the maximum plant height (110.82 cm) was recorded in G_6 (GA_3 at 200 ppm). Interaction data revealed that variety Harvey with application of GA_3 at 200 ppm was recorded with maximum plant height (119.66 cm. plant height increased with the increasing concentration of GA_3 applied. Increased plant height might be due to quick cell multiplication and cell elongation due to higher concentration of GA_3. These findings were in conformity with the findings of Nandre *et al*. (2009) on China aster, Baghele *et al*. (2012) in Rose, Girisha *et al.* (2012) in Daisy, Rani and Singh (2013) in Tuberose and Raveendra *et al*. (2014) in Daisy. The increase in plant height seems to be due to enhanced cell division and cell enlargement, promotion of protein synthesis by GA_3 application exogenously which might have resulted in enhanced vegetative growth (Girisha *et al*., 2012).

Significant differences were observed in number of leaves. No. of leaves influenced by different concentrations of growth regulator varies significantly among the varieties, and the maximum no. of leaves (189.37) was recorded in G_6 (GA_3 at 200 ppm). Among the varieties studied, maximum no. of leaves days was recorded in variety Harvey (191.19). Interaction data revealed that interaction of variety Harvey with GA_3 at 200 ppm was recorded with maximum no. of leaves (196.93). No significant effects were recorded with the application of NAA on no. of leaves. The production of more number of leaves per plant by GA_3 might be due to rapid growth and differentiation. Similar findings with respect to difference in no. of leaves due to the increasing concentration of GA_3 was observed by Rani and Singh (2013) in Tuberose, Raveendra *et al*. (2014) in Daisy and Chauhan *et al.* (2016) in African marigold.

No. of shoots were influenced by different concentrations of growth regulators varies significantly among the different treatments and the maximum no. of shoots (7.64) was recorded in G_6 (GA_3 at 200 ppm). Which is at par with G_5 (GA_3 at 150 ppm). Among the varieties studied maximum no. of shoots was recorded in variety Amado (7.00), which is at par with variety Bizet (6.96), this may be attributed to the effect of pinching and the influence of different concentrations of growth regulators applied. Interaction data revealed that interaction of variety Amado with GA_3 at 200ppm (V_3G_6) was recorded with maximum no. of shoots (7.73) which is at par with $\mathbf{T_{19}}$ (V_3G_4), $\mathbf{T_{13}}$ (V_2G_5), $\mathbf{T_{20}}$ (V_3G_5) and $\mathbf{T_{14}}$ (V_2G_6). These findings with respect to increase in no. of shoots due to increase in concentration of GA_3 were in conformity with the findings of Nandre *et al.* (2009) in China aster and Maitra and Roychowdhury (2015) in Carnation.

No. of internodes were recorded with significant differences among different treatments. No. of internodes due to the influence of different concentration of growth regulators was recorded maximum (17.33) in G_6 (GA_3 at 200 ppm).among the varieties studied, maximum no. of internodes was recorded in variety Harvey (14.47) Interaction data revealed that maximum no. of internodes (19.40) was recorded in $\mathbf{T_7}$ (V_1G_6). These characters may be attributed to the height of plants as influenced by the different concentrations of growth regulators applied.

Internodal length varies significantly among the varieties due to the effect of growth regulators applied. Maximum internodal length was recorded in variety Amado (6.22 cm) and the minimum was in variety Bizet (5.06 cm). Among different concentrations studied G_6 (GA_3 at 200 ppm) was recorded with maximum internodal length (7.37 cm). The interaction data revealed that maximum internodal length (8.31cm) was recorded in $\mathbf{T_{21}}$ (V_3G_6).internodal length will directly contributes to the height of the plant and this may be attributed to the cell elongation and differentiation as influenced by GA_3.

Table 3 : Effect of plant growth regulators on length of internodes in carnation varieties grown under naturally ventilated polyhouse.

Treatment	Length of Internodes (cm)			
	V1	V2	V3	Mean(G)
G_0	4.80	3.82	4.79	**4.47**
G_1	5.37	4.41	5.12	**4.97**
G_2	5.52	4.68	5.63	**5.28**
G_3	5.74	4.75	5.85	**5.45**
G_4	6.44	5.52	6.59	**6.18**
G_5	7.02	5.94	7.25	**6.74**
G_6	7.50	6.31	8.31	**7.37**
Mean (V)	**6.06**	**5.06**	**6.22**	
C.D @ 5%	**V**	**G**	**V x G**	
	0.05	0.07	0.13	

Flowering parameters

Significant variation was observed among each treatment for the days taken to bud initiation. Minimum days to flower bud initiation was recorded in variety Amado (82.14) and the maximum days to bud initiation was recorded in variety Bizet (113.16). This may be due to the influence of growing environment and the genetical characters of the varieties. Among different concentrations studied G_6 (GA_3 at 200 ppm) was recorded with minimum days to flower bud initiation (91.82). The interaction data revealed that, minimum days to flower bud initiation (74.93) was recorded in $\mathbf{T_{21}}$ (V3G6). These findings about the differences in no. of days to bud initiation as influenced by diffent concentrations of GA_3 applied were in conformity with the findings of Vijai Kumar *et al.* (2008) in Carnation Baghele *et al*. (2012) in Rose, Rani and Singh (2013) in Tuberose, Raveendra *et al*. (2014) in Daisy, Maitra and Roychowdhury (2015) in Carnation.

The days to flower bud opening due to the effect of plant growth regulators varies significantly among varieties. Minimum days to flower bud opening was recorded in variety Bizet (19.26) and the maximum was in variety Amado (24.35). Among different concentrations studied G_6 (GA_3 at 200 ppm) was recorded with minimum days to flower bud opening (17.86). The interaction data

Table 4 : Effect of plant growth regulators on days to bud initiation and flower opening in carnation varieties grown under naturally ventilated polyhouse.

Treatment	Days to Bud Initiation				Days to Flower Opening			
	V1	V2	V3	Mean(G)	V1	V2	V3	Mean(G)
G_0	107.13	116.93	88.86	**104.31**	25.20	23.06	28.13	**25.46**
G_1	99.93	114.73	84.73	**99.80**	22.06	19.93	25.66	**22.55**
G_2	100.53	114.60	84.26	**99.80**	22.26	20.06	25.66	**22.66**
G_3	99.73	114.26	84.06	**99.35**	22.13	19.60	25.53	**22.42**
G_4	98.06	112.66	79.86	**96.86**	20.06	18.06	23.86	**20.66**
G_5	95.26	111.06	78.26	**94.86**	19.06	18.06	21.93	**19.68**
G_6	92.66	107.86	74.93	**91.82**	17.86	16.06	19.66	**17.86**
Mean (V)	**99.04**	**113.16**	**82.14**		**21.23**	**19.26**	**24.35**	
C.D @ 5%	**V**	**G**	**V x G**		**V**	**G**	**V x G**	
	0.19	0.29	0.50		0.16	0.25	0.43	

Table 5 : Effect of plant growth regulators on no of cut flower stalk per plant and number of cut flower stalk per m^2 in carnation varieties grown under naturally ventilated polyhouse.

Treatment	No. of cut flower stalk per plant				No. of cut flower stalk per m^2			
	V1	V2	V3	Mean(G)	V1	V2	V3	Mean(G)
G_0	3.46	3.33	3.86	**3.55**	10.33	9.26	7.86	**9.15**
G_1	5.26	5.43	5.46	**5.38**	13.06	11.60	9.66	**11.44**
G_2	5.26	5.66	5.66	**5.53**	13.06	11.73	10.06	**11.62**
G_3	5.73	5.93	5.93	**5.86**	13.33	12.13	10.40	**11.95**
G_4	5.93	6.13	6.53	**6.20**	15.06	13.26	11.86	**13.40**
G_5	6.53	6.33	6.73	**6.53**	17.06	14.33	13.80	**15.06**
G_6	6.86	7.33	7.13	**7.11**	19.40	16.33	16.26	**17.33**
Mean (V)	**5.58**	**5.73**	**5.90**		**14.47**	**12.66**	**11.41**	
C.D @ 5%	**V**	**G**	**V x G**		**V**	**G**	**V x G**	
	0.10	0.25	1.27		1.22	1.27	3.23	

revealed that, minimum days to flower bud opening (16.06) was recorded in $\mathbf{T_{14}}$ (V_2G_6) the longest duration (28.13) was recorded in $\mathbf{T_{15}}$ (V_3G_0). This might be due to advanced blooming nature of variety Bizet, and the increased photosynthesis and respiration along with enhanced fixation by GA_3 that led to early flower bud initiation. The differences in no. of days to bud opening was recorded earlier by Vijai Kumar *et al.* (2008) in Carnation, Baghele *et al*. (2012) in Rose, Maitra and Roychowdhury (2015) in Carnation, Sharma and Joshi (2015) in China aster, Chauhan *et al.* (2016) in African marigold, Disha *et al.* (2016) in Marigold and Sajid *et al.* (2016) in Chrysanthemum.

Quality parameters

Quality parameter plays an important role in economical acceptability of carnations as a cut flower. Foliar spray of NAA did not have any marked effect on quality attributes of carnation cut flowers. Bud length was recorded with significant variations among different treatments. Maximum bud length was recorded in variety Amado (4.12 cm). Shortest bud length was recorded in variety Harvey (3.01 cm), variations were expected among the varieties since bud length is a genetically influenced character. Bud length varies significantly among different concentrations of growth regulators applied and maximum bud length (4.55) was recorded in G_6 (GA_3 at 200 ppm) and the minimum (3.06) was recorded in G_0 (control). Bud length due to the interaction

of growth regulators with varieties revealed that maximum bud length (4.76) was recorded in $\mathbf{T_{21}}$ (V_3G_6) and the minimum (2.28) was in $\mathbf{T_1}$ (V_1G_0). Differences in bud length were earlier documented by Baghele *et al*. (2012) in Rose.

Significant differences were observed in carnation varieties with respect to bud diameter due to the effect of plant growth regulators. Maximum bud diameter was recorded in variety Amado (2.45 cm). Shortest bud diameter was recorded in variety Harvey (2.29 cm). Bud diameter varies significantly among different concentrations of growth regulators applied and the maximum bud diameter (2.89) was recorded in G_6 (GA_3 at 200 ppm) and the minimum bud diameter (2.03) was recorded in G_0 (control). Interaction data revealed that maximum bud diameter (2.94 cm) was recorded in $\mathbf{T_{21}}$ (V_3G_6) and the minimum (2.01) was in $\mathbf{T_1}$ (V_1G_0). Foliar spray of NAA did not have any marked effect on quality parameters and similar findings about the differing bud diameter as influenced by increasing concentration GA_3 was also documented by Baghele *et al*. (2012) in Rose.

There were significant differences observed among treatments with respect to flower length. Maximum flower length was recorded in variety Harvey (5.40 cm) and the Minimum was recorded in variety Amado (4.65 cm). Flower length varies significantly among different concentrations of growth regulators applied and the maximum flower length (5.38 cm) was recorded in G_6 (GA_3 at 200 ppm) and the minimum flower length (5.02 cm) was recorded in G_0 (control). Interaction data revealed that maximum flower length (5.74 cm) was recorded in $\mathbf{T_7}$ (V_1G_6) and the minimum (4.17cm) was in $\mathbf{T_{15}}$ (V_3G_0). Variations in flower length among the varieties with relation to the increase in concentration of GA_3 was also documented by Baghele *et al*. (2012) in Rose, Girisha *et al.* (2012) in Daisy, Pooja *et al.* (2015) in Gladiolus.

Flower diameter of carnation varieties statistically varies due to the effect of growth regulators on different varieties of carnation. Maximum flower diameter was recorded in variety Amado (6.16 cm). Minimum flower diameter was recorded in variety Harvey (5.66 cm). Flower diameter varies significantly among different concentrations of growth regulators applied and the maximum flower diameter (6.44 cm) was recorded in G_6 (GA_3 at 200 ppm) and the minimum flower diameter (5.57 cm) was recorded in G_0 (control) which is at par with G_1 (NAA at 100 ppm), G_2 (NAA at 150 ppm), G_3 (NAA at 200 ppm). Interaction data revealed that maximum flower diameter (6.75 cm) was recorded in $\mathbf{T_{21}}$ (V3G6), which is at par with $\mathbf{T_{20}}$ (V_3G_5), $\mathbf{T_{14}}$ (V_2G_6) and the minimum (5.40 cm) was in $\mathbf{T_1}$ (V_1G_0), which is at par with $\mathbf{T_1}$ (V_1G_0), $\mathbf{T_2}$ (V_1G_1), $\mathbf{T_3}$ (V_1G_2), $\mathbf{T_4}$ (V_1G_3), $\mathbf{T_5}$ (V_1G_4), $\mathbf{T_8}$ (V_2G_0), $\mathbf{T_9}$ (V_2G_1), $\mathbf{T_{10}}$ (V_2G_2), $\mathbf{T_{11}}$(V_2G_3), $\mathbf{T_{15}}$ (V_3G_0). Increase in flower diameter might be due to active cell elongation in the flower which resulted in increased flower diameter. Similar findings on difference in flower diameter due to the effect of plant growth regulators was also recorded by Baghele *et al*. (2012) on Rose Sainath *et al*. (2014) in Chrysanthemum, Pooja *et al*. (2015) in Gladiolus, Sajid *et al.* (2016) in Chrysanthemum.

Stalk girth of carnation varieties were recorded with significant differences due to the effect of different concentrations of growth regulators. Maximum flower stalk girth was recorded in variety Bizet (25.71mm) which is significantly superior over the other varieties. and the minimum flower stalk girth was in variety Amado (18.10 mm). Flower stalk girth due to the effect of different concentrations of growth regulators recorded that maximum flower stalk girth (22.89mm) was in G_6 (GA_3 at 200ppm) and the minimum (21.97mm) was in G_0 (control). Interaction data revealed that maximum flower stalk girth was (26.19 mm) in $\mathbf{T_{14}}$ (V_2G_6) and the minimum flower stalk girth (17.84mm) was recorded in $\mathbf{T_{15}}$ (V_3G_0), which is at par with $\mathbf{T_{16}}$ (V_3G_1), $\mathbf{T_{17}}$ (V_3G_2). Similar findings with respect to flower stalk girth and diameter was recorded by Vijai Kumar *et al.* (2008) in Carnation, Nandre *et al.* (2009) in China aster.

Flower stalk length was recorded with significant differences due to the effect of different concentrations growth regulators on different varieties of carnation. Maximum flower stalk length was recorded in variety Harvey (97.95cm), which is significantly superior over the other varieties and the minimum flower stalk length was in variety Amado (80.52 cm). Flower stalk length due to the effect of different concentrations of growth regulators recorded that maximum flower stalk length (107.40 cm) was in G_6 (GA_3 at 200ppm) and the minimum (73.54 cm) was in G_0 (control). Interaction data revealed that maximum flower stalk length was (114.58 cm) in $\mathbf{T_7}$ (V_1G_6) and the minimum flower stalk length (62.81cm) was recorded in $\mathbf{T_{15}}$ (V_3G_0). The differences in stalk length may be attributed to plant height and intermodal length which increases with increasing concentration of GA_3. These findings were in close proximity with the findings of Chakradhar and Khirathkar (2003) in Rose, Vijai Kumar *et al.* (2008) in Carnation Baghele *et al*. (2012) in Rose.

Significant variations were observed in carnation varieties with respect to vase life due to the effect of different concentrations of growth regulators. Maximum

Table 6 : Effect of plant growth regulators on bud length and bud diameter in carnation varieties grown under naturally ventilated polyhouse.

Treatment	Bud Length				Bud Diameter			
	V1	V2	V3	Mean(G)	V1	V2	V3	Mean(G)
G_0	2.28	3.18	3.71	**3.06**	2.01	2.03	2.05	**2.03**
G_1	2.40	3.24	3.82	**3.15**	2.11	2.18	2.28	**2.19**
G_2	2.40	3.25	3.82	**3.16**	2.11	2.19	2.29	**2.20**
G_3	2.42	3.27	3.84	**3.18**	2.13	2.23	2.29	**2.21**
G_4	3.19	3.44	4.35	**3.66**	2.34	2.39	2.55	**2.43**
G_5	4.05	3.88	4.56	**4.17**	2.52	2.61	2.72	**2.62**
G_6	4.30	4.61	4.76	**4.55**	2.84	2.89	2.94	**2.89**
Mean (V)	**3.01**	**3.55**	**4.12**		**2.29**	**2.36**	**2.45**	
C.D @ 5%	**V**	**G**	**V x G**		**V**	**G**	**V x G**	
	0.01	0.02	0.03		0.006	0.04	0.01	

Table 7 : Effect of plant growth regulators on flower length and flower diameter in carnation varieties grown under naturally ventilated polyhouse.

Treatment	Flower Length				Flower Diameter			
	V1	V2	V3	Mean(G)	V1	V2	V3	Mean(G)
G_0	5.10	5.79	4.17	**5.02**	5.40	5.53	5.78	**5.57**
G_1	5.29	4.73	4.41	**4.81**	5.51	5.72	5.93	**5.72**
G_2	5.30	4.73	4.46	**4.83**	5.50	5.70	5.92	**5.71**
G_3	5.30	4.74	4.47	**4.83**	5.50	5.70	5.92	**5.71**
G_4	5.45	4.84	4.87	**5.05**	5.72	5.90	6.25	**5.95**
G_5	5.60	5.03	5.03	**5.22**	5.89	6.24	6.55	**6.23**
G_6	5.74	5.21	5.19	**5.38**	6.09	6.48	6.75	**6.44**
Mean (V)	**5.40**	**5.01**	**4.65**		**5.66**	**5.90**	**6.16**	
C.D @ 5%	**V**	**G**	**V x G**		**V**	**G**	**V x G**	
	0.006	0.01	0.01		0.5	0.22	0.39	

vase life was recorded in variety Amado (10.31), which is statistically superior over the other varieties. When considering the different concentrations of growth regulators maximum vase life (12.02) was recorded in G_6 (GA_3 at 200ppm) and the minimum vase life (6.42) was in G_0 (control). Interaction data revealed that longest duration of vase life (14.93) was recorded in $\mathbf{T_{21}}$ (V_3G_6) and the minimum vase life (4.53) was in $\mathbf{T_8}$ (V_2G_0). The differences in vase life may be due to the varietal characters and the growing environment of the crop.

Yield parameters

No. of cut flower stalks obtained from varieties due to the effect of different concentrations of growth regulators were recorded with significant differences. Maximum no. of cut flower stalks per plant was recorded in variety Amado (5.90) and the minimum was in variety Harvey (5.58). No. of cut flower stalks per plant due to the effect of different concentrations of growth regulators varies significantly and the maximum no. of cut flower stalks per plant (7.11) was recorded in G_6 (GA_3 at 200ppm) and the minimum (3.55) was in G_0 (control). Interaction data revealed that maximum no. of cut flower stalks per plant was (7.33) in $\mathbf{T_{14}}$ (V_2G_6), which is at par with $\mathbf{T_7}$ (V_1G_6), $\mathbf{T_6}$ (V_1G_5), $\mathbf{T_{12}}$ (V_2G_4), $\mathbf{T_{13}}$ (V_2G_5), $\mathbf{T_{19}}$ (V3G4), $\mathbf{T_{21}}$ (V_3G_6), $\mathbf{T_{20}}$ (V_3G_5) and the minimum (3.33) was recorded in $\mathbf{T_8}$ (V_2G_0) which is at par with $\mathbf{T_1}$(V_1G_0), $\mathbf{T_{15}}$ (V_3G_0). Increase in number of flowers and yield per plant as a result of GA_3 treatment might be explained in light of the fact that, GA_3 treatment resulted in marked increase in the plant height and leaf area per plant, which

Table 8 : Effect of plant growth regulators on cut flower stalk girth and stalk length in carnation varieties grown under naturally ventilated polyhouse.

Treatment	Cut flower stalk girth				Cut flower stalk length			
	V1	V2	V3	Mean(G)	V1	V2	V3	Mean(G)
G_0	22.90	25.18	17.84	**21.97**	82.78	75.04	62.81	**73.54**
G_1	23.32	25.68	17.97	**22.32**	89.7	79.98	75.89	**81.87**
G_2	23.34	25.73	17.97	**22.35**	91.55	85.04	75.54	**84.04**
G_3	23.41	25.73	17.99	**22.37**	93.60	85.36	76.53	**85.16**
G_4	23.66	25.54	18.28	**22.50**	102.17	94.58	85.46	**94.07**
G_5	23.90	25.92	18.33	**22.72**	111.28	98.82	89.74	**99.94**
G_6	24.16	26.19	18.33	**22.89**	114.58	109.98	97.64	**107.40**
Mean (V)	**23.53**	**25.71**	**18.10**		**97.95**	**89.83**	**80.52**	
C.D @ 5%	**V**	**G**	**V x G**		**V**	**G**	**V x G**	
	0.08	0.13	0.23		1.11	1.70	2.94	

Table 9 : Effect of plant growth regulators on vase life in carnation varieties grown under naturally ventilated polyhouse.

Treatment	Length of Internodes (cm)			
	V1	V2	V3	Mean(G)
G_0	6.86	4.53	7.86	**6.42**
G_1	8.53	5.46	8.46	**7.48**
G_2	8.66	5.66	8.66	**7.66**
G_3	9.06	5.73	8.73	**7.84**
G_4	9.86	6.13	10.26	**8.75**
G_5	10.46	7.06	13.26	**10.26**
G_6	12.06	9.06	14.93	**12.02**
Mean (V)	**9.36**	**6.23**	**10.31**	
C.D @ 5%	**V**	**G**	**V x G**	
	0.11	0.17	0.30	

improve source to sink ratio. Nandre *et al.* (2009), China aster, Baghele *et al*. (2012) in Rose, Raveendra *et al*. (2014), in Daisy, Sharma and Joshi (2015) in China aster,

No. of cut flower stalks obtained from varieties due to the effect of different concentrations of growth regulators were recorded with significant differences. Maximum no. of cut flower stalks per square meter was recorded in variety Amado (141.69) and the minimum was in variety Harvey (133.95). No. of cut flower stalks square meter due to the effect of different concentrations of growth regulators varies significantly and the maximum no. of cut flower stalks per square meter (170.66) was recorded in G_6 (GA_3 at 200ppm) and the minimum (85.33) was in G_0 (control). Interaction data revealed that maximum no. of cut flower stalks per square meter was (176.00) in $\mathbf{T_{14}}$ (V_2G_6) and the minimum (80.00) was recorded in $\mathbf{T_8}$ (V_2G_0), which is at par with $\mathbf{T_1}$ (V_1G_0). Production of more numbers of flowers with increasing concentration of GA_3 was also observed by Nandre *et al.* (2009), China aster, Baghele *et al*. (2012) in Rose, Raveendra *et al*. (2014), in Daisy, Sharma and Joshi (2015) in China aster.

Conclusion

Based on the findings of the experiment, it is concluded that the variety Amado is superior with the interaction of growth regulator (GA_3 at 200 ppm) with respect to no. of shoots, internodal length, earliness to flowering, bud length, bud diameter, flower diameter, vase life. While with variety Harvey resulted in maximum plant height, no. of leaves, no. of internodes, flower length, stalk length. Whereas the interaction of the same concentration *i.e.* GA_3 at 200 ppm with variety Bizet resulted in minimum days to bud opening, maximum stalk girth, maximum no. of flowers per plant and per meter square.

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