Original Research Article

EFFECT OF PLANT GROWTH REGULATORS GIBERELLIC ACID ($GA_{3)}$ AND SALICYLIC ACID (SA) ON GROWTH AND YIELD OF CARNATION (*Dianthus caryophyllus*) UNDER NATURALLY VENTILATED POLYHOUSE

ABSTRACT

The present investigation entitled "*Effect of plant growth regulators Gibberellic Acid (GA_3) and Salicylic Acid (SA) on the growth and yield of carnation under naturally ventilated polyhouse*", was carried out during November, 2021 to April 2022 in, Naturally Ventilated Polyhouse, Department of Horticulture, Naini Agricultural Institute, SHUATS, it was concluded that the plant growth regulators treatments rendered their significant effect on almost all the growth, flowering and yield characters as well as quality of carnation. The treatment T_3 i.e. application of GA_3 @ 200 ppm was found superior in terms of Plant height **(**102.27cm), number of leaves (203.67), number of shoots (7.67), internodal length (7.73cm), number of internodes per shoot (17), bud length (10cm), bud diameter (2.87cm), flower diameter (6.80cm), flower length (5.67cm), flower stalk length (96.93cm), vase life (10.33), number of cut flower stalks per plant (7.00) and number of cut flower stalks per square meter (175). However, plants treated with SA @ 120ppm took minimum days for bud initiation (112.67 days) and the days taken to bud opening (24.67). Among the different treatments the highest Gross return (Rs/200m^2) **(**7,00,000), Net return (441565), benefit cost ratio (2.70) was obtained under the use of GA_3 @ 200 ppm(T_3).

Key words: Carnation, Economics, plant growth regulators, GA_3, SA

INTRODUCTION

The carnation (*Dianthus caryophyllus* L.), a member of the Caryophyllaceae family, is one of the world's most popular cut flower harvests, ranking among the top 10 cut flowers. It is cultivated in many regions of the world and is thought to be a Mediterranean native having diploid chromosome number 2n = 30. It's a half-hardy perennial with branching stems and timid joints, and leaves that are linear, glaucous, and arranged in opposite or decussate pairs. Each stalk produces bisexual or occasionally unisexual terminal blooms. In mild weather, the hybrids have a remarkably lengthy flowering period, resulting in continuous blooms. Carnation is a popular flower crop with a high commercial value as a cut flower because of their long-lasting keeping quality, diverse range of colors, appealing forms, capacity to survive long distance transportation, and exceptional ability to rehydrate after continuous shipment (Bhatia *et al*., 2007). Aside from producing cut flowers, carnations can be used in the garden for bedding, edging, borders, pots, and rock gardens (Dole and Wilkins, 2005). Several exporting countries prefer carnations to roses and chrysanthemums because of their great keeping quality, vast choice of forms and colours, and ability to resist long distance transit.

Plant growth regulators are organic compounds, natural or synthetic, organic molecules that cause a change in plant growth or development when present or applied at low concentrations (DiPaola, 1988). Numerous biotic and abiotic stressors now impede seed germination, seedling growth, and plant development as a result of changing climatic conditions, resulting in lower biological and economic yields. Plant growth regulators (PGRs) have the potential to play a key role in regulating plant responses to a variety of abiotic stresses, and hence help plants adapt to harsh environments.

Salicylic acid (SA) is an emerging plant growth regulator that acts as signalling molecule in plants under biotic and abiotic stresses. Salicylic acid (SA) is one of natural and harmless chemicals used for postharvest quality conservation of horticultural and ornamental produces. Recently, many postharvest technologies for fresh and perishable produces including fruit, vegetables and ornamentals have been accepted where salicylic acid is in use (Ramtin *et al*., 2015). It regulates physiological activities in plants like growth, germination, photosynthesis, and ion absorption, as well as acting as a signalling molecule in response to diverse environmental conditions (Hayat S *et al*., 2007).

Gibberellic acid (GA_3) is a plant growth hormone that affects plant growth in a variety of ways, including promoting stem elongation and thus increased growth, modifying light requirements,

and influencing flower bud initiation (Veluru Aparna *et al*., 2018). Many commercial flowers have found that GA_3 is the best for improving vegetative characteristics and blossom initiation. Increased inter-node extension, increased leaf growth, increased plant diameter, increased number of flowers, induced flowering, and enhanced apical dominance are the most notable impacts of GA_3 on shoot growth. Increased shoot growth is induced in most photo-periodically sensitive plants, particularly in the form of long-day photoperiod. Gibberellins have been found to trigger early blossoming and enhance the quantity of blooms in many attractive plants.

Considering the significance and widespread use of PGRs in the floricultural business, the goal of this study was to identify the significance of GA_3 and SA in Carnation in order to improve its vegetative and floral quality.

MATERIALS AND METHODS

A field experiment entitled "***Effect of plant growth regulators Gibberellic Acid (GA_3) and Salicylic Acid (SA) on the growth and yield of carnation (Dianthus caryophyllus) under naturally ventilated polyhouse"*** was carried out in the Department of Horticulture, Naini, Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences during 2021-2022. The experiment was laid out in randomized block design with nine treatments and three replications. The experiment included application of different concentrations of plant growth regulators Gibberellic Acid (GA_3) and Salicylic Acid (SA). Treatments were given with concentrations of GA_3 @ 175, 200, 225 and 250 ppm and SA @ 60, 80, 100 and 120 ppm at 30, 60, 90 and 120 DAT whereas water was sprayed on control plants. All the package of practices were followed as per recommendation to raise a quality crop. 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. Data on various parameters were recorded and statistically analysed by applying the technique of analysis of variance using Randomized Block Design. The level of significance was kept at 5% ($p < 0.05$).

RESULT AND DISCUSSIONS

Data in Table 1 indicated significant (P≤0.05) differences regarding the vegetative parameters like plant height, number of leaves per plant, number of shoots per plant, number of internodes per plant and internodal length treated with different GA_3 and SA concentrations.

Plants attained maximum height (102.27cm) when treated with GA_3 @ 200 ppm followed by that of 175 (99.23cm) ppm concentrations. Plants grown in control were (75.67cm) tall. By promoting cell division and elongation, foliar treatment of GA_3 may have affected the stem lengthening and canopy expansion. Additionally, under the impact of GA_3, which retains swelling force against with the softening of cell wall and increases plant height, growth may be accelerated by osmotic uptake of water and nutrients (Kumar et al 2020). These findings are in conformity with Sajid et al. (2016), Alhajhoj et al (2017) and Girisha et al. (2012) in daisy

A similar trend was observed regarding the number of leaves parameter where maximum number of leaves (203.67) was observed when GA_3 @ 200 ppm was applied followed by that of 175ppm (200.33) concentrations. Plants in control treatment were 182.67. The initiation of more leaves was observed at higher GA_3 concentrations, which may be due to an increase in cell division, cell elongation, and tissue differentiation. Additionally, a greater number of shoots may have improved leaf commencement. Alhajhoj et al (2017). These findings are in line with those of Sajid et al. (2016), Patel et al. (2010), Kumar et al. (2012)

Maximum number of shoots per plant (7.67) was counted in GA_3 @ 200 ppm treatment followed by those of GA_3 @ 175 ppm (7.00) concentrations. Plants in control treatment produced minimum number of shoots per plant (4.33). The possible reason could be that the foliar application of GA_3 might influenced the vegetative growth by encouraging cell division and elongation that increased shoots numbers. Gibberellins regulate a variety of plant growth processes, but the most well-known one is the promotion of cell division, which results in stem elongation, canopy expansion, and branchial plants with more leaves. Alhajhoj et al (2017). Nagarjuna et al. (1988) recorded more number of branches with 200 ppm GA3 as compared to control in Chrysanthemum. These findings are in agreement with those of Sajid et al. (2016) and Rani and Singh (2013), who recorded a greater number of branches with increased concentration of GA3.

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 in T3 GA_3 @ 200 ppm (17.00) followed by those of GA_3 @ 175 ppm (16.33) concentrations. Plants in control treatment produced minimum number of internodes (11.00). The application of GA3 increases cell division which in turn causes increase in vegetative characters. Additionally, the increase in plant height also favoured for a greater number of internodes. These findings are in agreement with those of Justo. C. Benny et al. (2017) who recorded a greater number of internodes with 200ppm GA3 and Aparna et al (2018) in chrysanthemum.

Table 1 also showed that internodal length were higher when plants were treated with the concentrations of GA_3 such as @ 200 (7.73), followed by 175 ppm (7.23). Plants in control treatment (4.23). The positive response for increase in the internodal length was due to the effect of GA3 on stimulation of cell division as well as elongation of new cells formed in the plants. These findings are in conformity with those of Aparna et al (2018) in chrysanthemum and Benny et al. (2017) in carnation.

Without regardless which growth regulators were utilised or in what concentrations, all of the treatments outperformed the control in terms of flowering, quality and yield criteria. Minimum days to flower bud initiation was recorded in treatment T9 – SA @ 120 ppm (112.67) and followed by the treatment T3- GA3 @ 200ppm (115) whereas the maximum days to bud initiation was recorded in T1 – Control (135). The flowering promoting effect after SA application can also be indirect as SA alters the synthesis and/or signalling pathways of other plant hormones including jasmonic acid, ethylene and auxin. Early flowering and floral bud sprouts have also been induced by salicylic acid concentrations because this stimulating agent accelerates biosynthesis of secondary metabolites. SA as a manager of blooming time, Interacts with both photoperiod-dependent and self-governing pathways. Photoperiodism affects flowering by inducing the shoot to produce floral buds instead of leaves and lateral buds. These findings are in conformity with those of Samir Poudel (2020) and Aashuthosh et al. (2019).

Minimum days to flower bud opening was recorded in treatment T9- SA @ 120 ppm (24.67) and followed by the treatment T3 – GA3 @ 200 ppm (26) whereas the maximum was in the treatment T1 – Control (31.67).

The data’s regarding quality parameters like bud length, bud diameter, flower length, flower diameter, flower stalk length, vase life is showed in the table 3. Bud length was recorded with

significant variations among different treatments. Maximum bud length was recorded recorded in treatment T3- GA3 @ 200 ppm (3.10cm) and followed by the treatment T2 – GA3 @ 175 ppm (2.93cm) whereas the shortest bud length was recorded in the treatment T1 – Control (1.77cm). Increased floret production as a result of improved nutrition during the reproductive period can result in buds with a larger length. Variations in bud length among the treatments due to different concentration of GA3 was also documented by Baghele et al. (2012) in Rose.

Bud diameter was recorded with significant variations among different treatments. Maximum bud diameter was recorded recorded in treatment T3- GA3 @ 200 ppm (2.87cm) and followed by the treatment T2 – GA3 @ 175 ppm (2.70cm) whereas the shortest bud diameter was recorded in the treatment T1 – Control (1.73cm). Increased biomass production due to the application of GA3 might be responsible for enhanced flower quality parameters like flower and flower bud diameter values. Similar results were also observed by Aparna et al (2018) in chrysanthemum and Benny et al (2017) in Carnation.

Flower length was recorded with significant variations among different treatments. Maximum flower length was recorded recorded in treatment T3- GA3 @ 200 ppm (5.67cm) and followed by the treatment T2 – GA3 @ 175 ppm (5.40cm) which was at par with T4- GA3 @ 225 ppm (5.30cm) whereas the shortest flower length was recorded in the treatment T1 – Control (4.07cm). The increase in the flower size might be due to the increase in leaf numbers and leaf area, which lead to produced more photosynthesis. Similar findings were also observed in those of Alhajhoj et al (2017) in chrysanthemum, S. Vijayakumar et al (2017).

Flower Diameter was recorded with significant variations among different treatments. Maximum flower diameter was recorded recorded in treatment T3- GA3 @ 200 ppm (6.80cm) and followed by the treatment T2 – GA3 @ 175 ppm (6.53cm) which was at par with T4- GA3 @ 225 ppm (6.37cm) whereas the shortest flower diameter was recorded in the treatment T1 – Control (5.07cm). Increase in flower diameter might be due to active cell elongation in the flower, which increased the flower diameter and GA3 might be due to increased strength of the actively growing parts. Variations in quality parameters among the treatments due to different concentration of GA3 was also documented by S. Vijaykumar (2017) in china aster. These findings are in line with those of Baghele et al. (2012) on Rose, Pooja et al. (2015) in Gladiolus, Sajid et al. (2016) in Chrysanthemum.

Increased floret production as a result of improved nutrition during the reproductive period can result in flowers with a larger diameter and length. All of these elements eventually helped to

improve the distribution of photosynthates to reproductive sinks under the direction of GA_3. The increase in the flower size might be due to the increase in leaf numbers and leaf area, which lead to produced more photosynthesis, Alhajhoj et al (2017).

Flower stalk length was recorded with significant variations among different treatments. Maximum flower stalk length was recorded recorded in treatment T3- GA3 @ 200 ppm (96.93cm) and followed by the treatment T2 – GA3 @ 175 ppm (93.93cm) whereas the shortest flower stalk length was recorded in the treatment T1 – Control (70.60cm). The increase in the length of flower stalk might be due to an increase in the length of the branch. By promoting cell division and elongation, foliar treatment of GA_3 may have affected the stem lengthening and canopy expansion. These findings are in line with those of S. Vijayakumar et al (2017) in china aster, Benny et al (2017).

Vase life is an important factor which decides the demand of cut flowers for commercial cultivation. Maximum vase life was recorded recorded in treatment T3- GA3 @ 200 ppm (10.33) and followed by the treatment T2 – GA3 @ 175 ppm (10.00) whereas the minimum vase life was recorded in the treatment T1 – Control (6.67). The maximum extension of vase life which might be due to the overall modified effect on the vegetative and reproductive growth of the plant. This prolonged vase life of GA3 treated cut flowers might be due to strong flowering stems with more flower bud size. Because of the higher vigour in treated plants, cut stems may also contain more food reserves. Variations in quality parameters among the treatment's due different concentration of GA3 was also documented by S. Vijayakumar et al. (2017) in chrysanthemum, Aparna et al (2018) in chrysanthemum and Benny et al (2017) in carnation.

GA_3 @ 200ppm showed highest cut flower stalks per plant (7.00) and per square meter (175.00) as compared to other treatments and control. The increase in leaf area and number that GA_3 brought about may have contributed to the rise in flower production by facilitating the translocation of assimilates from source to sink. Additionally, the present study's enhanced leaf count resulted in greater photosynthetic activity, which promoted early blooming. Due to increased reproductive efficiency and photosynthesis in the restructured plant type, more shoots were produced at an early stage of growth, giving them enough time to accumulate carbohydrates for proper flower bud differentiation, which ultimately increased the yield per plant and per square metre. Kumar et al (2020), Alhajhoj et al (2017). These results are confirmed from those reported by Kumar et al. (2012) who recorded a substantial increase in

number of flowers when plants were treated with GA3 at 150 ppm in carnation, was also observed by Nandre et al. (2009), China aster, Baghele et al. (2012) in Rose, Sharma and Joshi (2015) in China aster

In case of economic parameter GA_3 @ 200 ppm gained maximum gross return (Rs. /200m^2) (700000), net return (Rs. /200m^2) (441565) and Cost Benefit Ratio (2.70), increment in Cost: Benefit is due to the increasing number of flowering shoots.

CONCLUSION

From the present study it may be concluded that among the foliar application of PGRs, application of GA_3 @ 200 ppm proved to be superior to other treatments in regarding all vegetative, flowering, quality and yield parameters like plant height, no. of leaves, no. of internodes no. of shoots, internodal length, bud length, bud diameter, flower diameter, flower length, flower stalk length, vase life, no: of cut flower stalks per plant and per square meter and economics. Earliness in flowering is observed in the treatment SA@ 120 ppm.

Table 1: Effect of plant growth regulators on vegetative parameters of carnation varieties grown under naturally ventilated polyhouse.

Treatments	Plant height	No. of leaves	No. of shoots	No. of internodes	Internodal length
Control	75.67	182.67	4.33	11.00	4.23
GA_3 @ 175ppm	99.23	200.33	7.00	16.33	7.23
GA_3 @ 200ppm	102.27	203.67	7.67	17.00	7.73
GA_3 @ 225ppm	97.57	198.67	6.67	16.00	7.00
GA_3 @ 250ppm	92.93	195.00	6.00	15.00	6.37
SA @ 60ppm	86.70	188.33	5.33	13.67	5.23
SA @ 80ppm	90.93	193.00	5.67	14.33	5.90
SA @ 100ppm	89.33	191.00	5.67	14.00	5.57
SA @ 120ppm	95.23	197.33	6.33	15.33	6.63
F – Test	S	S	S	S	S
S. Ed	0.35	0.46	0.27	0.27	0.07
CD @ 5%	0.75	0.97	0.58	0.56	0.15

Table 2: Effect of plant growth regulators on flowering parameters of carnation varieties grown under naturally ventilated polyhouse.

Treatments	Days taken for flower bud initiation	Days taken for flower bud initiation
Control	135.00	31.67
GA_3 @ 175ppm	116.33	27.00
GA_3 @ 200ppm	115.00	26.00
GA_3 @ 225ppm	116.33	26.33
GA_3 @ 250ppm	119.67	27.67
SA @ 60ppm	128.67	29.33
SA @ 80ppm	122.33	28.67
SA @ 100ppm	126.33	29.00
SA @ 120ppm	112.67	24.67
F – Test	S	S
S. Ed	0.83	0.39
CD @ 5%	1.75	0.83

Table 3: Effect of plant growth regulators on quality parameters of carnation varieties grown under naturally ventilated polyhouse.

Treatments	Bud Length	Bud Diameter	Flower Length	Flower Diameter	Flower stalk length	Vase life
Control	1.77	1.73	4.07	5.07	70.60	6.67
GA_3 @ 175ppm	2.93	2.70	5.40	6.53	93.93	10.00
GA_3 @ 200ppm	3.10	2.87	5.67	6.80	96.93	10.33
GA_3 @ 225ppm	2.77	2.63	5.30	6.37	92.33	9.67
GA_3 @ 250ppm	2.67	2.50	5.03	6.10	86.80	9.33
SA @ 60ppm	2.10	2.07	4.50	5.60	81.40	7.67
SA @ 80ppm	2.47	2.33	4.90	6.00	85.37	8.67
SA @ 100ppm	2.30	2.23	4.73	5.77	84.17	8.33
SA @ 120ppm	2.70	2.53	5.17	6.27	89.93	9.67
F – Test	S	S	S	S	S	S
S. Ed	0.05	0.04	0.06	0.04	0.44	0.36
CD @ 5%	0.11	0.08	0.13	0.08	0.94	0.75

Table 4: Effect of plant growth regulators on yield parameters and economics of carnation varieties grown under naturally ventilated polyhouse.

	YIELD PARAMETERS		ECONOMICS		
Treatments	No: of Cut Flower Stalks per Plant	No: of Cut Flower Stalks per Square Meter	Gross Return (Rs/200m^2)	Net Return (Rs/200m^2)	Cost benefit ratio
Control	2.67	66.67	266680	12520	1.04
GA_3 @ 175ppm	6.00	150.00	600000	342240	2.32
GA_3 @ 200ppm	7.00	175.00	700000	441565	2.70
GA_3 @ 225ppm	5.67	141.67	566680	307795	2.18
GA_3 @ 250ppm	5.00	125.00	500000	240665	1.92
SA @ 60ppm	4.00	100.00	400000	145075	1.56
SA @ 80ppm	4.67	116.67	466680	211485	1.82
SA @ 100ppm	4.33	108.33	433320	177900	1.69
SA @ 120ppm	5.33	133.33	533320	277630	2.08
F – Test	S	S			
S. Ed	0.42	10.39			
CD @ 5%	0.88	22.03			

REFERENCES

- **Aparna, V., Prakash, K., Neema, M., Ajay, A., Kumar, N. and Singh, M.C., 2018.** Effect of Gibberellic Acid on plant growth and flowering of Chrysanthemum cv. Thai Chen Queen under short day planting conditions, *International Journal of Agriculture Sciences.*, Vol. **10** (11): 6274-6278**.**
- **Banghele, R.D., Dhaduk, B.K., Chawla, S.I., and Radhika, J. 2012.** Effect of foliar spray of growth regulator and cow urine on flowering, quality and yield of rose (*Rosa hybrid* cv. poison) under naturally ventilated polyhouse. *Intl. J. Tropical Agric*., **34** (6): 0254-8755.
- **Bhatia, S., Gupta, Y.C. and Dhiman, S.R. (2007).** Effect of growing media and fertilizers on growth and flowering of Carnation under protected condition. *J. Orn. Hort.,* **8**(3): 239-240.
- **DiPaola, J. M. 1988**. *Turfgrass growth regulation In Chemical Vegetation Management*. J.E. Kaufmann and H.E. Westerdahl (eds.). Monsanto Graphic Service Publ.
- **Dole, J.M. and Wilkins, H.F.2005**. *Floriculture principles and species*, 2nd edition. Pearson prentice hall, Upper Saddle River, New Jersey. 347pp.

- **Girisha, R., Patil, V.S. and Krishnamurthy, G.H. 2012.** Growth, quality and yield characteristics of daisy (*Aster amellus* L.) cv. Dwarf Pink as influenced by different plant growth regulators. *Karnataka J. Agric. Sci.,* 25(1): 163-165.
- **Hayat S, Ali B, Ahmad A. 2007.** Springer, Salicylic Acid: Biosynthesis, Metabolism and physiological Role in plant, *Salicylic Acid: A Plant Hormone*. 1: 1-14.
- **Justo C. Benny, Devi Singh, U. Fatmi and Dona Ann Jose. 2017.** Effect of plant growth regulators, gibberellic acid (GA3) and naphthalene acetic acid (NAA) on growth and yield of carnation (*Dianthus caryophyllus* l.) Under naturally ventilated polyhouse. *Plant Archives.,* Vol. **17** (2):803-812.
- **Kiss, Z. O., Balogh, A., and Fodorpataki, L. (2001).** Investigation of the in vitro regeneration of mericlones in the Caribe variety of carnation. *International Journal of Horticultural Science*, **7**(3-4), 87-89.
- **Kumar, P., Singh, A., Laishram, N., Pandey, R.K., Dogra, S., Jeelani, M.I. and Sinha, B.K., 2020.** Effects of plant growth regulators on quality flower and seed production of marigold (*Tagetes erecta* L.). *Bangladesh Journal of Botany*, *49*(3), pp.567-577.
- **Kumar, V., V. Kumar, V. Umrao and M. Singh. 2012.** Effect of GA3 and IAA on growth and flowering of carnation. *Hort. Flora Res. Spect.,* 1(1): 69-72
- **Maitra, S. and Roychowdhury, N. 2015**. Effect pf plant growth regulators on growth, development and flowering of carnation (*Dianthus caryophyllus*. L) cv. Chabaud Super Mix. *J. Agric. Techno.,* **2** (1&2): 72-78.
- **Mani Ram, Virendra Pal, Manoj Kumar Singh and Mukesh Kumar.2012.** Response of different spacing and salicylic acid levels on growth and flowering of gladiolus (*Gladiolus grandiflora*). *HortFlora Research Spectrum.*, **1** (3): 270-273.
- **Mii, M., Buiatti, M., and Gimelli, F. (1990)**. Carnation. In: Ammirato P.V., Evans D.A., Sharp W.R., Bajaj Y.P.S. (Ed.), *Handbook of plant cell culture*. McGraw-Hill Pub. Co, New York, USA. 284-318pp.
- **Mohammed Refdan Alhajhoj, 2017.** Effects of Foliar Application of Plant Growth Regulators on Growth and Flowering Characteristics of Chrysanthemum CV. Paintball. *Pak. j. life soc. Sci.* 15(2): 114-119
- **Nandre, D.R., Navandar, U.O. and Archana, D.W. 2009.** Effect of growth regulators on growth, flowering and yield of China aster. *Asian J. Hort*., Vol **4** (1): 50-51.

- **Nagarjuna, B., V.P. Reddy, M.R. Rao and E.N. Reddy. 1988.** Effect of growth regulators and potassium nitrate on growth, flowering and yield of chrysanthemum (*Chrysanthemum indicum* L.). *South Indian Hort.,* 36: 136-140
- **Patil, Disha., Chopde, Neha., Lokhande, Sushma., and Bhande, M.H., 2016.** Studies on response of African marigold to plant growth regulators for seed production. Plant Archives, 16(1): 423-425.
- **Pooja R., Kuldeep Y., Nisha K., Narender S., and Muzafar, H.D. 2015.** Assessment of Growth, Floral and Yield Attributes of Gladiolus in Response to Gibberellic Acid treatment. *Botany Res. Intl.* 8(1): 01-06.
- **Rani. P. and Singh. P. 2013.** Impact of Gibberellic acid pre-treatment on growth and flowering of tuberose (*Polianthes tuberosa* L.) cv. Prajwal *J. Trop. Plant Physiol*. 5: 33-41.
- **Sajid, M., Amin, N., Ahmad, H.A.B.I.B. and Khan, K., 2016.** Effect of gibberellic acid on enhancing flowering time in *Chrysanthemum morifolium*. *Pak. J. Bot*, *48*(2): 477-483**.**
- **Sharma, M.K. and Joshi, K.L. 2015**. Effect of foliar spray of GA_3 and NAA on growth flowering and Yield of China aster (*Callistephus chinensis*) cultivars. *Intl. J. Agric. Sci. and Res.,* **5** (4): 105-110.
- **Vijayakumar, S., K. R. Rajadurai, K.R., & Pandiyaraj, P. 2017.** Effect of plant growth regulators on flower quality, yield and postharvest shelf life of china aster (*Callistephus chinensis* l. Nees.) Cv. Local. *International Journal of Agricultural Science and Research.,* **7**(2): 297-304.