Research Article

Effect of Plant Growth Regulators on Growth and Flower Yield of Calendula (*Calendula officinalis* L.) cv. Bon Bon

Syed khudus[1]*, V.M. Prasad[1] and S. M. Jogdand[2]

[1]Department of Horticulture, Allahabad School of Agriculture, Sam Higginbottom Institute of Agriculture, Technology & Sciences, Allahabad -211007, Uttar Pradesh, India
[2]Department of Horticulture, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Dist. Udham Singh Nagar, Uttarakhand, India

Abstract

The present investigation was carried out during 2015-16 at research field of department of horticulture, Allahabad School of Agriculture, SHIATS, Allahabad. The experiment included thirteen treatments and three replications. Treatment used were T_0 (Control), T_1 (GA_3 @100ppm), T_2 (GA_3@200ppm), T_3 (GA_3@300ppm), T_4 (NAA@50ppm), T_5 (NAA@ 100ppm), T_6 (NAA@150ppm), T_7 (NAA@200ppm), T_8 (CCC@250ppm) and T_9 (CCC@500ppm), T_{10} (CCC@750ppm), T_{11} (CCC@1000ppm), T_{12} (CCC@1250ppm). The results obtained showed that application of GA_3 @300 ppm was found to be superior in plant height(38.6cm), plant spread(45.7cm), number of branches(34.4), number of leaves(240.7), and diameter of flower(6.8 cm), whereas, NAA @200 ppm was found to best for weight of flower(4.5 g),number of flowers per plant(42.2),yield of flowers per plant(211.3 g),yield of flowers per plot(1056.2 g) and yield of flowers (19.3 t/ha) as compared with control. Therefore, it can be concluded that application with GA_3@300and NAA @200 ppm was found best for calendula growth and flower yield attributes.

Keywords: Calendula, Plant Growth Regulators, GA_3, NAA, CCC

***Correspondence**
Author: Syed khudus
Email: khorticos@gmail.com

Introduction

Calendula (*Calendula officinalis*L.) is one of the most commonly cultivated seasonal flowers. It is also known as english marigold or pot marigold, belongs to family Asteraceae. It is a free blooming annual with beautiful crowns, grown for garden decoration and cut flower purpose. The flower is found in diverse colors and used in making bouquets, garland and vase arrangements. It is a very hardy winter season annual, which is grown extensively in beds, baskets and boxes. Calendula is also used for their medicinal properties; calendula has anti-inflammatory, anti-septic, anti-viral anti-bacterial properties and help to boost the immune system. Calendula has been for long a popular domestic remedy for skin problems ranging for bites and stings to wounds and even various veins[1].

Gibberellic acid (GA_3) is a well-recognized plant growth regulator for flower induction in many herbaceous flower crops.The flower formation of long day or long short day plant can be controlled by regulating the endogenous level of gibberellins-like substances though the use of such growth retardant.The beneficial effects of $GA_3$and NAA on growth and flowering has been reported in calendula, marigoldand lily[2-4]respectively. Use of naphthalene acetic acid (NAA) in calendula successfully induced more concentrated flowering thereby, facilitating, harvesting. Initially it was thought that this success was due to the role of natural auxins in flowering but now it is known that the NAA had effect through the stimulation of ethylene production. On the other hand, Cycocel (CCC) is very diverse group of compound that generally retarded stem elongation by preventing cell division in the sub apical meristem usually without similarly affecting the apical meristem. These substances modify plant character like height, number and size of leaves and flowers, branching habits, internodes length,fresh and dry weight and root growth etc. Plant growth retardants in ornamental plants are applied for limiting stem elongation and produce a more appressed, sturdy potted and bedding plants with minimum changes in developmental patterns or extorting phytotoxic effects [5, 6]. Keeping the above facts in mind, the present investigation entitled “Effect of plant growth regulators on growth and flowering yield of Calendula (*Calendula officinalis* L.)” was performed under Allahabad climatic conditions to optimize the appropriate concentration of plant growth regulators for growth, flowering and yield parameters of calendula.

Materials and Methods

An experiment was under taken at research field, Department of Horticulture, Allahabad school of Agriculture, SHIATS, Allahabad during kharif season 2015-2016. The plants of calendula is planted at a spacing of 0.30 x 0.30 M was used for the present investigation.The experimental site is fairly level land with sandy loam soil of uniform fertility status with low clay and high sand percentage.The treatments consists of different combinations of plant growth regulators GA_3 (100,200,300 ppm) NAA (50,100,150,200 ppm), cycocel (250, 500, 750, 1000 and 1250 ppm) Gap filling, irrigation, mulching, weeding and plant protection measures were carried out as per the requirement of the crop. The experiment was layout in Randomized Block Design (RBD) with 13 treatments and each treatment replicated thrice. The experimental data were subjected to statistical analysis in order to find out which of the treatments showed significant variation in different parameters studied under investigation. The technique of analysis of variance (ANOVA) for randomized block design (RBD) was adopted [7].

Result and Discussion

Growth parameters

Data indicates that vegetative parameters were significantly influenced by different treatments (**Table 1**). Themaximum plant height (38.6 cm) significantly was recorded in treatment T_3 (GA_3@300ppm), followed by T_1 (GA_3@100ppm) (34.4 cm). The minimum plant height (23.5) was recorded with the treatment T_{10} (CCC @750ppm) respectively. Maximum spread of plant (45.7 cm) was recorded with treatment T_3 (GA_3 @300ppm) followed by T_1 (GA_3 @100ppm) (39.4 cm). The minimum plant spread (27.4cm) was recorded with treatment T_{10} (CCC @750ppm) respectively. Maximum number of branches per plant (34.4) was recorded in treatments T_3(GA_3@300ppm) followed by T_7 (NAA@200ppm) (32.3 cm). The minimum branches per plant (20.7) was recorded with treatment T_0 (Control) respectively. Maximum number of leaves per plant (240.7) was recorded in treatments T_3 (GA_3@300ppm) followed by T_7 (NAA @200ppm) (226.9). The minimum leaves per plant (204.8) was found in treatment T_0 (Control).Number of days required for first flower bud emergence from transplanting (56.3 days) was recorded in treatment T_7 (NAA @200ppm) followed by treatmentT_5 (NAA @100ppm) (58.3 days).The results obtained indicated that NAA showed the increased growth parameters above tested and this might be attributed to the role of NAA in controlling the growth of stems, root and convert stem into flowers, subsequently it stimulate cambium to divide and in stems cause secondary xylem to differentiate. NAA is auxins based and hence it act to inhibit the growth of buds lower down the stems (apical dominance)and also promote lateral root development and growth. The minimum number of days required for first flower bud (56.3) was founded the treatment T_7 (NAA@200ppm).The beneficial effect of GA_3 on increased growth parameters might be due to increasing auxinlevel of tissues which probably enhanced the conversion of tryptophan might through, causes cell division and cell elongation. The similar trend of growth and flowering parameters was confirmed in calendula, marigold, chrysanthemum and spider lily [8-12].

Table 1 Effect of plant growth regulators on vegetative parameters of Calendula (*Calendula officinalis*L.) cv. Bon Bon

Treatment/ Combination	Plant height (cm)	Plant Spread (cm)	Number of leaves per plant	Number of branches per plant
Control (T_0)	24.4	28.4	204.8	20.7
GA_3 @ 100 ppm (T_1)	34.4	39.4	224.9	26.9
GA_3 @ 200 ppm (T_2)	31.8	34.4	225.1	30.2
GA_3 @ 300 ppm (T_3)	38.6	45.7	240.7	34.4
NAA@ 50 ppm (T_4)	27.4	32.5	217.4	24.2
NAA@ 100 ppm (T_5)	28.4	33.5	218.0	28.1
NAA @ 150 ppm (T_6)	30.0	35.4	221.1	30.2
NAA @ 200 ppm (T_7)	32.3	36.4	226.9	32.3
Cycocel @250ppm (T_8)	27.2	29.6	211.6	28.4
Cycocel @500 ppm (T_9)	28.6	32.5	214.3	25.4
Cycocel @750 ppm (T_{10})	23.5	27.4	209.4	23.5
Cycocel @1000 ppm (T_{11})	26.6	31.5	209.9	26.3
Cycocel @1250ppm (T_{12})	27.3	32.7	216.4	24.5
S. Ed.(±)	0.15	0.18	0.72	0.42
C. D. at 5 %	0.31	0.38	1.45	0.86

Yield parameter

The data pertaining to yield parameters under different treatments are presented in **Table 2**. The yield parameters like weight of flower (4.7 g) was significantly increased in treatment T_7 (NAA@200ppm) followed by treatment T_{10} (CCC@750ppm) (4.0 g) respectively. The weight of flower (2.7) was recorded with treatment T_0 (Control) respectively. Flower diameter (6.8 cm) was significantly increase in treatment T_3 (GA_3@300ppm) followed by treatment T_1 (GA_3@100ppm) (6.5 cm). The minimum flower diameter (4.0) was recorded with treatment T_{10}(CCC @750ppm) respectively. Significantly increase in number of flowers per plant (42.2) was recorded in treatment T_7 (NAA @200ppm) followed by treatment T_5 (NAA @100ppm) (39.5). Significantly maximum yield of flower per plant (211.3g) was recorded in treatment T_7 (NAA @200ppm) followed by treatment T_5 (NAA@ 100ppm) (190.6g). The minimum yield of flower per plant (84.2) was recorded with treatment T_0 (Control) respectively. Significantly increase in yield of flowers per plot (1056.2g) were recorded in treatment T_7 (NAA @200ppm) followed by treatment T_5 (NAA@ 100ppm) (952.2 g) per plot. The minimum yield of flower per plot (421.0) was recorded with treatment T_0 (Control) respectively. Significantly increase in yield of flowers per hectare (11.7 t) were recorded in treatment T_7 (NAA @200ppm) followed by treatment T_5 (NAA@ 100ppm) (10.6 t) per hectare. The minimum yield of flower per hectare (4.6 t) was recorded with treatment T_0 (Control) respectively. The favorable effect of GA_3 and NAA might be attributed due to greater amount of carbohydrate accumulation and increased metabolic activities which leads to initiation of cell division and cell enlargement by promotion of protein synthesis coupled with higher dry matter of apical dominance.Similar results were also reported in chrysanthemum, marigold, gladiolus, spider lily and rose [11-16].The economics of experiment is very important as farmer is convinced with specific recommendation through economic aspect of the research. The cost of cultivation due to different treatments and gross income were calculated and presented in Table 2. The price of fruit was fixed at the prevailing market rate. Total price per hectare was depended upon the yield in different treatments. The maximum benefit: cost ratio (1:2.97) was calculated under T_7 followed by 1:2.70 in T_5. However, the minimum benefit: cost ratio (1:1.12) was observed in T_{12}.

Table 2 Effect of plant growth regulators on flowering and yield of Calendula (*Calendula officinalis*L.) cv. Bon Bon

Treatment/ Combination	No of days taken for first bud emergence	Weight of flower (g)	Diameter of flower (cm)	No of flowers per plant	Yield of flower per plant (g)	Yieldof flower per plot(g)	Flower yield per hectare (t)	Benefit Cost Ratio
Control (T_0)	70.4	2.7	4.1	20.3	84.2	421.0	4.6	1.17
GA_3 @ 100 ppm (T_1)	67.2	3.4	6.5	28.5	123.5	610.3	6.8	1.48
GA_3 @ 200 ppm (T_2)	66.3	3.2	6.2	30.7	136.0	680.6	7.6	1.44
GA_3 @ 300 ppm (T_3)	63.6	3.3	6.8	35.4	177.3	886.3	9.8	1.64
NAA@ 50 ppm (T_4)	68.4	3.9	5.3	25.5	106.1	530.6	5.9	1.50
NAA@ 100 ppm (T_5)	58.3	3.7	5.3	39.5	190.6	952.2	10.6	2.70
NAA @ 150 ppm (T_6)	59.3	3.6	5.4	33.4	164.2	821.0	9.1	2.31
NAA @ 200 ppm (T_7)	56.3	4.5	5.6	42.2	211.3	1056.2	11.7	2.97
Cycocel @250ppm (T_8)	61.5	3.5	4.1	29.3	130.5	652.7	7.2	1.78
Cycocel @500 ppm (T_9)	62.2	3.0	4.4	23.8	98.3	490.9	5.5	1.32
Cycocel @750 ppm (T_{10})	60.3	4.0	4.0	21.5	89.4	447.0	5.0	1.16
Cycocel @1000 ppm (T_{11})	64.7	2.9	4.5	24.5	101.3	507.0	5.6	1.26
Cycocel @1250ppm (T_{12})	62.5	3.1	4.8	22.5	91.5	457.3	5.1	1.12
S. Ed.(±)	0.24	0.10	0.10	0.17	0.61	0.41	0.01	-
C. D. at 5 %	0.49	0.20	0.20	0.34	1.26	0.84	0.03	-

Conclusion

It is well known that the plant bioregulators play vital role in the production of the bedding flowers like., Calendula, Portulaca, Pansy etc. The investigation concluded that the application of T_3 (GA_3@300ppm) showed the better growth over the control as well as other treatments. Maximum flower yield and cost benefit ratio (1:2.97) was recorded in the treatment T_7 (NAA @200ppm). Followed by(1:2.70) treatment T_5 (NAA@ 100 ppm) and the minimum cost benefit ratio was recorded in treatment T_{12} (CCC @1250ppm).

Acknowledgements

The authors acknowledge the receipt of all kind of help and support rendered by Dr. V.M Prasad Head, Department of Horticulture, Allahabad School of Agriculture, SHIATS, Allahabad for all the required infrastructure and facilities and time-to-time suggestion in making the assignment successful.

References

[1] Randhawa, G.S. and Mukhopdhyay, A. (1986). Floriculture in India.6:73.
[2] Kumar, M., Kumar, S., Kumar V. and Kakran, M.S. (2014). Response of GA3 and NAA on growth and flowering of calendula (Calendula officinalis L.). Progressive Agriculture. 14 (2): 342-343.
[3] Hore, J.K. and Sen, S.K. (1986). Effect of some chemicals on the performance of French marigold (Tagetespatula). Environment and Ecology. 4(4): 589-592.
[4] Sajid, G.M., Kaukab,M. and Ahmad,Z. (2009). Foliar application of plant growth regulators (PGRs) and nutrients for improvement of lily flowers. Pakistan Journal of Boatany.41: 233-237.
[5] Tayama, H.K., Larson, R.A., Hammer, P.A. and Rolls, T.J. (1992). Tips onthe use of chemical growth regulators on floriculture crops. Ohio Florists' Assn., Columbus, Ohio, 13: 75-77.
[6] Bhat, M.A., Tahir, I., Shahri, W. and Islam, S.T. (2011). Effect of cycocel and B-nine (growth retardants) on growth and flowering of Erysimummarshallii (Henfr.) Bois. J. Plant Sci., 1-7.
[7] Panse, V.G., Sukhatme, P.V. (1967). Statistical methods for agricultural workers, Indian Council of Agricultural Research, New Delhi.
[8] Tyagi, S., Tyagi, A.K., Kumar, V. and Kumar, N. (2008). Effect of GA3 and IAA on growth, flowering and yield of calendula (Calendula officinalis L.). Progressive Agriculture. 8(1): 118-120.
[9] Ramdevputra, M.V., Butani, A.M., Savaliya, J.J., Pansuriya, A.G. and Kanzaria, D.R. (2009). Effect of different gibberellic acid (GA3) concentrations on growth, flowering and yield of African marigold.Asian Journal of Horticulture. 4(1): 82-85.
[10] Gautam, S.K., Sen, N.L., Jain, M.C., Dashora, L.K. (2006). Effect of plant regulators on growth, flowering and yield of chrysanthemum (Chrysanthemum morifolium Ram.) cv. Nilima. Orissa Journal of Horticulture. 34(1): 36-40.
[11] Patel, S.R., Parekh, N.S., Parmar, A.B. and Patel, H.C. (2010). Effect of growth regulators on growth, flowering and yield of chrysanthemum (Chrysanthemum morifolium Ramat.) cv. IIHR-6, under middle Gujarati condition. International Journal of Agricultural Science. 6(1): 243-245.
[12] Parmar, A.B. Patel, H.C. and Chavda, J. R. (2009). Effect of plant growth regulators on growth and flowering of spider lily (Hymenocallisspeciosa L). Asian J. Hort. 4(1): 170-172.
[13] Dahia, D.S. and Raha, G.S. (2001). Regulation of flowering in chrysanthemum as influenced by GA3 and shade house of different intensities. South Indian Journal of Horticulture 49: 313-314.
[14] Tyagi, A. and Kand V Kumar (2006). Effect of gibberellic acid and vermicompost on vegetative growth and flowering in African marigold (Tageteserecta L.) Journal of Ornamental Horticulture. 9(2): 150-151.
[15] Neetu, Singh, A.K., Sisodia, A.and Kumar, R. (2013). Effect of GA3 on growth and flowering attributes of gladiolus cultivars. Ann. Agric. Res., New Series, 34(4): 315-319.
[16] Abadi, D.H. (2010). Yield and quality management of Rosa hybrida 'Poison' with plant growth regulators. Americ.Euras. J. Agric. Environ. Sci., 8(6):736-740.

Publication History

Received	07^{th} May 2017
Revised	24^{th} May 2017
Accepted	05^{th} June 2017
Online	30^{th} June 2017