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Effect of foliar application of gibberellic acid (GA_3) on quality attributes of calendula flowers (*Calendula officinalis*) cv. Gitana Fiesta in Chitwan, Nepal

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ABSTRACT: An experiment was conducted to study the effect of gibberellic acid (GA_3) on quality attributes of calendula (*Calendula officinalis* L.). Single factorial experiment based on completely randomized design including 7 treatments and 3 replications was carried out. The treatments used were different concentrations of GA_3 (0, 50, 100,150, 200, 250 and 300 ppm). Results showed that foliar application of GA_3 had positive effect on quality of calendula flowers. First bud initiation and first flowering were recorded significantly earlier ($p<0.05$) if plants were sprayed with T_5 (GA_3@200ppm) treatment. Similarly, the study showed that the maximum flower diameter (6.43 cm) was recorded in T_6 (GA_3@250ppm) which was significantly similar ($p>0.05$) to T_5 (GA_3@200ppm) treatment whereas minimum flower diameter (4.19 cm) was recorded in control. Significant differences ($p<0.05$) among treatments were recorded in weight of flower where maximum weight of flower (3.77 gm) was recorded in T_6 (GA_3@250ppm), while minimum weight of flower (2.86 gm) was recorded in control plants. These results suggest that GA_3 of dose 200 ppm to 250 ppm was ideal for enhancing the quality of flowers in calendula.

Keywords: Calendula, flower quality, flower size, gibberellic acid.

INTRODUCTION

Calendula (*Calendula officinalis*) also known as pot marigold, common marigold, and garden marigold of family Asteraceae are commonly cultivated for pot as well as cut flower (Filipović and Ugrenović, 2015; Jan and John, 2017). It is probably native to southern Europe, though its long history of cultivation makes its precise origin unknown, and it may possibly be of garden origin (Gazim et al., 2008). Calendula is an annual plant with yellow to orange flowers which are rich in pigments like carotenoids such as flavoxanthin, lutein, rubixanthin, β-carotene, γ-carotene, and lycopene (Pintea et al., 2003).

Plant growth regulators (PGRs) are produced by plant naturally or made synthetically and are small organic molecules which can modify the quality and other characteristics of flowers. It has an important role in growth regulation, acting as a stimulator and an inhibitor, depending on its concentration and others intrinsic plant characteristics (Teixeira and Marbach, 2000; Warner and Erwin, 2005; Rademacher, 2015). Gibberellic acid (GA_3) is a well-recognized plant growth regulator which determines important physiological changes in plants, such as cell division and expansion, promotion of stem elongation and flower induction in many herbaceous flower crops (Davies, 2004). Various researches have shown that GA_3 treatment leads to higher quality flowers (Teszlák et al., 2005). Gibberellic acid (GA_3) is supposed to increase flower quality and maintains uniformity in flower size and number (Chen et al., 2003; Delvadia et al., 2009). It is also supposed to promote plant growth and increase number of primary and secondary branches which eventually ensures higher production of flower (Azuma et al., 1997). Doddagoudar et al. (2004) observed that exogenous foliar application of Gibberellic acid (GA_3) stimulates flowering, pollination, fertilization and seed setting to get maximum yield.

Commercial production of calendula as cut flower and pot culture has a great demand in both national as well as international markets. The demand is increasing at a rapid pace, especially in winter when very few annuals bloom during that period. Despite this huge demand, only few commercial flower growers are seen growing Calendula flower in Nepal but still faces market problems because of poor quality flower coupled with low yield. The use of plant growth regulators has revolutionized the floriculture industry. It can be used to overcome the limitation in growth, quality and yield to harness maximum benefit. Thus, use of GA_3 in Calendula cultivation can encourage the flower growers to cultivate Calendula within the country to meet the increasing demand. Under this context, an experiment was done to observe the effect of gibberellic acid on quality of calendula flower and to find out appropriate dose to obtain high yield without compromising the flower quality.

MATERIAL AND METHODS

Site selection

The investigation was carried out in the form of a pot experiment at the Horticulture Farm of Nepal Polytechnic Institute, Bharatpur, Chitwan, Nepal from November 2017 to March 2018. It was situated at 27° 37' 3" North latitude and 84° 17' 43" East longitude and at an elevation of 175 meters from the sea level. The climate of the site is tropical between the temperatures 9 to 37°C with 2500 mm of annual mean precipitation. The average maximum and average minimum temperature recorded during research period is presented in Figure 1.

Selection of cultivar

The experiment was carried out using the cultivar Gitana Fiesta. This cultivar has elegant yellow color with bigger bloom. It is popular in Nepal for pot culture.

Treatment details

The treatments used were different concentrations of gibberellic acid except treatment T_1 which serve as control. These are shown in Table 1.

Treatment preparation and application

Gibberellic acid (GA_3) in powder form, as per the treatment (weighed using micro-balance), was dissolved in small volume of 0.1 N NaOH. Foliar application was done twice in morning hours using hand sprayer till run-off at 30 DAT and 45 DAT (DAT: Days after transplanting).

Table 1. Treatments groups with different concentration of gibberellic acid.

Treatments	Concentration of gibberellic acid
T_1	Control (foliar spray with water)
T_2	50 ppm GA_3
T_3	100 ppm GA_3
T_4	150 ppm GA_3
T_5	200 ppm GA_3
T_6	250 ppm GA_3
T_7	300 ppm GA_3

Experimental design

The experiment was conducted in single factorial completely randomized design with seven treatments replicated thrice. The potting media used was river sand, garden soil and vermi-compost in a ratio of 1:1:1. Each experimental unit consisted of 5 sample plants. All recommended package of practices were followed to raise the crop.

Parameters recorded

Different parameters regarding quality attributes were recorded during study like days to bud initiation, days to first flowering, number of flowers, diameter and weight of flower and per plant flower yield (at peak bloom when harvesting was done).

Statistical analysis

The collected data were entered, tabulated and processed in Microsoft Excel. The recorded data on different parameters were analyzed by using R- Stat software and the means were separated using Duncan's Multiple Range Test (DMRT) at 5% level of significance.

RESULTS AND DISCUSSION

The data on qualitative parameters presented in Table 2 showed significant differences ($p<0.05$) among the treatments used. The minimum number of days for first flower bud emergence or earliness which took (64.56 days) was found in T_5 (GA_3@200ppm) whereas T_1 (control) took maximum number of days (73.43 days) to produce visible flower bud which was statistically insignificant ($p>0.05$) (73.08 days) from T_2 (GA_3@50ppm). Similar results were recorded on days to first flowering where T_1 (control) took maximum number of days (90.77 days) for first flowering being at par ($p>0.05$) (90.37 days) with T_2 (GA_3@50ppm) whereas early flowering (83.58 days) was recorded in T_5 (GA_3@200ppm) treated plants.

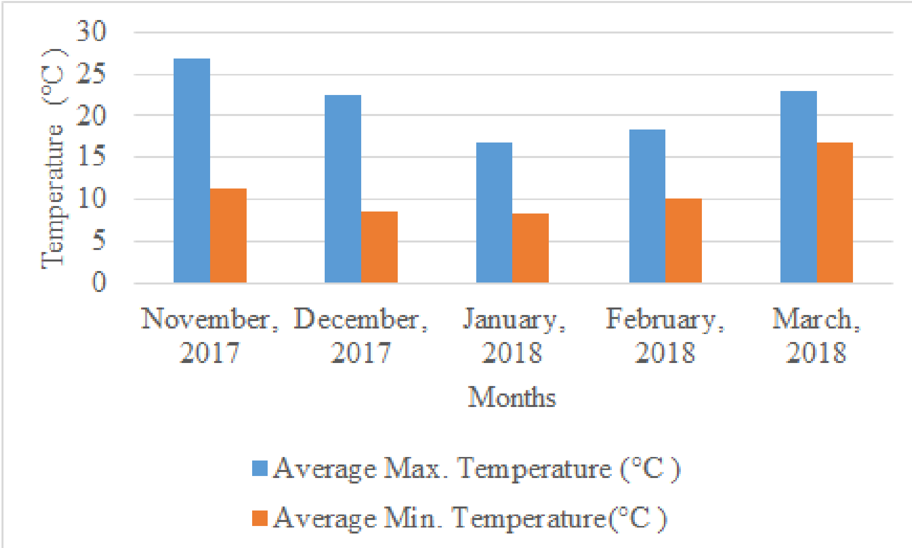

Figure 1. Average maximum and average minimum temperature recorded during research period from Nov. 2017 to Dec. 2018.

Table 2. Effect of gibberellic acid (GA_3) on flowering attributesof calendula (*Calendula officinalis* L.) cv. Gitana Fiesta.

Treatments	Days to first bud initiation	Days to first flowering
T1 (control)	73.43^{a}	90.77^{a}
T2 (50 ppm)	73.08^{a}	90.37^{a}
T3 (100 ppm)	67.53^{b}	86.98^{b}
T4 (150 ppm)	65.33^{bc}	86.56^{bc}
T5 (200 ppm)	64.56^{c}	83.58 ^{d}
T6 (250 ppm)	65.63^{bc}	84.72^{cd}
T7 (300 ppm)	64.97^{bc}	85.52^{bcd}
Grand mean	67.79	86.93
$LSD_{0.05}$	2.86	2.24
SEM (±)	1.32	1.03
CV (%)	2.37	1.45

This result is due to the fact that GA_3 increased cell division and cell elongation. GA_3 also induces earlier production of meristematic tissues. It is also the effect of GA_3 that causes flower initiation and early flowering by decreasing the concentration of ABA in plant shoot (Phengphachanh et al., 2012). Early flowering may also due to gibberellins action in reducing juvenile period (Palei et al., 2016). It also accumulates more carbohydrate in plant body which leads to early flower bud initiation as well as bud opening. Similar results were also found in research conducted by Sardoei and Shahdadneghad (2014) and Dheeraj and Saravanan (2018) in calendula.

According to Table 3, the study showed that the maximum flower diameter (6.43 cm) was recorded in T_6 (GA_3@250ppm) which was statistically similar ($p>0.05$) (6.40 cm) with T_5 (GA_3@200ppm), while minimum flower diameter (4.19 cm) was recorded in control. Similarly, maximum weight of flower (3.77 gm) was recorded in T_6 (GA_3@250ppm) which was found statistically significant ($p<0.05$) to control and T_2 (GA_3@50ppm), while minimum weight of flower (2.86 gm) was recorded in control plants. The plants receiving gibberellic acid in an optimum proportion could be with better flower quality due to increase in size of meristematic region, enhanced cell division and enlargement, promotion of protein synthesis along with higher dry matter (Dalal et al., 2009a; Kasturi and Shekhar, 2017). The mechanism by which gibberellins might stimulate cell elongation is that the hydrolysis of starch resulting from the production of GA_3 increased mobilization of starch in cotyledons by increasing amylase activity (Kaur et al., 2000). The increase in size of flower might be attributed to the increase in number of leaves and

Table 3. Effect of gibberellic acid (GA_3) on quality attributes of calendula (*Calendula officinalis* L.) cv. Gitana Fiesta.

Treatment	Diameter of flower (cm)	Weight of flower (gm)
T1 (control)	4.19^{e}	2.86^{c}
T2 (50 ppm)	4.59^{d}	3.13^{bc}
T3 (100 ppm)	5.47^{c}	3.37^{ab}
T4 (150 ppm)	5.83^{b}	3.52^{ab}
T5 (200 ppm)	6.40^{a}	3.56^{ab}
T6 (250 ppm)	6.43^{a}	3.77 ^{a}
T7 (300 ppm)	5.94^{b}	3.48^{ab}
Grand mean	5.55	3.39
$LSD_{0.05}$	0.26	0.50
SEM (±)	0.13	0.74
CV (%)	2.904	8.38

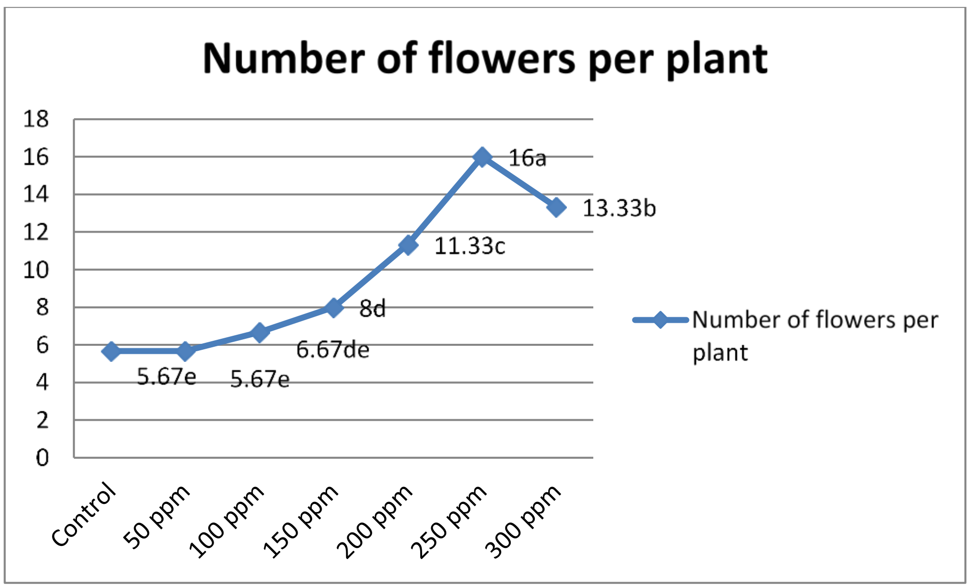

Figure 2. Effect of gibberellic acid (GA_3) on number of flowers per plant of calendula (*Calendula officinalis* L.) cv. Gitana Fiesta.

leaf area that produced more photosynthates which in turn might have increased the flower size and weight. These results are in close conformity with the findings of Sangma et al. (2017) in gerbera, Dheeraj and Saravanan (2018) and Singh (2003) in calendula. Bigger sized flowers as a result of GA_3 application have also been reported by Sharifuzzaman et al. (2011) in *Chrysanthemum*. Kumar et al. (2012) recorded increase in flower size in all GA_3 treatments as compared to control in carnation. El-Naggar et al. (2009) has stated that GA_3 foliar application had stimulating effects on flower induction of *Dianthus caryophyllus* L. and hence led to the increased inflorescence biomass.

Effect of gibberellic acid (GA_3) on number of flowers per plant (Figure 2) shows significant effect ($p<0.05$) among treatments applied where maximum number of flowers per plant (16.00) was recorded in T_6 (GA_3@250ppm). Minimum number of flowers per plant (5.67) was recorded in control which was statistically similar to T_2 (GA_3@50ppm) and T_3 (GA_3@100ppm). The increase in number of flower might be due to possible production of more laterals at early stage of growth, and thus enough time for carbohydrate accumulation for flower bud differentiation due to enhanced reproductive efficiency of the plant (Kumar et al., 2014). Sharifuzzaman et al. (2011) also reported that the increase in number of flowers by GA_3 application might be due to the increase in number of cells resulting increased number of leaves as well as leaf area. This might have enhanced the production and accumulation of photosynthates, that were diverted to the

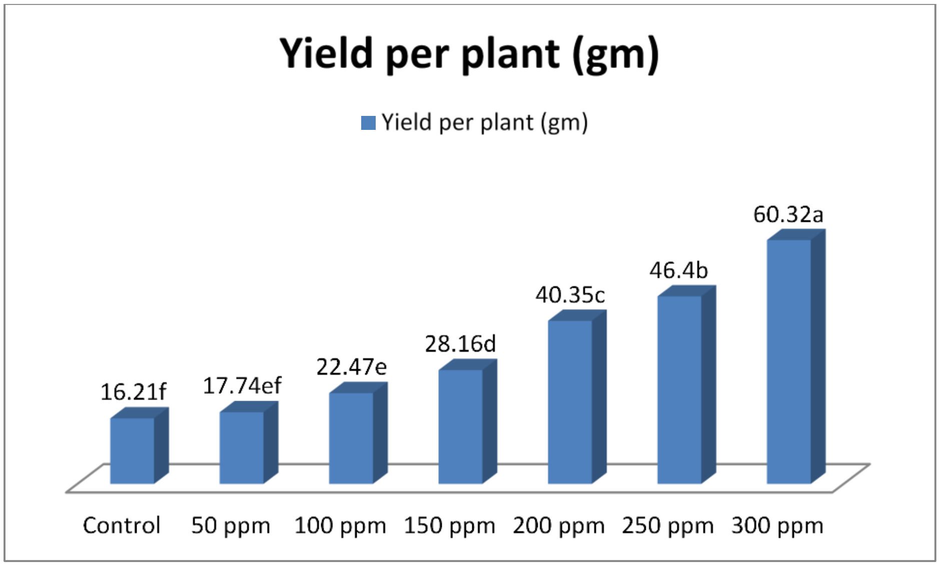

Figure 3. Effect of gibberellic acid (GA_3) on yield per plant of calendula (*Calendula officinalis* L.) cv. Gitana Fiesta.

sink and produced more flowers. These results are also confirmed by Kumar et al. (2012) who recorded a substantial increase in number of flowers when plants were treated with GA_3 at 150 ppm in carnation. Double application with GA_3 accelerated flower bud development of *Ajania pacifica*as reported by Zalewska and Antkowiak, (2013).

Figure 3 shows significant differences ($p<0.05$) in yield per plant of calendula where yield has increased with the increasing concentration of GA_3. Highest yield per plant (60.32 gm) was recorded at T_7 (GA_3@300ppm) whereas minimum yield per plant (16.21 gm) was obtained from control plants being at par ($p>0.05$) with T_2 (GA_3@300ppm). GA_3 through α-amylase activity, stimulates auxin, which results in cell loosening, division and elongation process influencing flowering. Therefore, leaf area increased resulting to more photosynthesis and accumulation of more carbohydrate in plant body which helps in early flower, bud initiation as well as bud opening, increased number of flowering and flower buds ultimately leading to increased yield. The result is also in conformity with those of Singh and Sharma (2004) in calendula, Nair et al. (2002) and Dalal et al. (2009b) in gerbera, Singh and Kumar (2013) in gladiolus, Priyanka and Singh (2012) in tuberose, Singh (2004) in California poppy and Prashanth et al. (2006) in floribunda rose cv. Iceberg. In a research done by Dheeraj and Saravanan (2018), the maximum number of flower per plant and yield of flower per plant was recorded with the application of GA_3 @ 300 ppm.

Conclusion

It is well known that plant bio-regulators play vital role in production of different flowers. In this investigation also, GA_3 showed positive results in flowering and quality parameters. All the facts and figures from this investigation suggest the scope of application of GA_3 at 200 to 250 ppm in Calendula cultivation for early and better quality flowers. However, as the study was carried out in pot culture, results may differ in field cultivation and may also be affected by locations. Therefore, it is recommended to conduct similar studies with further coverage in field cultivation, multi-location and multi-year trials to validate these preliminary findings before coming into a concrete conclusion.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interest.

REFERENCES

Azuma, T., Ueno, S., Uchida, N., & Yasuda, T. (1997). Gibberellin-induced elongation and osmoregulation in internodes of floating rice. *Physiologia Plantarum*, 99(4), 517-522.

Chen, J., Henny, R. J., McConnell, D. B., & Caldwell, R. D. (2003). Gibberellic acid affects growth and flowering of Philodendron 'Black Cardinal'. *Plant Growth Regulation*, 41(1), 1-6.

Dalal, S. R., Karale, G. D., & Momin, K. C. (2009a). Effect of growth regulators on growth, yield and quality of chrysanthemum under net house conditions. *Asian Journal of Horticulture*, 4(1), 161-163.

Dalal, S. R., Somavanshi, A. V., & Karale, G. D. (2009b). Effect of gibberellic acid on growth, flowering, yield and quality of gerbera under polyhouse conditions. *International Journal of*

Agricultural Sciences, 5(2), 355-356.

Davies, P. J. (Ed.). (2004). *Plant hormones: Biosynthesis, signal transduction, action.* Springer Science & Business Media. p. 750.

Delvadia, D. V., Ahlawat, T. R., & Meena, B. J. (2009). Effect of different GA3 concentration and frequency on growth, flowering and yield in gaillardia (*Gaillardia pulchella* Foug.) cv. Lorenziana. *Journal of Horticultural Sciences*, 4(1), 81-84.

Dheeraj, K. K., & Saravanan, S. (2018). Effect of Plant Growth Regulator on Growth and Flower Yield of Calendula (*Calendula officinalis* L.) cv. Calypso. *Indian Journal of Pure & Applied Biosciences*, 6(5), 130-134.

Doddagoudar, S. R., Vyakaranahal, B. S., & Shekhargouda, M. (2004). Effect of mother plant nutrition and chemical spray on growth and seed yield of China aster cv. Kamini. *Karnataka Journal of Agricultural Sciences*, 17(4), 701-704.

El-Naggar, A. H., El-Naggar, A. A. M., & Ismaiel, N. M. (2009). Effect of phosphorus application and gibberellic acid (GA3) on the growth and flower quality of Dianthus caryophyllus L. *American-Eurasian Journal of Agricultural and Environmental Science*, 6(4), 400-410.

Filipović, V., & Ugrenović, V. (2015). Pot marigold–one of the more demanded medicinal plants. *Thematic Proceedings*, 296.

Gazim, Z. C., Rezende, C. M., Fraga, S. R., Svidzinski, T. I. E., & Cortez, D. A. G. (2008). Antifungal activity of the essential oil from *Calendula officinalis* L. (Asteraceae) growing in Brazil. *Brazilian Journal of Microbiology*, 39(1), 61-63.

Jan, N., & John, R. (2017). *Calendula officinalis*: An important medicinal plant with potential biological properties. *Proceedings of the Indian National Science Academy*, 83(4), 769-787.

Kasturi, A., & Sekhar, R. C. (2017). Effect of plant growth regulators on vegetative growth of carnation (*Dianthus caryophyllus* L.) cv. Domingo in second season crop. *Plant Archives,* 17(2), 1113-1116.

Kaur, S., Gupta, A. K., & Kaur, N. (2000). Effect of GA3, kinetin and indole acetic acid on carbohydrate metabolism in chickpea seedlings germinating under water stress. *Plant Growth Regulation*, 30(1), 61-70.

Kumar, M., Singh, A. K., & Kumar, A. (2014). Effect of plant growth regulators on flowering and yield attributes of African marigold (*Tagetes erecta* L.) cv. Pusa Narangi Gainda. *Plant Archives,* 14(1), 363-365.

Kumar, V., Umaro, V., & Singh, M. (2012). Effect of GA3 and IAA on growth and flowering of carnation. *HortFlora Research Spectrum*, 1(1), 69-72.

Nair, S. A., Singh, V., & Sharma, T. V. R. S. (2002). Effect of plant growth regulators on yield and quality of gerbera under Bay Island conditions. *Indian Journal of Horticulture*, 59(1), 100-105.

Palei, S., Das, A. K., & Dash, D. K. (2016). Effect of plant growth regulators on growth, flowering and yield attributes of African marigold (*Tagetes erecta* L.). *Journal of Crop and Weed*, 12(2), 47-49.

Phengphachanh, B., Naphrom, D., Bundithya, W., & Potapohn, N. (2012). Effects of day-length and gibberellic acid (GA3) on flowering and endogenous hormone levels in *Rhynchostylis gigantea* (Lindl.) Ridl. *Journal of Agricultural Science*, 4(4), 217-222.

Pintea, A., Bele, C., Andrei, S., &Socaciu, C. (2003). HPLC analysis of carotenoids in four varieties of *Calendula officinalis* L. flowers. *Acta Biologica Szegediensis*, 47(1-4), 37-40.

Prashanth, P., Reddy, S., &Shrihari, D. (2006). Effect of growth regulators on flowering and flower quality parameters of floribunda rose (*Rosa hybrida* L.) cv. Iceberg. *Journal of Acharya N.G. Ranga Agricultural University*, 34(2), 18-21.

Priyanka, S., & Singh, A. K. (2012). Post-harvest life of tuberose as influence by GA3 and varieties. *Journal of Plant Development Sciences*, 4(1), 133-134.

Rademacher, W. (2015). Plant growth regulators: backgrounds and uses in plant production. *Journal of Plant Growth Regulation*, 34(4), 845-872.

Sangma, Z. C. N., Singh, D., & Fatmi, U. (2017). Effect of plant growth regulators on growth, yield and flower quality of gerbera (*Gerbera jamesonii* L.) cv. Pink Elegance under naturally ventilated polyhouse (NVPH). *International Journal of Current Microbiology and Applied Sciences,* 6(10), 468-476.

Sardoei, A. S., & Shahdadneghad, M. (2014). Effects of foliar application of gibberellic acid on chlorophyll and carotenoids of Marigold (*Calendula officinalis* L.). *International journal of Advanced Biological and Biomedical Research*, 2(6), 1887-1893.

Sharifuzzaman, S. M., Ara, K. A., Rahman, M. H., Kabir, K., & Talukdar, M. B. (2011). Effect of GA3, CCC and MH on vegetative growth, flower yield and quality of *Chrysanthemum*. *International Journal of Experimental Agriculture*, 2(1), 17-20.

Singh, A. K. (2003). Effect of growth regulators on growth and flowering in calendula (*Calendula officinalis*). *Indian Perfumer*, 47(3), 275-278.

Singh, A. K. (2004). Effect of growth promoting chemicals on growth and flower production in California poppy. *South Indian Horticulture*, 52(1/6), 383.

Singh, A. K., & Rakesh, K. (2013). Effect of different concentrations of GA_3 and varieties on growth and flowering of gladiolus. *Progressive Research*, 8(2), 263-265.

Singh, A. K., & Sharma, G. (2004). Effect of growth regulating chemicals on growth and seed attributes in *Calendula officinalis*. *Progressive Hort.*, 36(2), 266-268.

Teixeira, J. B., & Marbach, P. A. S. (2000). Fitohormônios. *Universa*, 8, 101-132.

Teszlák, P., Gaál, K., & Nikfardjam, M. S. P. (2005). Influence of grapevine flower treatment with gibberellic acid (GA3) on polyphenol content of Vitis vinifera L. wine. *Analytica chimica acta*, 543(1-2), 275-281.

Warner, R. M., & Erwin, J. E. (2005). Prolonged high temperature exposure and daily light integral impact growth and flowering of five herbaceous ornamental species. *Journal of the American Society for Horticultural Science*, 130(3), 319-325.

Zalewska, M., & Antkowiak, M. (2013). Gibberellic acid effect on growth and flowering of Ajania pacifica/Nakai/Bremer et Humphries. *Journal of Horticultural Research*, 21(1), 21-27.