Effect of GA$_3$ and Biofertilizer on Growth and Yield Parameters of Anthurium (*Anthurium andreanum* Lindex Ex Andre) cv. Tropical in Soilless Culture

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**A B S T R A C T**

An investigation was carried out during 2017-2018 to study the effect of GA$_3$ and biofertilizer on growth and yield of Anthurium (*Anthurium andreanum* Lindex Ex Andre) in soilless culture in the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat, Assam. The experiment was laid out in randomized block design and replicated 3 times. Data analysis over the period of experiment revealed that the highest plant height (42.78 cm and 40.66 cm), highest number of leaves (9 and 8), highest leaf length (32.26 cm and 29.89 cm), highest leaf breadth (20.23 cm and 19.57 cm), highest leaf area (309.37 cm$^2$ and 296.97 cm$^2$), highest plant spread (29.23 cm and 28.03 cm) were found in treatment T$_3$ (RDF + *Azospirillium* + 100 ppm GA$_3$) which is followed by T$_7$ (RDF + 100 ppm GA$_3$). T$_3$ recorded the highest number of sucker per plant (3.67) which was significantly superior to other treatments. Highest number of flower per plant (14.33) was recorded in the treatment T$_3$. This trend was reflected in spathe length (18.98 cm), spathe breadth (13.43 cm) and flower stalk length (42.27 cm) for T$_3$. The highest self life of spathe (52.20 days) and highest vase life of spathe (32.20 days) were recorded in treatment T$_3$. Hence considering the positive effects on growth, flowering, yield and quality, T$_3$ and T$_7$ both can be considered for adopting at the field level to reap good economic yield with better quality and high net return.

**Keywords**

*Anthurium andreanum*, GA$_3$, Biofertilizer, Growth, Yield

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**Introduction**

Anthurium (*Anthurium andreanum*) is one of the most important ornamental evergreen flower crops which are grown in many parts of the world. Taxonomically Anthurium belongs to family Araceae. This evergreen plant is native to Columbia, Peru, Central and South America. Anthurium is also known as ‘tail flower’ (Tajuddin and Prakash, 1996). Anthurium are tropical plant of great beauty and grown either showy cut flowers or for other unusually attractive foliage. They are very popular among flower arrangers because of the bold effect and long lasting quality of flower. It is well established that the growth and development of plants can be modified by exogenous application of growth substances through alteration in the levels of naturally occurring hormones. GA$_3$ is an important phytohormones and which is organic in nature, non nutrients, produced by plants in...
low concentrations. GA$_3$ influences a range of developmental processes like cell division and expansion, growth of shoots, induce seeds germination that needs cold or light, stimulation of enzyme production such as - amylase in the germination of cereal seeds, induce flowering, sexual expression, fruit development, senescence and abscission, break of the yolks dormancy, maintenance of apical dominance and promotion of stem elongation (Laschi, 1999). The continuous and unbalanced use of conventional fertilizers leads to decreased nutrient uptake efficiency of plants resulting in decreased crop yield. Eco-friendly, cost-effective and organic-based inputs such as botanical pesticides, biofertilizers, disease and pest-resistant varieties in cultivation of horticultural crops will be safeguarding the soil health, environment and quality production. The use of various bioinoculants like Azotobacter, Azospirillum and VAM along with PGPRs not only will supplement various nutrients in the soil or growing media but also improve the quality and quantity of crops.

Although studies on effect of GA$_3$ and biofertilizer on different ornamental plants has been done earlier, but information available about their effect on Anthurium is limited. Hence, the present investigation was conducted to evaluate the effect of GA$_3$ and biofertilizer (Azospirillum) on growth, and flowering characteristics of Anthurium.

**Materials and Methods**

A field experiment under agro shade net house was conducted at Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat (26°47' N and 94°12'E), during 2017-2018. The experiment was laid out in randomized block design with three replications. The treatments consisted of viz., T$_1$ – recommended dose of NPK fertilizers 19:19:19 (RDF), T$_2$ - RDF + Azospirillum, T$_3$ - RDF + Azospirillum + 100 ppm GA$_3$, T$_4$ - RDF + Azospirillum + 150 ppm GA$_3$, T$_5$ - RDF + Azospirillum + 200 ppm GA$_3$, T$_6$ - RDF + Azospirillum + 250 ppm GA$_3$, T$_7$ - RDF + 100 ppm GA$_3$, T$_8$ - RDF + 150 ppm GA$_3$, T$_9$ - RDF + 200 ppm GA$_3$, T$_{10}$ - RDF + 250 ppm GA$_3$.

The suckers of grown Anthurium were planted in the 30cm raised beds framed with cemented bricks walls which hold the growing media. The beds were constructed by giving a gentle slope of 3 inch. The bed size was 1.2m breadth and 12m length. In between two beds 80 cm gap was given. At bottom black polythene is placed to prevent the contact of media with soil. The beds were filled up with 10.2cm (4 inches) layer of brick pieces at the bottom, followed by 7.6cm (3 inches) layer of charcoal on its top followed by 5.1cm (2 inches) layer of coco husk (3cmX3cm pieces). A spacing of 30cm in between rows and 30cm in between plants were maintained. For planting of each sucker a small pit was prepared and filled up with coco peat and sand in 3:1 ratio. The 20 cm long uniform suckers were root dip in biofertilizer (Azospirillum) slurry for 20 mints and after that they were planted in the small pits prepared in the bed and the pits were filled up with coco peat and sand in 3:1 ratio. The planting was done on 17$^\text{th}$ of January, 2017 with 15 plants per treatment at spacing of 30 cm among plants and 30 cm from row to row. Different concentrations of GA$_3$ (100 ppm, 150 ppm, 200ppm and 250 ppm) were applied as foliar spray to the plants at 50 and 100 days after planting for better growth and establishment. Care was taken so that there was no drifting of spray solution from one treatment to other. Fertilizer was applied in the form of complete fertilizer i.e. 19 all @ 2g/l for twice a week. The intercultural operation like weeding and leaf pruning were done regularly. Manual weeding was done.
regularly along with the roots and removal of dead and decayed leaves of the plant at an interval of 15-20 days to improve the vigor of the plants. Availability of water is one of the most important factors for successful Anthurium cultivation. During the dry period watering was done twice a day and otherwise it was done once manually.

Results and Discussion

Growth parameters

Plant height

The highest plant height of 42.78 cm was recorded for the treatment T₃ (RDF + Azospirillum + 100 ppm GA₃) and height of 40.66 cm was recorded for the treatment T₇ (19 all + 100 ppm GA₃). This might be due the fact that gibberellin stimulates the expression of enzymes involved in cell wall loosening and genes controlling cell division and also stimulates microtubule rearrangements associated with cell expansion (Amber, 2012). Moreover, the root dip treatment with Azospirillum provided a more balance nutrition for plants as well as optimum absorption of more nutrition by roots accelerated the physiological process and improved the general growth phenomenon. The increase in plant height was due to the presence of a readily available form of nitrogen (Sankari et al., 2015).

Number of leaves per plant

The leaves serve as the active site for food synthesis in plant. The highest number of leaves per plant was recorded in the treatment T₃ (19 all + Azospirillum + 100 ppm GA₃) i.e. 9.00 and T₇ (19 all + 100 ppm GA₃) i.e. 8.00. Gibberellic acid increases the alpha amylase activity, auxin stimulating effect and cell wall loosing, increased cell elongation along with the cell enlargement. All these caused effect on increased number of leaf, thereby causing increased photosynthetic area. Thus, this caused increase in carbohydrate food material (Chaudhari 2003). Bio-fertilizers increase the absorption of the macro and micro nutrients of plant. Production of more number of leaves might also be due to the increased availability of N in growing media, which is an important component of chlorophyll and protein thus causing more growth (Kumar and Singh, 2007).

Leaf length and breadth (cm)

Significant increase in leaf length and breadth (32.26 cm and 20.23 cm respectively) was found for the treatment T₃ (RDF + Azospirillum + 100 ppm GA₃). Foliar application of GA₃ might have influenced cell division and cell elongation resulting in enhanced vegetative growth of plant which also influences the better leaf growth. The other notable cause may be due to increased absorption of nutrients which resulted in increase in the synthesis of carbohydrates, chlorophyll content and increase the activity of hormones produced by Azospirillum. It also helped better proliferation of root growth and uptake of other nutrients to a great extent (Patel et al., 2016).

Leaf area (cm²)

The leaf area is an important attribute as it has direct relevance with interception of light and photosynthesis and ultimately with overall growth and development. The maximum leaf area (309.37 cm² and 296.97 cm²) were recorded for the treatment T₃ (RDF + Azospirillum + 100 ppm GA₃) followed by T₇ (RDF + 100 ppm GA₃). This might be attributed to the fact that there was a concurrent increase in leaf numbers. More leaves with more photosynthetic area were capable of maintaining a high correlation with source-sink relationship obtained through
foliar spray of GA$_3$ (Marchner, 1986). The use of biofertilizer has long been recognized as an effective means of improving the structure and fertility of the soil and growing media increasing the microbial diversity, activity and population, improving the moisture-holding capacity of growing media and crop yield (Frederickson et al., 1997).

**Plant spread (cm)**

The plant spread was found significantly maximum in the treatment T$_3$ (RDF + *Azospirillum* + 100ppm GA$_3$). The increase in plant spread these treatments could be attributed to the physiological action of GA$_3$. Highest plant spread may be due to highest plant height, maximum leaf area and maximum number of leaves. According to Verma (1991) it was due to the formation of new cells in meristematic region and an increase in size and mass of cells produced. Bio-fertilizers increase the absorption of the macro and micro nutrients of plant which influences the overall growth of the plant. Significant increase in spread due to application of *Azospirillum*, and inorganic fertilizers has been reported earlier in Marigold (Sharma et al., 2015).

**Number of sucker per plant**

In the present study the number of suckers per plant was influenced significantly by plant growth regulators. T$_3$ (RDF + *Azospirillum* + 100ppm GA$_3$) recorded the maximum number of suckers per plant followed by T$_7$ (RDF + 100ppm GA$_3$) respectively. This is in agreement with the findings of Reddy et al., (1997) in China aster. The higher number of suckers by using GA$_3$ might be due to increase in the number and size of leaves as a result of higher translocation of the photosynthates and eventually that would have been used for the production of propagules (suckers) (Sharifuzzaman et al., 2011) and Maitra and Roychoudhury (2014) in Anthurium. More number of suckers production may be due to the bioactive substances produced by *Azospirillum* and the better network of mycorrhizal hyphae around root zone This result are in agreement with Chandrappa (2002) in Anthurium (Table 1).

**Yield parameters**

**Number of flowers per plant**

The number of flowers per plant is the major yield contributing factor in anthurium. The number of flowers per plant was significantly influenced by the different treatments. The treatment T$_3$ (RDF + *Azospirillum* + 100ppm GA$_3$) resulted in highest number of flower i.e. 14.33. The probable reason for increase in the number of flower could be due to the effect of gibberellic acid on transformation of metabolites from vegetative phase to reproductive phase by increasing number of flower buds. These results are in line with findings of Henny and Hamilton (1992), Purwoko et al., (1997) and Anjali et.al (2014) in Anthurium. The highest number of flower was found in the treatments which were treated with biofertilizer. This may be also due to *Azospirillum* which might have stimulated the rate of multiplication of lateral roots and root surface area so as to absorb more nutrients from media for flower production. Similar results were reported by Jawaharlal and Padmadevi (2004) in Anthurium (Table 2).

**Spathe length (cm) and spathe breadth (cm)**

Marked differences were noticed among the treatments on spathe length and spathe breadth. The highest spathe length and breadth were noticed for the treatment T$_3$ (RDF+*Azospirillum*+100ppm GA$_3$) and the second highest spathe length and breadth were noticed for T$_7$ (RDF+100ppm GA$_3$).
**Table 1** Effect of GA$_3$ and biofertilizers on growth parameters of Anthurium after 360 days after planting (DAP)

| Treatments                                                                 | Plant height (cm) | No. of leaves | Leave length (cm) | Leave breadth (cm) | Leaf area (cm$^2$) | Plant spread (cm) | No. of sucker per plant |
|---------------------------------------------------------------------------|-------------------|---------------|-------------------|-------------------|-------------------|-------------------|-------------------------|
| T$_1$ – Recommended dose of NPK fertilizers 19:19:19 (RDF)                | 33.85             | 5.67          | 24.05             | 17.26             | 193.24            | 22.53             | 1.00                    |
| T$_2$ - RDF + *Azospirillum*                                               | 35.76             | 7.00          | 25.13             | 17.73             | 213.86            | 23.86             | 1.00                    |
| T$_3$ - RDF + *Azospirillum* + 100 ppm GA$_3$                              | 42.78             | 9.00          | 32.26             | 20.23             | 309.37            | 29.23             | 3.67                    |
| T$_4$ - RDF + *Azospirillum* + 150 ppm GA$_3$                              | 39.11             | 7.00          | 27.32             | 18.83             | 291.26            | 24.90             | 1.66                    |
| T$_5$ - RDF + *Azospirillum* + 200 ppm GA$_3$                              | 38.23             | 6.67          | 25.87             | 18.26             | 280.29            | 24.80             | 1.33                    |
| T$_6$ – RDF + *Azospirillum* + 250 ppm GA$_3$                              | 35.06             | 5.67          | 23.16             | 17.30             | 229.50            | 23.23             | 0.67                    |
| T$_7$ - RDF + 100 ppm GA$_3$                                               | 40.66             | 8.00          | 29.89             | 19.57             | 296.97            | 27.03             | 2.00                    |
| T$_8$ – RDF + 150 ppm GA$_3$                                               | 37.15             | 6.33          | 25.45             | 18.56             | 245.40            | 24.70             | 1.67                    |
| T$_9$ - RDF + 200 ppm GA$_3$                                               | 36.31             | 6.33          | 25.05             | 17.86             | 237.06            | 23.76             | 1.33                    |
| T$_{10}$ - RDF + 250 ppm GA$_3$                                            | 34.95             | 5.67          | 23.47             | 16.90             | 221.03            | 23.13             | 0.67                    |
| S.Ed. (±)                                                                 | 1.15              | 0.52          | 0.99              | 0.27              | 1.69              | 1.62              | 0.42                    |
| CD$_{0.05}$                                                               | 2.54              | 1.10          | 2.10              | 0.57              | 3.55              | 3.41              | 0.85                    |
**Table.2** Effect of GA$_3$ and biofertilizers on yield parameters of Anthurium after 360 days after planting (DAP)

| Treatments                                      | No. of flower per plant | Spathe length (cm) | Spathe breadth (cm) | Stalk length (cm) | Self life (days) | Vase life (days) |
|------------------------------------------------|-------------------------|--------------------|---------------------|-------------------|------------------|-----------------|
| $T_1$ – Recommended dose of NPK fertilizers 19:19:19 (RDF) | 5.63                    | 14.17              | 8.58                | 28.17             | 38.13            | 18.40           |
| $T_2$ - RDF + *Azospirillum*                     | 6.26                    | 14.54              | 9.00                | 29.40             | 39.23            | 18.80           |
| $T_3$ - RDF + *Azospirillum* + 100 ppm GA$_3$    | 14.33                   | 18.98              | 13.43               | 42.47             | 52.20            | 32.60           |
| $T_4$ - RDF + *Azospirillum* + 150 ppm GA$_3$    | 10.37                   | 16.00              | 11.03               | 36.83             | 48.33            | 23.43           |
| $T_5$ - RDF + *Azospirillum* + 200 ppm GA$_3$    | 9.34                    | 15.54              | 10.86               | 33.90             | 46.73            | 21.80           |
| $T_6$ – RDF + *Azospirillum* + 250 ppm GA$_3$    | 7.30                    | 13.83              | 8.91                | 29.30             | 40.37            | 19.43           |
| $T_7$ - RDF + 100 ppm GA$_3$                    | 12.01                   | 16.56              | 11.75               | 39.93             | 49.16            | 25.26           |
| $T_8$ – RDF + 150 ppm GA$_3$                    | 8.65                    | 15.11              | 10.34               | 32.76             | 45.50            | 21.40           |
| $T_9$ - RDF + 200 ppm GA$_3$                    | 8.07                    | 14.98              | 9.87                | 31.73             | 43.27            | 20.63           |
| $T_{10}$ - RDF + 250 ppm GA$_3$                 | 7.33                    | 13.43              | 8.32                | 29.23             | 40.30            | 19.33           |
| S.Ed. (±)                                       | 0.98                    | 1.12               | 0.93                | 1.24              | 1.15             | 0.15            |
| CD$_{0.05}$                                      | 2.06                    | 2.35               | 1.95                | 2.64              | 2.45             | 0.31            |
The role of GA₃ in improving the spathe size may be ascribed to the translocation of metabolites at the site of spathe development. Gibberellic acid has been reported to induce an entire developmental program by activation of regulatory genes in the later stages of corolla development as observed by Preethi (1990) in rose. The increased spathe width might also be due to the role of biofertilizers in enhancing nutrient uptake and helped in production of auxin like substances which may be responsible for better translocation of photosynthates from site of synthesis to apical region and there by increased the spathe width. The present findings are in line with the reports of Pandey et al., (2017) in Dahlia, Pansuriya et al., (2018) in Gladiolus.

**Flower stalk length (cm)**

Flower quality parameters like flower stalk length was greatly influenced by the application of GA₃ and biofertilizer. The highest stalk length was recorded for 100 ppm GA₃. The gibberellic acid application accelerates cell division and longitudinal growths of the cell and plants as a result stem length and plant height increased simultaneously. This result is in line with findings of Sainath (2009) in chrysanthemum and Muthu Kumar et al., (2012) in rose. Due to application of biofertilizer better nutrient uptake, photosynthesis, source-sink relationship along with excellent physiological and biochemical activities prevail in the root zone. Similar results were also observed by Gupta et al., (2008) in gladiolus.

**Self life and vase life of flower (days)**

Like all other morphological characters in terms of superiority caused by T₃ (RDF + Azospirillum + 100ppm GA₃), the highest self life of spathe (52.20 days) and vase life of spike (32.60 days) was recorded for the treatment T₃ (RDF + Azospirillum + 100ppm GA₃). The increase in self life and vase life of flowering may be due to the application of GA₃ as foliar spray that might have influenced the continuity in the water conductance by the tissues without any blockage and GA₃ might have also increased the osmatically driven water uptake by the flower stalks. The self- life of the flowers depends on genetic makeup and water quality, the major factor contributing to deterioration is vascular blockage (Chandrashekararaiah, 1973). Similar findings of increase in the self life and vase life of flowers with GA₃ application was reported by Delvadia et al., (2009) in gaillardia. Inoculation with biofertilizers influenced flower longevity due to the increased nutrient uptake by plant and greater development of water conducting tissues. The delay in senescence may be due to presence of ethylene inhibitors in plant which delay senescence of florets. These results are in corroboration with the findings of Barreto et al., (2002) in gerbera. It might also be due to overall food and nutrient status of flowers under the treatments. Srivastava et al., (2007) reported the effect of Azospirillum and organic manures on the post harvest quality of tuberose cv. Double and showed significant increase in vase life over the untreated control. This might be due to the availability of N to the plant which improves the quality of flower due to better phosphorelation in plants.

The results of the present investigation revealed that treatment T₃ (RDF+Azospirillum+100ppm GA₃) and T₇ (RDF+100ppm GA₃) were found to be the most efficient treatments in terms of both growth and flowering. Hence, these two treatments may be adopted by the growers for commercial cultivation of Anthurium to feed national and international market.
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