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Effect of different GA_3 concentration and biofertilizer on growth and flowering parameters of anthurium (*Anthurium andreanum* Lindex Ex Andre) cv. tropical in soilless culture

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Abstract
An investigation was carried out during 2017-2018 to study the effect of GA_3 and biofertilizer on growth and flowering parameters of Anthurium (*Anthurium andreanum* Lindex Ex Andre) in soilless culture in the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat, Assam. As a result, different growth and flowering parameters like the highest plant height (42.78 cm), highest number of leaves (9), highest leaf length (32.26 cm), highest leaf breadth (20.23 cm), highest leaf area (309.37 cm^2), highest plant spread (29.23 cm), highest number of sucker per plant (3.67), highest number of flower per plant (14.33), spathe length (18.98cm), spathe breadth (13.43cm) and flower stalk length (42.27cm), highest self-life of spathe (52.20 days) and highest vase life of spathe (32.20 days) were found in treatment T_3(Recommended dose of fertilizer i.e. RDF+ *Azospirillium*+ 100ppm GA_3). Hence considering the positive effects on growth, flowering, yield and quality, T_3 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, flowering parameters

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) [28]. 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 yolk's dormancy, maintenance of apical dominance and promotion of stem elongation (Laschi 1999) [13]. 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 biofertlizer 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 biofertlizer (*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 (26º47′ N and 94º12′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 (3cmX 3cm 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. Planting was done on 17^{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 which is the also the recommended dose of fertilizer. 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 (Table 1 and Figure 1) of 42.78cm was recorded for the treatment T_3 (RDF+*Azospirillum*+100ppm GA_3) and second highest height of 40.66 cm was recorded for the treatment T_7 (19 all+100ppm GA_3). 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) [1]. 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) [24].

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

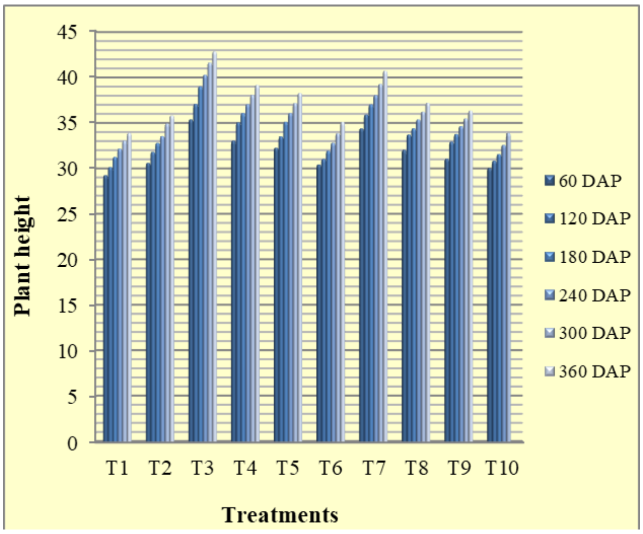

Fig 1: Plant heights in different growth stage

Number of leaves per plant

The leaves serve as the active site for food synthesis in plant. The highest number of leaves per plant (Table 2 and Figure 2) was recorded in the treatment T_3 (19all+*Azospirillum*+100ppm GA_3) i.e. 9.00 and T_7 (19 all+100ppm GA_3) 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 leafs, thereby causing increased photosynthetic area. Thus, this caused increase in carbohydrate food material (Chaudhari 2003) [6]. 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) [11].

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

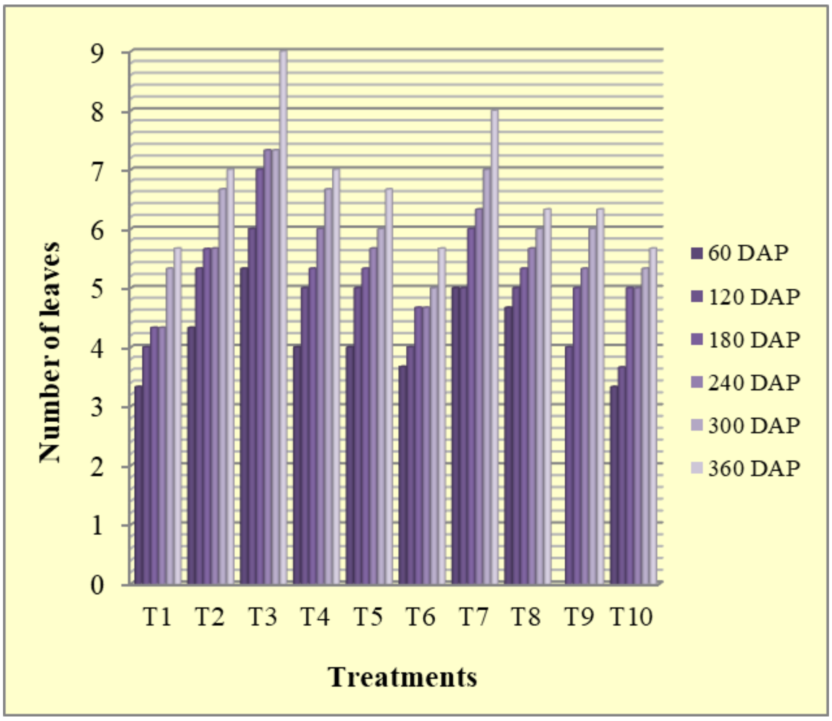

Fig 2: Number of leaves at different growth stages

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 T_3 (RDF+*Azospirillum*+100ppm GA_3) showed in Table 1. 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) [19].

Leaf area (cm^2)

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 cm^2 and 296.97 cm^2) were recorded for the treatment T_3 (RDF+*Azospirillum*+100ppm GA_3) followed by T_7 (RDF+100ppm GA_3) and this is showed in Table 1. 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) [15]. 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) [8].

Plant spread (cm)

The plant spread (Table 1) 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) [29] 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) [26].

Number of suckers 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 which is showed in Table 1 and Figure 3. This is in agreement with the findings of Reddy *et al*. (1997) [22] 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) [25] and Maitra and Roychoudhury (2014) [14] in Anthurium. More number of sucker's 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) [5] in Anthurium.

Flowering 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 flowers i.e. 14.33 (Table 1 and Figure 3). The probable reason for increase in the number of flowers 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) [10], Purwoko *et al.* (1997) [21] Anjali *et al.* (2014) [2] in Anthurium. The highest number of flowers 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) [12]. in Anthurium.

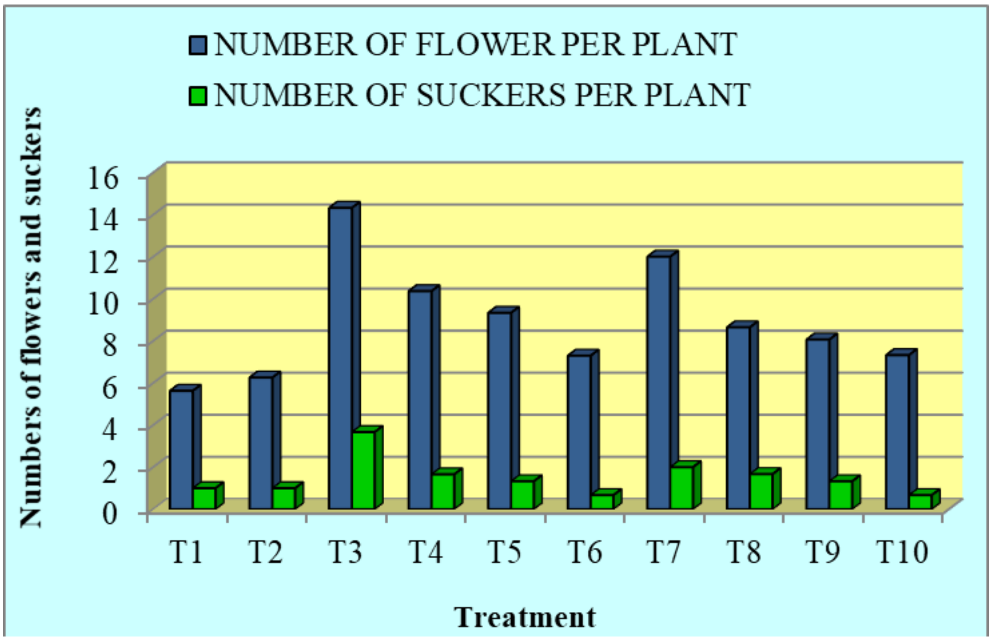

Fig 3: Number of flower and number of suckers per plant

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) which is showed in Table 2 and Figure 4. The role of GA_3 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) [20] 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 at*., (2017) [17] in Dahlia, Pansuriya *et al*., (2018) [18] in Gladioulus.

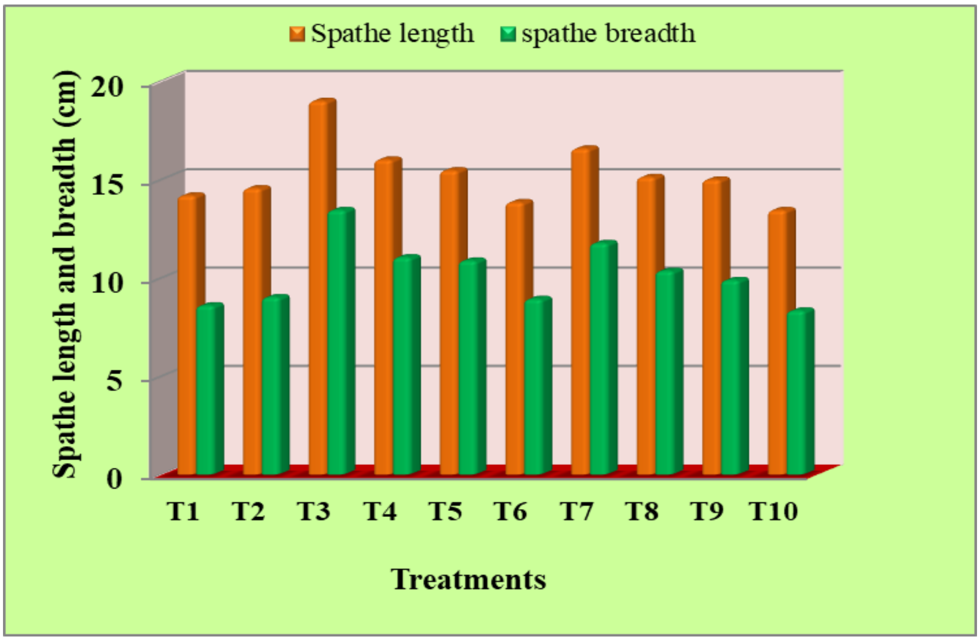

Fig 4: Spathe length and spathe breadth

Flower stalk length (cm)

Flower quality parameters like flower stalk length was greatly influenced by the application of GA_3 and biofertilizer. The highest stalk length was recorded for 100 ppm GA_3. 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) [23] in chrysanthemum and Muthu Kumar *et al.*, (2012) [16]. 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) [9] 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 GA_3), 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 GA_3) which is showed in Table 2. 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 (Chandrashekaraiah, 1973) [4]. Similar findings of increase in the self-life and vase life of flowers with GA_3 application was reported by Delvadia *et al.* (2009) [7] 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) [3] in gerbera. It might also be due to overall food and nutrient status of flowers under the treatments. Srivastava *et al.* (2007) [27] 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 T_3 (RDF+*Azospirillum*+100ppm GA_3) and T_7 (RDF+100ppm GA_3) 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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