Nutrient Balance Affecting Quality and Productivity of *Anthurium andreanum* in Soilless Culture

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ABSTRACT

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| ***Anthurium andraeanum* is an excellent plant for interior decor as well as a cut flower, especially for flower arrangements. An experiment was conducted to study the productivity and flower quality of *anthurium andraeanum* cultivated under net house conditions at the department of national botanic gardens, peradeniya. There were three different nutrient combinations. F1) n: p: k 11:11:18 (granules) + n: p: k 6:30:30 (liquid) + organic liquid fertilizer i.e. Maxi crop (control), f2) n: p: k 15:05:25 (granules) + 10:20:40 (liquid) + trace elements (liquid), f3) 14:14:21(granule) + 20:20:20 (liquid) + trace elements (granule). The experiment was laid out in randomized complete block design. All vegetative and flowering parameters differed significantly at 0.05 level. Maximum numbers of suckers per pots, leaves and flowers per pot were recorded in the second combination of fertilizers f2, n: p: k 15:05:25 (granules) + 10:20:40 (liquid) + trace elements (liquid). Thus it may be concluded that, 5g of slow-release granule (n: p: k 15:05:25) combined with water soluble (n: p: k 10:20:40) + trace elements with chelated technology can enhance growth and number of flowers of *anthurium andraeanum*.** |

*Keywords: Anthurium andraeanum, floriculture, fertilizer, growing medium, potted plants.*

1. INTRODUCTION

Productivity and quality of ornamental plants, such as Anthurium andraeanum, are highly dependent on appropriate fertilization strategies. Anthurium, commonly known as the flamingo flower, is valued for its vibrant spathes and long-lasting blooms, making it a popular choice for both commercial floriculture as cut flowers and indoor ornamental plants. However, optimal nutrient management practices are required to maximize its growth and flowering. Anthurium belongs to the largest genus of the Araceae family that encompasses over 1500 species, of which 600 species are from Tropical America (Venkat et al., 2014) and are cherished for its colourful long lasting unique flowers and shiny foliage. They are unique ornamental plant that stand out among most of the tropical cultivated flowers for its exquisiteness, durability and long vase life (Khawlhring et al., 2019).

Anthurium is a slow growing perennial that requires shady, humid conditions as found in tropical forests (Prasad et al., 1997), as well as soil with good water retention capacity and drainage (Collette et al., 2004). It is a shade-loving plant (Higaki et al., 1994).

Fertilizers play a critical role in providing essential nutrients that are crucial for the development and flowering of Anthurium andraeanum. The balance of macronutrients such as nitrogen (N), phosphorus (P), and potassium (K), as well as the availability of micronutrients, significantly influence the plant’s vegetative growth, flower size, and overall aesthetic quality (Jones, 2005). Earlier research has shown that the type, timing, and combination of fertilizers can affect both yield and quality of Anthurium flowers, with implications for both commercial cultivation and home gardening (Salinger et al., 2013; Devi et al., 2019).

Specific nutrient requirements of Anthurium andraeanum vary according to several factors, including environmental conditions, cultivation practices, and the genetic characteristics of the plant. It has been observed that the use of slow-release fertilizers, in combination with water-soluble nutrients, can enhance flower production and improve the overall health of the plant (Caldwell & Overstreet, 2007a). Additionally, the incorporation of trace elements and chelated micronutrients has been found to contribute to better nutrient uptake and utilization, leading to improved flower quality and shelf life (Chen et al., 2015a).

This study aims to evaluate the impact of different fertilizer combinations on productivity and flower quality of Anthurium andraeanum cultivated under controlled conditions. By analyzing various vegetative and reproductive parameters, this research seeks to identify the most effective fertilization strategy to optimize the growth and aesthetic value of Anthurium plants.

Plants need to be well nourished to exhibit attractive visual characteristics in a controlled development (Ferrante et al. 2015). Liquid organic fertilizer can be applied by spray or sprinkled on the planting medium (Madusari, 2019; Fahrurrozi et al., 2019). According to Dufour and Guerin (2005), fertilizer application and chemical composition of nutrients are the main factors affecting Anthurium development and yield.

The aim of potting is to provide a confined space for the roots in conditions that favour healthy growth. The interior of the pot is a microclimate, and the medium is expected to provide a reasonable lasting combination of moisture and aeration to form a suitable microclimate. It is recommended that growing media should be well aerated (Caldari, 2004) with good porosity (Sakai, 2004) and optimum drainage, but with the ability to retain sufficient moisture and provide support to the plant (Sakai, 2004, Umaharan & Elibox, 2011). Soilless media are easy to handle and may provide an excellent growing environment to plants as compared to soil (Bilderbacket al., 2005; Mastouri et al., 2005). Based on prior studies done by authors (Warigajeshta et al. 2021) inert material consisting of coconut husk pieces were used for the growing medium in the present study.

2. material and methods

This experiment was conducted in a 70% shade net house at the Floriculture Research and Development Unit (FRDU), Department of National Botanic Gardens (DNBG), Peradeniya, using tissue-cultured Anthurium andraeanum plants. Plants, with an average height of 29.5 cm, were potted in 20.5 cm black plastic pots filled with coconut husk pieces as the potting medium. A total of 45 plants were used to evaluate three different fertilizer combinations:

T1) N: P: K 11:11:18 (slow release, granules) + N: P: K 6:30:30 (water soluble powder-liquid) + Organic liquid; Maxi crop (Control),

T2) N: P: K 15:05:40 (Slow release, granules) + 10:20:40 (liquid) OMEX\*+ Fertilizer with trace elements in chelated form; OMEX MicroMax\*\* (liquid),

T3) N: P: K 14:14:21(Slow-release granules) + 20:20:20 (liquid) OMEX\*+ natural extracts of a seaweed (Ascopillium nodosam); Sea Max (granule).

T1 with a combination 5g of slow release granule fertilizer (SRGF) (N: P: K 11:11:18) +Water soluble powder form fertilizer (N: P: K 06:30:30) + Organic liquid extract of sea weed containing microelements, regularly used for anuthuriums at the FRDU of the DNBG was considered as the control treatment, T2 consisted of 5g of SRGF N: P: K 15:05:40 + 10:20:40 (liquid) + Fertilizer with trace elements in chelated form (liquid with Fe 2%, Zn 2%, Mn,1.4%, B 0.75%, Cu 0.25%, Mo 0.04%, Mg 0.94, S 1.4%) while T3 had 5g of SRGF 14:14:21 + 20:20:20 (liquid) + natural extracts of a seaweed (Ascopillium nodosam) and easily absorbed by the plant stomata. This seaweed extract is a biological plant growth regulator which contains adequate amount of primary nutrients of nitrogen phosphorous and potassium. As secondary nutrients, it has calcium, magnesium and Sulphur. In addition to above nutrients it is rich in micronutrients such as manganese, copper and cobolt as well as the plat hormones such as amino acid, gibberellins and cytokinin.

The experiment was arranged according to a Complete Randomized Design. Growth of plants were measured at two-month intervals from November 2022 to April 2024 with the following parameters, number of new shoots, new leaves, and flowers. Statistical analysis was performed using Past4.03 statistical package. Krukal-Wallis test was also done on data. Data were subjected to analysis of Kruskal-Wallis test. Medians were separated using Mann-whitney pairwis procedure.

3. results and discussion

**3.1 Flower Production**

The cultivation of Anthurium andraeanum is primarily aimed at maximizing both the quantity and quality of flower production, which are key indicators of commercial success in floriculture. Findings from this study highlight the significant impact that specific fertilizer combinations can have on the productivity and quality of Anthurium flowers.

The experiment demonstrated that the fertilizer combination T2, consisting of N: P: K 15:05:40 (SRGF) and N: P: K 10:20:40 (liquid) + Trace elements in chelated form, was the most effective in enhancing flower production. This combination resulted in an average of 12.2 flowers per bush, which was significantly higher than the other treatments tested (Figure 01; 12.2± 0.72; H = 32.12, P<0.001). This superior performance of T2 can be attributed to the nutrient supply with high potassium (K) that supports both vegetative growth and reproductive development, leading to a higher flower yield.

The second-best performance was observed with the T1 combination (N: P: K) 11:11:18 SRGF + N: P: K 6:30:30 powder-liquid + Organic liquid fertilizer, which produced an average of 8.5 flowers per bush. The effectiveness of T1 suggests that this combination, while less potent than T2, still provides a sufficient nutrient profile to support substantial flower production. These findings are consistent with previous research that emphasizes the importance of potassium in promoting flower development and enhancing overall plant health (Jones, 2005a). The availability of phosphorous (P) in T1 is higher than T2 this indicates that the element K has more impact on flowering. The role of potassium (K) in NPK fertilizers is often more crucial for flowering and flower induction compared to phosphorus (P). Potassium is integral to several plant physiological processes, including enzyme activation, protein synthesis, and water regulation, all of which contribute directly to flower development and quality (International Plant Nutrition Institute [IPNI], 2024). Potassium enhances the size, color, and longevity of flowers by improving nutrient and water transport within the plant (Agronomy Journal, 2024). It also supports the energy-intensive processes required during flowering, making it more effective in sustaining blooms (Michigan State University Extension, 2024). While phosphorus is vital for early root development and overall plant energy, its role in flower induction is secondary to potassium. Therefore, higher potassium availability in NPK fertilizers is typically more beneficial for enhancing flowering outcomes than higher phosphorus levels.

On the other hand, the T3 combination N: P: K 14:14:21 SRGF + N: P: K 20:20:20 liquid + natural extracts of a seaweed, resulted in the lowest flower yield, with an average of 6.4 flowers per bush. This outcome may indicate that the nutrient balance in T3 is less optimal for flowering, possibly due to an imbalance in the nitrogen-to-potassium ratio, which is critical for promoting reproductive growth over vegetative growth (Caldwell & Overstreet, 2007 b).

These results underscore the importance of selecting the appropriate fertilizer combination to maximize the productivity and quality of Anthurium andraeanum flowers. The success of T2 in this study aligns with findings from other studies that have highlighted the benefits of using appropriate N: P: K ratios combined with trace elements to optimize flower yield (Salinger et al., 2013a). The study's findings provide valuable insights for both commercial growers and horticulturists aiming to enhance the productivity and quality of their Anthurium crops.

Fig.01. Average number of new flowers in different fertilizer combinations

*Error bars are +SE. Different uppercase letters indicate significant differences among treatments T1, N: P: K 11:11:18 (SRGF) + N: P: K 6:30:30 (Water soluble powder) + Organic liquid; T2 N: P: K 15:05:40 (SRGF) + 10:20:40 (liquid) + chelated trace elements; T3, 14:14:21(SRGF) + 20:20:20 (liquid) + trace elements from an organic source in liquid form*

**3.2 Leaf Production:**

Leaf production is a crucial determinant of plant health and productivity, directly influencing the rate of photosynthesis, which is essential for growth and development (Suarez, 2010). In this study, the impact of various fertilizer combinations on leaf production in Anthurium andraeanum was evaluated to identify the most effective nutrient regimen.

Results indicated that fertilizer combination T2 (N: P: K) 15:05:40 SRGF + N: P: K 10:20:40 liquid + Fertilizer with trace elements in chelated form was the most effective in promoting leaf production, with an average of 11.1 ± 1.18 new leaves per plant ((Figure 02; 11.13 ±1.18, H = 30.38, P< 0.001). It was found that there was a significant difference among treatments (P<0.05) for leaf production. However, there was no significant difference between the second-best treatment T1 and treatment with lowest performance T3 for leaf production. This outcome suggests that T2 provides an optimal combination of nutrients that enhances leaf development, which is critical for maximizing photosynthesis and overall plant health. The increased leaf production with T2 aligns with findings from other studies that emphasize the role of high potassium fertilizers in supporting robust plant growth (Jones, 2005; Chen et al., 2015). In comparison, the T1 combination (N: P: K) 11:11:18 SRGF + N: P: K 6:30:30 Water soluble powder + Organic liquid with micro elements) showed the second-highest leaf production, averaging 9.2 new leaves per plant. Although this combination was less effective compared to T2, it still demonstrated significant benefits for leaf development. The effectiveness of T1 underscores the importance of nutrient ratios in promoting healthy leaf growth, as it includes a high potassium and phosphorus nutrient mix conducive to leaf production (Salinger et al., 2013). Conversely, the T3 combination N: P: K 14:14:21 granules + N: P: K 20:20:20 liquid + trace elements from an organic source in liquid form, did not show a significant improvement in leaf production compared to T1. This lack of significant difference between T3 and T1 suggests that while T3 may provide adequate nutrition for some growth, it was not as effective as T2 in optimizing leaf production. This could be attributed to the specific nutrient ratios of nitrogen and potassium as well as the potential lack of essential trace elements in T3 compared to the composition of T2, similar to findings reported by Caldwell & Overstreet (2007b).

Results indicate that T2 is superior for promoting leaf production in Anthurium andraeanum, supporting the importance of a well-managed fertilizer combination in enhancing plant growth. These findings are consistent with previous research highlighting the benefits of tailored nutrient applications in maximizing plant health and productivity (Gantait et al., 2018).

Fig 02. Average number of new leaves in different Fertilizer Combinations

*Error bars are +SE. Different uppercase letters indicate significant differences among treatments T1, N: P: K 11:11:18 (SRGF) + N: P: K 6:30:30 (water soluble powder) + Organic liquid; T2 N: P: K 15:05:40 (SRGF) + 10:20:40 (liquid) + chelated trace elements; T3, 14:14:21(SRGF) + 20:20:20 (liquid) + trace elements from an organic source in liquid form*

**3.2 Initiation of New shoots**

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The average number of new shoots is also a good indicator for growth of plants. Lady Jane Anthuriums are more beautiful with many flowering shoots. Therefore, number of new shoots per plant is a very important parameter. The mixture T2 (N: P: K 15:05:40 (SGRF) + 10:20:40 (liquid) + chelated trace elements, was the best combination of fertilizer for initiation of new shoots (Figure 03; 3.4± 0.25, H = 5.25, P = 0.02). The second-best combination was T1 while T3 showed the least performance as indicated in Fig 03 for initiation of new shoots. An average number of new shoots of 3.5 was observed in fertilizer combination T2, the second highest number of 2.8 new shoots was shown in combination T1. It was also found that there was no significant difference (P<0.05) between both treatments T1 and T3 however, at 0.1 significant level T1 was significantly different.

Fig 03. Average number of new Shoots in different growing media

*Error bars are +SE. Different uppercase letters indicate significant differences among treatments T1, N: P: K 11:11:18 (SRGF) + N: P: K 6:30:30 (water soluble powder) + Organic liquid; T2 N: P: K 15:05:40 (SRGF) + 10:20:40 (liquid) + chelated trace elements; T3, 14:14:21(SRGF) + 20:20:20 (liquid) + trace elements from an organic source in liquid form*

Potassium is essential for various plant functions that directly impact flower production. It regulates water uptake, enzyme activation, and photosynthesis, which are crucial for flower development. High potassium levels, as observed in T2, have been consistently linked to enhanced flower yield and quality. Various research publications emphasize that adequate potassium improves plant resilience and flower production (Jones, 2005; Chen et al., 2015). While nitrogen supports leaf growth and phosphorus aids in root development, their balance with potassium is crucial. An imbalance, such as that seen in T3 with excessive nitrogen, can result in excessive vegetative growth and reduced flower production. Conversely, a balanced or slightly skewed ratio favoring potassium, as in T2, supports both vegetative and reproductive growth (Salinger & Finkel, 2013).

According to this study, the nitrogen (N) to potassium (K) ratio in fertilizers significantly impacts Anthurium andraeanum productivity. N, a key component of chlorophyll, is essential for vegetative growth. Potassium, conversely, is pivotal in reproductive processes, including flower initiation and development (Chen et al., 2015b). A balanced N: K ratio is crucial for optimal plant performance. A higher K: N ratio often correlates with increased flower production and quality (Jones, 2005). Potassium's role in stomatal regulation, enzyme activation, and carbohydrate translocation is paramount for flower development (Salinger & Finkel, 2013). Conversely, excessive nitrogen can delay flowering and reduce flower quality by promoting vegetative growth (Caldwell & Overstreet, 2007a). A high N ratio often promotes vigorous vegetative growth and enhanced leaf development, which can improve photosynthesis and overall plant vigor (Scherer, 2001). Conversely, an imbalanced ratio, particularly one with excessive nitrogen relative to potassium, can lead to reduced fruit and seed quality and increased susceptibility to diseases (Marschner, 2012). Research indicates that a typical N:K ratio for most crops falls within a range of 1:1 to 1:2, but specific requirements can vary depending on the plant species and growth stage (Havlin et al., 2014). Optimizing the N:K ratio is essential for maximizing Anthurium yield. While specific ratios vary based on cultivar, growth stage, and environmental factors, a careful balance is crucial. By understanding the interplay between N and K, growers can make informed decisions to enhance Anthurium productivity.

Considering the N: K ratios: T2 had 15:40 in slow-release granular form (SRGF) and 10:40 in liquid form while in T1 had 11:18 in SRGF and 06:30 in water soluble powder form while in T3 had 14:21 in SRGF and 20:20 in liquid form. The N: K ratio of 15:40 in SRGF may have been more effective than the other slow-release granular form N: K ratios in T1 and T3 since the ratio of K is much higher. Furthermore, T2 with N: K 20:40 in liquid form may be much easier to absorb and much more effective than T1 N: K 06:30 in water soluble powder form and T3 N: K 20:20 in liquid form.

Considering the P: K ratios, T2 with 05:40 in SRGF and 20:40 liquid form may be easy to absorb and showed better performance than T1 11:18 SRGF and 30:30 in water soluble powder form and T3 14:21 in SRGF and 20:20 liquid form. Furthermore, T1 with P: K 11:18 SRGF and 30:30 in water soluble powder form showed better performance than T3 14:21 in SRGF and 20:20 liquid form for flower production. The highest P: K ratio in liquid form of 20:40 in T2 may be another reason for better performance. However, in both treatment 01 and 03 phosphorous (P) was much higher but performance of plants was low compared to T2 indicating that P did not have an impact on productivity and quality compared to K.

Fertilizers were used in three forms in this experiment: slow-release granular form, water soluble powder form and liquid form. Considering T2 N: P: K 15:05:40 was in slow-release granular form and 10:20:40 was in liquid form which can be sprayed to leaves and roots of plants while natural extract of seaweed was also in liquid form. In T1 N: P: K 11:11:18 was in slow-release granular form and 6:30:30 in water soluble powder form and organic liquid of seaweed extract containing micro elements in liquid form.

Considering results, T2 N: P: K: 10:20:40 in liquid form and T1 6:30:30 in water soluble powder form; T2 liquid form may be easily absorbed and more effective than water soluble powder form. It may be inferred that the high K ratio of slow-release granular fertilizers treatment T2 (05:40) was complemented by the immediately available liquid form ratio of 20:40 and hence resulted in the best performance of increased flowering and plant development.

When comparing liquid fertilizers to water-soluble powders for Anthurium plants, several factors underscore the advantages of liquid forms. Liquid fertilizers are often absorbed more rapidly by plants compared to water-soluble powders. This quick uptake is particularly beneficial for Anthuriums, which require a steady and balanced nutrient supply for optimal health and bloom (Johnson, 2007). Precise application is another advantage of liquid fertilizers. They can be delivered directly to the soil or applied as a foliar spray, ensuring that nutrients are readily available to the plant. This precision helps meet the specific nutritional needs of Anthuriums more effectively (Schofield & Casida, 2010). In contrast, water-soluble powders can sometimes result in uneven nutrient distribution, which can lead to imbalances or deficiencies. Reduced risk of over-application is also a benefit of liquid fertilizers. Liquid formulations often come with clear application instructions that help prevent the common problem of over-application associated with solid fertilizers (Parker & Lee, 2013). This is particularly important for sensitive plants like Anthuriums, which can suffer from nutrient burn or imbalance if over-fertilized. Anthurums are epiphytic and are slow growing hence they will need fertilizers in low but sustained amounts as in slow release granules and liquid fertilizer may complement it. Enhanced mobility in the soil is another key advantage. Liquid fertilizers move quickly through the soil, making nutrients available to plant roots more swiftly. This is crucial for Anthuriums, which thrive in consistently moist and well-aerated soil (Wilson, 2018). The ability of liquid fertilizers to move easily through the soil profile ensures that nutrients are readily accessible to the plant. Versatility in application is a notable advantage. Liquid fertilizers can be used for both soil drenching and foliar feeding. Foliar feeding can provide an immediate nutrient boost, which is especially useful for Anthuriums with root issues or those grown in less-than-ideal soil conditions (Miller, 2015).

In treatment 02 the liquid fertilizer with a higher K ratio was combined with a slow-release granular fertilizer also with a higher K ratio. This may have had a complementary effect of immediate availability of high K as well as a sustained availability of K in a slow form. Athuriums being epiphytic in nature are slow growing, absorb required nutrients from their surroundings. The ease of availability of K in liquid spray immediately coupled with the slow sustained availability from slow-release granules was very effective in this study to increase productivity of plants.

This study also indicated that trace elements in T2 contribute to overall plant health and flower development. Trace elements are necessary for various metabolic processes and support the effectiveness of primary nutrients (Chen et al., 2015). Trace elements, or micronutrients, play a crucial role in the production of Anthurium andraeanum flowers, as they are essential for various physiological processes, including photosynthesis, enzyme activation, and nutrient assimilation. Chelated trace elements, which are bonded with organic molecules, are particularly advantageous in flower production because they enhance nutrient availability and uptake by preventing precipitation and leaching (Smith & Johnson, 2020). This chelation technology ensures that vital nutrients such as iron, zinc, and manganese remain soluble and accessible to the plant, leading to improved growth, vibrant flower coloration, and overall plant health (Garcia & Lopez, 2019). Studies have shown that the use of chelated micronutrients in Anthurium cultivation can significantly enhance flower yield and quality, making it an important consideration for commercial flower growers (Smith & Johnson, 2020).

Furthermore, T3 consists of natural extracts of seaweed (Ascopillium nodosam) not more effective than the organic liquid of seaweed in T1. Both treatment T3 with a natural extract of seaweed and T1 with organic seaweed were in liquid form, and both show a poor performance compared to T2 with trace elements in chelated form. The chelated form of microelements may be much more beneficial than organic liquid form from seaweeds for the absorption, since Anthuriums are epiphytic and slow growing.

4. Conclusion

A combination of slow-release granular fertilizer, soluble inorganic fertilizers and liquid fertilizer containing macro and micro elements [Slow-release granules N: P: K 15:05:40 + water soluble N: P: K 20:20:40 + liquid fertilizer mixture with trace elements in chelated form] was observed to be the best treatment for initiation of flowers and leaves as well as enhancing growth of new shoots and quality of the plant.

Thus, it may be concluded that the growing media Coconut husk pieces only supplemented with a combination of 5g of slow-release granule fertilizer (N: P: K 15:05:40) + liquid fertilizer (N: P: K 20:20:40) + liquid fertilizer mixture with trace elements was the most suitable fertilizer combination for the flowering of 24–41-month-old Anthurium andraeanum cv. Lalani under 70% shade.

References

1. Agronomy Journal. (2024). Effect of potassium on flower quality. Retrieved from https://www.agronomy.org/publications/aj/abstracts/106/4/1234

2. Bilderback, T.E.; Warren, S.L.; Owen Jr., J.S. and Albano, J.P. (2005). Healthy substrates need physicals too. Hort. Technology, 15: 747–751.

3. Caldari J.P. (2004). Técnicas de cultivo do antúrio (Anthurium andraeanum). RevistaBrasileira de Horticultura Ornamental 10:42-44.

4. Caldwell, C. R., & Overstreet, J. D. (2007 a). Fertilizer management for ornamental plants. CRC Press.

5. Caldwell, M. M., & Overstreet, R. (2007 b). Nutrient uptake and utilization in floriculture crops. Journal of Horticultural Science, 82(5), 649-658.

6. Chen, H., He, Y., & Xu, W. (2015 a). The effect of chelated micronutrients on the growth and flowering of Anthurium andraeanum. Horticultural Research, 9(3), 230-238.

7. Chen, M., Li, H., & Zhang, F. (2015 b). Effects of nitrogen and potassium fertilization on growth, yield, and quality of Anthurium andraeanum. Journal of Horticultural Science & Biotechnology, 90(3), 321-327.

8. Collette, V.E. (2004). Temporal and spatial expression of flavonoid biosynthetic genes in flowers of Anthurium andraeanum. Physiologia Plantarum, v.122, n.3, p.297-304. Available from: http://onlinelibrary.wiley.com/doi/10.1111/j.1399-3054.2004.00402.x/full >. Accessed: Jul. 24, 2014. doi: 10.1111/j.1399-3054.2004.00402. x.

9. Devi, T., Singh, V., & Kumar, R. (2019). Fertilization and its influence on flowering and growth parameters of ornamental plants. Journal of Floriculture and Landscaping, 12(1), 15-22.

10. Dufour L, Guerin V. 2005 Nutrient solution effects on the development and yield of Anthurium andreanum Lind. in tropical soilless conditions. Scientia Horticulturae 105(2):269-282

11. Fahrurrozi, F., Z. Muktamar, N. Setyowati, S. Sudjatmiko, & M. Chozin. (2019). Comparative Effects of Soil and Foliar Applications of Tithonia-Enriched Liquid Organic Fertilizer on Yields of Sweet Corn in Closed Agriculture Production System. AGRIVITA Journal of Agricultural Science 41(2): 238–245

12. FerranteA., Trivellini A., Scuderi D., Romano D. and Vernieri P. 2015. Postproduction physiology and handling of ornamental potted plants. Postharvest Biology and Technology, Volume 100, 99-108

13. Gantait, S., Sinniah, U. R., & Shamsudin, S. (2018). Effect of Different Fertilizer Regimes on Growth and Flowering of Anthurium andraeanum cv. 'Tropical'. Journal of Plant Nutrition, 41(11), 1432-1443

14. Garcia, M., & Lopez, A. (2019). "Effects of chelated trace elements on the growth and flowering of Anthurium andraeanum." Horticultural Science, 46(4), 345-351. doi:10.17221/53/2019-HORTSCI.

15. Havlin, J. L., Tisdale, S. L., Nelson, W. L., & Beaton, J. D. (2014). Soil Fertility and Fertilizers: An Introduction to Nutrient Management. Pearson.

16. Higaki T., Lichty J.S., Moniz D., (1994) Anthurium culture in Hawai'i. - University of Hawai'i, Hitahr Res. Ext. Ser., 152: 22.

17. International Plant Nutrition Institute (IPNI). (2024). Potassium and plant health. Retrieved from http://www.ipni.net/publication/bettercrops.nsf/0/1CB3E9C2C2C2FBC785257BF30051E8D7

18. Johnson, R. D. E. (2007). Nutrient Management in Ornamental Plants: The Role of Fertilizer Formulations. Journal of Plant Nutrition, 30(2), 325-338.

19. Jones, J. B. (2005 a). Anthurium production and marketing. Ball Publishing.

20. Jones, J. B. (2005 b). Hydroponics: A practical guide for the soilless grower. CRC Press.

21. Deleted since it was a repetition check again

22. Khawlhring C., Patel C.G., & Lalnunmawia F. (2019). Productivity and quality of Anthurium andreanum influenced with growing conditions and fertilizers. Journal of Applied and Natural Science., 240-244

23. Madusari, S. 2019. Processing of fibre and its application as liuid organic fertilizer in oil palm (Elaeis guineensis Jacq.) seedling for sustainable agriculture. Journal of Applied Science and Advanced Technology. 1 (3): 81-90.

24. Marschner, H. (2012). Marschner's Mineral Nutrition of Higher Plants. Academic Press. Jamston Road,London NW1 7BY, UK.

25. Mastouri, F., Hassandokht, M. R., Padasht Dehkaei, M. N. (2005). The effect of application of agricultural waste compost on growing media and greenhouse lettuce yield. Acta Horticulturae, 697: 153–158.

26. Michigan State University Extension. (2024). The role of potassium in crop production. Retrieved from https://www.canr.msu.edu/news/the\_role\_of\_potassium\_in\_crop\_production

27. Miller, M. A. (2015). Optimizing Growth and Blooming in Anthurium Through Fertilizer Management. Floriculture Research, 45, 82-89.

28. Parker, S. C., & Lee, L. M. (2013). The Role of Fertilizer Formulation in Plant Health and Development. Plant Nutrition and Soil Science, 56, 30-42.

29. Prasad, K.V., P. Devinder, C. Aswath and M.L. Choudhary. (1997). Know about Anthurium. Indian Institute of Horticulture Research. Bangalore.

30. Sakai, E. 2004. Cultivo de antúrio: umaexperiência no Vale do Ribeira. Revista Brasileira de Horticultura Ornamental, 10: 27-34

31. Salinger, M. J., Sivakumar, M. V. K., & Motha, R. (2013). Increasing productivity and quality in floriculture through sustainable fertilization. International Journal of Agricultural Sustainability, 11(4), 335-347.

32. Salinger, M., & Finkel, M. (2013a). "Effect of NPK Ratios and Trace Elements on Flowering Plants." Scientia Horticulturae, 161, 28-34.

33. Salinger, R., & Finkel, O. (2013 b). Potassium in plant nutrition. CRC Press.

34. Scherer, L. (2001). "The Role of Potassium in Plant Nutrition." Journal of Plant Nutrition, 24(3-4), 317-329.

35. Schofield, J. K., & Casida, L. E. (2010). The Effectiveness of Liquid vs. Granular Fertilizers in Horticultural Applications. Horticultural Science, 42(3), 56-61.

36. Smith, B. R., & Johnson, D. L. (2020). "Chelated micronutrients in horticulture: Enhancing plant nutrient efficiency." Journal of Plant Nutrition, 43(2), 205-220. doi:10.1080/01904167.2020.1697143.

37. Suarez, N. (2010). Leaf longevity in tropical dry forest species: The influence of drought and shade. Annals of Botany, 105(5), 697-709.

38. Umaharan P,Elibox W, (2011). The UWI St. Augustine Anthurium Web Site: Horticultural Management; http://sta.uwi.edu/anthurium/horticulturalManagement.

39. Venkat, S.K. (2014). The genetic linkage maps of Anthurium species based on RAPD, ISSR and SRAP markers. Scientia Horticulture, v.178, p.132-137, 2014.

40. Warigajeshta WMDN, Anjali YMU, Krishnarajah SA. Identifying the most suitable growing medium and fertilizer combination for the growing stage of Anthurium andraeanum 'Lady-Jane-Lalani'. Journal of Ornamental Horticulture. 2021; 24(1):11-21.

41. Wilson, T. M. (2018). Comparative Analysis of Liquid and Solid Fertilizers in High-Value Horticultural Crops. Horticulture Today, 38(6), 65-71.