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Future Directions and Opportunities in Anthurium Breeding Research

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ABSTRACT:

Anthurium has gained immense popularity as an ornamental crop because of its colourful and unusual blossoms. This paper explores the ever-changing field of crop breeding for Anthurium. Understanding the genetic diversity of Anthurium species is essential to breeding programmes that are effective. Genetic diversity evaluations are so essential because they help breeders choose parents wisely and support conservation efforts. A wide range of characteristics, such as blossom colour, shape, size, smell, and pest and disease resistance, are sought after in breeding. To accomplish these goals, breeding strategies that range from conventional hybridization to state-of-the-art biotechnological procedures are used. The review explains the selection while navigating the complex process of cultivar development. Prominent cultivars that emerged from these efforts attest to the effectiveness of breeding initiatives with hybridization, mutation breeding techniques. Novel approaches to improving breeding efficiency and hastening trait with in-vitro culture, double haploids production. However, the field faces difficulties like scarce genetic resources, drawn-out breeding cycles, and issues with sustainable production. Despite these obstacles, cooperation and creativity are still essential for advancing Anthurium breeding. Expanding genetic resources, incorporating innovative features, refining breeding tactics, and embracing cutting-edge technologies are the future objectives to be pursued. Anthurium breeders can further enhance the ornamental diversity and robustness of this classic crop by successfully navigating these frontiers. This assessment acts as a thorough road map, outlining the development of Anthurium crop breeding and providing insights into future direction.

KEYWORDS: Anthurium, breeding, ornamental crops, genetic diversity, cultivars, breeding methods.

1. INTRODUCTION

The name "anthurium" is a composite of two Greek words, Anthos and oura, with Anthos meaning flower and oura meaning tail. Consequently, this flower is commonly known as a tail flower or tailed flower. It is also identified by various other names, including flamingo flower, flamingo lily, painter's palette, oilcloth flower, and occasionally laceleaf. Anthuriums are acknowledged for their ability to purify the air, as indicated by NASA's Clean Air study, contributing to the removal of harmful substances such as formaldehyde, ammonia, toluene, and xylene from the surrounding environment (Wolverton *et al*., 1989)

Anthuriums are symbols of hospitality, happiness, and abundance. Specifically, the red varieties are associated with love, lust, and sensuality, while the white ones signify purity and peace. They are also believed to bring good luck and offer protection against evil. Due to its eye-catching, long-lasting inflorescences (Hamidah et al., 1995, 1997a,b; Zeng et al., 2004) and long vase life (Elibox and Umaharan, 2010). Anthurium is a well-liked genus of the Araceae (order Saphirorae) as an ornamental cut flower and pot plant.The attractive leaves of anthuriums are commonly used in floral arrangements as cut greens, and these plants have gained popularity as potted plants, ranking among the top five in the global house plant market.

Anthurium andraeanum (Hort.) is a collective name for modern Anthurium cultivars that are intricate, interspecific hybrids between *A. andraeanum*Linden ex André and other species within the section Calomystrium that were originally brought to Hawaii from Colombia, where an intensive breeding programme was put into place (Nakasone and Kamemoto, 1962; Kamemoto and Kuehnle, 1996). Despite the widespread cultivation of numerous commercial varieties, the anthurium industry still requires more diverse options with unique colors and shapes, high stress tolerance, extended vase life, and other desirable traits.

2. HISTORY, ORIGIN AND DISTRIBUTION

The discovery of the first anthurium species can be attributed to the Austrian explorer Karl Von Scherzer in Colombia during the 1850s. This plant, named *Anthurium scherzerianum* (Higaki*et al.,* 1972), marked the initiation of anthurium exploration. With over 900 known species and approximately 1500 species overall, anthurium is mostly found in neotropical areas that stretch from northern Mexico to Central America and southern Brazil, as well as the Caribbean Islands. (Boyce *et al*., 2018). As the largest genus in the arum family, Araceae, anthurium comprises over 1000 species of flowering plants. Originating from the jungles of Colombia and various parts of Central and South America, many new species have been discovered in the Andes of western South America.Numerous helophytic species can be found growing on rock with exposed areas (Gonçalves, 2005; Haigh et al., 2011); they rarely occur in aquatic settings (Coelho et al., 2009; Gonçalves and Jardim, 2009). Their habitats might be considered terrestrial in forest species, an epiphytic, or hemiepiphytic vines.

3. BOTANY AND CYTOLOGY

Anthuriums, categorized as a genus of monocotyledonous herbs, are commonly cultivated as epiphytes, and some serve as terrestrial ornamental plants. Despite being popularly known as the flamingo flower, Anthuriums do not produce true flowers. Instead, they feature slightly waxy or velvety heart-shaped leaves that collectively create a spathe. This vibrant leaf, also known as a bract, plays a pivotal role in the plant's pollination process. The spadix, a spike-shaped cluster of small flowers ranging in color from white to yellow, extends from the stem of an Anthurium. About 150-300 flowers are arranged in a helical pattern on the spadix (Higaki *et al.,* 1984). Anthuriums exhibit a hermaphroditic flower structure. Due to the flower's protogynous nature, there exists an approximately week-long interval between the stigma's receptivity and the anther's dehiscence (Higaki *et al.*, 1984 Moreover, since a spadix first develops a female phase, which is followed a month later by a male phase, this lowers the frequency of flowers self-pollinating and increases the frequency of cross-pollinating. (Callotte, 2004).

The recognized subgeneric classification of Anthurium species consists of sections, with all clades deriving from a progenitor with the most prevalent chromosome number (2n=30), cytological variety, and sporadic polyploidy in the majority of the sections. 2n=24 is shared by numerous species, such as *Anthurium scandens* ssp. Pusillum. 2n= 48 could be the result from a polyploidy activity in *A. scandens*. The *Anthurium scandens*ssp, which is Scandens cytotype 2n=48 loses 6 chromosomes to 2n=42, then polyploidizes to produce 2n=84..(Bliss *et al.,* 2012). The chromosome number vary with species but most common is 2n=30. (Nascimento *et al.,* 2019).

The genus is well known for its intraspecific polyploidy. Examples of this include *A. pentaphyllum*G.Don at 2n = 30, 60 (Cotias-de Oliveira *et al*., 1999), *A. digitatum*(Jacq.) G.Don with 2n = 30, 60 (Rice *et al*., 2015), Three of the six plant species via the southeast and southern Brazil that were analysed showed intraspecific polyploidy, indicating a predominance of either tetraploid or diploid cytotype, as in the cases of *A. intermedium*Kunth and *A. urvilleanum* Schott and *A. harrisii*G.Don (Viegas*et al*., 2006). Furthermore common are B chromosomes, which have been found in both diploid & tetraploid samples.*A.*

urvilleanum populations near Parati, in the state of Rio de Janeiro, Brazil, to have 2n = 30 + 0-2Bs, but another group within the same.According to (Villegas *et al*. 2006), the township displayed 2n = 60 + 0-2Bs. B chromosomes are present in Anthurium frequently, however because of their size, shape, and methodological approach, they are difficult to recognise.

Marutani and Kamemoto (1983) conducted the most comprehensive examination of B chromosome in Anthurium, using *A. warocqueanum* Moore's somatic and meiotic cells as study subjects. While there were several various relationships throughout metaphase I of meiosis (a single trivalent in nature, one bivalent, a single univalent, or all three univalents), the researchers observed that the number of B chromosomes within somatic cells in a species had been constant (2n = 30 + 3B), suggesting that they were transmitted to both the female & male gametes.This resulted in a range for B chromosomes with selfed offspring.

4. SPECIES OR CULTIVARS :

The important species or cultivars are listed in the table: 1.

Table: 1

SPECIES/ CULTIVARS	IMPORTANCE/FEATURES	REFERENCE
Anthurium roseospadix	The largest species, Tetraspermium	(Bliss *et al*., 2012)
Anthurium obtusum	The smallest species, Calomystrium	(Bliss *et al*., 2012)
Anthurium andreanum	Famous for cut flower prouction, flowering perennial herbaceous indoor plant.	(Chowdhuri *et al*., 2021)
Anthurium amnicola	An erect purple spathe, fragrant flower, abundant blossoming species.	(Suzuki *et al*., 2017)
Anthurium scherzerianum Schott	It is a pot plant with durable inflorescence.	(Hamidah *etal*., 1997)
A. caldasii	Leaf blade is ovate, with dark purplish-brown spathe with a smooth surface, a rounded base lacking auricles.	(Mendez-Urbano *et al*., 2022)

Anthurium caramantae	Leaf blade is ovate to widely ovate, spathe is large and with a cordate-assymteric base forming auricles.	(Mendez-Urbano *et al*., 2022)
Anthurium rubrinervium	Fragrant, quite pleasant and flowery, detected between 9:30 a.m. and nightfall.	(Hentrich *et al*., 2007)
Anthurium decipiens	Massive species, violet-purple spadix, violet-streaked spathe, foul-smelling spadix and black berries that are bright orange/scarlet in color,	(Hay *et al*., 2019)
Anthurium tiswatl	New species of Anthurium sect. Andiphilium from Mexico. Similar morphologically to A. macdougallii, differs in having long blades and cataphylls, spadix from the 1st or 5th pairs of basal veins and shows yellowish to whitish berries as they ripe.	(Jimenez *et al*., 2024)

4.1 List of important flowering and Foliage Species (Bhati 2023).

Flowering Species:

The following are the important flowering species with their important features in the table 2 given below.

Table: 2

Flowering Species	**Important Features**
Anthurium andraeanum	Spathe can be white/reddish orange/scarlet/waxy red, Heart shaped with straight spadix.
Anthurium regnellianum	It has narrow green spathe with dark green spadix.
Anthurium scherzerianum	Brilliant scarlet colour spathe and orange-red to goldenn yellow color spadix.
Anthurium brownie	Spathe is greenish, rose tinted.
Anthurium spathiphyllum	Spathe is pale green or white, pale yellow spadix.

4.2 Foliage Species

The table: 3 given below gives the list of important foliage species with their characteristic features.

Table: 3

Foliage Species	**Characteristic features**
Anthurium magnificum	Leaves are olive-green with white nerves
Anthurium crystallinum	Leaves are heart-shaped, deep green in color.
Anthurium regale	Dull green leaves with white veins.
Anthurium warocqueanum	Oblong-lanceolate deep velvety green color leaves with contrasting mid-ribs.
Anthurium splendidum	Leaves have depressions, glaucous.
Anthurium veitchii	It has metallic green leaves with deep sunk nerves.
Anthurium pallidiflorum	It has tapered light green leaves.

5. BREEDING OBJECTIVES

Anthurium is a visually appealing and widely used decorative plant in trade. Among tropical flowers, anthuriums are closest in trade value to tropical orchids. It is the world's second-biggest crop of tropical flowers. Different spathe hues of anthurium cultivars are desperately needed in the global market (Li *et al*., 2024). Hence there is a need for improvement in the following characters.

- Development of unique colour of spathe and spadix.
- Improvement in the number of bloom per plant.
- Focus on extending the flowering period.
- Development of cultivar suitable for exhibition purposes: The adage, "The bigger the blossom, the better," might be applicable to exhibitions and competitions, but all flower sizes are required for commercial cut flower production.
- Development of cultivar with reclining spadix:It is thought that a reclining spadix will both make flower packing easier for shipping and enhance the flower's attractiveness. (Kamemoto, H., & Nakasone, H.Y., 1963).
- Production of dwarf plants.
- Improved shelf life/vase life of flowers.
- Development of variegated foliage varieties.
- Focus on enhancing the fragrance.
- Breeding for the development of glossy foliage of anthurium.
- Focus on the development of multicolor spadix.
- Development of resistant varieties to bacterial blight especially.
- Resistant varieties development for drought, high light & low intensity and tolerant to open field conditions.
- To work out on improving the storage life.

6. BREEDING METHODS

In Anthurium breeding, various methods are employed to create new cultivars with desired traits. They are Hybridisation, polyploidy, Mutation breeding and by using of biotechnological tools.

6.1 HYBRIDISATION

The requisite pollination hasn't always been able to be carried out due to a shortage of pollen or an incongruity between stigma receptivity and pollen availability. The stigma becomes receptive shortly after the spathe unfolds, making the botanical flower protogynous. Generally speaking, a shift in spadix color corresponds with receptivityPollen is functional early in small flowers on some immature seedlings, although it usually sheds long once the spathe opens. Since the protogynous nature of clones prevents selfing in a single spadix, many plants of the clone are needed to enable self-pollination.

(Kamemoto and Nakasone, 1963).

The hybrid's distinct grayish-orange spathe color is the consequence of combining the purplish-brown of A. wendlingerii with the scarlet of A. scherzerianum (Kamemoto& Sheffer, 1978).

Some of the examples of hybrid varieties are listed in the table: 4 below.

Table: 4

HYBRID	**PARENTS**	**FEATURES**	**REFERENCE**
"Centennial," UH 1272	Light pink A494 (*Anthurium. Andraeanum*x *A. antiquiense*) &white x lavender hybrid 570-77 ([uniwai x *Anthurium. lindenianum*] x *A. amnicola*)	Resistance to anthracnose, good choce for both potted plants and cut flowers.	(Kuehnle *et al.*, 2007)
Princess Aiko (UH1299)	*A. antioquiense* x Tatsuta pink obake	Pink fragrant variety, sweet aroma, beautiful longlasting flowers.	(Kuehnle *et al.*, 2004)
Regina	Marian Seefurth x *A. formosum*	Distinctive huge purple blossom, resistant to bacterial blight.	(Kuehnle *et al.*, 2004)
Victory Flag	*A. andraeanum*"Tropical" x *A. andraeanum*"Choco"	Spadix is green initially, turns yellow on opening.	(Junhai*et al.*, 2021)

6.2 POLYPLOIDY

The kind of explant and the dose at which colchicine was applied determined the effect on anthurium explants; node and root explants exhibited the highest capacity for anthurium mutant regeneration; exposure of the explants to colchicine at the doses used resulted in aneuploid plants (monosomic and trisomic), which displayed morphological traits distinct from those of the wild genotype. Breeding programs for anthuriums can produce genetic variability by using colchicine.

Variants with desired traits, like larger blooms, more dazzling colors and shapes, longer postharvest life, and higher resilience to biotic and abiotic stress, can be produced using polyploidy (Roughani*et al*., 2018).

6.3 MUTATION BREEDING

Mutagenesis is an essential breeding strategy for ornamentals. Novelties and oddities, improved plant architecture, longer shelf life, disease and pest resistance, and the creation of new hues and forms are all achieved with its help. Combining mutant breeding with in vitro propagation methods is an excellent way to breed a wide range of ornamentals. Although hybridization is not taking place in vegetatively grown plants, mutagenesis is commonly used to generate and make use of genetic variations. With only a few published research to date, induced mutation represents a relatively fresh approach for crop enhancement in the instance of anthurium.

Natural mutation have effectively given the rise to new varieties in the Anthurium genus.

One of the earliest hybrid species, *Anthurium andreanum* 'Red Hot,' grew compactly and well-branched, producing an abundance of gorgeous brilliant red spathes that were perfect for potted plants. "Orange Hot" is the name given to *Anthurium andreanum*, a mutation found in a significant number of tissue-cultured offspring of the plant Anthurium "Red Hot."(Sheena and Sheela 2014).

A program on breeding novel traits in Anthurium ornatum resulted in the production of a natural mutant known as "IIHR A1" in the IIHR Bangalore, India. This plant releases its mint aroma 15–17 days after bloom initiation, during stigma receptivity. The faint aroma last for between two and three days, and usually for a week, if the plant remains untrimmed.

According to (Aswath and Prakash 2005), flower-fragrance breeding programs can use this plant material, which can be grown both indoors and outdoors.
In vitro irradiation tests were conducted using the Anthurium variety 'Nitta'. To determine the ideal concentration (LD50), ethyl methane sulphonate (EMS) was applied to the meristimal nodular calli of Anthurium var. Valentino for ninety minutes at different concentrations. The findings showed that calli survival percentages at concentrations of 0.5 and 0.75% of EMS were 60 and 34 percent, accordingly (LD50 = 0.62%). When EMS was applied at a rate of 0.75%, the size of the spathe was less than when the control group had a 14.2% yellow spadix.60% of the yellow spadix was created by EMS at 1%, compared to pink spadix in the control treatment. Furthermore, the spadices obtained from the EMS-treated group exhibited a more rigid angle (45-90°) and were shorter than those from the control treatment (25°). 0–50% less female flower development occurred than in the control that produced female flowers 100% (Te-Chato and Susanon, 2005).

Anthurium andreanum var. propagation in vitro. One variegated plantlet was formed from the sonate, which had leaves that were half green and half yellow due to partial parenchymal tissue's chlorophyll loss.From the three primary chimera types—dark green and albino—two more stable leaf color mutations—the rubescent type & an etiolated type—were acquired by indirectly shoot regeneration through the callus tissue or axillary bud emergence (Sheela and Sheena, 2014).

6.4 USE OF BIOTECHNOLOGY

6.4.1 Micropropogation:

By using controlled circumstances to cultivate plant tissues, organs, and somatic cells, a technique known as micropropagation can be used as an alternative to conventional propagation to quickly generate a large number of genetically identical progeny plants. The ability of plant cells to create entire plants from individual plant components is known as totipotency, and it is a crucial characteristic. Some characteristics of micropropagation that make it a desirable option for commercial production are its ability to multiply quickly, produce in a disease-free and healthy manner, and generate a population all year round (Atak and Celik, 2012).
According to the variability of anthurium seeds, the main uses of in vitro seed culture are for the preservation of uncommon or endangered anthurium species and for increasing the number of unidentified phenotypes in the breeding pool (Tanabe et al., 1989). In Anthurium

antioquienseEngl, successful micropropagation employing seeds as explants has already been achieved (Murillo-Gómez et al., 2014).

6.4.2 Double HaploidsProdution

The utilization of anther culture for the generation of homozygous for double-haploid (DH) lines in the plant could be highly significant due to anthurium's high rate of crossing, strong heterozygosity in seed-derived offspring, and extended growing period following pollination. *Anthurium andraeanum* 'Carnaval,' a native Indonesian accession, as well as *A. andraeanum* 'Casino,' 'Laguna,' and 'Safari' have all had successfully developed anther cultures.(Karjee*et al*., 2020).

6.4.3 Invitro Multiplication

Utilizing in vitro techniques for propagation offers several advantages over conventional methods, primarily by utilizing small plant pieces, known as explants, to maintain and increase plant numbers efficiently. The key objective is to develop new strategies that reduce the time and cost per plant. However, when propagation involves an indirect callus phase, it can lead to a decrease in the genetic identity of the progeny. This presents a significant challenge in commercial propagation as it can impact the uniformity of the offspring. Moreover, the formation of callus increases the occurrence of somaclonal variation, which is a crucial concern. Prolonged periods of callus growth contribute to an increased incidence of somaclonal variation. Additionally, the origin of the callus also influences somaclonal variation (Atak and Celik, 2012).

Prakasha *et al*., (2017) presented a mass multiplication strategy in the well-known *Anthuriumandreanum* cultivar. Tropical Red, Acropolis, and Esmeralda through callus-mediated organogenesis. All cultivars' petioles with leaves (PL), on the leaf lamina with midrib explants were sterilized before being injected into the callus induction and induction of shoots media. After 30-35 days of inoculation, a creamy, compact callus forms in the cut ends on the veins of the explants. Cv. Esmeralda had the considerably higher callus induction response in both PL (94.45±9.45) & LLMR (74.67±5.89) explants.

Oo*et al*., (2019) usedthe plant growth regulators, specifically 2,4-D and BAP, in the process of indirect organogenesis in callus cells development for Anthurium andraeanum Linn. micropropagation. The study examined the creation of calluses, their proliferation, the initiation and multiplication of shoots, and the formation of roots from regenerated shoots. As explants in the current experiment, several segments of the mature plant's youngest & latest leaf laminas and the petiole were utilized. Exposure to the plant hormones previously indicated in basal MS at full strength medium resulted in the regeneration of plantlets in both explant segments. The MS media had the highest callus development.

7.ACHEIVEMENTS:

Two new cut flower types, "Apapane" and "I'iwi," have been bred from the patented "Tropic Fire" variety patented by the University of Hawaii. The vivid, glossy red spathes are reminiscent of the vibrant, endangered "apapane and "i'iwi" birds of Hawai'i. They are also bigger and more heart-shaped compared to those of the parent species, "Tropic Fire." Siblings "Apapane" (UH1651) and "I'iwi" (UH1679) were chosen in July 1992 through a cross between "Tropic Fire," an orange selection, and UH931. "Apapane" shows signs of resistance to anthracnose and tolerance to bacterial blight. "I'iwi" possesses a longer, more rounded spathe than "Apapane." Because of their vividly colored spathes, "Apapane" and "I'iwi" might be considered as interiorscape specimens. It is also tolerant of bacterial blight and has a modest resistance to anthracnose. (Amore TD *et al*., 2011).

A. andreanum comes in a number of noteworthy varieties, such as Salmon, Anmol, Canca, Pistache, Regina, Honduras, Marina, Agnihotri, Tropical, Nitta, KalingPong Pink, Tinora, and Ozaki Red.

The cultivar Tropical has the longest flowering period (230 days), with its primary flowering season occurring from July to February. 'Regina' (226.7 days) follows closely behind. The cultivar Marina had the lowest flowering period (96.1 days)(Chowdhuri *et al*., 2021).

8. CONCLUSION:

In conclusion, Anthurium breeding has made significant progress in recent years, resulting in the development of diverse and high-quality cultivars. However, there is still ample room for innovation and improvement in breeding practices.. Anthurium breeding may include expanding genetic resources, incorporating novel traits, optimizing breeding strategies, and adopting innovative technologies. Anthurium breeding and emphasizes the importance of collaboration between breeders, researchers, and industry stakeholders. By leveraging genetic diversity, embracing new technologies, Anthurium breeders can continue to enhance the ornamental value and sustainability of this beloved crop.

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