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PROGRESS IN BREEDING OF ORNAMENTAL FOLIAGE PLANT: A REVIEW

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ABSTRACT

Ornamental foliage plants have witnessed immense popularity in recent years because of their captivating array of colours, textures, and shapes that make them stand out in garden landscapes, indoor spaces, and commercial settings. This review offers a thorough summary of the history, origin, objectives, constraints and methods of breeding of ornamental foliage plants, with a particular emphasis on important elements such as breeding techniques, and future prospects.A wide range of characteristics, such as foliage colour, shape, size, pest and disease resistance, and glowing foliage are sought after in breeding.The breeding of ornamental foliage plants is a constantly evolving and diverse area that combines conventional breeding methods with the latest biotechnological progress. Various breeding methods, including introduction, selection, mutation breeding,hybridization, tissue culture, and genetic engineering, are employed to enhance genetic variability and introduce novel traits. However, there are certain constraints in ornamental foliage plant breeding including natural flowering, protandry, protogyny, low seed quality, and fruit maturity. This can be solved by collaboration between breeders, researchers, growers, and regulatory authorities leading to sustainable and responsible breeding practices.The future of breeding of ornamental foliage plants looks bright, because of the ongoing research into different methods of breeding of ornamental foliage plants. By integrating recent breeding technologies with traditional breeding methods, there is a promise of accelerating trait discovery, improving breeding efficiency, and developing robust and visually attractive varieties suitable for various landscapes and climates.This review aims to provide valuable insights into the current state and future directions of breeding ornamental foliage plants, offering a foundation for further research and development in this vital field.

KEYWORDS: ornamental foliage, breeding, breeding constraints, breeding methods, conventional breeding, breeding efficiency.

1. INTRODUCTION

For generations, people have coexisted withornamental plants. These, which are essentially a source of aesthetic experience, enhance daily life experience and show love, respect, thanks, or tribute. They are used to adorn religious or secular rituals and are given to others on various occasions (Lee *et al*.,2021)**.**Employing ornamental plants to enhance rituals and national days as is customary in Latin America, Asia and Africa. This scenario raises the attractiveness of ornamental plants on occasion. The bedding plants, garden plants and interior foliage plants are currently the ornamental plants that are growing the fastest (Zahara *et al*.,2020) and have great demand in the international market.

Foliage plants are the ones that are grown for their distinctive leaves havinga variety of forms, colours, patterns, and textures and are often used for exterior landscaping or interior scaping. Foliage plants are one of the fundamental components of aesthetic crops. It gives an aesthetic appeal to a room, offers practical elements like separation and screen, and has been shown to enhance task performance and uplift mood (Lee *et al.*,2021). Someof the important foliage plants include *Aglaonema*, *Dieffenbachia*, *Anthurium*, *Calathea*, *Spathiphyllum*, ferns, etc. These are used as pot plants, hanging baskets, vertical gardens, aquascaping, terrariums, dish gardens, and flower arrangements. In addition to the ornamental usesornamental foliage plants are being used for phytoremediation, for improving indoor air quality, increasing concentration and efficiency in offices, and for therapeutic uses in hospital indoors and outdoors gardening, therefore it is not surprising that over the past few years, the market demand for foliage pants has increased and their market share in the floriculture business has increased.

The increase in demand has increased keen interest in developing unique cultivars with appealing leaf shapes, colours, and sizes(Seneviratne *et al.*,2020). In this part, to improve the foliage plant, more focus was given to creating variation in leaf colour, form, texture, and developing biotic and abiotic. Stress-tolerant varieties. But in the present era, effortshave been made for the development of new cultivars having illuminated leaves, more phytoremediation properties, and enhancing biodiversity, selection of germplasm having more indoor air quality reduction potential, and development of cultivars having important volatile compounds in it, which will improve its therapeutic potential.All of today’s ornamental varieties have evolved through a variety of processes, including the crossing of the open-pollinated interspecies, the crossing of open-pollinated intra-species, man-made crosses, natural mutations, induced mutations, *in vitro* mutagenesis, mass selection, induced polyploidy, molecular methods, *etc* (Datta *et al.*,2022).

2. HISTORY OF IMPROVEMENT OF ORNAMENTAL FOLIAGE PLANTS:

In Europe, foliage plants began gaining popularity in the second half of the 19th century. Foliage plants from conservatories, botanical gardens and private estates were introduced to middle-class and wealthy homeowners for commercial use in the late 1890s. At the same time, greenhouse farmers in the northeast United States purchased shiploads of European plants for future growth or resale. Due to the favourable climatic circumstances, foliage plants moved to California and Florida in less than 20 years (Henny *et al*.,2010).

The foundation of the current foliage plant industry is provided by foliage plants from tropical or subtropic areas of the world. *Aglaonema, Dieffenbachia, Dracaena, Epipremnum, Ficus, Peperomia,Philodendron, Sansevieria, Syngonium,* and plants from a number of palmae species were among the industry's top competitors between 1956 and 1967. All other genera were outcasted by Philodendron, which accounted for 50% of wholescale values in 1956 and 36% in 1967.*Aglaonema*, *Dieffenbachia*, *Dracena*, *Epipremnum*, *Ficus*, *Philodendron*, *Syngonium*, ferns, and palm cultivar numbers have drastically changed during the past 25 years. The creation of new cultivars involves either conventional breeding or the selection of cultivars from propagation. The constant infusion of new cultivars, which sustains consumer interest in these plants, is a major contributor to their dominant position in the market.

The Boston fern (*Nephrolepsisexaltata*) was the first and almost only plant grown in Central Florida from 1913 until the early 1930s, and it was essential in the establishment of the foliage plant business. *Cyrtomium, Asplenium,Davallia, Adiantum, Nephrolepis, Pteris,* and *Platycerium* are among the numerous ferns growing in Florida's leaf business today. *Adiantum raddianum* 'Fragantissimum' and 'Gracillimum' ,*Adiantum hispidulum* 'Bronze Venus', *Adiantum pedatum*'Finger Maiden Hair Fern', *Adiantum Tenerum* 'Scutum Roseum' are new cultivars. As a novel cultivar of *Asplenium nidus*, only 'Cristatum' is listed. *Nephrolepisbiserrate* 'Western King', *Nephrolepiscordidolia*' Ecuadorian Sword' and 'Timmii' and Nephrolepisexaltata 'Emerald Queen', 'Smithii' and 'True Massii' are 6 new cultivars.

The number of cultivars of the *Aglaonema* genus, often known as Chinese evergreen, spiked from 10 in 1975 to 36 at the end of the 1990s. Additionally, cultivar retirement and release havehappened quickly. Nearly all new cultivars were created using conventional breeding. In R.J. Henny's program at the University of Florida, years of breeding and selection have led to the development of the bay series of Aglaonema cultivars. The cultivar "Emerald Bay" has a stem mottled with white and green. The stem of "Golden Bay" have striking cream and green colour variegation. Twenty new cultivars created by Thai breeders were introduced by Sunshine Foliage World in Zolfo Springs, Florida. "Emerald Star" and "Jewel of India" are two cultivars created by Indian breedersthat along with "Stars" have been shown to be extremely resilient to freezing temperatures.

The multicolored leaves of the genus Dieffenbachia, also referred to as "dumb canes", is the main reason it is grown. There are roughly 30 species in the genus, but *D. amoena* and *D. maculate* selections are the most popular cultivars. The number of Dieffenbachia cultivars expanded from 7 in 1975 to 29 in 1988-1989 through hybridization and sports selection. Since then, it has stabilized at around 20 varieties. 'Tropic Star', 'Victory', 'Starry Nights', 'Star White', 'Star Bright', and 'Sparkles' are 6 released hybrids that were created by traditional breeding. These hybrids typically freely develop basal shoots, have huge leaves with short petioles, and diverse variegation patterns (Chen et al.,2002).

Hernandez, 1651 made the first publication about begonia. The work included an illustration of a plant called 'Tononcaxoxocoyollin', which are later identified as *Begonia gracilis*. Begonia is the name given by the Franciscan monk Chales Plumier to plants he discovered on his travels to Haiti and the island of Martinique. He dedicated them to Michel Begon, the guy in charge of the missions directly (Hyoslef*et al.,* 2006). Begonia taxa have been recorded from all over the world, comprising 2,052 species. Because there are still many new species discovered each year, the number of species is expected to expand further. Wild Begonia species thrive in a wild range of habitats in Indonesia, from karst hills to wet tropical forests in the lowlands to highlands. The recent discovery of new species in Indonesia demonstrates the enormous diversity of wild Begonia species. Begonia's enormous diversity is thought to be due to polyploidy and hybridization. It is stated that natural hybrids of Begonia, among others, existed in China, with 50 populations consisting of 31 natural hybrids from 29 species of Begonia. Begonia 'Crested' a hybrid formed by an artificial cross between *Begonia sudjanae*and *Begonia puspitae* with attractiveyellow-green exotic leaves (Permata *et al*.,2022).

Spathiphyllumis currently one of the most popular foliage-plant genera in the business. In 1998, the overall value of processed Spathiphyllum was $32 million (Chen *et al*.,2008).

These easy-to-care plants, sometimes known as peace lilies, are native to Central America's tropical jungles. The foliage on the plants is dark and evergreen (Henry *et al*.,2008). 'Clevelanii' and 'Manua Loa' were the only two cultivars readily accessible in the early 1970s. Spathiphyllum cultivars now number more than 50 in just Florida. Traditional breeding, the development of interspecific hybrids, and the selection of somaclonal variations from tissue culture have all contributed to the explosion of novel cultivars.

The largest genus, Calathea contains 100 species that are native to Tropical America and live in damp to swampy forest conditions. The majority of Calatheas are cultivated for their exquisite colour, texture, and spectacular leaf ornamentation. Even though *Calatheapicturata, Calatheaargentea and Calatheavandenheckei* cultivars can be grown from seeds, Calathea is often propagated via division. Nowadays, tissue culture is used to propagate several cultivars. Three species- *Calathea insignis*, *Calatheamarkoyana*, and *Calathearoseo-picta*were the only ones that were regularly grown in 1975. More than 12 species are now being grown. Calathea's genetic breeding resources have been substantially widened by the collection and introduction of new species, which has increased both the number of cultivars available in the foliage plant market and their genetic diversity. Dr Helen Kennedy, a specialist in the Marantaceae family, found 11 new species of Calathea in Costa Rica and Panama. The development of cultivars has greatly benefited from interspecific hybridization by plant amateurs and collectors. *Calathea Royal* is a hybrid that evolved from a cross between *Calatheaveitchiana* and *Calathearoseo-picta*. *Calatheaodora, Calathea corona, and Calathea medallion* are 3 further well-known interspecific hybrids. Magdalena J.M. van Rijin of the Netherlands selected sports from *Calathea rose picta*to create at least 3 cultivars Silvia, Angela and Cora (Chen *et al*.,2010).

3. ORIGIN OF ORNAMENTAL FOLIAGE PLANTS:

The majority of foliage plants come from tropical or subtropical regions worldwide. It's believed that more than 100 genera and over 1000 species of plants have been and can be cultivated as foliage plants (Chen *et al*.,2010). Significant genera of foliage plants native to tropical Africa consist of Aloe, Asparagus, Chlorophytum, Dracena, Kalancloe, Pandanus, Sansevieria etc. Asia serves as the place of origin of foliage plants for a range of foliage plants, including *Aeschynathus radicans, Aglaonema commutatum, Alocasiamacrorrhizos, Aspidistra elatior, Aapleniummusifolium, Aucuba japonica, Begonia, Chlorophytum, Codiaeum, Coleus, Cordyline, Epiprem, Epipremnum, Fatsia, Ficus, Gynura, Homalomena, Hoya, Phoenix, Pittosporum, Polyscias, Sansevieria, Schefflera,* and *Spathiphyllum*.Differentiating between the origin of foliage plants in Australia-Oceania and

Southeast Asia can be challenging. Generally, *Araucaria*, *Asplenium*, *Blechnum*, *Cissus*, *Cordyline*, *Dizygotheca*, *Howea*, *Platycerium*, *Polyscias,* and *Schefflera* are believed to predominantly originate from the Australia-Oceania region.The warm and humid climates of South and Central America nurture a diverse array of foliage plants, including *Adiantum*, *Aechmea*, *Anthurium*, *Ananas*, *Aphelandra*, *Billbergia*, *Calathea*, *Chamaedorea*, *Dieffenbachia*, *Episcia*, *Fittonia*, *Guzmania*, *Maranta*, *Monstera*, *Neoregelia*, *Nephrolepis*, *Nidularium*, *Nolina*, *Peperomia*, *Philodendron*, *Pilea*, *Polypodium*, *Ruellia*, *Senecio*, *Spathiphyllum*, *Stromanthe*, *Syngonium*, *Tillandsia*, *Vriesea*, *Yucca*, and *Zebrina*.In North America, a few notable foliage plant genera, primarily *Agave*, *Peperomia*, *Yucca*, and certain Bromeliaceae and Cactaceae genera, are indigenous.Hedera is likely the primary foliage plant genus native to Europe.

Most of the foliage plants are native to the tropical area. Their plants are typically tolerant of light intensities, sensitive to cold temperatures, and day-neutral. Since they either thrive as understory plants shaded by enormous forest trees or as vines hanging on trees, foliage plants can withstand only a small amount of heat, drought, and freezing temperatures. They can also become dormant in winter (Chen *et al*.,2005).

4. BREEDING OBJECTIVES:

Foliage plants are valued for their aesthetic appeal, improving indoor air quality, medicinal use, industrial use,and many more.So, to accomplish and increase the value of ornamental foliage plant breeders are focusing on the following different objectives of breedingResearch efforts have focused on several key areas in the development of new foliage plant cultivars. These include the development of variegated leaf cultivars, which exhibit unique color patterns, adding aesthetic value. Cultivars suitable for exterior environments are being developed to withstand harsher conditions. Temperature-resistant cultivars are also under development to thrive in varying climate conditions. Additionally, efforts are directed towards cultivars tolerant to different humidity levels, crucial for diverse growing environments. Salt stress-tolerant cultivars are being bred to combat soil salinity issues. Disease and insect-resistant cultivars are also a priority to reduce reliance on pesticides. Novel plant forms are being explored to create unique visual interest, while cultivars with glowing foliage are being developed for their decorative appeal, highlighting the innovative nature of foliage plant breeding programs.

VARIEGATED LEAF: Variations in leaf colour can enhance the plant's attractive features and give it an entirely distinct appearance. Consumer opinion ranked leaf variegation as one of the plant characteristics, influencing purchasing decisions. On the basis of varieties,two types of lineage variation can be characterized i.e. Cell lineage types or non-cell lineage types. Genetic mosaics exhibit cell lineage variegation, but non-cell lineage variegation only manifests in a subset of cells.

Foliar variegation inheritance has been reported in Caladium. A single dominant gene controls the netted venation pattern of Caladium, whereas the recessive genotype has no pattern. In Caladium leaves, the red main vein predominates over the green, and white predominates over both green and red. It was further determined that the red vein was epistatic to netted venation. Codominant alleles in the Caladium plant are responsible for the red and white leaf splash (Deng *et al*.,2009).*Iresineherbestii*bronze-coloured leaveshave been developed genetically and that can be used for landscaping and vertical gardening.(Gottschalk *et al*.,1983).

Adaptation to interior environment: The interior environment refers to the conditions inside any enclosed space like a home, or office. This includes factors like light, temperature, humidity,and air quality. A characteristic of foliage plants is their capacity to adapt to indoor conditions while maintaining their visual appeal. After being installed in an interior location, healthy plants should be able to keep their attractive appearance for at least 6 months. There is general knowledge about how common foliage plant genera function indoors, but the mechanism underlying these adaptations to the indoor environment is mostly unknown. Potential parents for developing new hybrids could be cultivars with good interior performance.

Temperatureresistance:Due to their origin in the tropics and subtropics, foliage plants are highly susceptible to chilling temperatures, which typically range from 0-15°C. Chilling injury is a significant reason why foliage plants fail during production, transportation and indoor landscaping. In foliage plants, there is genetic variation in chilling resistance. The most significant cultivar of the foliage plant industry,*Aglaonema* cv. Silver Queen, is particularly susceptible to chilling.Emerald Star, Jewel of India or Stars are cultivars of aglaonema that are resistant to chilling injury(Henry et al.,2010).

Humidity: The indoor environment has different humidity levelsRoom, kitchen, and bathroom all have different humidity levels. So before placing plants in any of these places the humidity of the area is checked. FB08-163 is a red-flowered wax begonia that adapts well to humidity. It's a clone that was picked out of a seeding cross between *Begonia semperflorens 'Kaylen'* and '*Begonia Schmidtianashanzim*(Pounders *et al*.,2015).

Salt stressresistance: The osmotic impact of salt around the roots, which limits water availability to leaf cells, is one of the earliest responses of plants to salinity, and it causes a decrease in the rapidity of leaf growth. High levels of external salt can also limit root growth, resulting in a decrease in the mass, length and function of the roots (Dhakar*et al*.,2017).Kotagiri et al.,2017 conducted a study to examine the effect of different salinity concentrations on the growth of different species of coleus plant growth, biomass, leaf area, and carbohydrate content.They concluded that among the five Coleus species *Coleus aromaticus* and *Coleus amboinicus* showed better tolerance to salinity stress in terms of their morphology, carbohydrate content, decreased water potentials, increased electrolyte leakage, and water uptake capacity. These species can be further utilised for developing salt stress resistance cultivars.

Disease resistance: Diseases have a lower impact on foliage plants. But if a disease affects a foliage plant, then it will decrease its aesthetic value in the market as well as at home. Wet foliage mixed with high temperatures and humidity can lead to bacterial and fungal illness. (Laveti*et al.*,2021). Anthurium variety *Anthurium antioquiense* is resistant to bacterial blight (Elibox *et al*.,2008).

Insect resistance: In huge populations of foliage plants, insects and mite infestations can grow quickly. Thrips, scales, aphids, caterpillars, aphids and mealybugs are the main insects and pests. However, foliar plants in indoor areas pose the biggest threat to pest control. The creation of new cultivars with insect pest resistance is the greatest remedy for this (Henry *et al.*,2010).

Glowing plant: Ornamental glowing foliage plants are plants that have leaves that appear to glow or shimmer due to the presence of specialized cells called iridoplasts. Iridoplasts contain stacks of plate-like structures called iridoids, which reflect and refract light, causing the leaves to appear iridescent or glowing. The iridescent or glowing effect of their leaves can add a touch of magic and whimsy to any garden or indoor space, making them a popular choice for those looking to create a visually striking display. The plant nanobionic technique is one of the methods used to provide luminosity in plants. This method is successful in the case of watercress *(Nasturtium officinale)* (Kwak *et al*.,2017).

5. BREEDING CONSTRAINTS:

Natural flowering: Many ornamental foliage plants within the same species or genera has different natural flowering cycles which create difficulties for breeders. In heated greenhouses, *Spathiphyllum*,*Aglaonema*,*Philodendron*, and *Dieffenbachia* all naturally flower in the late winter or early spring. Plant breeders may find it challenging when different aroid species within the same genus have different natural flowering cycles. Since only 3 to 5 inflorescences per stem are produced year in genera like Dieffenbachia and Aglaonema, careful planning is necessary to provide a sufficient supply of flowers for breeding (Henny *et al.*,2004).

Protogyny: Protogyny is a condition where the female reproductive organs of flowers mature before male ones.This condition is also reported in *Aglaonema* before the staminate blooms producing pollen, Aglaonema's pistillate spadix is open to receiving pollen. The first unfurling of the spathe on the pistillate bloom indicates its receptivity. Pollen is typically generated 2 days later, by which time the stigmatic section of the pistillate flower has turned discoloured and is very fragile (Henny, R.J.*et al.*,1988).

Protandry: Protandry is a condition where the male reproductive organs of a flower mature beforethe female ones. In Dieffenbachia, the male flowers shed their pollen approximately 1 to 2 days after the spathe initially opens. Unfortunately, at this stage, the female flowers are no longer capable of receiving pollen.In some monoecious flowers such as Anthurium and Spathiphyllum, the spathe unfolds and exposes the spadix several days before female flowers are receptive.

Seed quantity: Many ornamental foliage plants have low seed quality. Even though the seed was collected from flowers that were pollinated within a day following spathe unfurling, sometimes the quality of seeds decreases.

Example: Pollen germination studies using Aglaonema demonstrated that the quantity of seeds was decreased.

Pollen germination: Pollen germination is a very important parameter. Dieffenbachia flowers need a relative humidity of 100% right after pollination for the pollen to start germinating. After pollination, Aglaonema also needs high relative humidity for maximum pollen germination and seed output.

Fruit maturity: Fruits from Dieffenbachia, Aglaonema, and Anthurium mature in 5 to 6 months, 4 to 6 months and 6 months, respectively, while some hybrids can take up to a year. A crimson seed covering in Aglaonema and Dieffenbachia indicates that the seed is mature. Spadices of Spathiphyllum and Anthurium start to soften, change colour, and show signs of having seeds. So most of them need to grow for 1 year before being evaluated (Henny *et al*.,2004).

Micropropagation protocol: Micropropagation is a plant tissue culture technique used to produce large numbers of genetically identical plants in a short period. **Example:**Aglaonema sp. has been micro-propagated using various protocols, but these have not yet achieved the desired results. This is primarily because it is challenging to maintain aseptic culture conditions, endogenous microbial contamination is an important issue in the micropropagation of Aglaonema. Aglaonema has a low rate of shoot multiplication, and there is a dearth of technical knowledge regarding Aglaonema micropropagation techniques(Zahara *et al*.,2020).

Genetic diversity: In cultivated *Dieffenbachia*, the potential scarcity of genetic diversity is rooted in the heightened risk of susceptibility to new diseases and pests, alongside a diminishing pool of genetic variation for enhancing cultivars. Nevertheless, research on the genetic relatedness of Dieffenbachia cultivars has not been done (Chen *et al*.,2004).The genetic variation in Syngonium cultivars commercially grown is extremely limited. As for disease resistance, no information is available on potential genetic sources (Norman *et al*.,2003).

Somaclonal variants: Some somaclonalvariantsare unstable, it may be harmful to a cultivar. Dieffenbachia hybrids 'Starry Nights' and 'Star white' were an example of this, they were too unstable in tissue culture to be profitable (El-Mahrouk*et al*.,2016).

6. DIFFERENT METHODS OF ORNAMENTAL FOLIAGE PLANT IMPROVEMENT:

1) Introduction:

Introduction is a breeding method used to bring new genetic material into a population or breeding program. It is the process of introducing new genes or genotypes into a population to increase genetic diversity and improve the performance of the population for a particular trait or set of traits. Table 1 shows the introduced varieties of different foliage plants:

Table1: Varieties of Introduced Foliage Plants: A Display of Diverse Species for Green Enthusiasts

Foliage Plant	**Introduced**	**Reference**
Anthurium	Red Heat, Gemini, Lady Ruth and Polly.	Chen *et al*.,2002
Dieffenbachia	Tropic Rain, Tropic Breeze, Tropic Forest and Tropic Dawn	
Ficus	Ficusbinnendijkii 'Amstel King', 'Ali', and 'Sabre', Ficusbenjamina 'Too Little', and 'Midnight Princess' and Ficuselastica 'Cabernet', 'Melany' and 'Sylvie'.	
Syngonium	'Key Lime', 'Pink Allusion', 'Julia Allusion'.	
Spathiphyllum	Green Velvet, Little Angel, Mini, Silver Streak and Domino.	
Alocasia	White Knight, Fantacy, Frydek and Loweii	
Calathea	Corona, Ellipse, Maria and Helen.	

2) **Selection:**The selection method in plant breeding is a process used to identify and select individuals with desirable traits. This method is commonly used in breeding programs to improve the overall quality of a crop or ornamental plant.Table 2 shows the selection varieties of different foliage plants:

Table 2: Selection varieties of different foliage plants

Foliage plant	**Selection cultivar**	**Reference**
Aglaonema	Emerald Star	Chen *et al*.,2002
Dieffenbachia	Tiki	
Dracaena	*Dracaena deremensis* 'Michiko', 'Kerry', 'Gold Star', 'Lisa',	

	'Warneckii Jumbo' and 'Lemon Lime'.	
Ficus	*Ficusbenjamina* 'Wiandi', 'Monique', 'Midnight'and 'Indigo'.	
Calathea	Ellipse, Corona, Helen, Cynthia	

3) **Mutation:**

The unexpected heritable change in the living cell's DNA that is not brought on by the processes of genetic segregation or recombination is known as Mutation. It is the main contributor to genetic variation (Van Harten and A.M.*et al*.,1998). In ornamental foliage crop improvement mutation technique has played an important role.

Mariana *et al*.,2011 demonstrated the effectiveness of the bombardment of particle approach of mutagenesis for Aglaonema and have produced 10 distinct types of unique, distinctive leaf colourationsincluding red blush, white and red, white, green, green and white, totally green, wilting, green with a little white, green with white vascular, and red and white. Among these red and white aglaonema leaf color was the most desired outcome in the investigation since it resembles the flags of Singapore and Indonesia.In this, it has also been proven that 250 M is the ideal NMU (N Nitroso N Methylurea) concentration for mutagenesis. For mass production,these new aglaonema types have been potted out and are being further propagated in tissue culture.Henney *et al*.,2004 revealed that the variegation pattern in *Dieffenbachiamaculata* 'Camille' was produced by a mutation of the Pv allele to Pvl (Henny, 1986b). The expression of the Pv allele is concealed by the Pvl allele.*Dieffenbachia* 'Honey Dew' is a sport mutation of *Dieffenbachia* 'Camilla'. Dieffenbachia 'Snowflake' emergered from *Dieffenbachia* 'Tikki'(Chen *et al*.,2004).*Dieffenbachia* '007' emerged from*Dieffenbachia masculata* cv. Perfection (Henny and R.J. *et al*.,1977).

Rajesh *et al*.,2011 demonstrated the effect of mutagenic treatments applied to basal shoot explants of Syngonium resulted in notable morphological variations. As the concentrations of EMS increased (1%,1.5% and 2%), observable changes in chlorophyll colour occurred. Microshoots began to exhibit characteristics such as turning a lighter shade of green and even becoming albino. Furthermore, the micro shoots treated with higher concentrations (1.5% and 2% EMS) displayed stunted growth, with a height of only 1.9cm.The Australian Bastard Cannabis presents itself as a promising mutant for the potted plant industry. It exhibits a succulent, shrub-like form, adorned with glossy, small, smooth, and un-serrated leaves. Among the cultivated varieties, "Divina", which was introduced by Casano, stands out as a unique mutant due to its albinism. It gives rise to variegated leaves and tissues, making it the sole selected mutant introduced for its ornamental qualities within the cannabis plant category (Hesami *et al*.,2022).The mutation 'orange hot' was discovered within a substantial population of tissue-cultured descendants of Anthurium 'Red Hot' (Sheela *et al*.,2014).

4) **Hybridisation:**It is the crossing of two or more different species or cultivars of plants to create new genetic combinations. It can be interspecific or intervarietal. Table 3 shows some examples of hybridisation in foliage plants.

Table 3: Cultivars of ornamental foliage plants developed through hyberdisation breeding methods:

Foliage plant	**Parents**	**Result**	**Reference**
Aglaonema	*Aglaonema* X 'Manila' and *A.nitidum* 'curtisii'	*Aglaonema* 'Stripes'	Henny *et al*.,2008
	*Aglaonema commutatum*treubii X *Aglaonema commutatum*curtissi	*Aglaonema* 'Scenic Bay'	Henny *et al*.,2010
	Aglaonema commutatum Schott 'Treubii' X *Aglaonemanitidum* Kunth 'Curtisii'	Silver Queen	Chen et al.,2004
	Aglaonema commutatum'Echo' *X Aglaonema marantifolium*Blume 'Trcolor'	Peacock	Chen *et al*.,2004
Dieffenbachia	*Dieffenbachia picta* X *Dieffenbachia weirii*	*Dieffenbachia*cv.Bausei	Shen *et al*.,2008
	Dieffenbachia 'Victory' X	*Dieffenbachia* 'Trophic	Shen *et*

	Dieffenbachia 'Trophic Marianne'	Honey'	*al.*,2008
	Dieffenbachia 'Victory' X Dieffenbachia 'Tropic Marianne'	*Dieffenbachia* 'Gold Rush'	Chen *et al.*,2004
	Dieffenbachia maculata 'Marianne' X *Dieffenbachia maculata* 'Wilson Delight'	*Dieffenbachia*'Paradise'	Chen *et al.*,2004
	Dieffenbachia masculata X *Dieffenbachia weirii*	*Dieffenbachia* 'Corsii'	Chen *et al.*,2004
Begonia	*Begonia sudjanae* C.A. Janson X *Begonia puspitae*Ardi	*Begonia* 'Crested'	Siregar *et al.*,2021
	*Begonia hercleifolia*var.heracleifolia X *Begonia* 'Locheil'	*Begonia* 'kimbrook'	Permata *et al.*,2021
	Begonia puspitae X *Begonia pasamanensis*	*Begonia* 'Lovely Jo'	SIREGAR and H. M. *et al.*,2016

5) **Somaclonal variant:** Somaclonal variation is the genetic variation that arises among plants regenerated from plant tissue culture. Table 4 shows some examples of somaclonal variation in foliage plants:

Table 4: Some examples of somaclonal variation in foliage plants

Parent	**Somaclonal variant**	**Reference**
Aglaonema 'Silver Bay'	*Aglaonema* 'Diamond Bay'	El-Mahrouk*et al.*,2016
Aglaonema 'Golden Bay'	*Aglaonema* 'Emerald Bay'	
Dieffenbachia 'Panther'	*Diffenbachai*'Camouflage'	Shen *et al.*,2008

6) **Genetic Engineering**

Recently, there have been exciting developments in creating glowing plants using newly discovered bioluminescent systems and enhanced suboptimal luminescence**.**Through genetic engineering, it is possible to incorporate luminescence systems into living plant cells, serving as biomarkers. Certain plants engineered with luminescent systems can glow dimly in the dark, visible to the naked eye, offering a new lighting resource. These plants have the potential to be used as a natural light source for reading and writing, although most of them are still relatively dim. As a soft light source, bioluminescence and fluorescence offer several advantages over traditional artificial light, including reduced glare and increased energy efficiency. This makes glowing plants a valuable resource for both aesthetics and lighting.

Ornamental glowing plants will become available once the fluorescence or bioluminescence reaches a sufficient brightness level. The gene expression cassette of fluorescent proteins (FPs) can be easily integrated into the genome, and FPs can accumulate significantly within plant cells. This makes it feasible to generate fluorescent plants.

Example-CpYGFP, a yellowish-green fluorescent protein (FP) sourced from marine plankton Chiridiuspoppei, can be excited using a 509 nm laser line, with emission collected at 517 nm, representing a red-shifted visible light. Commercial plants were genetically modified with the CpYGFP gene, leading to the observation of green fluorescence from the flowers when emission filters were employed.

Furthermore, two derivatives of CpYGFP, namely eYGFP and eYGFPuv, were expressed in the flowers of, *Petunia hybrida*. Green fluorescence was visible to the naked eye from the flowers when illuminated with visible light and ultraviolet LED, respectively (Li *et al.*,2021)

CONCLUSION:

Foliage plants are the ones that are produced for their distinctive leaves in a variety of forms, colours, patterns, and textures and are often used for exterior landscaping or interior scaping. Because of increasing industrialization and urbanization, people prefer to have indoor scaping and foliage plants are known best for their properties as air purifiers and temperature control agents. So to get unique colours, patterns, and textures and to fulfil the increasing demand for foliage plantsbreeders optedfor breeding methods like selection, introduction, hybridization, mutation, and biotechnology. There are many native or wild foliage plants in India There used to be domesticated for commercialization and commercial cultivation.For most varieties that are developed by mutation still more work is required to be done in engineering techniques.

FUTURE PROSPECT:

Although enough breedingmethods are used for the breeding of ornamental foliage plants enough modification is still required like the formation of multi-coloured foliage plants or growing plants by using gene editing techniques.

- Development of foliage plants that requirefewer chemicals for better growth. Indoor plants are still mostly dependent on chemicals for their better growth.
- Development of fragment foliage plants. The research can be done as the plant can be given the particular fragrance the customer requires, Traditional methods of crop improvement will have less result by using genetic engineering or gene editing techniques can be successful for this objective.
- Development of cultivars that can control indoor and outdoor pollution.
- Development of multiple-usecultivars such as pollution control, glowing properties, and herbal properties.

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