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Review Article


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# Plant chimera and its management for the floriculture industry

**S. K. Datta***

Retired Scientist, CSIR-National Botanical Research Institute, Lucknow- 226001, Uttar Pradesh, India,
Present address: A5/1 Kalindi Housing Estate, Kalindi-700089, Kolkata, India

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***Corresponding Author:**
S. K. Datta
E-mail: subodhskdatta@rediffmail.com

## ABSTRACT

In the floriculture industry, there is always a demand and necessity for new varieties. This industry has prospered due to science-based techniques and a steady supply of improved plant materials and new varieties. A massive amount of literature has been accumulated on developing new ornamental varieties. Bud sports and induced mutations are well-established methods for crop improvement and have played a major role in developing many new flower color/shape mutant varieties in ornamentals. But the main bottleneck is that in both the methods mutation appears as a chimera and isolation of such chimeras is a great challenge. The use of plant chimera in the floriculture industry is an ancient but innovative subject. A novel *in vitro* technique (tissue culture) has been standardized for managing such chimeric tissues through direct shoot regeneration. The prime intention of this write-up is to evaluate management techniques for chimera to develop new varieties for the floriculture trade. The technique will enrich the floriculture industry with new varieties through the retrieval of chimeric tissues.

**KEYWORDS:** Bud sport, Induced mutation, Chimera, Management, New variety, Floriculture

## INTRODUCTION

Floriculture is an extremely professional industrial section. Science-based techniques supported floriculture to progress into a global industry. In the floriculture industry, there is always demand and necessity for new varieties due to changes in consumer's tastes and fashion. Breeders are always benefitted by supplying new varieties with commercial qualities as per customers' demand. For developing new varieties in any horticultural/floriculture crops breeders, scientists and nurserymen worldwide apply different conventional and advanced techniques. In floriculture breeders mostly develop varieties through selections of sports and from conventional open-pollinated interspecific/intraspecific crosses and planned crosses. The paper highlights how the tissue culture (*in vitro*) technique can be exploited to enrich the floriculture industry with new varieties through the management of sport and artificial mutation-induced chimeras. Bud sports (spontaneous mutation) and induced mutations have played a very important role in developing new ornamental varieties for the floriculture trade. Spontaneous mutations occur by natural process. Bud Sport may create new shoots with changed morphological features in any existing ornamental variety. The new changes may be in leaf character, flower character, branch character, or plant stature. The new branch is propagated by vegetative means and established as a new cultivar. Such changes occur due to mutation at the genetic level. Induced mutations result due to the artificial treatment of propagating materials either through physical mutagens (ultraviolet light, x-ray, gamma ray, alpha and beta particles, protons and neutrons, etc.) or chemical mutagens (EMS, MMS, dES, EI, ENU, ENH, MNH, Azides, etc.). All mutations in ornamental plants appear as chimera. Chimera means the existence of mutated and non-mutated cells side by side. The mutant character is manifested if the mutated cell survives in competition (diplontic or intrasomatic selections) with the normal cells. Plant chimera in the form of leaf variegation and change in flower color/form are very sensational topics of scientific importance and economic value in the floriculture trade for the development of new varieties. There are many chimera-related issues to debate in publications relating to different terminology, origin, management, phenotypic expression, etc. The present article will cover the relevance and contribution of bud sports, induced mutation, and plant chimera to produce new mutant varieties for the floriculture industry. The primary objective is to highlight how the *in vitro* technique (tissue culture) can be explored for the management of chimera to develop new varieties.

Literature on the subject is very rich in the form of books, book chapters, and research articles and in many other forms which have covered many aspects of plant chimeras (Wasscher, 1956; Tilney-Bassett, 1963; Neilson-Jones, 1969; Grant, 1975; Lineberger & Druckenbrod, 1985; Szymkowiak & Sussex, 1996; Marcotrigiano, 1997; Datta, 2009; Liu *et al.*, 2015; Morimoto

*et al.*, 2020; Nassar, 2022). The subject and the knowledge generated so far are immeasurable and it will not be prudent to amplify the same literature by simple storytelling. Plant chimera is defined as when more than one genotype cells grow adjacent to the same meristem, organ, or tissues in one plant. Chimera is also pronounced as plant genetic mosaics with mutated genotypes. Plant mosaics were identified by nurserymen when they developed as bud sports with changed phenotypes (Darwin, 1968; Poethig, 1987).

Chimera in the floriculture industry has created remarkable diversity in germplasm and a range of new and novel varieties. Chimera mostly develops in somatic cells which finally become enduring notable ornamental varieties for floriculture trade through vegetative propagation. The main two contributions of chimera in floriculture are the development of new varieties with new flower color/form and chlorophyll variegations in leaves. Some other commercially desirable morphological features were also developed. The development of new ornamental varieties is highly beneficial in the floriculture industry. The scientific community, nurserymen, ornamental breeders, amateur growers, and flower lovers are directly associated with breeding and creating new varieties. Chimeras may have their origin through different procedures like grafting, bud sports/spontaneous mutation, induced mutation, sorting out from variegated seedlings, mixed callus cultures, or protoplast fusion. The majority of varieties in floriculture plants developed from such chimeras. The successful use of these chimeras in a true-to-type mode is determined by the available appropriate propagation protocol. The article provides a factual review account of the induction of chimera through bud sports/spontaneous mutation and induced mutations, isolation of chimera as a new variety, and the benefaction of these plant chimeras for promoting floriculture.

## INTRODUCTION TO CHIMERA

The literature on plant chimera, as mentioned, is very rich and reported from time to time. However, a short fundamental portrait of plant chimera is pertinent to understanding its origin, basic structure, management, and phenotypic expression. Knowledge of the organization of the shoot apex is necessary to understand the origin of chimeras. The nature of chimera and its stability depends upon the pattern of cell division, frequency of cell division, and layered organization of the cells in the apical meristem. There are two zones (tunica and corpus) at the shoot apex of angiosperms which are liable for different types of plant growth. The outer layer is tunica composed of small cells from which the epidermis and outer cortex are developed. The corpus is the inner zone of cells that produces the inner cortex, procambium, and pith. Three symbols LI, LII, and LIII have been denominated to differentiate shoot meristem organizations like LI (epidermal cells), LII (next inner layer, gametes), and LIII (innermost cells and vascular system) (Satina & Blakeslee, 1941). Likewise, three terminologies periclinal-, mericclinal- and sectorial- chimeras have been judiciously resolved based on origin and position in the growing shoot apex (Figure 1). Periclinal chimeras are very notable and steady which can be propagated and multiplied vegetatively. Here the mutated cell forms an entire layer of genetically unlike cells. Mericlinal chimeras do not envelop the whole apical dome and are restricted to a single segment of the meristem. Sectorial chimeras stretch along the layers of a section of the apical meristem. It is very unsteady and produces both normal and mutant types depending upon its position (Figure 1). Shoot apex organization, cell division frequency and pattern, and layered arrangements of the cells in the shoot apex resulting type of chimera have been well explained (Datta, 2009).

An enormous quantity of work has been done on different ornamental plants covering both bud/spontaneous (natural) and induced (radiations and chemicals) mutations. In both processes, mutation develops as a single-cell affair. The mutated cell is exposed to surrounding nonmutated cells and there is a struggle for survival between mutated and non-mutated cells i.e. diplontic or intrasomatic selections. The phenotypic expression of a mutated cell depends upon its survival. The mutated cell grows into a group of cells and finally a mutant cell layer i.e. a chimeric zone of normal and mutated cells. Competition during diplontic/intrasomatic selection between mutated and non-mutated cells has been shown in Figure 2a-d. Chimera is the main drawback in spontaneous mutation and induced mutation techniques. Such competition limits mutation frequency and spectrum. The range of phenotypic expression

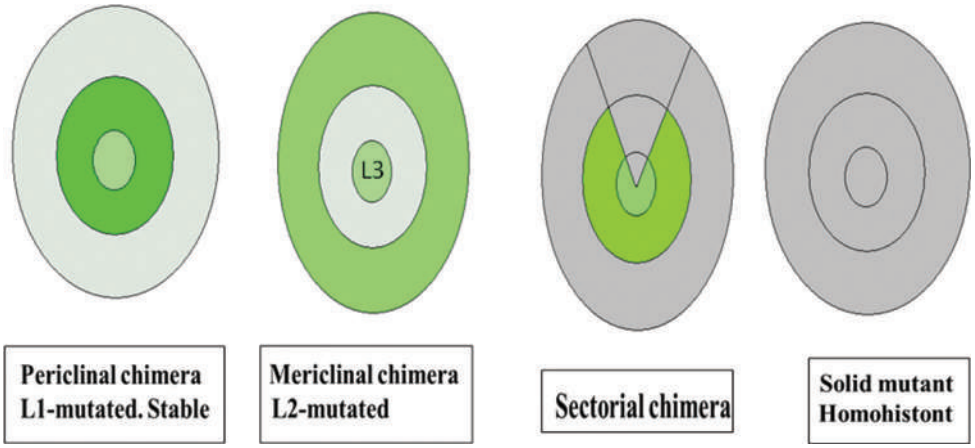


**Figure 1:** Diagrammatic representation of different types of chimera

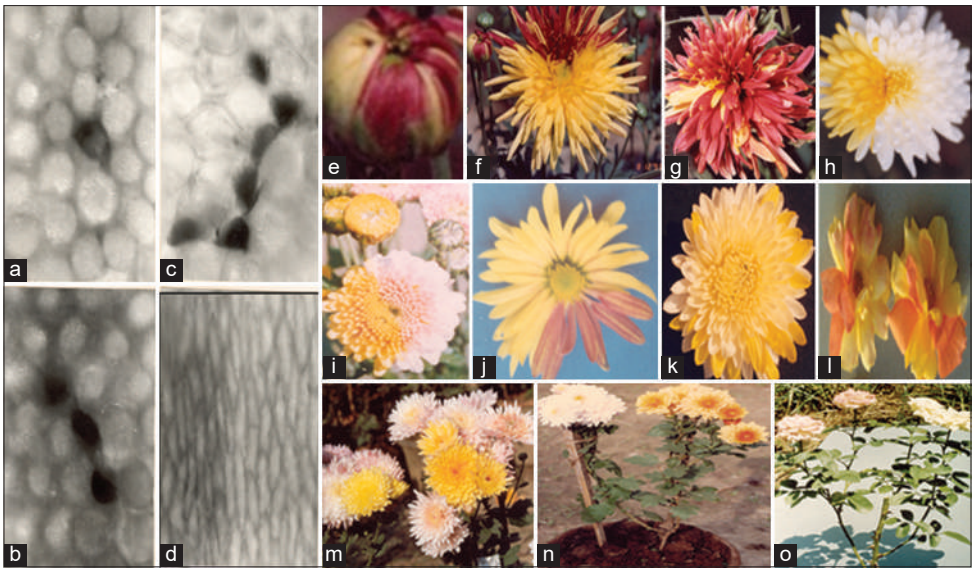


**Figure 2:** a) Single mutant cell, b) how it divides into 3, c) multiple and d) finally chimeric zone. Mutagen induced chimera. e) Bud chimera in chrysanthemum, f-k) Different forms of floret chimera in chrysanthemum, l) Petal chimera in rose, m, n) Branch chimera in chrysanthemum and o) Branch chimera in rose

of chimeric zone varies in different species -from a thin stripe on a single petal to a whole petal; several petals; - fifty percent flower or entire flower; and from a part of a branch to whole branch (Figure 2e-o).

The role of bud sports and induced mutations enriching chimeric mutant varieties in ornamental plants are topmost in the floriculture industry. Both are the results of genetic mutations. Mutant varieties are appealing due to their new novel leaf, flower, bract, and branch traits, or plant features.

Induced mutation in vegetatively propagated plants, here in chrysanthemum, is detected in the first generation (M1v1). Experiments have established that mutations are also noticed in the second and subsequent generations and mostly as non-chimeral mutants. Propagation of cultural practice is very important for such mutations in chrysanthemum. After blooming is over chrysanthemum is also propagated from lower mature stems through cuttings. The mutant cell manifests if it gets the opportunity to express in M1v1. In favorable conditions, mutant cells persist in the dormant state in the lower axillary buds and give expression when included in propagation to develop M1v2 (Chakrabarty *et al.*, 2000).

Although a large number of flower color/type mutants have been evolved by induced mutations, the general question is how these mutations arise. According to available literature, the mutagen-induced flower color changes may be due to chromosomal aberrations, changes in chromosome number, gene mutation, rearrangement of different histogenic layers, and mutation occurring in the biochemical pathway leading to pigment formation. A handful of earlier works report that flower color changes are due to the reshuffling of histogenic layers. The author made a critical analysis of cytomorphological, radiosensitivity, anatomical, palynological, and biochemical characteristics for a better and clearer understanding of the exact mechanism involved in the origin and evolution of somatic flower color mutations. These observations indicated that although root, shoot, and flowers are developed from different histogenic layers, rearrangements of histogenic layers do not have any specific role in the development of somatic mutations in flower color. The author detected a series of new flower color mutations from a single starting variety in different varieties of chrysanthemum and rose. Reshuffling of histogenic layer theory cannot justify these results. In the course of experiments on different ornamentals, it has been almost proved that reshuffling of histogenic layers applies to the development of chlorophyll variegations in leaf only not in flower color. This aspect has been elaborately reported and reviewed by the author (Datta, 2023a, b, c).

The origin of bud sports in different ornamentals has been reported and reviewed from time to time (Wasscher, 1956) but regrettably, no central database has yet been developed where one can get details of bud sport varieties. Recent publications spotlighted the names of many interesting bud sport varieties in different ornamentals (Datta, 2021). The list of bud sport varieties and the list of common ornamental varieties that developed sports are very large.

## SPORT VARIETIES

The major ornamental species Anthurium, Bougainvillea, Chrysanthemum, Dianthus, Gladiolus, Petunia, Rosa, Lilium, Pelargonium, Gerbera, etc. provided the maximum number of varieties through sports, conventional breeding, and induced mutagenesis. A great number of variegated varieties grown for the floriculture industry are chimeras developed through mutations. Many uncommon ornamental peculiarities have been developed through steady periclinal chimeras. Chimeral plants often play an adequate contribution in floriculture and breeding for creating desirable foliage, floricultural, and landscape plants. Plenty of new selections of chimeric

vegetative foliage and new flower traits are available in commerce - *Hosta*, *Dieffenbachia*, *Peperomia*, *Chlorophytum*, *Saintpaulia*, *Pittosporum tobira*, bromeliad, *Begonia*, aloes, *Paphiopedium*, *Alpinia zerumbet* (shell ginger), *Pisonia umbellifera* '*Variegata*', *Ficus aspera*, *Saccharum officinarum*, *Hedera helix*, *Abutilon*, *Euonymus japonica*, *Acalypha wilkesiana* 'Marginata', *Calathea makoyana*, aroids, *Callisia elegans*, *Tradescantia zebrine*, Silybum marianum, *Ficus elastica*, *Ficus benjamina* 'Golden Princess', Azaleas, Rhododendron, Punica, Chaenomeles, Carnation, Camellia, African violet, clovers, *Pelargonium*, *Oxalis*, *Coleus*, Red Clover (*Trifolium pratense*), *Aralia elata* 'Aureovariegata', *Carex ornithopoda* 'Variegata', *Cornus alba* 'Argenteo Marginata', *Vinca minor* 'Variegata', *Ajuga reptans* 'Burgundy Glow', etc. (Datta, 2009).

Development of bud sport varieties is very common in many ornamentals like bougainvillea, chrysanthemum, rose, dahlia, pelargonium, cosmos, etc. The range of such varieties is soaring and unfortunately, no genuine centralized data is available. For induced mutant varieties there is a centralized database (IAEA Mutant Database, Vienna) that provides all information about mutants (name of mutant variety, mutagen details, country, mutant character, etc.). Mutant varieties, developed in different countries, are registered here and released. The lack of such a database for sports varieties is a genuine shortcoming. Here breeders do not disclose the details of sports and commercialize their varieties by giving a suitable name without evaluation or registration. Breeders need to characterize and evaluate the new variety as per international rules to protect plant breeder's rights before commercial exploitation. This causes duplications in the names of varieties. In addition, the same varieties are named in different names at different places. This is a very sensitive issue and requires serious attention by the breeders. As the majority of ornamental varieties are developed through sports, some societies should take the initiative to form a forum and encourage the breeders to register their sports varieties following proper scientific documentation procedures before commercialization.

It is very meaningful to speak briefly about the influence of bud sports in a few ornamentals like bougainvillea, chrysanthemum, gladiolus, and rose where, perhaps, maximum numbers of sport varieties have evolved in elemental species and varieties (Datta, 2021). It is extremely challenging to speak the definite whole number of bud sport varieties not only in these important ornamentals but also in all ornamentals in general. However, a handful of very early reports are accessible which speak briefly about the percentage of bud sport varieties in bougainvillea (31.60%), chrysanthemum (30%), carnation (25%), rose (40%), begonia (70%) etc. The origin of the moss rose was observed for the first time in 1696 as a mutant of *Rosa centifolia* (Datta, 2018). Among 5819 rose cultivars marketed during 1937-1976, 865 were developed from bud mutations (Haenchen & Gelfert, 1980). A series of striped roses have been developed through bud sports. Reports speak briefly that the highest number of bud sport varieties has originated in bougainvillea, chrysanthemum, and rose.

Sports regularly occur in heterozygous and polyploid plants which generally multiply vegetatively. Heterozygosity in some ornamentals (bougainvillea, chrysanthemum, gladiolus, rose, etc.) has built up due to human selection pressure during domestication, through a network of inter-specific crosses between basic species and varieties and natural genetic variation through bud sports.

## MANAGEMENT OF CHIMERA

As mentioned, bud sports and induced mutations create two types of chimera i.e. chlorophyll variegated leaves and new flower form (color, shape, size, etc.) as a result of mutations. The size of these chimeras has been mentioned above. Management of chimera i.e. isolation and establishment of chimera in pure form is the major hurdle in vegetatively propagated ornamentals. The prevailing propagation technique (cuttings) can isolate when a portion of a branch or an entire branch is mutated as a chimera after spontaneous and induced mutation (Figure 2m-o). Normal branches of chimeric plants are removed to encourage better growth of the mutant branch. The mutant branch is isolated and multiplied by cuttings. A large number of new flower color varieties have been developed worldwide following this method in many ornamentals (Broertjes & van Harten, 1988; Datta, 2023a, b).

Such a normal cutting technique cannot separate small sectorial chimeras (Figure 2e-l) resulting loss of a huge number of new mutant traits developed both through bud sports and induced mutations. The author and his colleagues worked thoroughly to develop new varieties through the

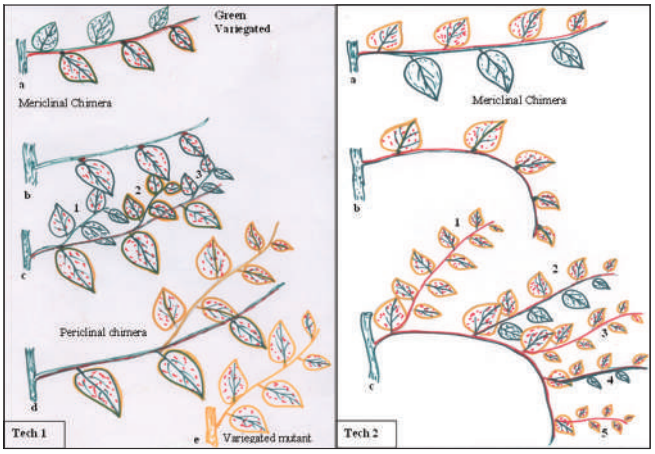


**Figure 3:** Simple propagation techniques (Tech 1 and Tec 2) for management of chlorophyll variegated chimeras. Tech 1 and Tech 2 show different steps to convert mericlinal chimera to stable periclinal chimera. Tech 1: a) Mericlinal chimera with alternate green and variegated leaves, b) Green leaves have been removed, c) Development of mericlinal (1 and 3) and periclinal (2) branchs from axillary buds of variegated leaves, d) Mericlinal branches are removed to encourage growth of periclinal branch and e) Isolation of stable periclinal branch by cuttings. Tech 2: a) Mericlinal branch with green and variegated leaves, b) Green leaves are removed and the branch is artificially bent to make an arch to encourage growth of axillary buds of variegated leaves and c) Development of periclinal (1,3,5) and mericlinal (2,4) branches from leaf base. Periclinal branches can be isolated by cuttings. For mericlinal branches same procedure (as mentioned in Tech 1) may be followed to convert it to periclinal form.

management of such chimeras as new chlorophyll variegations and flower color/shape mutants (Datta & Chakrabarty, 2009; Datta, 2015, 2023a, b, c).

## Management Strategies

Management of chimera is so powerful and important in floriculture that, the author recommended the value of the technology in many publications (Datta, 2015, 2018, 2023a, b) as is elucidated here. Two techniques have been systematized- one popular method for chlorophyll variegated mutations and another tissue culture method for the mutated flower sector. Mutation technique protocol has been especially powerful for the success of both techniques (Datta, 2020, 2023c).

### *In vivo technique*

As mentioned, periclinal chimeras are quite steady and are in great market demand. The unsteady nature of mericlinal chimera is due to frequent variation in the number of chlorophyll variegated and normal branches. The apical dominance of the mericlinal shoot inhibits the development of axillary buds linked with variegated leaves. Two approaches (Tech 1 and Tech 2) were exercised to avoid apical dominance. Simple but powerful working methods have been systematized to transform mericlinal chimera into periclinal form. Mericlinal chimeras are composed of both green and variegated leaves (Figure 3, Tech 1a). In Tech 1 the axillary buds of variegated leaves were encouraged to grow and increase in size by detaching all the green leaves (Figure 3, Tech 1b). In another approach, the mericlinal branch is forcibly bent like a half-moon to allow

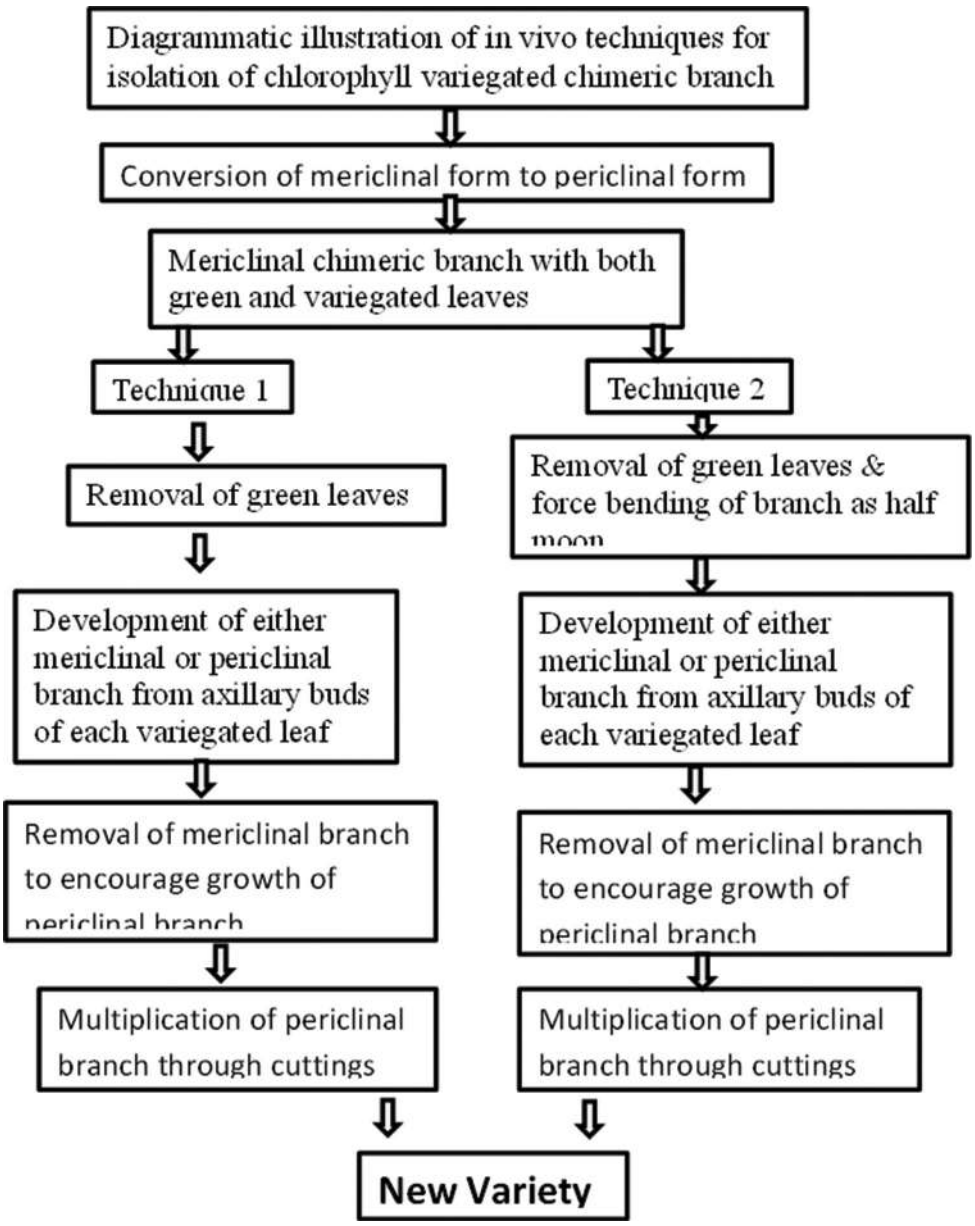


**Figure 4:** Diagrammatic representation of conversion of mericlinal to periclinal chimera by *in vivo* methods

well growth of axillary buds associated with variegated leaves after removing all green leaves (Figure 3, Tech 2b). Both techniques are performed when leaf variegation is visible in the chimeric branch. New periclical (Figure 3, Tech 1c (2) & Tech 2c (1,3,5)) or mericlinal (Figure 3, Tech 1c (1,3) & Tech 2c (2,4) branches originate from the axillary buds of variegated leaves. The periclinal branches are established as new varieties by cuttings (Figure 3, Tech 1e) and for mericlinal branches, the same exercise is followed. Both technical approaches for the conversion of mericlinal chimera to periclinal chimera have been shown diagrammatically (Figure 4).

***In vitro technique***

Work done on *in vitro* management of chimera and *in vitro* mutagenesis in India necessitates special mention. The concept of *in vitro* mutagenesis was proposed by earlier researchers but the quantum of work in India and its results not only opened new vistas to floriculture but also the mutation technology for vegetatively propagated ornamentals were prolific. Systematized *in vitro* protocol (tissue culture) for straight shoot regeneration from a single floret of chrysanthemum has been standardized (Figure 5a-e). Protocol resulted in the creation of a series of new mutant varieties in different chrysanthemums from chimeric petals developed through both spontaneous and induced mutations (Figure 5f-p). This chimera separating technique has enormous practical value not only for chrysanthemum but for any other ornamentals and it will develop a new direction to create new traits by direct management of mutated cells. The prime advantage of this technique over conventional breeding is that new varieties can be developed comparatively in a short time.

*In vitro* protocol was further standardized and utilized for *in vitro* mutagenesis to develop solid mutants (Misra *et al.*, 2003; Datta *et al.*, 2005). Additionally, critical endeavor resulted in the development of trait-specific (NaCl-tolerant) mutant chrysanthemum (Hossain *et al.*, 2006a, b).

The only limitation of the *in vitro* technique is the non-availability of a standardized protocol for all ornamentals. Scientists/breeders will have to develop tissue culture technology packages for different explants like petals, shoot buds, leaves, etc.

Chimeric mutant varieties after establishing in pure form can be utilized for further development of new varieties by treating them with mutagens. Development of a mutant from a mutant genotype is an interesting topic in mutation breeding (Datta, 2023a, b; Datta & Shukla, 1996).


**Figure 5:** a-e) Direct shoot bud regeneration from ray florets of chrysanthemum, f) Original chrysanthemum cultivar, g) Sectorial mutant chimera developed through bud sport, h) establishment of yellow sector in pure form through tissue culture, i) Gamma ray induced yellow sector and isolation of yellow mutant sector in pure form, j, k) Gamma ray induced yellow mosaic chimera in white chrysanthemum, l) isolation of yellow mutation in solid form, m) Gamma ray induced yellow chimeric sector, n) isolation of yellow mutant, o) Colchicine induced yellow mutation and p) establishment of mutant yellow

## DISCUSSION

Chimeras developed through bud sports and induced mutations are one of the most important sources of development of new ornamental varieties. We account only for those sports varieties that could be isolated easily through cuttings. But there is no record of sectorial chimeras that could not be isolated and lost by natural processes. The number of these chimeric sports is many times more than the established number of sport varieties. The picture is also the same for induced mutations.

Breeders mostly record these sports in their ornamental germplasm collections. The author detected numerous chimeric sports in the germplasm collections of different ornamentals at the botanic garden of CSIR-NBRI, Lucknow, India. The author noticed innumerable chimeras during his almost 30 years of involvement in induced mutagenesis work with physical and chemical mutagens. Few petal chimeric photographs are cited (Figure 6). This is a very delicate issue in floriculture. Tissue culture protocol has been standardized elaborately at CSIR-NBRI for direct shoot regeneration from chrysanthemum florets (Chakrabarty *et al.*, 1999, 2000; Mandal *et al.*, 2000a, b; Datta, 2001, 2009; Dwivedi *et al.*, 2002; Misra *et al.*, 2003; Datta *et al.*, 2005). Different steps of chimera at the cellular level and floret/flower stage, and their *in vitro* management have been very clearly shown in Figs. 2-4. Similar *in vitro* techniques for the management of chimera have also been standardized by other scientists in different ornamentals like Chrysanthemum, Gerbera, *Gypsophila* Saintpaulia, Pelargonium, etc. (Johnson, 1980; Grunewaldt 1983; Walther & Sauer, 1986; Jerzy, 1990; Jerzy & Zalewska, 1996; Nagatomi *et al.*, 1996; Okamura *et al.*, 2002; Barakat & El-Sammak, 2011; Kaul *et al.*, 2011; Verma *et al.*, 2012; Lema-Rumińska & Sliwinska, 2015; Kapadiya *et al.*, 2016; Haspolat *et al.*, 2019; Din *et al.*, 2021; Nasri *et al.*, 2022). This powerful tissue culture protocol is waiting for commercial exploitation to develop new varieties through the management of all such chimeras. This technique will give an opportunity to breeders to convert these natural and induced incidents into wealth in the form of new varieties.

A special statement is essential for Bougainvillea which has now occupied a very prominent position in the floriculture industry for its multipurpose use. Worldwide efforts are going on for developing new varieties mainly through the isolation of bud sports, breeding, and induced mutations. The author has a practical judgment that numbers of bud sport chimeras in leaf chlorophyll variegation and mainly in bract color in bougainvillea are highest among ornamentals. The nature of bract chimeras observed in Bougainvillea is shown in Figure 7. A Major part of such chimeras is lost due to the non-availability of techniques to isolate such chimeras. Although the grafting technique is now very efficient in bougainvillea tissue culture will be a bonanza for good destiny for the management of all natural and induced chimeras. I am optimistic that an emperor of the new bougainvillea can be developed by using this *in vitro* chimera management technique (Datta, 2024). Bougainvillea manifests it to be a storehouse of never-ending secret wealth of genetic affluence to create new diversity. As a consequence, bud sports are a continuing affair and breeders should keep sharp surveillance of the germplasm

**Figure 6:** Showing petal chimeras of different ornamentals developed through bud sports

**Figure 7:** Different range of bract chimeras in bougainvillea developed through bud sport

to recognize spontaneous mutations. Standardization of *in vitro* protocol to regenerate from bracts and management of chimeras is an untouched area of research in bougainvillea. For developing new varieties in Bougainvillea there is a necessity to shift viewpoints, management of work attitudes, and selection of proper breeding/propagation concepts. This will be very helpful to the breeders to utilize the right innovative technique. There is a need to stop some routine breeding undertakings and breeders should be educated and qualified with the required expertise in current technical details to achieve the goal at the right time. The ornamental breeding community should be sensitive to exploiting such breeder's breeder-friendly technology for developing new varieties in their ongoing research areas to boost the floriculture industry.

## CONCLUSION

The contribution of bud sports in floriculture is massive in terms of the development of new varieties. A huge amount of mutagen-induced new flower color/shape mutants and/or spontaneously developed mutants are lost due to a lack of microtechnique for the management of such chimeric tissues. It has been well established that chimera management has excellent practical importance in floriculture for the development of new varieties. Standardization of such regeneration protocol was essential for the isolation of chimeric tissues for commercial exploitation. *In vitro* management of chimera is almost an untouched area in horticulture/floriculture. This technique will open up a new way to enrich floriculture with new varieties by isolating new ornamental cultivars through retrieval of chimeric mutated cells. There is a need to change the mindset of ornamental breeders for future ornamental breeding. Breeders should develop expertise in *in vitro* techniques for their judicious application in their breeding program. There are possibilities for economic strengthening of nurserymen and floriculture trade through converting these unexploited chimeras into new varieties.

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