



Evolution in Bougainvillea (*Bougainvillea* Commers.) - A review

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Received: September 29, 2016; Revised received: March 10, 2017; Accepted: July 25, 2017

Abstract: Bougainvillea is a popular ornamental, mostly valued for its multicoloured bracts. It can be used in the garden as a shrub, climber, pot plant or as a specimen plant. By keeping the view of its multiple uses there is always demand for the new coloured and forms of bracts in bougainvillea. All the present day colourful bracted bougainvilleas are developed through bud sports, mutations and inter and intra specific hybridization. There is no record of varieties evolved in bougainvillea through classical breeding in different countries. Present article will provide maximum information generated in India by different research institutes on classical and mutation breeding on bougainvillea.

Keywords: Bougainvillea, Breeding, Mutation, Ornamental plants

INTRODUCTION

Bougainvillea is a popular ornamental plant mainly grown for its attractive colourful bracts that splash colour to the surrounding. It is popular among parks, home and institutional gardens grown mainly as bush, climber, hedge, topiary, standard, pot plant, bonsai, on pergolas and trees (Roy, 1987; Sharma and Roy, 2001). Wide adaptability to different agro-climatic conditions and easy multiplication has made it a popular ornamental plant of the world. Moreover, as it is a drought and pollution resistant plant, it is well suited for industrial places and on road dividers (Kumar and Prasad, 2002).

Bougainvillea is originated in South America and was first collected by Commerson, a French Botanist, at Rio-de-Janeiro, Brazil. The genus '*Bougainvillea*' belongs to family Nyctaginaceae and was discovered by French Botanist Commerson in 1766-69. The generic name *Bougainvillea* Commers. was first published by A. L. De Jussieu in his work *Genera Plantarum* in 1789 (Jussieu, 1789). It is not clear whether the cultivars outside South America were derived from plants already cultivated in Brazil or from truly wild plants (Holttum, 1938). Much of the evolution in *Bougainvillea* took place outside its native home, primary factor being natural hybridisation and showy bracts accompanied by self incompatibility (Zadoo *et al.*, 1975). The *B. glabra* and *B. spectabilis* are widely used species and most of the present *Bougainvillea* cultivars are thought to have originated from them. Third species, *B. peruviana* is also of horticultural importance. According to Khoshoo (1998), *Bougainvillea* also has

three hybrid groups namely, *B. × buttiana* (*glabra* × *peruviana*), *B. × specto-peruviana* and *B. × specto-glabra*. Among these, *B. spectabilis* and *B. glabra* were reported to be more tolerant to cooler climate. *Bougainvillea* grows well throughout the plains of India, but only *B. glabra* thrives well at higher altitudes (Pal and Swarup, 1974).

Considering its ornamental and commercial importance in nursery trade, R and D were taken up by different national research institutes (IARI, IIHR, NBRI, BARC), state agricultural universities, Agri-Horticultural Societies (Kolkata and Chennai) and even by progressive nursery men. As a result, a large number of new cultivars have been developed in India. Considering the contribution made by India, the international registration authority for new cultivars lies in the Indian Agricultural Research Institute (IARI), New Delhi, which is an international recognition conferred upon by International Society for Horticultural Science.

In India, crop improvement work was started in early 20th century with the introduction of *B. spectabilis* in 1860 from Europe. However, the popularity really started with the introduction of cv. 'Mrs. Butt' from Royal Botanic Garden, Kew to The Royal Horticultural Society, Kolkata in 1923 (Swarup and Singh, 1995). Percy Lancaster, the renowned British horticulturist, has been credited for the development of first cultivar of Bougainvillea - 'Scarlet Queen' in 1920 and subsequently another excellent bi-coloured cultivar 'Mary Palmer' developed by him paved the way for *Bougainvillea* cultivation in India.

Flower morphology: To understand the morphology of a flower is very important for the crop improvement programme of any crop. The flowers of *Bougainvillea* are hermaphrodite, tubular in shape with a constriction in the middle and borne in clusters of three, each flower subtended by a brightly coloured bract, which helps to attract insects for cross pollination. Bract colour in *bougainvillea* is contributed by betacyanins and betaxanthins *i.e.* betalains (Mabry and Dreiding, 1968). The tip of the flower is conspicuous with a star. There is a solitary carpel at the base surrounded by a ring shaped nectar. During morning hours (around 10 am) anthesis takes place followed by anther dehiscence and stigma receptivity. Butterflies visit the flowers attracted by the brightly coloured bracts and the nectar glands aids in cross pollination. The opened flowers remain so for a day, after which the upper part of the flower tube gets twisted in a spiral. Most of the *Bougainvillea* cultivars are diploid with a chromosome constitution $2n = 34$, irrespective of the species / hybrid group to which they belong (Zadoo *et al.*, 1975). Xu *et al.*, 2009 reported the occurrence of sixteen stages during bud and flower development in one inflorescence of *Bougainvillea*.

Major facts in the evolution of cultivated *Bougainvillea*: The year 1910 was marked by a major discovery in cultivated *Bougainvillea* when Mrs. R.V. Butt brought crimson coloured *Bougainvillea* cuttings from Cratagena (Columbia) to Trinidad. Over the years the cultivar turned out to be evermutating, being the source of various colour mutants that have added materially to the richness of the colour in the genus. The plant was named after Mrs. Butt. This plant reached Kew in 1915 and from there it got distributed to India, Africa, Australia, Malaya and Singapore in 1923 (Holttum, 1955).

The cv. 'Scarlet Queen' was introduced to India directly from West Indies by Mr. Tomlinson in 1920. Percy Lancaster gave the name Scarlet Queen to this variety. According to him, the coloured bracts of this plant are slightly darker than Mrs. Butt but the actual flower is malformed, so instead of there being three white or cream coloured flowers in the bracts, there are merely little bunch of anthers (Holttum, 1955; Zadoo *et al.*, 1976).

In 1931, Mrs. McClean of Trinidad produced apricot orange bracts instead of the normal crimson bracts of Mrs. Butt plant. This variant was propagated by R.O. Williams and named as cv. 'Mrs. McClean' (Holttum, 1955).

The cv. 'Scarlet Queen' produced orange coloured variety in 1932 at Madras in the garden of Mrs. Louis Wathen. It was named as 'Louis Wathen' by Mr. B.S. Nirody. Subsequently majolica yellow sports appeared from Louis Wathen and Mrs. McClean by spontaneous bud variation and were named as Enid Lancaster and Mary Baring (Pal and Swarup, 1974).

S. Percy Lancaster had separated a purple coloured

sport from Scarlet Queen in 1942 and named it as Alick Lancaster. The variegated leaved bud sports from Scarlet Queen has been released as cvs. 'Scarlet Queen Variegata' and 'Rao' (Pal and Swarup, 1974).

An important floriferous and recurrent blooming seedling was raised by P.S. Swaminathan at Madras from Princess Margaret rose and named it Mrs. H.C. Buck (Lancaster, 1951; Holttum, 1955).

The famous bicoloured variety Mary Palmer was isolated from Mrs. H.C. Buck in 1949 by S. Percy Lancaster (Holttum, 1957).

'Thimma' with variegated foliage and 'Shubra' with pure white bracts were evolved as a sport of Mary Palmer (Pal and Swarup, 1974).

Milestones in the bougainvillea cultivation: The first milestone in the history of *Bougainvillea* cultivation that created a sensation among the *Bougainvillea* lovers was the evolution of a bicoloured cultivar 'Mary Palmer' bearing white and magenta coloured bracts on the same plant in 1949. It appeared as a bud sport of 'Mrs. H.C. Buck following its drastic pruning, resulting in a complex chimera. It was named after Mrs. Palmer, in whose garden at Alipore, Calcutta, it appeared first. This is one of the most outstanding and popular cultivars of *Bougainvillea* even today.

The second milestone was the evolution of *Bougainvillea* cultivars having variegated foliage which remains attractive even when plants are not in bloom. These cultivars are very much preferred for pot culture. Some of the outstanding varieties which have variegated foliage are Archana, Arjuna, Louis Wathen Variegata, Marietta, Parthasarthy, Scarlet Queen Variegata, Surekha and Thimma.

The third milestone was the evolution of multibracted cultivars commonly known as 'Million Dollar' group as a bud sport of *B. X buttiana* in Phillipines namely Cherry Blossom, Los Banos Beauty, Mahara and Roseville's Delight having 18-21 bracts as against to common occurrence of three per flower. This group has further brightened the usefulness of this plant for ground as well as pot culture.

The fourth milestone was the evolution of *Bougainvillea* cultivar Shubhra. It has fulfilled the long felt desire of having parchment white bracts, with perpetual blooming habit. It is also hardy and easy to multiply.

Progress in *Bougainvillea* breeding was hampered all over the world largely because of the extensive pollen and/ or seed sterility. Thus the choice of female and male parents is limited only to a few relatively fertile types which, more often were not attractive cultivars. After detailed studies of the reasons for sterility, fertility was restored by colchiploidy. This has been the fifth milestone, which has enabled immediate broad basing of germplasm by inclusion of such cultivars in the breeding programme that were out for reach of *Bougainvillea* breeders all over the world (Sharma, 1986).

Breeding approaches in *Bougainvillea*: India is one

of the major repositories of a wide range of bougainvilleas, and approximately 50 % of the present-day cultivars have been evolved in India (Janakiram *et al.*, 2013). The work on development of Bougainvillea has largely been done by the Agri-Horticultural Societies at Calcutta and Madras. The Lal Bagh Garden at Bangalore also contributed a great deal by introducing a large number of exotic cultivars, particularly the multi-bracted varieties from the Philippines. Different breeding approaches followed in bougainvillea are hybridization, polyploidy, mutation and bud sports. A large number of varieties have been developed at the NBRI (Lucknow), BARC (Mumbai) and IIHR (Bengaluru).

Hybridization: Hybridization enable the origin of totally new colour forms of *Bougainvillea*. It also increased the possibilities and limits of selection. The natural hybridization with polyploidy has been the single factor contributing to evolution in nature and under domestication by plant breeding (Khoshoo and Mukherjee, 1970).

The cultivars developed from interspecific crosses are:

Crosses	Varieties
<i>B. peruviana</i> x <i>B. glabra</i>	: Begum Sikander, Mrs. Butt
<i>B. peruviana</i> x <i>B. spectabilis</i>	: Wajid Ali Shah
<i>B. buttiana</i> x <i>B. peruviana</i>	: Chitra
<i>B. spectabilis</i> x <i>B. buttiana</i>	: Dr. R.R. Pal, Summer Time, Spring Festival
<i>B. glabra</i> x <i>B. spectabilis</i>	: Maharaja of Mysore, Pink Beauty, Pixie, Rose Queen

The cultivars which were developed from intraspecific crosses are:

Crosses	Varieties
<i>B. glabra</i> (Trinidad x Formosa)	: Dr. H.B. Singh
<i>B. glabra</i> (Formosa x Trinidad)	: Purple Wonder
<i>B. spectabilis</i> (Lalbagh x Red Glory)	: Chitravati
<i>B. peruviana</i> (Dr. B.P. Pal x Princess Margaret Rose)	: Mary Palmer Special

(Swarup and Singh, 1995)

The varieties which were evolved through hybridization at IIHR (Indian Institute of Horticulture), Bangalore are Dr H.B. Singh, Chitravati and Purple Wonder. Among these varieties, Dr H.B. Singh was patented as Krishna in Australia (Anonymous, 1996)

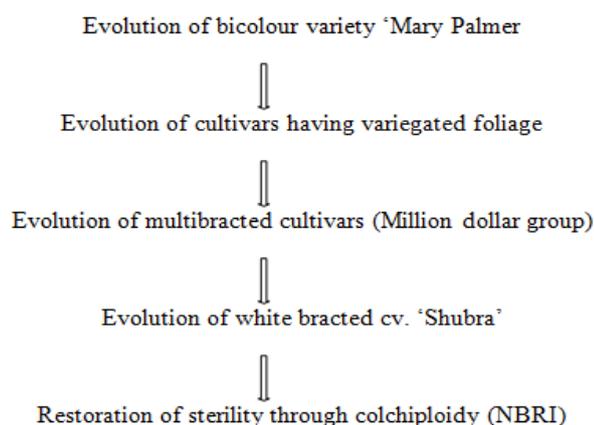
Mutation: The hybridization is not possible in multi-bracted bougainvillea due to absence of flower tubes/flowers and all varieties are not able to set seeds at all places. Hence, a alternative method, i.e. induced mutation breeding resulted in evolution of different new Bougainvillea cultivars (Swaroop *et al.*, 2015). Mutation leads to the origin of many new forms of *Bougainvillea*. In recent years, mutation breeding has been used as a valuable supplement to traditional methods of plant breeding which helps in the development of better cultivars (Arora and Pahuja, 2008). Most of the

cultivars of *Bougainvillea* were developed through selection of 'budspots' or by mutation breeding. Mutation breeding is one of the important methods to create variability in flower crops and it also reduces the time required to develop a new variety (Kannan *et al.*, 2002). Mutation breeding is the only method that can be used to improve double bracted Bougainvillea, since conventional cross-breeding is not possible because of the absence of flowers (Datta, 1990).

Different bract colours ranging from white to yellow, orange, magenta, red, purple and violet have arisen as a result of mutation among various forms of three basic species (Mabry and Dreiding, 1968). The relative proportion of these pigments determines the variation in bract colour (Kochhar and Ohri, 1977). Bract colour variations were due to qualitative and quantitative differences in pigment composition (Anand *et al.*, 1997).

The mutation studies of bougainvillea has been carried out at National Botanical Research Institute, Lucknow and Bhabha Atomic Research Center, Bombay (Banerjee, 2010). The mutants developed at National Botanical Research Institute, Lucknow were as follows:

Mutant	Parents	Characteristics	Developed/Reported by
Arjuna	Gamma ray mutant of 'Partha'	Single bract cultivar with pinkish purple colour and variegated leaves	Gupta and Shukla, 1974
Los Banos Variegata	Los Banos Beauty	Variegated leaves with excellent pattern, attractive leaves and bract colour is mallow purple	Banerjee and Datta, 1987
Pallavi	Roseville's Delight	Variegated leaves having pale and light green combination	Banerjee <i>et al.</i> , 1987
Mahara Variegata	Mahara	Variegated leaves with creamish yellow and green Bract rhodamine purple	Datta and Banerjee, 1994
Mahara Variegata abnormal leaves	Mahara	Variegated leaves Bract colour unaltered but shape and size reduced	Banerjee, 2002
Los Banos Variegata silver margin	Los Banos Beauty	Attractive variegated leaves with green and silver margin	Banerjee, 2002
Los Banos Variegata 'Jayanthi'	Chemical mutagen (EMS 0.02 %) induced mutant of cv. Los Banos Beauty	Differs from the original variety in foliage colour	Jayanthi <i>et al.</i> , 2000
Pixie Variegata	Chemical mutagen (EMS 0.02 %) induced chlorophyll variegated mutant of cv. 'Pixie'.	Margin of the leaves creamish colour	Banerjee, 2009
Los Banos Variegata Silver Margin	Gamma ray mutant of Los Banos Beauty	Leaf lamina is green and its margin is silver (1-2 mm width), variegated leaves are extremely curved	Banerjee, 2012



Flow chart of evolution of bougainvillea varieties

Bhabha Atomic Research Centre, Bombay developed mutants of *Bougainvillea* such as Lady Hudson of Ceylon Variegata (Induced mutant of Lady Hudson), Jaya (Induced mutant of Jayalaxmi), Jayalaxmi Variegata (Induced mutant of Jayalaxmi) (Broertjes and Van Harten, 1998), Suvarna (Induced mutant of Lady Hudson), Poultoni Variegata (Gamma ray induced mutant of 'Poultoni') and Silver Top (Induced mutant of 'Versicolour') (Raghava, 1999).

Bud sports: Some excellent cultivars of bougainvillea were originated as a result of spontaneous bud variation namely Alick Lancaster, Bhabha, Cherry Blossom, Fantasy, Jawaharlal Nehru, Lady Mary Baring, L.N. Birla, Louis Wathen, Mary Palmer, Mrs. McClean, Parthasarthy, Roseville's Delight, Shubhra *etc.* Spontaneous bud variation resulted in three change in the cultivated *Bougainvillea* *i.e.* Change in bract colour, imperfect flower tube development and leaf variegation (Holttum 1955,1957). The cv. 'Sholay' and 'Usha' are important seedling selections at IIHR from Red Glory and Lady Hope respectively (Anonymous, 1996). From cv. 'Arjuna' a chlorophyll variegated bud sport originated which were named as 'Abhimanyu'. It was detected by Dr. Banerjee at NBRI, Lucknow (Banerjee, 2012).

In the year 1963-1967, Dr. J.V. Pancho first reported the multibracted cultivars of bougainvillea in Laguna, Phillipines. The cultivar such as Carmentica, Cherry Blossom, Mahara, Godrej Cherry Blossom, Los Banos Beauty, Mahara Variegated, Pallavi, Rosevilles Delight, Archana and Marietta are multibracted. They are called multibracted cultivars as they have 20-40 bracts as compared to the normally occurring three bracted cultivars of bougainvillea. Also the flower tube is absent or rudimentary in such varieties. The multibracted varieties originated from the cultivars of *B.x Buttiana* (Pal and Swarup, 1974; Banerjee, 2012).

Polyploidy: Due to seed sterility in bougainvillea further breeding was hindered as a result of which it limits the selection of male and female parents for developing new cultivars. After detailed studies, fertility in

bougainvillea was restored by colchiploidy. Thereafter, numerous colourful and floriferous bicoloured cultivars at triploid, tetraploid and aneuploid has been raised. Some of the cultivars with induced polyploidy are-Wajid Ali Shah, Mary Palmer Special, Dr. B.P. Pal, Tetra Mrs. McClean, Chitra and Begum Sikander.

Characterization: Many varieties have recognized the basis of morphological and agronomical features in previous days. Even though varieties carry some morphological and agronomical features through their genetic background but these features can be influenced by the environment (Fu *et al.*, 2008). With consideration of *Bougainvillea* cultivars, are widely diverse among themselves mainly due to the color of bracts leaf and bract size, foliage variegation, floral tube, star, a presence of pubescence *etc.* Collectively, all these factors generate a lot of confusion in the identification of the particular cultivar (Mac Daniels, 1981). Therefore, researchers are willing fully seeking the easier and effective way to identify these cultivars.

Classification of *Bougainvillea* cultivars based on the different characters studied by Kumar *et al.* (2015) which will lead to the characterization of a particular genotype. This quantification of existing genetic variation and identification of cultivar based on economic traits and grouping the cultivars based on genetic divergence helps in selecting appropriate cultivar and utilizes them for future bougainvillea improvement through systematic and scientific breeding approaches.

Molecular characterization of *Bougainvillea*: In recent years, several molecular approaches have become available, for characterization of a genotype at the genomic level. Among them, RAPD is most commonly used for the identification of cultivar due to its simplicity, rapidity and requirement of only a small quantity of DNA to generate numerous polymorphisms (Wight *et al.*, 1993; Cheng *et al.*, 1997). For quantifying genetic variation in plant species, morphological traits are commonly used since they provide a simple technique while simultaneously assessing genotype performance under relevant growing environments (Fufa *et al.*, 2005). In *Bougainvillea*, till date, only a few studies were conducted to assess the genetic variation including, growth behavior studies (Gupta *et al.*, 2006, Kumar *et al.*, 2002), correlation studies (Singh *et al.*, 2010, Singh *et al.*, 2006).

Although the characterization work in *Bougainvillea* is more dealt with RAPD markers they were not much preferred as suitable marker systems for diversity and evolutionary studies due to their less reliability and lower reproducibility (Chatterjee *et al.*, 2007, Hammad 2009, Srivastava *et al.*, 2009). Reduction of duplications in *Bougainvillea* through the development of molecular markers profile which also serves as a potential tool in cultivar identification. Therefore, use of more reliable and reproducible molecular markers like SSRs becomes indispensable in *Bougainvillea*, like in any

other plant species.

Simple Sequence Repeats (SSRs or microsatellites) have become genetic markers of choice in many plant species due to their multi-allelic nature, a high abundance, co-dominant inheritance, reproducibility, high degree of polymorphism, and extensive genome coverage (Varshney *et al.*, 2005). To make out the relationship between the different cultivars of bougainvillea, SSR markers were used in a study by Kumar *et al.*, (2014) to characterize the cultivars. The investigation further revealed the fact that, the SSR markers are robust in detecting a high level of molecular polymorphism to characterize and in grouping the *Bougainvillea* cultivars besides establishing the genetic relationship and diversity which further used in crop improvement programmes.

Bougainvillea promotion: BSI (Bougainvillea Society of India) was founded by Dr. B.P. Pal during 1962-63 with the main objective to organize bougainvillea festival every year to create awareness among the people. BSI, New Delhi has more than 350 life members. Division of Floriculture and Landscaping, Indian Agricultural Research Institute, New Delhi, is the International Bougainvillea Registration Authority, appointed by the International Society for Horticultural Science, Belgium, for registration of bougainvillea germplasm since 1966 and it has compiled a checklist of more than 300 varieties developed all over the world. This check-list is a very useful document for reference purposes, giving authentic descriptions of the varieties. At present, the repository maintains more than 95 varieties of Bougainvillea (Janakiram *et al.*, 2013).

Conclusion

Bougainvillea is a very important landscape plant which plays a devoid role in the gardens. The availability of different forms in flower and plant habit made bougainvillea popular among the garden lovers. Most of the bougainvillea cultivars are evolved through natural mutations (Bud sports), whereas, induced mutation and hybridization also bring down significant contribution to the development of various forms. In ornamentals, consumers always seek for the new variant and hence, there is still to develop new variants with different flower colours and plant architecture. In this regard, the above information may be beneficial for development of new cultivars with novel colour and forms.

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