# MYSURU MALLIGE- HERITAGE CROP OF MYSURU: A Review


## Abstract

Jasmine being cultivated throughout India, its production/ largest area is concentrated in Tamil Nadu and Karnataka states. India stands next to Egypt and Morocco in Jasmine Concrete Production with >15 tons per annum. Modern Knowledge as fixed Jasmine as Persian origin, distribution pattern of 72 *Jasminum* spp. across India suggests India may be the primary home which has its mention in the 500 BC Tamil literature and 7$^{th}$ to 3$^{rd}$ BCE Ramaynam mythological literature. In Karnataka, a number of *Jasminum* spp. Maintain the grammar Are being cultivated throughout the state of which Mysuru Mallige, Udupi Mallige and Hadagali Mallige are being unique and are largely concentrated in the respective and adjoining districts. Government of India has registered these three jasmine cultivars with Geographical Indication tag under the Intellectual Property Rights. Though the demand for these GI crops is on increase, the area and production is declining slowly. Here is an attempt to compile the updated knowledge on genetic resources of *Jasminum* spp. with focus on the heritage crop of Mysuru- 'Mysuru Mallige'.


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Key words: Jasmine, Mysuru Mallige, Fragrance, Geographical Indication Crop.




## Introduction

Jasmine (*Jasminum* spp.) is a climbing, trailing and erect flowering shrub belongs to the family Oleaceae, order Oleales. The genus with basic chromosome number of X=13 (1), (2). There are both deciduous and evergreen species in jasmine. The leaves are opposite and alternate, simple, trifoliate or pinnate, leaflets are entire. Flowers are white, yellow or rarely reddish flower. Sometimes solitary, more often in cymes cluster of three to many, usually fragrant, acrid and bitter with a sharp taste, 2 loculed with 1 to 4 erect ovules. Fruit is a berry and black in color, rarely with separate capsules and each having 2 seeds. The main beauty and uniqueness of jasmine is its fragrance, which cannot be imitated by any known synthetic aromatic chemical and has a unique status in the perfume Industry in the world. Although more than 2000 species are known, 40 species have been identified in India and 20 are being cultivated in South India (3).

Jasmine plants are of great economic value as a field crop for the florist, landscape, medicinal and pharmaceutical industries. Jasmine can be grown in a variety of climate and soils. Generally, it prefers mild tropical climate for proper growth and flowering. Mostly, jasmine plants are grown in houses and gardens for ornamental purposes, and are also used for loose flowers to make garlands. However, there are a few species with fragrant flowers. Among these species, *Jasminum Grandiflorum* (Linn.), *Jasminum Auriculatum* Vahl and *Jasminum Sambac* Ait. (reference) are commercially cultivated for oil extraction. Jasmine oil blends well with every floral scent imparting smoothness and elegance to the perfume composition. It is useful in treating diseases of the mouth and teeth, especially for toothache.

*Jasminum sambac* Ait. (Arabian jasmine or Tuscan jasmine) is most common among the important species of jasmine. There are several cultivars like Motia, Double mogra, Hazara, Gundu mallige, Bela, Khoya, Rai Japanese, Madanban, Iruvatchi, Oosimalli, & Sooji mallige. These are bushy weak stemmed shrub with pubescent branches.

In India, Jasmine is cultivated throughout the country. However, the largest area under Jasmine flower production is in Tamil Nadu followed by Karnataka. The annual production of jasmine concrete is more than 15 tonnes in India, the largest producer being Egypt, followed by Morocco, India, Italy, France and China. However, jasmine has almost no seeds. Former investigations reported that only, 0.17 per cent (ranged from 0.13% to 0.19%) of its plants can set seeds in the fields mainly due to low pollen viability add few more reasons (3).

In Karnataka a number of species have been covered all over the state, among these Mysuru mallige is most commonly cultivated in Mysuru and adjoining districts, Udupi mallige is commonly cultivated in Udupi district and Hadagali Mallige is commonly cultivated in Bellary district. Mysuru Mallige, Udupi Mallige and Hadagali Mallige have been registered under Intellectual Property Rights and Government of India gave Geographical Indication (GI) tags for these three cultivars for their fragrance and flowering characters. These cultivars are usually grown by small and marginal farmers. In recent days area under cultivation and production is declining drastically. Mention the years and references

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An effort has been made to present the existing literature on the importance, origin, distribution, taxonomy, classification, descriptive studies, evolutionary aspects and morphological and molecular studies on different Jasmine species and varieties.

**Importance:**

Mysuru mallige is grown for its exceptionally scented blossoms. The blossom buds are gathered early morning and are integrated along a solitary plane utilizing banana fiber and or cotton string. As many as 200 to 400 buds are gathered tightly with a fine banana fiber or cotton string is used to adorn around the hair bundle by traditional women folk. Moggina Jade is an extended extravaganza used to cover the greater portion of hair on the head along the hair length especially in auspicious and special occasions like marriages. Similarly, a gathering of around two hundred flower buds integrated is called an 'Atte' and one long 'Atte' comprises of around eight hundred bloom buds collapsed into four columns and is called as 'Chendu' are the local measures in Udupi/ Mangaluru mallige. The flowers are utilized for hair decorations as Veni and furthermore in religious practices. The blossoms generally keep going for a day and the buds typically open between 6.30 to 7.30 PM. The blossoms have a great demand in local market *i.e.* Devaraja flower market, Mysuru from where flowers are marketed to local demands besides Kerala and Tamil Nadu and different parts of the country as well as other countries too (Saudi Arabia). Likewise they have industrial uses *viz*., essential oil extraction and cosmetic preparation.

## 2.1 Origin and distribution

Jasmine is local of tropical and subtropical territories and introduced to India in the mid-sixteenth century. Among the immense number of species existing, only three species have achieved criticalness in commercial cultivation. The Arabian or Tuscan jasmine (*Jasminum sambac*) is considered as a native of the East Indies, contrary opinion as to its home being the region west of India (4). The Royal jasmine or regular white jasmine or Poet's jasmine (*Jasminum officinale*) is regarded as Persian origin. The third species, *Jasminum auriculatum* is distributed in the western peninsula of India, with more even presence in Circars, Deccan Carnatic zones and in the southern areas of Travancore up to dry inclinations of the *Western Ghats* (5). The distribution pattern of 72 out of 89 species in India, Malaysia and China gives a strong base to ensure that India may be one of the primary focal points of beginning of *Jasminum* species. The references to the three developed species, *viz.*, *J. auriculatum, J. grandiflorum* and *J.*

*sambac* in antiquated Tamil literature of Sangam times before 500 BC recommend that South India may possibly be the home of most likely a part of these species. Reference about plants and flowers of *J. grandiflorum*, *J. officinale, J. pubescens* and *J. sambac* is well documented in a variety of traditional or mythological literature dating back to the period of Ramayanam spread over 7$^{th}$ to 3$^{rd}$ BCE (6)

Jasmine is commercially grown in various parts of India particularly Tamil Nadu (Coimbatore, Madurai, & Chennai), Karnataka (Mysuru, Chamarajanagara, Ramanagara, Bengaluru, Ballari, Koppala, Vijayanagara, Udupi, Mangaluru, Uttara Kannada, Shivamogga, and many places), Andhra Pradesh, Uttar Pradesh and some parts of Bihar and West Bengal (7).

Mysuru mallige is grown only in and around Mysuru and Mandya districts. Places of Mysuru jasmine traditional/ heritage/ geographic identical/ commercial cultivation are Devanoor-Kere, Hole Kesaruru, Matti, K.R. Mill colony and Rajarajeshwarinagar. Geographical extent of the Mysuru Mallige growing areas is concentrated between Longitude of 76° 23' 55.22" E to 76° 51' 39.19" E and Latitude of 11° 54' 27.63" N to 12° 24'16.6" N.

### 2.2 Cytology of *Jasminum* species

The somatic chromosome number of *Jasminum* differs from medium-sized to short, as compared to those of other genera. Size difference amongst the chromosomes is present from the longest to the shortest. The normal somatic number is found to be a multiple of thirteen, ranging from 2n=26 to 2n=52. The secondary constriction chromosome number varies from four in *J. angustifolium* to ten in *J. sambac*. It was by determined The basic chromosome number of Oleaceae family as X=13 by Taylor in his work on cytotaxonomy and phylogeny (1). Soon it was revealed that, diploids, triploids and tetraploids (2) in *Jasminum viz.,* 'Iruvantige' (two whorls) and 'Yelusuttu-mallige' (seven whorls) as diploids (2n=26) and 'Dundu-mallige' as a triploid (2n=39). ~~Raman (1955b)~~ has given a schematic depiction of the lines of differentiation in corollas of four varieties in *Jasminum sambac* and examination on cytology has presented a conceivable course of evolution of various varieties and species of jasmine (8). This gave the connection among simple and compound leaves, as well as the origin in regard of leaves, calyx and corolla lobes.

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The speciation in *Jasminum* genus has been fundamentally impacted by the structural difference in chromosomes and incessant conglomeration of these structural changes has been the main role behind the cause of new species, in spite of the fact that polyploidy additionally has helped at first (9). It was detailed (10) the polyploidy and gene mutation assumed noteworthy role in the cause for various species in jasmine. They also demonstrated that, there is incredible extension for developing new, appealing, fragrant and widened jasmine bloom for a larger part of the year containing more fragrance in it.

Sharma and Sharma (1958b) Inspection of 33 taxa of *Jasminum* for the mitotic chromosome quantities with details of region of collection and ploidy status demonstrated that, the somatic chromosome number of all the thirty three taxa of *Jasminum* occurs in multiples of 13 (11). Polyploid arrangement of 2n=26, 39, 52, 65 and 78 with diploids prevailing (51.5%) trailed by tetraploids (11%), triploids (3%), pentaploids and hexaploids (2.65% each). It is revealed that, 12 and 13 as the basic chromosome number of *Jasminum*. It is contended in light of the fact that sexual generation is to some degree outdated and totally missing in the greater part of the *Jasminum* species and a large portion of them are proliferated vegetatively. The variety shows a wide range of variation in ploidy level with diploids (2n=26) prevailing by triploids (2n=39), tetraploids (2n=52), pentaploids (2n=65) and hexaploid (2n=78). The most astounding ploidy level so far known in *Jasminum* is that of the tetraploid. The fundamental quantities of *Jasminum* X=12 and 13 may have been derived by aneuploid increase from an ancestral basic chromosome number X=11. Polyploidy including aneuploidy within *Jasminum* is summed to be the consequence of cytomixis in shoot tip and other physical meristem causing changes in chromosome number prompting their definitive advancement and speciation (12, 13).

### 2.3 Speciation in *Jasminum* species

Evolutionary forces like gene mutation and recombination, forms the basis of raw material of evolution. In the meantime, there are around 500 species of jasmine and only a few varieties exist today. The marvel of cytomixis is described by the relocation of chromatin or chromosomes between the proximate meiocytes through cytoplasmic channels or intercellular scaffolds. In the pollen mother cell re-arrangement of chromosome couldn't be normal; hence, the meiotic item either deteriorates or becomes non-functional. It results in various ploidy levels mostly aneuploidy. When one of the

cells with aneuploid number experiences ordinary mitotic divisions, it experiences a homogenous however, it was a heteroploid tissue. A shoot emerging from such a tissue when proliferated vegetatively after constant selection offers ascend to another variety or species (13).

Speciation in *Jasminum* spp. has been mainly influenced by change in chromosome number (9). Persistent gathering of these basic changes has been the principle behind the origin of new species, despite the fact that polyploidy also has helped in the speciation of the family. An examination (12) demonstrated that the sterility of the pollen is due to some inadequate capacity in their meiotic cells causing different meiotic anomalies, including cytomixis which happens suddenly and inexhaustibly in their pollen mother cells. Polyploidy and gene mutation assumed a significant job in speciation of the genus and there is incredible demand for advancing new and elite types of jasmine (10). Jasmine is predominantly trained and domesticated by vegetative methods. Sexual generation is practically missing in jasmine species, many being either pollen sterile.

***Jasminum auriculatum* Vahl**: Plants are shrubby having shiny leaves with auricles. Flowers are white, sweet scented, borne in pubescent compound many bloomed flax cymes; Corolla is lobed elliptic, carpels single and globose. Fruits are black. Blossoms are utilized for production of scents.

***Jasminum beesianum* Forest & Diels**: It is called as Rosy jasmine. It is a tough and low climber grows up to about 2.4 m, with slim furrowed stems. Leaves are basic, opposite, ovate-to-lanceolate, sharp pointed and dim dull green in colour. Blooms are little fragrant, pink to profound rose in colour.

***Jasminum calophyllum* Wall. Ex G.Don**: A profuse blooming species grown in home gardens. Flowers are scented, white and produces flower round the year and free from insect pests.

***Jasminum dichotomum* Vahl**: It is called as Gold Coast jasmine and is a vigorous climbing woody vine with simple and dim green leaves, flowers are single or in whorls of three. The little, fragrant blooms are produced in much-branched, tight terminal groups and produce flowers at interims throughout the year. Unopened bloom buds are tinted red outwardly; yet open blossoms are pure white inside.

***Jasminum flexile* Vahl** syn. ***Jasminum caudatum* Wall.**: A profuse blossoming species grown in home garden for its scented blooms which are produced consistently throughout the year. Plants are commonly free from pests and diseases.

***Jasminum floridum* Bunge**: Plants are evergreen and of rambling habit. Shoots are angulated and glabrous. Leaves alternate, leaflets oval or obovate. Blossoms are borne in terminal groups, corolla yellow in colour.

***Jasminum fluminense* Vell.**: A strong developing woody vine. Leaves opposite, compound and comprise of three dull green leaflets, the middle leaflet is bigger and has a more extended leaf stalk. Flowers little, exceptionally fragrant and borne in loose clusters.

***Jasminum grandiflorum* (L.)** syn**.** ***Jasminum officinale*** var. ***grandiflorum* (L.)**: Common jasmine or Spanish jasmine. A woody shrub having pinnate leaves with three to five leaflets of equivalent size. Blooms are large, white, reddish underneath, brilliantly fragrant and are borne in axillary or terminal cymes.

***Jasminum sambac* (L.) Aiton**: It is known as Arabian jasmine, Tuscan jasmine, Evergreen twiner. Leaves are simple, opposite or in threes, cordate to oblong, practically sessile and dull green in colour. Blooms are white, fragrant, usually small, three forked cymes. Essential oil is removed from the blossoms to make perfume.

### 2.4. Propagation

Propagation of Mysuru mallige is done through cuttings as well as layering. The scandent nature of plant is useful in making the layering type of propagation. The plant roots at the nodes where it contacts the ground. The established plants are cut below the rooting point and planted in new pit or pot or bag. Good healthy stem cuttings (15 cm long) with pencil thickness (14) are usually chosen and planted in polythene bags or soil beds for propagation. Usually soil, well decomposed farmyard manure and sand mixture in equal proportion are being used as media for rooting in cuttings of Mysuru mallige. Well rooted and established cuttings being transplanted into the ground. September planting of the cuttings either in soil beds or in polythene bags gives better results. reference Due early care is needed for field establishment of the plantings. Blossoming begins during March-April and proceeds up to June-July with April-May being the pinnacle season.

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### 2.5 Morphological variation in *Jasminum* species

Development of any crop relies upon at the availability of genetic variation in the germplasm of the crop and heritability of the traits. Selection of beneficial traits from cultivated and wild germplasm is an age-old practice accompanied for crop improvement. Genetic variability estimation of working collections (germplasm) is a prerequisite for any crop development programme. The variability found in the population may be due to genetic and environmental factors. Genetic gain is feasible when the relative contribution of many factors for total variability is present.

Fairy a good amount of selection has been attempted and accomplished by Tamil Nadu Agricultural University, Coimbatore, India among various types of jasmine and their clones. Differences in morphological characters in wild and cultivated forms of *Jasminum rigidum* were observed (15). Wild type had elliptic to ovate to lanceolate leaves (6.0 x 2.5 cm) and corolla lobes (1.5 x 0.5 cm) whereas, cultivated type had cordate to ovate to acuminate leaves (7.5 to 8.0 x 6.0 cm) and corolla lobes (2.0 x 0.5 cm). A high yielding clone 'Parimullai' in the species *J. auriculatum* was selected (16) and accounted to be impervious to gall mite, which is a noteworthy issue in jasmine.

There have been attempts of polyploidy studies in this crop. A triploid type of *J. grandiflorum* with longer leaves, longer petals, peduncle, corolla cylinder and expanded size and thickness of buds contrasted with the diploid cultivars was reported (17). The chromosome number of *J. grandiflorum* 2n= 39. Further, they have noticed the size of open blooms in *J. nitidum* to be bigger than those of *J. auriculatum* and cultivars "Iruvatchi" and "Gundumalli" of *J. sambac*. Likewise they detailed that, there was no critical upgrade in blossom number per plant, bloom size or yield in the tetraploid *J. rigidum* over diploids.

A population of *J. auriculatum* grouped into five gatherings of morphological variations (18) specifically long pointed bud, medium pointed bud, short pointed bud, long round bud and short round bud. While concentrating on the blooming propensity and blossom yields of some *Jasminum* spp., it was discovered that, *J. grandiflorum* gave highest blossom yield pursued by *J. flexile* (19). In any case, largest blooms and buds were found on *J. sambac* var. Two fold Mohra and Big Double. Another attempt has revealed 15 morphological variations in *J. sambac* which concluded that the variety Madanban was the best pursued by Gundumalli and Ramabanam for different economically significant characters like shape of bud, length of pedicel, length of corolla

tube, diameter of flower, number of blossoms per plant and time taken for a bud to open up completely (20).

Study with the seedlings obtained through open fertilization in *J. auriculatum* reported a great range of variation in length of flower bud, length of corolla cylinder and distance across of bloom bud (21).

Concentrating on the genetic improvement in *J. auriculatum,* it was found that the best seedlings for yield, weight of blossom buds and diameter of flower buds were obtained from the mother clone, Short Round (22). Further, a high fluctuation for blossom bud weight, corolla tube length and bloom bud breadth was detailed (23). The environmental impact was accounted to be exceptionally high for yield and low for other flower characters. Muthukrishnan and Pappiah (1980) 1..or 3…? journal notation number is missing for the authors detailed the alluring bloom bud character like strong and long corolla tube in CO-1 Mullai (*J. auriculatum)* has been detailed (24). It was observed that the clone of *J. grandiflorum* gave high return of 10.15 ton of flower buds per hectare (25), and solid yield per hectare of 29.42 kg with solid recuperation of 0.29 per cent. This clone was later named as CO-1 Pitchi.

Distyly in blossoms of *J. pubescens* was accounted well (26).. Plants producing white blossoms were long styled (pin) where as those with pink blooms were short styled (thrum) where, thrum type excelled pin type by having high fragrance and indole mixes in blossom and furthermore higher yields per day during the sprouting season. They also reported that, stick type had higher bud weight and longer corolla tube length however these blooms lacked aroma and indole compound. Further, the description of four horticultural varieties of *Jasminum sambac*, namely: Suji mallige', 'Iruvantige', 'Yelu suthu mallige' and 'Gundu mallige' has been given (2) which has later grouped these varieties based on the shape of leaf and corolla lobes (8) into two groups:

a. Elliptic Leaves; conical buds –'Suji mallige'- needle or pointed Jasmine, 'Iruvantige' and forms.

b. Ovate Leaves; Globosebuds– 'Yelu suthu mallige'- seven whorl and 'Gundu mallige'-round or globular jasmine-

Another study indicated *Jasminum sambac* variety 'Yelu suthu mallige' as *Jasminum sambac* variety 'trifoliatum' based on the leaves occurring in triplet at the extremity of flowering branches (27).

Occurrence of floral dimorphism in stylar lengths of genus *Jasminurn grandifIorm* has been reported/documented (28). The study resulted in separation of two types of clones with varying stylar lengths i.e. pin type-long styled and thrum type-short styled. Clones of *J. grandiflorum* collected from various states of India (25), there was a considerable variation with regard to bloom production as well as of jasmine concrete was found. The mean blossom yield of the six clones ranged from 4329 to 10144 kg/ha while, that of jasmine concrete demonstrated a scope of 13.85 to 29.42 kg/ha. The shading of bloom bud is pink and alluring with charming scent suitable both for fresh flower exchange and oil extraction.

Comparative work done in *J. auriculatum* showed a high yielding gall mite resistant clone Parimullai which was released by the Tamil Nadu Agricultural University in 1971 for commercial cultivation. The clone is described by long blooming period of nine months and a mean blossom bud yield of 10 t/ha (29). An investigation with seedlings acquired from open pollination in *J. auriculatum*, four seedlings showed exceeding expectations in the commonly grown cultivar Parimullai (21). In a comparable report, 175 to 284 percent expanded yield in elite seedlings over the standard Parimullai clone was documented (22).

### 2.5.1 Character association and path analysis for productivity and quality traits

Highly inherited characters are controlled by one or few genes. Additive gene action forms the basis of heritable part of genetic variation in a variable population. A character under study will respond better to continuous selection if other components of genetic variability namely dominance and epistasis (non-additive gene action) are absent or very negligible (30). Correlation, regression coefficient and path analysis of eight characters comprising yield and its components in jasmine revealed that, number of flowers to be significantly correlated with yield (31). Weight of hundred flowers had a significant and positive correlation with bud diameter, corolla tube length and bud shape index. Number of flowers had the maximum direct effect on yield followed by total floral bud length and floral bud length excluding the corolla tube.

Positive association of number of primary laterals and the length of style with yield in *J. auriculatum* was observed (32). They also found that, weight of flower buds, length of internodes and numbers of days taken for flowering are directly related with corolla tube length. While studying the correlation and path analysis in pin and thrum

types of open pollinated progeny in *J. auriculatum*, (33) it was observed that, flower yield of the plant to be significantly correlated with diameter of flowers, petal length, bud length, 100 bud weight, number of flowering branches per plant and number of flowers per plant with flower yield in pin type. They concluded that 100 bud weight and number of flowers per plant in case of thrum type and number of flowers per plant in case of pin type to have major contribution to yield.

### 2.5.2 Morphological variability

Morphological traits are the most established and broadly utilized genetic markers for certain germplasm and cultivar management applications, where the cultivars have been classified on the premise of leaf, panicle, fruit and other physical attributes. Nonetheless, these characters may change with ecological conditions. Moreover, the genuine character of certain cultivars is still being referred to, in light of the fact that comparative cultivars developed in various regions regularly have been differently named (34). The prime preferences of the morphological markers are simplicity, inexpensive assay, even herbarium and other dead tissues can be distinguished and checked.

Genetic relationships among eight varieties of *J. sambac* and two varieties of *J. grandiflorum* collected from Southern India was studied (35). The genetic dissimilarity matrix revealed a maximum genetic distance of 83 per cent between vars. 'Co-2 Pitchi' and 'Single Mohra', which belong to different species and the minimum genetic distance (21%) was between vars. 'Khoya' and 'Khoya Large' belonging to same species (*J. sambac*). The dendrogram was constructed based on the Ward's method of cluster analysis, which at 58 linkage distances clustered into two major clusters 'A' and 'B' with varieties of *J. sambac* and *J. grandiflorum,* respectively.

Safeena *et al.* (2017) 1..or 3...? journal notation number is missing for the authors Collection *Jasminum* species from various regions of Goa revealed maximum flower bud diameter (1.14 cm) was noticed in accession J-8 whereas shortest (0.264 cm) was noticed in J-5. Maximum and minimum bud lengths were recorded in J-8 (4.7 cm) and J-7 (1.84 cm), respectively (36). Flower diameter was recorded the maximum (6.68 cm) in J-6 while it was minimum in J-5 (1.9 cm). Flowers of J-10 had maximum number of petals/flower (43) whereas lowest (5.0 petals/flower) was found in J-1. Flowers of J-14 had longest corolla tube length (2.70 cm) while it was shortest (0.864 cm) in J-10.

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Five species of jasmine expressed similarity with respect to six parameters and variations with respect to the remaining parameters (37. The six parameters for which the five species expressed similarity were open flower colour, number of whorls of corolla, number of pistils, ovary type, year-round flowering behaviour and fruit setting potential. Variations were observed with respect flower diameter of the species ranged between 2.1 to 4.2 cm. *Jasminum nitidum* had the maximum flower diameter while *J. flexile* had the least. The mature flower bud colour of *J. calophyllum* and *J. flexile* was white, whereas the remaining three species namely *J. multiflorum* (Pink), *J. nitidum* and *J. rigidum* produced pink tinged buds. Number of stamens was two in all the species with the exception of *J. rigidum* wherein flowers with 2 stamens as well as 3 stamens (in 6.66 per cent of the sampled flowers) were observed. In all the species except *J. multiflorum* (Pink), the pistil was exerted, slightly protruding out of the mouth of the corolla tube. The tip of the stigma was distinctly bifid in *J. calophyllum,* whereas in the other species it was either undivided or not distinctly divided. Season affects the flowering duration in the commercial species *viz., J. sambac, J. auriculatum* and *J. grandiflorum.* The seasonal variation of flowering in *Jasminum* species is due to the variations in photo-thermal units which profoundly influence flowering.

An experiment to analyze multivariate analysis based on cluster and principal component (PC) for yield and its eighteen contributing traits in 30 Mysore mallige local collections was carried out during 2018-19 (38). The cluster analysis categorized all 30 Mysore mallige into 2 major clusters. Extreme genetic divergence was estimated among clusters. Average intra-cluster distance was found maximum (D2=1254.18) between cluster 1 and cluster 2. The character, flower bud weight (53.10%) contributed maximum to the genetic divergence among the genotypes followed by number of petals (18.85%). Highest cluster mean values for lengths of corolla tube, and the leaf was found in cluster 1 followed by cluster 2. Principal component analysis revealed that first five principal components (PC1, PC2, PC3, PC4 and PC5) accounted for 83.44% of the total variations with the proportionate contribution values of 40.88%, 18.42%, 10.17% and 8.19%, respectively.

Karteka *et al.* (2021), A study was conducted with 34 genotypes comprising of traditional landraces collected from all over Tamil Nadu and evaluated for 40 qualitative traits according to the DUS descriptors specified for *Jasminum sambac* (39). In order to reduce the dimensionality of the data, examine the variation and the relative contribution

of the traits for the total variability, Principal Component Analysis (PCA) method was adopted. PCA test in 34 genotypes for all the 40 characters resulted in fifteen Principal Components (PCs) with an eigen value more than one accounted for 97.21 per cent of the total variability and revealed that the traits leaf margin undulation, flower bud shape, flower shape, shape of corolla lobe, flower petal tip, leaf blade undulations, flower bud length and root suckers exhibited maximum variation. Agglomerative Hierarchical Clustering and PCA results showed that the genotypes Acc. Js- 11, Acc. Js- 12, Acc. Js- 13, Acc. Js- 14, Acc. Js- 20, Acc. Js- 25, Acc. Js- 27 and Acc. Js- 32 were found to be the most diverse genotypes.

An experiment using RBD with two replications had recorded 20+ quantitative characters in 30 Mysore mallige local collections (40). High (>20%) genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) was observed for bud length, bud breadth, the number of whorls, the number of petals, pedicel length, length of corolla tube, length of filament, length of style, length of stigma and flower bud weight. Moderate (10 to 20%) GCV and PCV were observed for petiole length, leaf length, leaf breadth, flower diameter, calyx length, the number of calyx teeth, petal size and the number of stamen and length of the anther. The PCV was more than the GCV for all characters studied. The higher (>20%) values of genetic advance over mean (GAM) coupled with very high (>80%) estimates of heritability were observed for characters *viz*., bud length, bud breadth, flower diameter, calyx length, the number of calyx teeth, the number of whorls, the number of petals, petal size, pedicel length, length of the corolla tube, the number of stamens, length of anther, length of the filament, length of the style, length of the stigma and flower bud weight. Moderate heritability (40-60%) with low GAM was observed for petiole length. The variance due to genotypes was highly significant for all the characters except for length of the leaf.

### 2.6 Molecular markers

Phenotypic characters are phylogenetically inherited and are highly influenced by environmental conditions. Consequently, the information acquired by such assessments are not comprehended at genetic level, frequently bringing about maintenance of duplicate accessions. In this regard the advent of molecular markers had revolutionized the entire scenario of plant sciences. DNA based markers *viz.*, Randomly Amplified Polymorphic DNA (RAPD), Restriction Fragment Length Polymorphism (RFLP), Amplified Fragment Length Polymorphism (AFLP), Sequence Related Amplified

Polymorphism (SRAP) and Simple Sequence Repeat (SSR) provides excellent tools for studying diversity at DNA level, discriminating cultivar, elucidating misnaming, and genetic purity analysis.

A set of 35 primers gave 5 bands/ primer when 32 cultivars of *Jasminum* spp. were screened using RAPD markers with one hundred and forty random ten base long primers (41). Among them, eight primers gave on an average ten strong repeatable bands and chosen for measuring diversity. From these primers 134 bands were amplified and number of polymorphic bands ranged from 13-26. Dissimilarity matrix based on Squared Euclidean Distance and clustering by Ward's coefficient indicated a moderate diversity among the 32 jasmine cultivars.

Sampath *et al.* (2008) worked on the genetic relationships among eight varieties of *Jasminum sambac* and two varieties of *J*. *grandiflorum*, RAPD profiles was done with eight random primers and 120 amplified fragments were obtained (35). The genetic dissimilarity matrix was determined based on Squared Euclidian Distances, which expressed a maximum genetic distance of 83 per cent between vars. 'Co-2 Pitchi' and 'Single Mohra', which belong to different species and the minimum genetic distance (21%) was between vars. 'Khoya' and 'Khoya Large' belonging to same species (*J*. *sambac*). The study revealed moderate to high genetic diversity among the both *Jasminum* spp. RAPD markers combined with morphological analysis proved to be a quick, simple and significant testing method to assess genetic diversity among *Jasminum* spp.

The genotyping in jasmine species using 54 primers yielded good amplifications with 26 primers (42). 19 primers produced 100 per cent polymorphism with an average of 90.6 per cent for 26 primers. Two major clusters were obtained based on morphological and RAPD markers analysis.

OPX 6 primers produced most distinguished 75 bands with 8-11 bands per sample in a genetic diversity of jasmine species by DNA fingerprinting study with hRAPD markers (43). Most of the bands were monomorphic with some polymorphic bands. The described approach holds great promise for genetic diversity polymorphism, cultivar characterization and genetic population conservation of Jasmine species.

Genetic variations of the 53 accessions representing eight species of *Jasminum* collected from different regions of Iran were evaluated using ISSR (44). A total of 21

ISSR primers were used which generated 981 bands of different sizes. Mean percentage of polymorphic bands was 90.64 %. Maximum resolving power, polymorphic information content average, and marker index values were 21.55, 0.35, and 14.42 for primers of 3, 4, and 3, respectively. The unweighted pair group method with arithmetic mean dendrogram based on Jaccard's coefficients indicated that 53 accessions were divided into two major clusters. The first major cluster was divided into two subclusters; the subcluster A, included *J. grandiflorum*, *J. officinale*, and *J. azoricum* and the subcluster B consisted of three forms of *J. sambac* (single, semi-double, and double flowers). The second major cluster was divided into two subclusters; the first subcluster (C) included *J. humile*, *J. primulinum*, *J. nudiflorum* and the second subcluster (D) consisted of *J. fruticans*. At the species level, the highest percentage of polymorphism (34.05 %), numbers of effective alleles (1.16), Shannon index (0.151), and Nei's genetic diversity (0.098) were observed in *J. officinale*. The lowest values of percentage polymorphism (0.011), number of effective alleles (1.009), Shannon index (0.007), and Nei's genetic diversity (0.005) were obtained for *J. nudiflorum.* Based on pairwise population matrix of Nei's unbiased genetic identity, the highest identity (0.85) was found between *J. officinale* and *J. azoricum* and the lowest identity (0.69) was between *J. grandiflorum* and *J. perimulinum*. Based on analysis of molecular variance, the amount of genetic variations among the eight populations was 83 %. This study demonstrated that the ISSR is a useful tool in jasmine genomic diversity studies and to detect their relationships.

The dendrogram constructed using NTSYS-SHAN clustering and separated the thirty local collections of Mysuru mallige into two major clusters, one with 16 genotypes and other with the 14 genotypes (45). These two shared a common node at 56% similarity level. The larger major cluster was further subdivided into two sub clusters of which one sub cluster contains 7 genotypes *viz*., COHM-UHSB-1, COHM-UHSB-4, COHM-UHSB-12, COHM-UHSB-27, COHM-UHSB-26, COHM-UHSB-10 and COHM-UHSB-28 and the other sub cluster with nine genotypes *viz*., COHM-UHSB-2, COHM-UHSB-5, COHM-UHSB-7, COHM-UHSB-9, COHM-UHSB-11, COHM-UHSB-13, COHM-UHSB-23, COHM-UHSB-6 and COHM-UHSB-14 sharing a common node at 82% similarity level. The remaining major cluster included two sub clusters sharing a common node at 69% similarity level. The sub cluster containing COHM-UHSB-3, COHM-UHSB-8, COHM-UHSB-17, COHM-UHSB-24, COHM-UHSB-20, COHM-UHSB-21, COHM-UHSB-19, COHM-UHSB-5, COHM-UHSB-18, COHM-UHSB-16, COHM-UHSB-29 and

COHM-UHSB-30 share a common node at 80% similarity level whereas second sub cluster, COHM-UHSB-22 and COHM-UHSB-25 share a common node at similarity level of 94%. The results revealed that Mysuru mallige with single whorled were found in Sub cluster A, whereas, remaining two whorl, three whorl, five whorl and seven whorls were grouped in Sub cluster B. Among the SSR marker giving polymorphic bands, allele frequency ranged from 0.67 for the SSR marker Js063 to 2.19 for the SSR marker Js035 with an average of 1.05 across all the SSR markers. In population genetics, an allele frequency is used to depict the amount of genetic diversity at the individual, population or species level. Changes in allele frequencies over time can indicate that genetic drift is occurring or that new mutations have been introduced into the population. Another measure of diversity among the population is the extent of polymorphic information content value (PIC) of markers. The average PIC for all SSR markers was 0.11 suggesting existence of sufficient genetic diversity among Mysuru mallige local collections.

**Summary and conclusions:**

Jasmine is a popular and inimitable name in perfumery and cosmetics industry. India is one of the centers of origin of jasmine and is the largest exporter of jasmine oil. Success of crop improvement programme depends on the extent of genetic variability existing in the germplasm or population. The magnitude of genetic variability can determine the pace and quantum of genetic improvement through selection or through hybridization followed by selection. Therefore, assessment of genetic variability, genetic divergence through morphological and molecular (SSR) markers in Mysuru mallige is an important breeding tool for the improvement of Jasmine. Besides there is an urgent need to explore the *Jasminum spp*. in general and Mysuru mallige genetic diversity in specific for biotic and abiotic resistance traits to cater the growing demand and to stop the declining production and productivity.

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