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Mysuru Mallige-Heritage Crop of Mysuru: A Review

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Review Article

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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 has accepted 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 7th to 3rd BCE Ramaynam mythological literature. In Karnataka, a number of *Jasminum* spp. are being cultivated throughout the state of

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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'.

Keywords: Jasmine; mysuru mallige; fragrance; geographical indication crop.

1. INTRODUCTION

Jasmine (*Jasminum* spp.) is a climbing, pendulous and erect flowering shrub in the family Oleaceae, order Oleales. This genus has a basic chromosome number of X=13 [1,2] with both deciduous and evergreen *Jasminum* spp. Leaves are opposite and alternate, simple, trifoliate or pinnate, with entire leaflets. Flowers are usually white, sometimes yellow and rarely with yellowish or reddish tinge with white. Sometimes solitary, more often in three to many clusters of cymes, usually fragrant, pungent and bitter, 2 loculed with 1 to 4 erect ovules. The fruit is a black berry, rarely contains two seeds in separate capsules. The primary feature of jasmine's beauty and uniqueness is its fragrance, which is unparalleled in the perfume industry worldwide and cannot be replicated by any known synthetic aromatic chemical. Although there are more than 2000 species, 40 have been found in India, and 20 are being grown in South India [3].

As a field crop, jasmine plants are highly valuable to the florist, landscaper, pharmaceutical, and medical industries. Jasmine can be grown in a wide range of soils and climates. In general, for proper growth and flowering, it prefers mild tropical climates. The majority of jasmine plants are grown for ornamental purposes in gardens and homes, and they can also be used to make garlands out of loose flowers. There are, however, a few species that produce fragrant flowers. The *Jasminum grandiflorum* (Linn.) species is one of these. *Jasminum sambac* Ait and *Jasminum auriculatum* Vahl are being commercially grown for the purpose of extracting oil. Jasmine oil enhances the perfume's smoothness and elegance by blending well with all floral scents. It is helpful for treating mouth and tooth diseases, particularly 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.

Jasmine is grown extensively throughout India. However, Tamil Nadu and Karnataka account for the majority of the Jasmine flower production area. India produces more than 15 tons of jasmine concrete annually; Egypt is the largest producer, followed by Morocco, India, Italy, France, and China. However, there are almost no seeds in jasmine. Due to low pollen viability, previous investigations indicated that only 0.17 percent (ranging from 0.13 percent to 0.19 percent) of its plants are able to set seeds in the fields [3].

There are a number of species that can be found throughout Karnataka. Mysuru mallige (Plate 1) is most commonly grown in Mysuru and the districts that are adjacent to it, Udupi mallige is commonly grown in Udupi, and Hadagali mallige is commonly grown in Bellary district. The Intellectual Property Rights of Mysuru Mallige, Udupi Mallige, and Hadagali Mallige have been registered, and the Government of India has given these three cultivars Geographical Indication (GI) tags because of their fragrance and flowering characteristics. Typically, these cultivars are grown by marginal and small farmers. The extent of land area used for cultivation and production has decreased dramatically recently.

The existing literature on the significance, origin, distribution, taxonomy, classification, descriptive studies, aspects of evolution, and morphological and molecular studies of various Jasmine species and varieties has been presented herein.

2. IMPORTANCE

The highly fragrant blossoms of Mysuru mallige are the reason this plant is being grown. Using a cotton or banana fiber, the blossom buds are gathered during the early morning hours and are arranged in a single line. Traditional women folk

adorn their hair bundle with as many as 200 to 400 buds tightly gathered. 'Moggina Jade' is a head adornment veil with plaited buds on a thin cardboard or leaves, worn to cover the head and veni aong the length of the hair, especially for auspicious and special occasions like weddings. The local measurements in the Udupi/ Mangaluru mallige are called as "Atte" and "Chendu". An atte consists of approximately 200 flower buds integrated into one group, while a Chendu consists of approximately 800 flower buds collapsed into four columns which form the most popular and traditional head gears for women folk in coastal and western ghat areas of Karnataka. As Veni, the jasmine flowers are used in religious ceremonies as well as day to day hair decorations. The jasmine buds typically open between 6.30 and 7.30 PM, and the blossoms typically last for a day. The blossoms are in high demand in the Devaraja flower market which is the local and main market in Mysuru. From here, they are sold to meet local needs in addition to Kerala and Tamil Nadu and other parts of the country. The demand by foreign markets is also catered from Devaraja flower market, Mysuru among which the share of Saudi Arabia is cognizable. Additionally, they are utilized in industry for cosmetic preparation and extraction of essential oils.

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. Contrary to popular belief that, the Arabian or Tuscan jasmine (*Jasminum sambac*) is thought to have originated in the East Indies, western region of India is its home [4]. The Royal jasmine or regular white jasmine or Poet's jasmine (*Jasminum officinale*) is regarded as Persian origin. *Jasminum auriculatum*, can be found throughout the western peninsula of India. It is more common in the Circars, Deccan Carnatic zones, and southern Travancore, all the way up to the dry inclinations of the Western Ghats [5]. The pattern of distribution of 72 of the 89 species in India, Malaysia, and China provides a solid foundation for the possibility that India was one of the primary centres of orgin for *Jasminum* species. The three developed species *viz., J. sambac, J. grandiflorum*, and *J. auriculatum* are articulated in Indian antique literature. . 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 7th to 3rd BCE [6].

Jasmine is grown commercially in many parts of India, especially in Tamil Nadu (Coimbatore, Madurai, and Chennai); Karnataka (Mysuru, Chamarajanagara, Ramanagara, Bengaluru, Ballari, Koppala, Vijayanagara, Udupi, Mangaluru, Uttara Kannada, Shivamogga, and a lot of other places); Andhra Pradesh, Uttar Pradesh and some parts in Bihar as well as West Bengal states [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*. In his work on cytotaxonomy and phylogeny, Taylor determined that the Oleaceae family's basic chromosome number was X=13 [1]. Soon, it was discovered that Jasminum had diploids, triploids, and tetraploids are there in *Jasminum* spp. [2]; 'Iruvantige', which has two whorls and 'Yelusuttu-mallige', which has seven whorls, are diploids (2n=26) and 'Dundu –mallige' as triploids (2n=39). A possible path of evolution for various jasmine varieties and species has been presented with the help of cytological examination and schematic depiction of the lines of differentiation in the corollas of four varieties of *Jasminum sambac* [8]. This revealed the connection between compound and simple leaves, as well as the origin of the calyx, corolla, and leaf lobes.

In spite of the fact that, polyploidy initially assisted the structural differences in chromosomes had a significant impact on the speciation of the Jasminum genus. Constant conglomeration of these structural changes has been the primary factor in the emergence of new species [9]. It was explained in detail that gene mutation and polyploidy played a significant role in the development of various jasmine species [10]. They also demonstrated that there is a significant amount of time remaining for the development of new, enticing, fragrant and expanded jasmine blooms that last longer and have more fragrance. 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

The basic raw material for evolution is formed by forces like gene mutation and recombination. In the meantime, there are approximately 500 species of jasmine, but there are currently only a few varieties. The relocation of chromatin or chromosomes between the proximate meiocytes *via* cytoplasmic channels or intercellular scaffolds exemplifies the marvel of cytomixis. Chromosome reorganization in the pollen mother cell could not be normal; as a result, the meiotic component either deteriorates or ceases to function. It causes various levels of ploidy, most commonly aneuploidy. When a cell with an aneuploid number goes through normal mitotic divisions, it produces homogenous tissue; however, it produced heteroploid tissue. When proliferated vegetatively after constant selection, a shoot from such a tissue gives rise to another variety or species [13].

Species in the *Jasminum* genus has been primarily influenced by a change in the number of chromosomes [9]. Despite the fact that polyploidy has also contributed to the family's speciation, the principle behind the origin of new species has been the persistent accumulation of these fundamental changes. According to an examination [12], the pollen's sterility is caused by a lack of capacity in their meiotic cells, which results in a variety of meiotic anomalies, including cytomixis, which occurs suddenly and inexorably in their pollen mother cells. Polyploidy and gene mutation played a significant role in the *Jasminum* speciation, and there is a great demand for developing new, elite jasmine varieties [10]. Vegetative methods are primarily used to train and domesticate jasmine. Most jasmine species lack sexual generation because many are pollen sterile.

***Jasminum auriculatum* Vahl:** The plants are shrubby and have auricles on their shiny leaves. The white, sweet-smelling flowers are produced by many blooming flax cymes in a pubescent compound; carpels are single and globose, the corolla has lobed ellipses and the fruit is black in colour. Scents are produced with the help of blossoms.

***Jasminum beesianum* Forest & Diels:** Rosy jasmine is its popular name. It is a tough, low climber that can reach about 2.4 meters in height and has slim and furrowed stems. The leaves are basic, obtuse, ovate-to-lanceolate, sharp-pointed and light green leaves in colour. The blooms are pink to deep rose in color and have a little scent.

***Jasminum calophyllum* Wall. Ex G.Don:** It is a species with a lot of blooms with yearround blooming grown mostly in home gardens. White flowers are fragrant and pest-free.

***Jasminum dichotomum* Vahl:** Vigorously climbing woody vine known popularly as Gold Coast jasmine which has simple and dark green leaves. The tiny, fragrant blooms appear at intervals throughout the year and are produced in tightly branched terminal groups. Outwardly, unopened bloom buds are red; but the inside of

open blossoms is pure white and are single or three-flowered flowers.

***Jasminum flexile* Vahl** syn. ***Jasminum caudatum* Wall:** A species with a profuse blooms grown in home gardens for its fragrant and year-round blooms. This species is almost free from pests and diseases.

***Jasminum floridum* Bunge**: Plants have a rambling habit and are evergreen with glabrous and angulated shoots. Leaflets are oval or obovate arranged alternately. The flower corolla is yellow in color and it blossoms in terminal groups..

***Jasminum fluminense* Vell.**: It has a strong 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 with concealed reddish tinge below, dazzling fragrance. Flowers appear on terminal or axillary cymes.

***Jasminum sambac* (L.) Aiton**: A most popular jasmine also known as Evergreen twiner or Tuscan jasmine or Arabian jasmine. The leaves are dull green, simple, arranged opposite or in threes, cordate to oblong and almost sessile. Flowers are white, fragrant, and typically small with three forked cymes. *J. sambac* blossoms' are well known and used extensively in the perfume industry by extracting the essential oil.

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. 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.

2.5 Morphological Variation in *Jasminum* Species

Any crop's development depends mainly on the availability of genetic variation and heritability of traits among the germplasm. Selecting advantageous traits from cultivated and wild germplasm is the god old method of crop improvement. Genetic variability estimation of working the collections (germplasm) is necessary for crop improvement. Genetic and environmental factors are the cause of the population's variability. When many factors contribute to total variability, the genetic gain is possible. Fairly 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. The wild and cultivated forms of *Jasminum rigidum* differed with morphological characteristics [15]. The wild type had corolla lobes measuring 1.5 x 0.5 cm and elliptic to ovate to lanceolate leaves (6.0 x 2.5 cm), whereas the cultivated type had slightly bigger corolla lobes (2.0 x 0.5 cm) and cordate to ovate to acuminate leaves (7.5 to 8.0 x 6.0 cm). Among *J. auriculatum* clones, an high-yielding clone "Parimullai" [16] was chosen for its resistance to gall mite infestation, a major problem in jasmine.

Polyploidy studies have been attempted in jasmine for crop improvement. In contrast to the diploid cultivars, a triploid type of *J. grandiflorum* (2n=39) was described with longer leaves, longer petals, a peduncle, a corolla cylinder, and buds that were larger and thicker [17,18]. In addition, the open blooms of *J. nitidum* are larger than those of *J. auriculatum* and the two *J. sambac* cultivars *viz.,* "Iruvatchi" and "Gundumalli." It was noted that the tetraploid *J. rigidum* did not significantly outperform the diploids in terms of bloom size, yield, or number of blooms per plant.

A population of *J. auriculatum* was divided into five morphological groups based on bud shape and size *viz.,* long pointed bud, medium pointed bud, short pointed bud, short round bud and long round bud. Focus on some *Jasminum* spp. blooming propensity and blossom yields, it was

found that *J. grandiflorum* produced the most blossoms, followed by *J. flexile* [19]. Two *Jasminum sambac* varieties, 'Two fold Mohra' and 'Big Double' had the largest buds and blooms. Another attempt revealed Madanban was the best variety among 15 *J. sambac* morphological variations pursued by Gundumalli and Ramabanam for various economically important characteristics like the shape of the bud, the length of the pedicel, the length of the corolla tube, the diameter of the flower, the number of blossoms per plant, and the amount of time it takes for a bud to open completely [20].

According to a study on open-fertilized seedlings of *J. auriculatum*, lengths of the flower bud and the corolla cylinder and the distance across the bloom buds varied greatly [21,22]. Focusing on the genetic improvement of *J. auriculatum*, it was discovered that the seedlings of mother clone, Short Round, were the best in terms of yield, weight and diameter of blossom buds. In addition, a significant variation in the weight of the blossom bud, the length of the corolla tube and the width of the bloom bud was also noted [23]. It was determined that the impact of the environment was extremely low for other flower characteristics and was extremely high for yield. The CO-1 Mullai (*J. auriculatum*) bloom bud character -a strong and long corolla tube, has been described in detail [24]. A clone of *J. grandiflorum* was found to have a high return of 10.15 tons of flower buds and a solid yield of 29.42 kg per hectare with a solid recovery of 0.29% [25] which was named as 'CO-1 Pitchi' later.

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; Globose buds– 'Yelu suthu mallige'- seven whorl and 'Gundu mallige'- round or globular jasmine-

Based on the leaves occurrence in triplates at the ends of the flowering branches, *Jasminum sambac* variety "Yelu suthu mallige" was indicated as *Jasminum sambac* variety "trifoliatum" [27].

Occurrence of floral dimorphism in stylar lengths of genus *Jasminurn grandiflorm* 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

One or a few genes will control the highly inherited traits. Heritable portion of genetic variation in a variable population is based on the additive gene action. If the other aspects of genetic variability, such as dominance and epistasis (non-additive gene action), are absent or negligible, a character under study will respond better to continuous selection [30]. In jasmine, a correlation, regression coefficient, and path analysis of eight characters that contribute to yield and its components revealed that there was a significant correlation between the number

of flowers and yield. The bud diameter, corolla tube length, and bud shape index all had significant and positive correlations with the weight of one hundred flowers. The number of flowers had the greatest direct effect on the yield, followed by the total length of the bud [31].

There was a positive correlation between the length of the style and the number of primary laterals and yield in *J. auriculatum* [32]. They also discovered that the length of the corolla tube is directly related to the weight of the flower buds, the length of the internodes and the number of flowering days. The correlation and path analysis studies with open pollinated *J. auriculatum* progeny from pin and thrum types [33] revealed that the per plant flower yield was significantly correlated with flower diameter, petal length, bud length, 100 bud weight, number of flowering branches per plant, and number of flowers per plant for the pin type. They came to the conclusion that 100 bud weight and the number of flowers per plant in thrum type and pin type *J. auriculatum* had a significant impact on yield.

2.5.2 Morphological variability

Among many germplasm and cultivar management applications, morphological traits are the most well-established and widely used genetic markers where in, the cultivars are categorized based on leaf, panicle, fruit and other physical characteristics. However, these characters may respond variedly to environmental conditions. Some genuine characteristics in some cultivars are still being discussed due to the fact that comparable cultivars developed in different regions frequently have distinct names [34]. Morphological markers are preferred for their simplicity, cost-effectiveness and ability to distinguish and examine even in herbarium specimens as well as other dead tissues. The maximum genetic distance between eight varieties of *J. sambac* and two varieties of *J. grandiflorum* collected across southern India was 83% [35]. The genetic dissimilarity matrix showed that. Co-2 Pitchi and Single Mohra are two distinct species with a genetic distance of just 21% between them. Both "Khoya" and "Khoya Large" are members of the same species, *J. sambac*. Based on Ward's method of cluster analysis, the dendrogram was created at 58 linkage distances grouped *J. sambac* and *J. grandiflorum* varieties into two major clusters, ‘A’ and ‘B’, respectively [36].

The collection of *Jasminum* species from various parts of Goa revealed that accession J-8 had the largest flower bud diameter (1.14 cm), while J-5 had the smallest (0.264 cm). Accession J-8 (4.7 cm) and J-7 (1.84 cm) had the longest and shortest bud lengths, respectively (36). Accession J-6 had the largest flower diameter (6.68 cm), while J-5 had the smallest (1.9 cm). Accession J-10's flowers had the most petals per flower, while J-1's flowers had the fewest (5.0 petals per flower) (43). The corolla tube length of J-14 flowers was 2.70 cm, while that of J-10 flowers was 0.864 cm which was longest and shortest, respectively.

Six parameters were found to be similar among five species of jasmine, which varied with respect to rest of the parameters [37]. The six characteristics which was shared by five species were: open flower color, number of corolla whorls, number of pistils, type of ovary, year-round flowering behavior and fruit setting potential. The flower diameters varied, ranging from 2.1 to 4.2 centimeters. While *J. flexile* had the smallest flower diameter, *J. nitidum* had the largest. *Jasminum calophyllum* and *J. flexile* produced white mature flower buds, whereas the remaining three species, *J. multiflorum* (Pink), *J. nitidum* and *J. rigidum*, produced pink-tinged buds. All species had two stamens, with the exception of *J. rigidum*, which had flowers with two and three stamens as observed with 6.66% of sampled flowers). Except for *J. multiflorum* (Pink), the pistil was exerted, slightly protruding from the mouth of corolla tube, in all the species. In contrast to the other species with undivided or not at all divided stigma, *J. calophyllum* had a clearly divided stigma tip. Flowering duration significant impacted by the season in the commercial species, *J. grandiflorum, J. auriculatum* and *J. sambac*..

Multivariate analysis of 30 Mysore mallige local collections based on cluster and principal component analysis (PCA) for yield and its eighteen contributing traits was conducted in 2018-19 [38] divided them into two major clusters. The greatest average intra-cluster distance was found between them (D2=1254.18). Flower bud weight (53.10%) contributed the most to the genetic divergence, followed by the number of petals (18.85%). Lengths of the corolla tube and the leaf, cluster 1 had the highest mean values than cluster 2. According to principal component analysis, the first five principal components were responsible for 83.44% of the total variations, with proportionate

contribution values of 40.88%, 18.42%, 10.17% and 8.19%, in order.

Another study with 34 traditional landraces from all over Tamil Nadu evaluated for 40 qualitative traits using the DUS descriptors for *J. sambac* [39]. The PCA method was deployed to examine variation and the traits' relative contributions to total variability, as well as to reduce the data's dimensionality. Genotypes exhibited the greatest variation for the traits *viz.,* leaf margin undulation, flower bud shape, flower shape, shape of corolla lobe, flower petal tip, leaf blade undulations, flower bud length and root suckers. The PCs with an eigen value greater than one accounted for 97.21% of the total variability. The results of PCA and Agglomerative Hierarchical Clustering demonstrated that genotypes *viz.*, Acc. Js- 11, Acc. Js- 12, Acc. Js- 13, Acc. Js- 14, Acc. Js- 20, Acc. Js- 25, Acc. Acc. 27 and Js. Js-32 were found to be the most diverse..

More than 20 quantitative characters had been recorded for 30 Mysore mallige local collections (Plate 2) in an RBD experiment with two replications [40]. Bud length, bud breadth, number of whorls, number of petals, pedicel length, length of corolla tube, length of filament, length of style, length of stigma and flower bud weight registered high genotypic and phenotypic coefficients of variation (GCV & PCV) (>20%). Petiole length, leaf length, leaf breadth, flower diameter, calyx length, number of calyx teeth, petal size number of stamen and length of the anther exhibited moderate (10-20%) GCV and PCV. For each character studied, the PCV was greater than the GCV. Characters such as, length of the bud, width of the bud, diameter of the flower, length of the calyx, number of teeth on the calyx, number of whorls, number of petals, size of the petals, length of the pedicel, length of the corolla tube, number of stamens, length of the anther, length of the filament, length of the style, length of the stigma and weight of the flower bud had higher (>20%) genetic advance over mean (GAM) values coupled with very high (>80%) heritability estimates. Petiole length registered a low GAM and moderate heritability (40-60%). Except for the length of the leaf character, the genotypic variance was highly significant for all characteristics.

2.6 Molecular Markers

Phenotypic traits are strongly influenced by environmental conditions and are inherited phylogenetically. As a result, the information gathered by phenotypic tests cannot be understood at the genetic level besides; it results in the maintenance of duplicate accessions. In this sense, the development of molecular markers had completely altered the landscape of plant science. DNA-based markers offered excellent tools for studying diversity at the DNA level, distinguishing cultivars, elucidating misnaming and genetic purity analysis are provided by such tools like, Randomly Amplified Polymorphic DNA (RAPD), Amplified Fragment Length Polymorphism (AFLP), Sequence Related Amplified Polymorphism (SRAP) and Simple Sequence Repeats (SSR).

When 32 cultivars of *Jasminum* spp. were examined using RAPD markers with 140 random ten base long primers and screened, a set of 35 primers produced 5 bands per primer [41]. Eight primers were chosen for diversity measurement because they produced an average of ten strong repeatable bands. 134 bands were amplified using these primers, and the number of polymorphic bands ranged from 13 to 26. The 32 jasmine cultivars showed moderate diversity when clustered using Ward's coefficient and dissimilarity matrix based on Squared Euclidean Distance.

With eight random primers, 120 amplified fragments were obtained with two and eight each varieties of *J. grandiflorum* and *J. sambac*, respectively when creating RAPD profiles [35]. Squared Euclidian Distances were used to calculate the genetic dissimilarity matrix, which indicated a maximum genetic distance of 83% between varieties 'Co-2 Pitchi' and 'Single Mohra' which are from two distinct species. The genetic distance of just 21% between Khoya' and 'Khoya Large' was observed which are the varieties of *J. sambac*. The study indicates that these two Jasminum spp. have moderate to high genetic diversity. Study demonstrated that, combining morphological analysis with RAPD markers proved to be an effective, quick and straightforward method for determining genetic diversity of *Jasminum* spp. Good amplifications were achieved with 26 primers in the genotyping of jasmine species using 54 primers [42]. There was 100% polymorphism in 19 primers and an average of 90.6 percent polymorphism in 26 primers. Based on the analysis of morphological and RAPD markers, two major clusters were found.

In a DNA fingerprinting study using hRAPD markers on the genetic diversity of jasmine

Plate 1. A close-up view of a Mysuru Mallige accession at college of horticulture Mysuru, Karnataka, India

species, OPX 6 primers produced the most distinct 75 bands, with 8 to 11 bands per sample [43]. Along with a few polymorphic bands, the majority of the bands were monomorphic. Jasmine species genetic population conservation, cultivar characterization and genetic diversity polymorphism can get great benefit from this method.ISSR was used to evaluate the genetic variations of 53 accessions from eight species of Jasminum collected from various regions of Iran [44]. 981 bands of varying sizes were produced by employing a total of 21 ISSR primers. The average polymorphic band percentage was 90.64%. For primers of 3, 4 and 3, the maximum resolving power, average polymorphic information content and marker index values were 21.55, 0.35, and 14.42, respectively. 53 accessions were divided into two major clusters using the Jaccard's coefficients-based arithmetic mean dendrogram and the unweighted pair group method. There were two subclusters within the first major cluster: The subclusters A and B contained three varieties of *J. sambac*: single, semi-double, and double flowers. Subcluster A contained *J. grandiflorum*, J. *officinale* and *J. azoricum*. Two subclusters were formed from the second major cluster: *J. humile*, *J. primulinum* and *J. nudiflorum* were found in the first subcluster (C), while *J. fruticans* were found in the second subcluster (D). *Jasminum officinale* had the highest percentage of polymorphism (34.05 percent), the highest Shannon index (0.151) and the lowest Nei's genetic diversity (0.098) at the species level. *Jasminum nudiflorum* exhibited the lowest percentage polymorphism (0.011), effective allele count (1.009), Shannon index (0.007) and Nei's genetic diversity (0.005) values. The pairwise population matrix of Nei's unbiased genetic identity revealed that *J. officinale* and *J. azoricum* shared the highest genetic identity (0.85), while *J. grandiflorum* and *J. perimulinum* shared the

lowest genetic identity (0.69). Eighty-three percent of the eight populations had genetic variations, according to molecular variance analysis. This study demonstrated that the ISSR can be used to identify relationships between jasmine genomic diversity studies. As many as thirty Mysuru mallige local collections were divided into two major clusters by the NTSYS-SHAN clustering dendrogram, one with 16 genotypes and the other with 14 genotypes at 56% similarity level and had a similar node [45]. The larger major cluster was further broken up into two sub-clusters at 82% similarity level. One of which contains seven genotypes, COHM-UHSB-1, COHM-UHSB-4, COHM-UHSB-12, COHM-UHSB-27, COHM-UHSB-26, COHM-UHSB-10 and COHM-UHSB-28; as well as the other sub cluster that contains nine genotypes, namely, 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. The remaining major cluster had two sub-clusters that shared a common node with 69% similarity. Genotypes, 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 shared a common node at a similarity level of 80%. Mysuru mallige with one whorled flowers were found in Sub-Cluster A, while those with two, three, five and seven whorls were found in Sub-Cluster B. The allele frequency of the SSR markers that produced polymorphic bands ranged from 0.67 for the SSR marker Js063 to 2.19 for the SSR marker Js035 with an average of 1.05 for all SSR markers. An allele frequency is a measure of genetic diversity at the individual, population, or species level in population genetics. Allele frequency fluctuations over time may indicate genetic drift or the introduction of new mutations into the population. The degree to which markers have a polymorphic information content value (PIC) is yet another indicator of population diversity. The fact that all SSR markers had an average PIC of 0.11 indicates that Mysuru mallige local collections have sufficient amount of genetic diversity.

Plate 2. Mysuru Mallige flowers and buds of two, three, one and seven whorls (Clockwise from top right)

3. SUMMARY AND CONCLUSIONS

In the perfumery and cosmetics industries, Jasmine is a well-known and has a distinctive brand. India is the largest exporter of jasmine oil and one of the centers of origin for jasmine. The degree of genetic variation present in the germplasm or population determines the program's success. Through selection or hybridization followed by selection, the rate and magnitude of genetic improvement can be determined by the extent of genetic variability. Use morphological and molecular (SSR) markers to assess genetic variation and divergence in Mysuru mallige is an important breeding tool for Jasmine's improvement has been initiated. In addition, the *Jasminum* spp. genetic diversity needs to be investigated immediately, in general and Mysuru mallige in particular for yield and quality traits besides biotic and abiotic resistance to meet rising demand and halt production and productivity declines.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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