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ORIGINAL ARTICLE **OPEN ACCESS**

Diversity evaluation of floral morphological traits of *Jasminum spp.* in relation to flower trade

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ABSTRACT
Jasmines are one of the commercially important flower crops of Southern and Eastern parts of India. Labour availability is a major problem in the cultivation of jasmines, especially during harvesting of flower buds and tying them into garlands. Availability of good sized buds with proper ratio between bud length and stalk (corolla tube) is a necessity for making good garlands, which is a constraint in commercially important species, J. sambac. There is a necessity to identify variants with flower buds having good ratio between the bud and the stalk to include them in breeding programmes for developing elite varieties. In the present study involving commercial and wild species, distinct variation was noticed in floral characters among 48 genotypes belonging to 26 different species. Descriptive statistics indicate very high Coefficient of variability for ratio between bud length and corolla tube length, number of whorls and number of petals. Flowers with corolla tube length of 0.5 cm to 1.0 cm and a ratio around 1.0, between bud length and corolla tube length can make good buds for making garlands. The present analysis show that among the 48 genotypes only seven genotypes J. sambac4, J. sp5 Lalbagh, J. sp7 Shimoga, J.multiflorum 2 , J. multiflorum 4, J. multiflorum6, and J. ritchiei have a ratio around 1.0 between bud length and corolla tube length. The cluster analysis using 'R'statistics revealed that these 48 genotypes can be grouped into four major clusters based on 15 floral characters.
Keywords: jasmine, diversity, floral, morphological, traits, flower trade.

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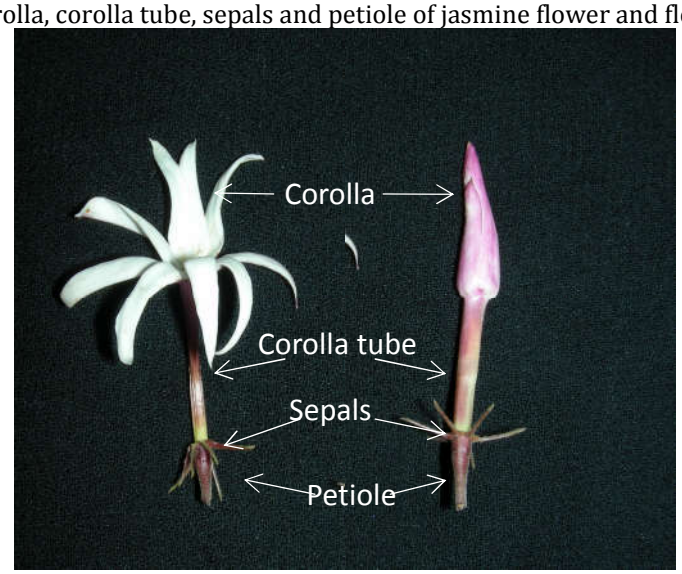
INTRODUCTION

Jasmines are one of the commercially important flower crop cultivated in the Southern and Eastern parts of India for their attractive and fragrant flowers. *J. grandiflorum, J. auriculatum, J. sambac* are the three commercially important species with fragrant flowers while *J. multiflorum* with non fragrant flowers having good post harvest life is also gaining market. The flowers are sold in both local and distant markets. About 15000 kgs of loose flowers are sold every day in big cities viz., Calcutta, Bombay, Delhi, Madras and Bangalore. They are also used in extraction of essential oil which is a highly lucrative business. Major jasmine producing states in our country are Tamil Nadu and Karnataka. In Karnataka it is grown in area of 6360 hectares with a production of 43,600 tonnes [1]. Jasmine flowers produced in Tamil Nadu and Karnataka state are being exported to the neighboring countries viz., Sri Lanka, Singapore, Malaysia and Middle East countries apart from being sold in local markets as mentioned above.

Jasmine is an ideal crop for small farmers whose land holdings are less than one acre. However, the demand for jasmine flowers in the market is not throughout the year and is mainly dependent on the season such as festivals and marriages during which these flowers are sold at a very high price. This kind of situation prevails even in Philippines where farmers from peri-urban area grow jasmines for their livelihood. It is the Philippine national flower and is considered as a symbol of honor and dignity.[15]. As a fresh flower, jasmine is used in bouquets and garlands to honor guests. Hence, research is necessary to increase volume of production and improve the
blossom quality to exploit local and export markets. [6]. In the Philippines jasmine has an all-year round demand for use in garlands, leis and flower arrangements for clusters and adornments. Harvesting of flower buds and tying them to make garlands are the two major operations that are labour intensive in

jasmine cultivation and marketing. Labour availability is a major problem in the present day crop production. Also, tying flowers is an art and a skill. Availability of good sized buds with proper ratio of the bud to stalk (the botanical corolla tube, Fig. 1) is a necessity for making good garlands which is a constraint in commercially important species *J. sambac*. Though research is concentrated around production of cultivars with higher flower yield, resistance to pests and diseases etc., no work has been initiated to evolve varieties with good floral characters such as bud length to stalk (corolla tube) length ratio. The present study aims at comparing flowers of various species and cultivars of jasmine to examine the variability existing among the genotypes with respect to characters related to floral trade. As there are no set standards for bud length, stalk length or their ratio, in the present study we have attempted to analyze diversity in flower characters of different species and tried to identify those flower types suitable for trading in the market so that they can be utilized in crop improvement programmes.

Fig 1. Corolla, corolla tube, sepals and petiole of jasmine flower and flower bud.



MATERIAL AND METHODS

Data on morphological characters of flowers were recorded from fortyeight genotypes belonging to 26 species maintained at Agricultural College, Hassan campus, University of Agricultural Sciences, Bangalore, India. This collection included 18 species growing in wild and eight species either cultivated commercially or found in home gardens (Table 1).

Table 1. List of genotypes used for the study.

Genotype #	Genotype name	Region	Wild/Cultivated
1	*J. sambac*1	Tamil Nadu	Cultivated (Commercial)
2	*J. sambac*2	Tamil Nadu	Cultivated (Commercial)
3	*J. sambac*3	Karnataka	Cultivated (Home garden)
4	*J. officinale*	Karnataka	Wild
5	*J. sambac* 4	Karnataka	Cultivated (Home garden)
6	*J. sp*1,Bangalore	Karnataka	Wild
7	*J. sambac* 5	Karnataka	Cultivated (Commercial)
8	*J. grandiflorum*1	Tamil Nadu	Cultivated(Commercial)
9	*J. sambac*6	Karnataka	Cultivated (Home garden)
10	*J. flexile*	Karnataka	Cultivated (Home garden)
11	*J. grandiflorum*2	*Tamil Nadu*	Cultivated(Commercial)
12	*J. sambac*7	*Karnataka*	Cultivated (Home garden)
13	*J. sp*2, Bangalore	*Karnataka*	Wild
14	*J. cuspidatum*	*Karnataka*	Wild
15	*J. multiflorum*1	*Karnataka*	Cultivated(Commercial)
16	*J. auriculatum*1	*Tamil Nadu*	Cultivated (Commercial)
17	*J. mesne*	*Karnataka*	Cultivated (Home garden)
18	*J. rigidum*	*Karnataka*	Cultivated (Home garden)
19	*J. sambac*8	*Karnataka*	Cultivated (Commercial)
20	*J. sambac*9	*Karnataka*	Cultivated (Commercial)

21	*J. sambac*10	*Karnataka*	Cultivated (Home garden)
22	*J. sambac*11	*Karnataka*	Cultivated (home garden)
23	*J. sambac* 12	*Karnataka*	Cultivated (Commercial)
24	*J. sp*3Lalbagh	*Karnataka*	Wild
25	*J. primulinum*	*Karnataka*	Cultivated (Home garden)
26	*J. dichotomum*	*Karnataka*	Wild
27	*J. angustifolium*	*Karnataka*	Cultivated (Commercial)
28	*J. communis*	*Karnataka*	Wild
29	*J. sp* 4 Lalbagh	*Karnataka*	Wild
30	*J. sp* 5 Lalbagh	*Karnataka*	Wild
31	*J. sp* 6 Lalbagh	*Karnataka*	Wild
32	*J. auriculatum*2	*Karnataka*	Cultivated (Commercial)
33	*J. roxburghianum*	*Karnataka*	Wild
34	*J. sp* 7 Shimoga	*Karnataka*	Wild
35	*J. sp* 8 Puttur	*Karnataka*	Wild
36	*J. sambac* 13	*Karnataka*	Cultivated (Home garden)
37	*J. malabaricum* 1	*Karnataka*	Wild
38	*J. malabaricum* 2	*Karnataka*	Wild
39	*J. malabaricum* 3	*Karnataka*	Wild
40	*J. multiflorum* 2	*Karnataka*	Cultivated (Commercial)
41	*J. calophyllum*	*Karnataka*	Cultivated (Home garden)
42	*J. multiflorum*3	*Karnataka*	Cultivated (Commercial)
43	*J. multiflorum* 4	*Karnataka*	Cultivated (Commercial)
44	*J.multiflorum* 5	*Karnataka*	Cultivated (Commercial)
45	*J. multiflorum*6	*Karnataka*	Cultivated (Commercial)
46	*J. rottlerianum*	*Karnataka*	Wild
47	*J. sambac* 14	*Karnataka*	Cultivated (Home garden)
48	*J. ritchiei*	*Karnataka*	Wild

The morphological traits related to flower buds and open flowers for all the 48 genotypes belonging to 26 species are listed in the table 2.The data was analyzed for simple statistics: Range, Mean, Standard deviation. The genotypes were clustered using "R" statistical package [12]. Digital visual database of flowers was prepared from the set of 48 genotypes (Not presented). To record the aroma of the flowers, a scale between 0-5 was adopted. A score of 0 was given to those flowers with no aroma, 1–very mild, 2 mild, 3- moderate, 4- high, 5-very high.

Table 2. Morphological Traits of *Jasminum* under consideration for evaluation.

Trait	Characters recorded
Bud	Length, diameter, colour, Bud length to breadth ratio, Corolla tube Length, Bud length to corolla tube length ratio
Flower	Number of whorls, Flower Diameter, Number of Petals, Petal length, Petal breadth, Ratio of petal length to breadth, Flower stalk length, Aroma

RESULTS AND DISCUSSION

Genetic diversity is a prerequisite, for any crop improvement programme. Exhaustive utilization of the genetic resources can enhance the performance of the crop species. Many of the landraces and wild species in the biodiversity contribute to the genetic resources. Intra- specific genetic variation creates genetic diversity and is a fundamental material for plant breeding. Genetically heterogeneous populations produce more and stable yield than genetically homogeneous lines [14]. Conventionally, morphological traits have been used to differentiate plant germplasm as well as to elucidate their genetic relationship [2].

Genetic diversity of any crop plays a very important role in developing new and novel desired forms through breeding and selection. Knowledge of diversity and its response to natural/human selection through hybridization is necessary for future breeding plan [3, 4], and is applicable to crop improvement programmes of loose flowers or traditional flowers such as Jasmine, Chrysanthemum, China aster, Marigold etc. Genus of Chrysanthemum, occupies an important place in Indian flower industry because of its variation in shape, size and color. All the present day colourful varieties of Chrysanthemum morifolium Ramat. have been developed through complex interspecific crosses among elemental species, open

pollination, indiscriminate intervarietal hybridization, spontaneous and induced mutation, selection and management of chimera. In floriculture industry there is always demand and necessity for new varieties. There is no record of total chrysanthemum varieties developed through classical breeding in different countries and there is an urgent need for developing crop wise database [4]. Depending on the consumer preference and requirements in the floriculture industry, efforts have been made by various research workers to select chrysanthemum varieties with specific economic characters. Lim-JinHee *et al*., [10, 11] 10] developed new Chrysanthemum cultivar "Sunny Pang Pang" having pompon type flowers with orange yellow petals and red flower center having a flower diameter of 4.4 cm with11 flowers per stem. Another variety developed,"Plaisir D' Amour", was a single type flowers with mixed color by dark pink and white edged showed excellent flower setting and early blooming with multi-floret with a flower diameter of 5.4 cm and15.5 flowers per stem. These varieties were developed depending on the market preference.

Early flowering in the season, duration of flowering, flower size, stalk length, flower weight and yield are also important economic characters in loose flower production. Dahiya, Sehrawat & Rana [5] reported that of the ten cultivars of spray chrysanthemum that they evaluated, flowering was earliest in the variety Lal Pari. Duration of flowering was maximum in Varieties – Guari,Vasantika, Puja, Flirt, Jayanti, Jaya. Maximum flower size and stalk length were recorded in Puja and minimum in Gauri and Jayanti, respectively. Flower weight was maximum in Basanti and minimum in Gauri. Maximum number of flowers and yield per plant was recorded in Puja and minimum in Jayanti.

Characterizing the genetic diversity present in a working set of plant germplasm can contribute to its effective management and genetic improvement. With the repeated germplasm exchange and intensive breeding activities, it remains a major task in genetic research. Li-PiRui et al, (2016) characterized the genetic diversity and the population structure of a worldwide collection of 159 (Chrysanthemum morifolium Ramat.) varieties, and applied an association mapping approach to identify DNA-based markers linked to five plant architecture traits and six inflorescence traits. The genotyping demonstrated that there was no lack of genetic diversity in the collection and that pair-wise kinship values were relatively low. The clustering based on a Bayesian model of population structure did not reflect known variation in either provenance or inflorescence type. A principal coordinate analysis was, however, able to discriminate most of the varieties according to both criteria. The findings provide an in-depth understanding of genetic diversity and population structure present in cut flower chrysanthemum varieties, and an insight into the genetic control of plant architecture and inflorescence-related traits.

Zhai-LiLi *et al*., [17] established a synthetic system for assessing the ornamental values and drought and flooding resistance of Guoqing chrysanthemum with small inflorescences, and to offer a theoretical support for selection, extension and application. A synthetic system was established by using analytic hierarchy process and the K-Means clustering method was applied to differentiate the rank of cultivars. 5 excellent and 11 good cultivars were selected that could be extended in lager areas.

Genetic variation and genetic relationship among genotypes is an important consideration for classification, utilization of germplasm resources and breeding [8]. The presence and magnitude of genetic variability in a gene pool is the pre-requisite of a breeding programme [2]. Apart from this correlations as well as path coefficient are important tools for the selection of desirable traits and to enhance the productivity of the African marigold to meet the market demand. The main objective for a plant breeder is to evolve high yielding varieties. It is therefore, desirable for plant breeder to know the extent of relationship between yield and its various components, which will facilitate selection based on component traits. Usha *et al* [16] analyzed and determined the traits having greater interrelationship with flower yield utilizing the correlation and path analysis and to help breeders in improvement of African marigold. Plant height, number of flowers per plant, flower size, single flower weight and number of petals per flower are the characters that need to be given importance for selection during breeding for high flower yield in African marigold. The path coefficient analysis indicated that the characters viz., plant height, number of flowers per plant, flower size, single flower weight, number of petals, number of harvests per plant and total crop duration are reliable indices for selection of genotypes for yield.

Varietal improvement progrmammes aiming at development of suitable varieties to meet the market requirement is a major research activity in china aster also which is another important loose flower in Indian market. Sailaja *et al*, [13], recorded variation in yield characters of four varieties of China Aster with respect to number of flowers per plant, and flower yield per hectare. Maximum yield was noticed in the variety Phule Ganesh White.

Crop improvement programme in jasmines involving commercially important species have always aimed at enhancing the flower yield, essential oil content of flowers besides resistance to pests and diseases. However, certain morphological traits of flowers are also of commercial importance as far as the loose flower production is considered. These morphological traits of loose flowers are - length of pedicel (influences the ease with which flower buds can be picked), length of corolla tube (important in tying of

flowers to make floral streamers and garlands) and size and shape of the bud (affects the quantum of filling in flowers) [7].

In the present study among 48 genotypes involving commercial and wild species, distinct variation was noticed in floral characters. Table 3 indicates the variability of floral characters existing among the genotypes belonging to 26 different species. Descriptive statistics indicate very high Coefficient of variability for ratio between bud length and corolla tube length, number of whorls and number of petals.

Maximum variability noticed in case of ratio between bud length and corolla tube length indicates occurrence of genotypes with a very good range between 10 and 0.31. This variability helps in selection of parents for developing varieties with buds having length proportionate to corolla tube so that such buds can be harvested easily and preparation of garlands will be less tedious minimizing labour requirement.

Variability noticed in number of whorls, though high, is not of much importance as mostly single whorled flowers are preferred in the market. Also, flowers with more than one whorl is noticed only *J. sambac* and *J. primulinum. J. sambac* has many variant specially in flower whorl containing double, three, five, seven, twelve and multiple whorls while *J. primulinum* flowers have two whorls in addition to single whorl flowers. Genotypes under these two species have contributed to high variability in number of whorls.

Number of petals influences the size and shape of the bud which in turn affects the quantum of filling in flowers. High variation was also noticed in number of petals per flower. However except *J.sambac* and *J. primulinum* since all other species have single whorl, this variation is the major contribution of only *J. sambac* and *J. primulinum*. However, as the number of petals is also related to number of whorls and the maximum number of petals seen per flower is 62, in a multi whorled flower, importance should be given to single whorled flowers with more number of flowers rather than mere number of petals.

Bud length and corolla tube length, which are also the morphological characters of commercial importance show less variation among the genotypes. Bud length is very good in *J. malabaricum* 3 while corolla tube length is more in case of *J. rottlerianum*.

Table 3. The descriptive statistics of*Jasminum*flowers of 48 genoytpes

Sl No.	Flower character	Average	Standard deviation	Maximum	Minimum	Range	Coefficient of variation
1	Bud Length (cm)	1.25	0.46	2.6	0.42	1.75	37.25
2	Bud Breadth (cm)	0.63	0.48	2.59	0.2	3.78	76.5
3	Ratio (Bud length x breadth)	2.45	1.07	5.2	0.45	1.94	43.6
4	Flower Diameter (cm)	3.1	0.89	5.36	1.45	1.26	28.7
5	Flower Stalk length (cm)	0.66	0.54	2.33	0.15	3.3	82.4
6	Calyx Length (cm)	0.88	0.41	1.86	0.23	1.85	46.03
7	Number of Calyx Teeth	6.83	4.77	38	4.3	4.94	69.87
8	Corolla Tube Length (cm)	1.59	0.5	3.08	0.2	1.81	31.38
9	Ratio (Bud Length x Corolla tube length)	0.98	1.36	10	0.31	9.87	138.94*
10	Number of Whorls	1.73	2.15	12	1	6.35	123.8*
11	Number of Petals	12	12.4	62	4.7	4.77	103.34*
12	Petal Length (cm)	1.4	0.44	2.57	0.65	1.37	31.28
13	Petal Breadth (cm)	0.59	0.28	1.6	0.2	2.36	47.10
14	Ratio (Petal Length x Petal breadth)	2.71	1.08	5.36	0.75	1.7	40.00
15	Aroma	3.21	1.65	5	0	1.56	51.42
16	Flower length	2.84	0.73	4.53	1.57	1.04	25.6

*values more than hundred as extreme variations are noticed in corolla tube length, number of whorls and petals.

Flower diameter shows very less variation compared to number whorls and number of petals. Flowers of *J. roxburghianum* are very small, flower diameter being as low as 1.45 cm while that of *J. angustifolium* flowers are large and has a maximum flower diameter of 5.36 cm.As such the flower diameter in

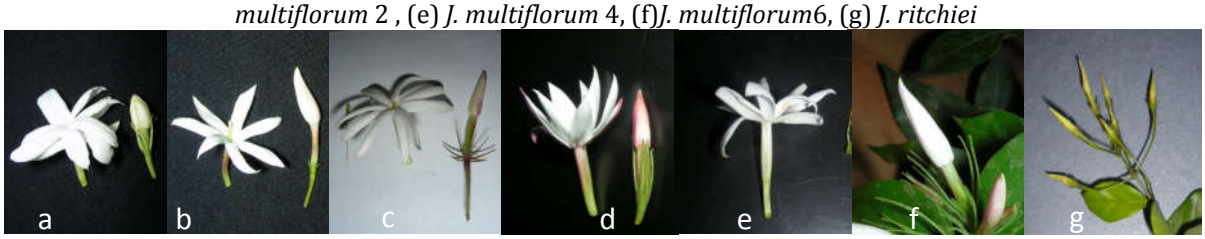
commercially cultivated species are optimum and are accepted by the consumer. However, the available variation can be further exploited in breeding programmes.

The prominent variation noticed in ratio between bud Length and corolla tube length is a noteworthy factor. This ratio is an important trait of loose flowers as far as the marketability and acceptance is considered. Good bud length and corolla tube length are a preferred for preparation of garlands and for tying of flowers. The bud and corolla tube length are highly related to genotype. Among commercially cultivated types *J. sambac* have small buds with short corolla tube than the other three species namely *J. auriculatum, J. grandiflorum* and *J. multuflorum.* Among the*J. Sambac* variants studied, minimum bud length of *J. sambac* buds was 0.94 cm and maximum was 2.40 cm.

There are no set standards with respect to ratio between bud length and corolla tube length. However flower types with corolla tube length of 0.5 cm to 1.0 cm and a ratio around 1.0 between bud length and corolla tube length can make good buds for making garlands. Very long corolla tubes with small sized buds will also be unacceptable as loose flowers.

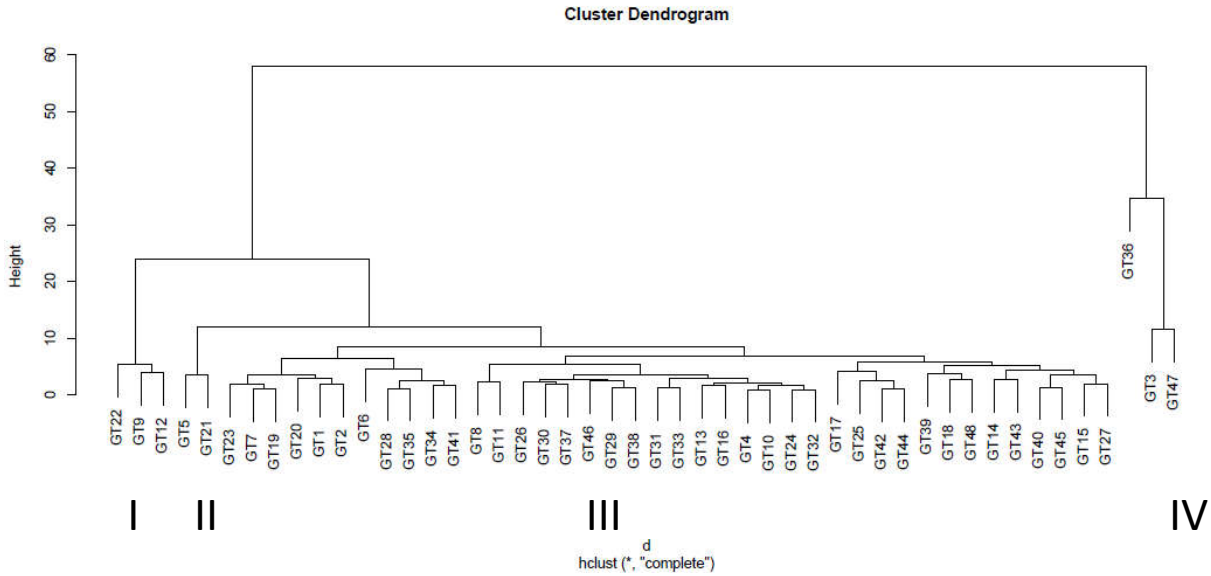
The present analysis show that of the 48 genotypes only seven genotypes *J.sambac* 4, *J. sp* 5 Lalbagh, *J. sp* 7 Shimoga, *J.multiflorum* 2 , *J. multiflorum* 4, *J. multiflorum*6, *J. ritchiei*have a ratio around 1.0 between bud length and corolla tube length (Fig. 2)

Fig.2 Flower buds or flowers of genotypes of (a) *J. sambac* 4, (b) *J. sp* 5 Lalbagh, (c) *J. sp* 7 Shimoga,(d) *J. multiflorum* 2 , (e) *J. multiflorum* 4, (f)*J. multiflorum*6, (g) *J. ritchiei*



The cluster analysis using 'R'statistics revealed that these 48 genotypes can be grouped into four major clusters based on 15 floral characters mentioned in the table 2. Of the 48 genotypes, 45 genotypes fell in one major group having three clusters, while the other three genotypes formed a fourth cluster which resulted in a separate group (Fig. 3).

Fig. 3. Dendrogram depicting the grouping of *Jasminum* genotypes based on floral characters



In the first group of 45 genotypes, the cluster I and cluster II consisted of only three (*J. sambac*11, *J. sambac 6, J. sambac 7*)and two genotypes (*J. multiflorum 1, J. sambac 10) re*spectively while cluster III had 40 genotypes and was the largest cluster. All the three genotypes in cluster I were *J. sambac* variants having flowers whorls more than two *i.e.,* three and five while the genotypes in cluster II consisted non-cultivated *J. sambac* variants consisting of flowers only with two whorls. Further, the three genotypes in

cluster IV are also of *J. sambac* variants and have flowers with more than five whorls, such as seven, twelve or multi whorl. All these variants of *J. sambac*are not commercially important and are grown in home gardens.

The major cluster III with 40 genotypes, all the commercially cultivated and wild species of jasmine including those grown in home gardens with single whorled flower type except for *J. primulinum.* This species produces double whorled flowers that are yellow in colour.

Hitherto, there has been no reports are available on clustering of jasmine species based on their floral characters. The present study helps in grouping the genotypes of 26 species in to various clusters which aids in making the selection process easier for further crop improvement programme with respect to floral characters keeping in mind the consumer preference.

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