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RESEARCH ARTICLE

Diversity Analysis and Characterization of Jasmine (*Jasminum* spp.)

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Abstract

Twenty-one *Jasminum* accessions were evaluated for morphological traits. The jasmine accessions exhibited bush and climber types of plant growth habits. Simple, pinnately compound and trifoliate compound leaves were noticed among the accessions. The highest leaf length was recorded in accession TNAU Jn 1(10.22 cm), while higher leaf breadth and leaf area were recorded in KAU Js 2 (05.35 cm and 29.60 sq.cm, respectively). The majority of accessions had pointed and round-shaped flower buds with white flower and flower bud color. Accessions *viz.* KAU Jm 3, KAU Jn 1, KAU Jn 2, TNAU Jn 1 and CO 2 *Pitchi* had pink flower buds. The highest flower bud length was observed in *J. grandiflorum* accessions, while the flower bud width was high in *J. sambac* accessions (KAU Js 1 and KAU Js 11). Significantly highest flower diameter was recorded in TNAU Jn 1 and KAU Jn 1. Most of the accessions were seasonal, while some flowered throughout the year (*J. multiflorum* and *J. nitidum*). The accession KAU Jm 1 was found superior in terms of total flower yield. Cluster diagrams on quantitative characters indicated significant diversity among the accessions.

Keywords: Genetic divergence, Jasmine, *Jasminum* spp., K-means clustering, Morphological characterization.

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Introduction

Jasmine (*Jasminum* spp.) is one of the oldest fragrant flowers cultivated by man. The genus *Jasminum* is the largest genus in the olive family Oleaceae, which has more than 200 species, 40 of which have been recognized in India, and 20 are grown in South India. (Bhattacharjee, 1980; Green and Miller, 2009). In India, only three species, *viz*., *Jasminum sambac, J. grandiflorum,* and *J. auriculatum* are under commercial cultivation.

Jasmine flowers are well known for making garlands floral decorations and for essential oil extraction. They give out a strong, persistent scent that is fine, sweet, and fruity, which commands a high price in the international essential oil markets. India is the largest exporter of jasmine oil in the world, with a 40% share of total world exports (Kumar *et al.*, 2009). Jasmine essential oil is considered unique as it blends well with other floral extracts and is highly coveted worldwide for producing high-grade perfumes and cosmetic products (Ramdas *et al.*, 1993).

There is the scope of promoting under-exploited species of *Jasminum* like *J. nitidum* and *J. multiflorum* (Nair, 2000), which are now encouraged in commercial cultivation due to their positive traits, *viz*., off-season flowering, biotic stress resistance, *etc*. (Ganga *et al.*, 2015). The collection of jasmine germplasm and its morphological evaluation will provide an idea about the diversity and relatedness among the genotypes. This will further assist the planned breeding program (Nirmala *et al.*, 2017), which will yield improved cultivars. So, a better understanding of genetic diversity is essential for commercial utilization and its conservation. As a popular commercial crop in Kerala, a detailed characterization of the different *Jasminum* species prevalent in Kerala is essential.

Materials and Methods

The present study was carried out at the Department of Floriculture and Landscaping, College of Agriculture, Kerala Agricultural University, Vellanikkara (10^0 54′ N and 76^0 28′ E), Thrissur, from 2021-2022. The experiment was conducted using a randomized block design (RBD) with five replications. About 21 accessions of *Jasminum* belonging to seven different species available at AICRP on Floriculture, Vellanikkara, Thrissur, Kerala, were selected for the study (Table 1).

The observations on vegetative and floral characters were recorded for one year among 21 jasmine accessions (Figure 1), as per the DUS guidelines prescribed by the Protection of Plant Varieties and Farmer's Rights Authority, Government of India. Parameters like the phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), correlation coefficients, heritability (H^2), and genetic advance as percentage of the mean (GAM) and path coefficient (Chandramohan *et al*., 2016) were computed, analyzed using statistical software GRAPES 1.0.0 package (Gopinath *et al*., 2020). Mahalanobis D^2 statistics (1936) was employed to assess the genetic divergence among the genotypes, and they were classified into various clusters using Tocher's method (Singh *et al*., 2020).

Results and Discussion

The jasmine accessions showed significant variation in plant growth, displaying two growth habits: bush and climber (Table 1). Accession with viny nature had more plant height compared to the shrub type. The highest plant height was noticed in KAU Jm 1 (225.06 cm). Pigmentation in young shoots of certain cultivars of *J. sambac* was documented by Chaitanya *et al*. (2020), and in our study, similar pigmentation was observed in *J. nitidum* as well (Table 1).

The majority (76%) of accessions exhibited simple leaf types (Table 1), while 24% displayed pinnately compound and trifoliate leaves. Similar variations in jasmine leaf characteristics were reported by Kartheka *et al.* (2021). All the accessions exhibited opposite phyllotaxy, with sharp leaf tips being dominant. Leaf pubescence was absent in 86% of accessions, except in KAU Ja 1, KAU Jm 1 and KAU Jm 2. Significant variation in leaf length and breadth was recorded among the accessions, with TNAU Jn 1 having the longest leaves and KAU Js 2 having the widest leaves and highest leaf area (5.57–29.60 cm^2) (Table 2). Variations in the characteristics are illustrated in Figure 2.

In 80% of the accessions recorded terminal and axillary flower-bearing positions, others had terminal flower-bearing

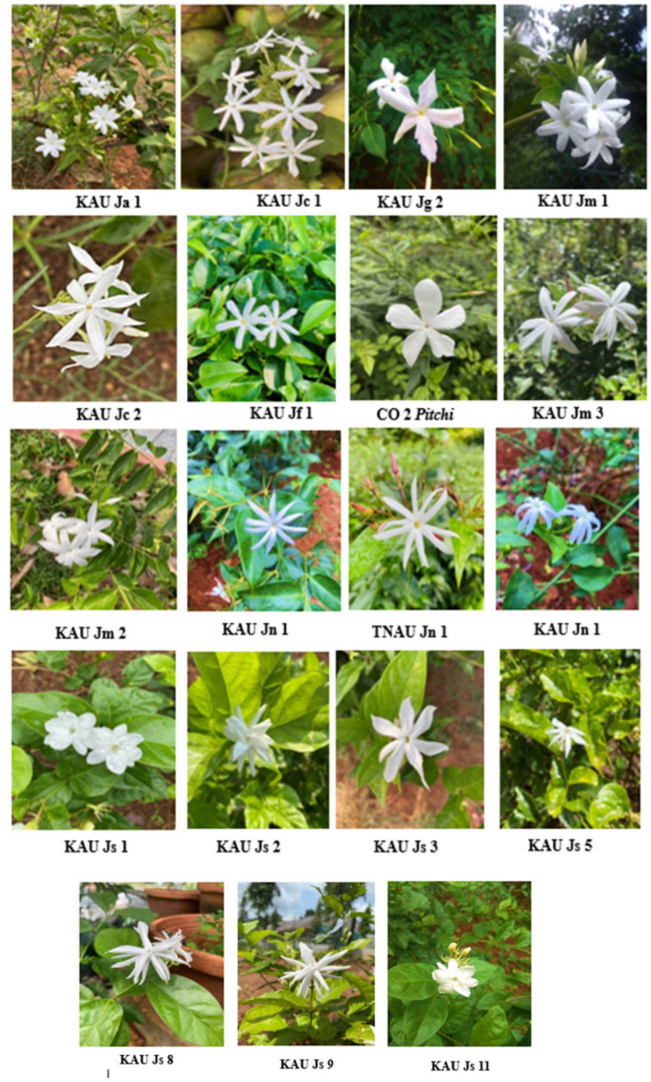

Figure 1: Accessions used in the study

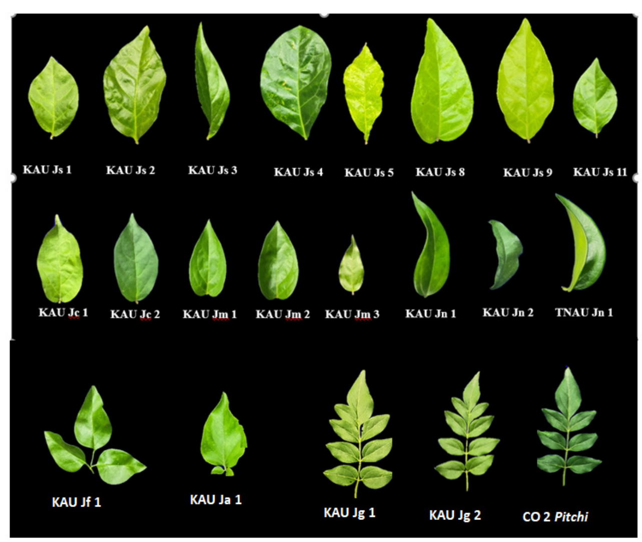

Figure 2: Variations in leaves of *Jasminum* accessions

Table 1: Qualitative characters of *Jasminum* accessions

Name of the accessions	*Accessions*	*PGT*	*PYS*	*LT*	*LA*	*LTi*	*LP*	*FBP*	*FBH*	*FT*	*FBS*	*TFB*	*SCL*	*FF*	*SS*
J. auriculatum	KAU Ja 1	Shrub	A	TC	O	Sh	P	T&A	C	SW	R&L	A	Short	P	P
J. coarctatum	KAU Jc 1	Climber	A	S	O	Sh	A	T&A	C	SW	P&S	A	Short	P	P
J. coarctatum	KAU Jc 2	Climber	A	S	O	Sh	A	T&A	C	SW	P&S	A	Short	P	P
J. fluminense	KAU Jf 1	Shrub	A	TC	O	Sh	A	T	C	SW	R&L	A	Short	P	A
J. grandiflorum	KAU Jg 1	Shrub	A	PC	O	Sh	A	T	C	SW	P&L	A	Long	P	A
J. grandiflorum	KAU Jg 2	Shrub	A	PC	O	Sh	A	T	C	SW	P&L	A	Long	P	A
J. grandiflorum	CO 2 *Pitchi*	Shrub	A	PC	O	Sh	A	T	C	SW	P&L	P	Long	P	A
J. multiflorum	KAU Jm 1	Climber	A	S	O	Sh	P	T&A	C	SW	P&S	A	Medium	P	A
J. multiflorum	KAU Jm 2	Shrub	A	S	O	Sh	P	T&A	C	SW	P&L	A	Medium	A	A
J. multiflorum	KAU Jm 3	Shrub	A	S	O	Sh	A	T&A	C	SW	P&L	P	Long	A	P
J. nitidum	KAU Jn 1	Shrub	P	S	O	Sh	A	T&A	C	SW	P&L	P	Medium	P	A
J. nitidum	KAU Jn 2	Shrub	A	S	O	Sh	A	T&A	C	SW	P&L	P	Medium	P	P
Jasminum nitidum	TNAU Jn 1	Shrub	P	S	O	Sh	A	T&A	C	SW	P&L	P	Medium	P	A
Jasminum sambac single whorled	KAU Js 1	Shrub	A	S	O	M	A	T&A	C	SW	R&F	A	Medium	P	A
Jasminum sambac double whorled	KAU Js 2	Shrub	A	S	O	M	A	T&A	S&C	DW	R&L	A	Long	P	A
Jasminum sambac var. *Soojimalli*	KAU Js 3	Shrub	P	S	O	Sh	A	T&A	S&C	SW	R&L	A	Long	P	A
Jasminum sambac multi whorled	KAU Js 4	Shrub	A	S	O	M	A	T&A	S&C	MW	R&S	A	Short	P	A
Jasminum sambac single whorled	KAU Js 5	Shrub	P	S	O	Sh	A	T&A	C	SW	P&S	A	Medium	P	A
Jasminum sambac multi whorled	KAU Js 8	Shrub	A	S	O	M	A	T&A	C	MW	R&L	A	Medium	P	A
Jasminum sambac multi whorled	KAU Js 9	Shrub	A	S	O	M	A	T&A	C	MW	R&L	A	Medium	P	A
Jasminum sambac single whorled	KAU Js 11	Shrub	A	S	O	M	A	T&A	C	SW	R&F	A	Medium	P	A

PGT – Plant growth type PYS- Pigmentation of young shoot A- Absent P- Present LT- Leaf type PC- Pinnately compound TC- Trifoliate compound S- simple LA- Leaf Arrangement LTi- Leaf Tip Sh-Sharp M- Medium LP- Leaf pubescence FF-Flower fragrance SS- Sees setting FBP- Flower bearing position T&A- Terminal & Axillary T- Terminal FBH- Flower bearing habit C- Cluster S&C- Solitary & Cluster FT- Flower type SW- Single whorled DW- Double whorled MW- Multi whorled FBS- Flower bud shape R&L-Round & long P&S- Pointed & short P&L-Pointed & long R&S-Round & short R&F- Round & flattened TFB- Tinge on the flower bud FBC-Flower bud colour SCL- Size of calyx lobes

Table 2: Quantitative characters of *Jasminum* accessions

Accessions	*PH (cm)*	*NPB*	*NSB*	*Leaf length (cm)*	*Leaf breadth (cm)*	*Leaf area (cm^2)*	*FBL*	*FBW*	*FD*	*CTL*	*CTG*	*NFPS*	*NCL*	*LP*	*WP*
KAU Ja 1	117.30	5.00	16.33	4.46^{k}	2.83^{h}	7.58^{l}	2.87^{e}	0.51^{d}	2.86^{k}	1.58^{f}	0.20^{f}	29.89^{b}	4.96^{f}	1.11^{h}	0.41^{kl}
KAU Jc 1	225.06	6.33	14.66	8.71^{de}	5.28^{a}	28.54^{b}	3.64^{b}	0.37^{f}	2.96^{k}	2.53^{a}	0.28^{bc}	12.73^{f}	5.70^{e}	1.11^{h}	0.43^{ijkl}
KAU Jc 2	60.00	4.00	4.66	8.82^{cd}	5.30^{a}	28.33^{b}	3.26^{d}	0.33^{g}	2.97^{k}	2.55^{a}	0.28^{bc}	12.35^{f}	5.63^{e}	1.51^{fg}	0.32^{m}
KAU Jf 1	99.13	6.66	15.66	6.50^{h}	3.37^{g}	11.41^{k}	3.36^{cd}	0.52^{d}	3.06^{jk}	2.02^{d}	0.20^{f}	35.06^{a}	6.06^{cde}	1.33^{g}	0.40^{l}
KAU Jg 1	220.00	6.66	13.33	8.32^{f}	4.56^{de}	15.56^{i}	3.93^{a}	0.33^{g}	4.25^{cde}	2.22^{b}	0.13^{g}	23.79^{c}	5.13^{f}	1.78^{de}	0.88^{bc}
KAU Jg 2	154.10	6.33	14.66	8.32^{f}	4.49^{e}	15.34^{ij}	3.86^{a}	0.33^{g}	4.02^{ef}	2.16^{bc}	0.14^{g}	20.46^{de}	5.03^{f}	1.89^{cde}	0.90^{b}
CO 2 *Pitchi*	158.80	6.66	16.66	8.64^{de}	4.71^{c}	16.71^{h}	4.00^{a}	0.33^{g}	4.14^{e}	2.47^{a}	0.14^{g}	20.99^{cd}	5.13^{f}	1.89^{cde}	0.85^{c}
KAU Jm 1	229.16	7.00	19.66	6.25^{i}	3.50^{g}	14.68^{j}	2.48^{gh}	0.33^{g}	3.73^{g}	1.39^{gh}	0.24^{de}	2.96^{k}	6.30^{bcd}	1.48^{g}	0.49^{gh}
KAU Jm 2	83.86	4.66	8.33	6.21^{i}	3.47^{g}	15.10^{ij}	3.31^{d}	0.50^{d}	3.61^{gh}	1.78^{e}	0.28^{bc}	21.67^{d}	5.93^{cde}	1.71^{ef}	0.60^{de}
KAU Jm 3	72.93	3.66	9.33	4.28^{k}	2.20^{i}	5.57^{m}	3.54^{bc}	0.43^{e}	4.43^{bcd}	2.01^{d}	0.29^{b}	17.76^{e}	6.00^{cde}	1.99^{bc}	0.53^{fg}
KAU Jn 1	125.16	5.66	17.00	9.24^{b}	4.59^{cde}	25.89^{d}	3.64^{b}	0.37^{f}	4.64^{ab}	2.07^{cd}	0.26^{cd}	13.66^{f}	5.93^{cde}	2.19^{a}	0.46^{hij}
KAU Jn 2	103.56	5.33	17.00	5.30^{j}	2.18^{i}	7.87^{l}	2.92^{e}	0.23^{h}	3.43^{hi}	1.45^{g}	0.24^{d}	2.83^{h}	6.63^{ab}	2.01^{abc}	0.42^{jkl}
TNAU Jn 1	135.96	5.66	16.66	10.22^{a}	3.69^{f}	23.01^{e}	3.37^{cd}	0.37^{f}	4.81^{a}	2.03^{d}	0.23^{de}	12.72^{f}	5.86^{de}	2.19^{a}	0.45^{ijk}
KAU Js 1	111.86	5.00	20.66	7.50^{g}	4.66^{cd}	21.35^{f}	2.37^{h}	0.96^{a}	3.29^{ij}	1.30^{hi}	0.33^{a}	7.41^{g}	6.60^{ab}	1.34^{g}	0.94^{a}
KAU Js 2	129.53	5.33	21.33	8.92^{c}	5.35^{a}	29.60^{a}	2.80^{ef}	0.81^{c}	4.19^{de}	1.47^{g}	0.31^{ab}	1.54^{h}	6.53^{ab}	1.98^{bc}	0.56^{ef}
KAU Js 3	135.00	4.33	21.66	9.36^{b}	3.42^{g}	17.65^{g}	3.22^{d}	0.39^{f}	4.51^{bc}	2.23^{b}	0.21^{ef}	2.87^{h}	6.56^{ab}	2.18^{ab}	0.39^{l}
KAU Js 4	129.56	4.66	22.00	8.42^{f}	5.39^{a}	28.62^{b}	1.60^{i}	0.94^{a}	2.95^{k}	1.15^{j}	0.30^{ab}	2.55^{h}	5.93^{cde}	1.09^{h}	0.56^{ef}
KAU Js 5	85.60	4.66	13.66	7.59^{g}	3.75^{f}	17.93^{g}	2.66^{fg}	0.32^{g}	2.59^{l}	1.45^{g}	0.23^{de}	2.80^{h}	6.86^{a}	0.69^{i}	0.46^{hi}
KAU Js 8	92.80	3.33	7.66	9.31^{b}	4.58^{cde}	28.58^{b}	3.18^{d}	0.80^{c}	3.79^{fg}	1.30^{hi}	0.31^{ab}	2.97^{k}	6.20^{bcd}	1.91^{bc}	0.61^{d}
KAU Js 9	93.26	3.33	08.33	8.51^{ef}	4.89^{b}	27.06^{c}	3.33^{d}	0.86^{b}	3.85^{fg}	1.27^{i}	0.29^{b}	2.86^{h}	6.36^{bc}	1.84^{cde}	0.59^{de}
KAU Js 11	138.16	5.00	20.66	7.52^{g}	4.67^{cd}	23.54^{e}	2.30^{h}	0.96^{a}	3.27^{ij}	1.33^{hi}	0.33^{a}	6.73^{g}	6.60^{ab}	1.46^{g}	0.94^{a}
C. V (%)				1.57	2.28	2.27	3.70	3.96	4.43	3.24	7.23	13.02	4.39	7.23	4.25
C. D (0.05)				0.20	0.15	0.73	0.19	0.03	0.27	0.09	0.03	2.88	0.43	0.19	0.04

PH- Plant Height NPB- No. of Primary Branches NSB- No. of secondary branches/plant FBL- Flower bud length FBW- Flower bud width FD- Flower diameter CTL- Corolla Tube Length CTG- Corolla tube girth NFPS- Number of forks per cyme NCL- No. of calyx lobes LP- Length of petal WP-Width of petal positions (19%). Most of the accessions showed cluster bearing habit which is preferred for loose flowers, as they will produce a greater number of flowers and also make them suitable for home gardens. Mukundan *et al.* (2008) identified single-whorled, double whorled and multi-whorled flower types in *J. sambac*. Most of the accessions studied (81%) have a single-whorled type, which is preferable for garland making and essential oil extraction. Double-whorled (KAU Js 2) and multi-whorled (KAU Js 4, KAU Js 8 and KAU Js 9) can be used for landscaping. Multi whorl type is more suitable for gardens. It can also be used in crop improvement programs to enhance flower size (Table 1).

The majority of the accessions had two stamens, with significant variations in the length of filament, anther, style and stigma. Deng *et al.* (2017) observed that pollen viability and stigma receptivity varied depending on the petal phenotype and flowering stage.

Pointed and round-shaped flower buds were dominant in jasmine accessions. The pointed buds are preferred for making flower strings, whereas round buds are suitable for garlands due to their larger appearance. So, the accessions KAU Js 3, KAU Js 5, KAU Jg 1, KAU Jg 2 and CO 2 *Pitchi*, KAU Jn 1, TNAU Jn 2 and KAU Jn 1, KAU Jm 1, KAU Jm 2 and KAU Jm 3 can be used for making flower strings for hair decoration, while, KAU Js 1, KAU Js 2, KAU Js 4, KAU Js 8, KAU Js 9, KAU Js 11 will be more suitable for garlands. 76% of the flower buds also exhibited white color. However, accessions such as KAU Jm 3, KAU Jn 1, KAU Jn 2, TNAU Jn 1 and CO 2 *Pitchi* have pink colour on the ventral surface of flower buds. Flower bud colors of accessions are depicted in Figure 3.

Significant variations in floral characters were also recorded (Figure 3, Table 3). The longest flower bud was observed in *J. grandiflorum* accessions, while the highest flower bud width was noticed in KAU Js 1 and KAU Js 11. The larger flower diameter was noted in *J. nitidum* accessions (TNAU Jn 1 and KAU Jn 1). Khan *et al.* (1970) observed variations in the width of the flower bud, the diameter of the flower and the corolla tube length in *J. sambac* could be due to natural crossing, simple mutation and polyploidy.

The number, length and width of petals have economic importance for loose flower trade. *J. sambac* KAU Js 4 had the highest petal count. Longer corolla tube in jasmine is preferred for ease in tying flowers, and was noticed in *J. coarctatum* (2.54 cm). Khan *et al.* (1970) reported that the larger corolla tube length and petal in *J. grandiflorum* may be due to its triploid nature. Hence triploid breeding in selected jasmine species can be further added to the improvement in floral characters.

Significant variation was also observed in corolla tube girth. In all the species except KAU Jm 3 and *J. sambac*, the pistil was slightly protruding out of the mouth of the corolla tube. A similar observation was reported (Srivastava and Kumar, 2004), wherein floral dimorphism expressed long and short carpel in *J. multiflorum* (Figure 4). The tip of the stigma was distinctly bifid in *J. sambac* accessions, whereas, in the other species, it was not distinctly divided. This aligns with the findings of Lakshmi and Ganga (2017). A greater number of calyx lobes was observed in KAU Js 5, which is not desirable as they increase the time of picking and sorting of flower buds. Similar studies have been reported by Raman *et al.*, (1969). Tinge on the calyx lobes was recorded in KAU Js 3 and KAU Js 5 only. The highest number of forks per cyme

Figure 3: Variations in the floral characters of jasmine accessions

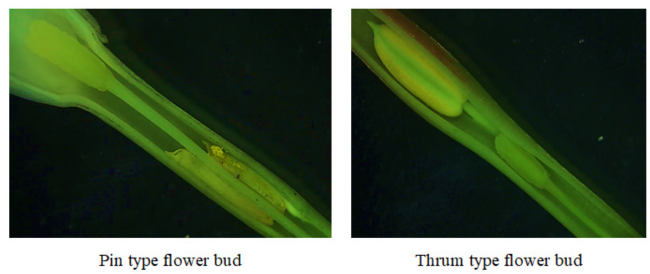

Figure 4: Floral dimorphism in *J. multiflorum*

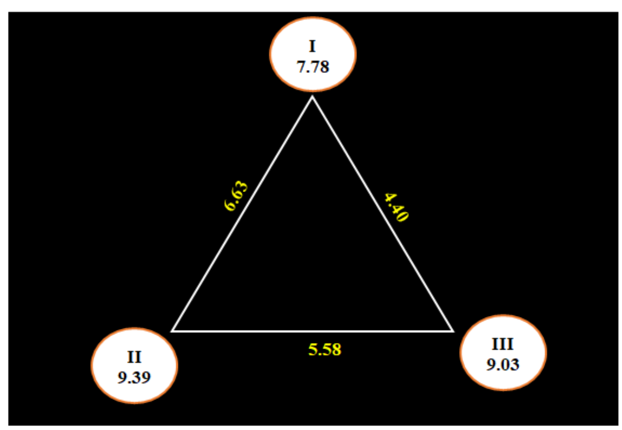

Figure 5: Cluster diagram showing inter and intra cluster distance

Table 3: Quanitative characters of *Jasminum* accessions

Accessions	*HFW*	*NP*	*LP*	*LS*	*LSt*	*LA*	*LF*	*TFY*	*SLRT*	*SLCS*	*CC*
KAU Ja 1	89.33^{l}	8.39^{fg}	1.74^{c}	1.10^{k}	0.45^{c}	0.41^{def}	1.15^{gh}	42.97	3.0^{a}	6.33^{a}	0.25^{ab}
KAU Jc 1	85.33^{lm}	8.67^{f}	1.74^{c}	1.87^{c}	0.34^{d}	0.37^{fg}	1.67^{a}	20.78	2.0^{b}	3.33^{gh}	0.18^{e}
KAU Jc 2	89.33^{l}	8.08^{fghi}	1.66^{d}	1.58^{fg}	0.35^{d}	0.38^{fg}	1.66^{a}	9.04	2.0^{b}	3.66^{fgh}	0.18^{de}
KAU Jf 1	106.33^{j}	8.44^{fg}	1.45^{e}	1.02^{l}	0.28^{fg}	0.41^{def}	1.23^{fg}	200.79	1.5^{c}	3.66^{fgh}	0.19^{d}
KAU Jg 1	100.00^{k}	5.13^{m}	2.38^{a}	1.48^{h}	0.42^{c}	0.50^{abc}	1.43^{bcd}	274.30	1.5^{c}	3.00^{h}	0.24^{b}
KAU Jg 2	81.33^{m}	5.06^{m}	2.28^{b}	1.39^{i}	0.43^{c}	0.49^{abc}	1.35^{cde}	109.71	1.5^{c}	3.00^{h}	0.25^{a}
CO 2 *Pitchi*	76.00^{n}	5.06^{m}	2.30^{ab}	1.85^{cd}	0.29^{efg}	0.51^{abc}	1.47^{b}	162.50	1.5^{c}	3.00^{h}	0.25^{a}
KAU Jm 1	152.66^{h}	8.18^{fgh}	1.44^{e}	1.70^{e}	0.27^{gh}	0.31^{gh}	0.60^{m}	749.02	3.0^{a}	5.33^{bc}	0.19^{de}
KAU Jm 2	134.66^{i}	6.30^{l}	1.08^{g}	1.79^{d}	0.30^{efg}	0.46^{bcd}	0.64^{m}	21.39	2.0^{b}	5.00^{cd}	-
KAU Jm 3	157.66^{h}	7.86^{ghi}	0.75^{jk}	1.27^{j}	0.30^{efg}	0.52^{ab}	1.35^{de}	74.20	2.0^{b}	6.00^{ab}	-
KAU Jn 1	176.33^{f}	10.90^{e}	2.26^{b}	1.83^{cd}	0.52^{b}	0.56^{a}	1.02^{ij}	94.45	1.5^{c}	4.33^{def}	0.18^{e}
KAU Jn 2	86.00^{lm}	7.03^{jk}	1.28^{f}	1.58^{fg}	0.32^{def}	0.27^{h}	0.75^{l}	93.19	1.5^{c}	4.00^{efg}	-
TNAU Jn 1	181.33^{f}	10.56^{e}	2.23^{b}	1.40^{i}	0.52^{b}	0.55^{a}	0.93^{jk}	82.87	1.5^{c}	4.33^{def}	0.18^{e}
KAU Js 1	238.00^{e}	7.41^{ij}	0.75^{jk}	1.55^{g}	0.35^{d}	0.44^{cdef}	0.95^{jk}	280.56	2.0^{b}	5.33^{bc}	0.20^{c}
KAU Js 2	415.33^{c}	12.60^{d}	0.70^{k}	2.04^{a}	0.41^{c}	0.41^{def}	1.44^{bc}	16.52	2.0^{b}	5.33^{bc}	-
KAU Js 3	163.00^{g}	7.54^{hi}	0.09^{h}	2.04^{a}	0.64^{a}	0.49^{abc}	1.34^{de}	94.29	2.0^{b}	5.33^{bc}	0.19^{d}
KAU Js 4	293.66^{d}	27.10^{a}	0.72^{k}	1.64^{ef}	0.33^{de}	0.46^{bcde}	1.12^{hi}	138.62	2.0^{b}	4.66^{cde}	0.20^{c}
KAU Js 5	106.00^{j}	6.61^{kl}	0.08^{ij}	1.93^{b}	0.45^{c}	0.33^{efg}	1.07^{hi}	54.65	2.0^{b}	5.00^{cd}	0.19^{d}
KAU Js 8	467.33^{b}	23.07^{c}	0.53^{l}	1.85^{cd}	0.23^{hi}	0.40^{def}	1.30^{ef}	61.14	2.0^{b}	5.33^{bc}	0.18^{de}
KAU Js 9	482.66^{a}	25.13^{b}	0.55^{l}	1.98^{b}	0.20^{i}	0.39^{defg}	1.40^{bcd}	58.22	2.0^{b}	5.00^{cd}	0.19^{de}
KAU Js 11	233.00^{e}	7.83^{ghi}	0.81^{ij}	1.55^{g}	0.35^{d}	0.39^{defg}	0.88^{k}	242.36	2.0^{b}	5.33^{bc}	0.20^{c}
C. V (%)	3.68	4.17	3.53	2.32	6.43	10.19	4.86	-	0.01	12.15	3.48
C. D (0.05)	1.02	0.71	0.07	0.06	0.04	0.07	0.09	-	0.01	0.92	0.01

HFW- Hundred flower weight (g) NP- No. of petals (nos.) LP- Length of pistil (cm) LS- Length of stamen LSt- Length of stigma (cm) LA- Length of anther (cm) LF- Length of filament (cm) TFY- Total flower yield (g per plant) SLRT- Shelf life at room temperature (days) SLCS- Shelf life at cold storage (days) CC-Concrete Content

Table 4: Genetic parameters for morphological character

Characters	*Range*	*Mean*	*GV*	*PV*	*GCV (%)*	*PCV (%)*	*H2 (%)*	*GAM (%)*
Plant height (cm)	60.00-229.16	128.61	2262.75	2318.03	36.98	37.43	97.00	75.27
No. of primary branches	3.33-7.00	5.20	0.98	1.82	19.02	25.91	53.90	28.76
No. of secondary branches	4.66-22.00	15.22	24.93	28.47	32.80	35.05	87.60	63.23
Leaf length (cm)	4.28-10.22	7.73	2.72	2.73	21.31	21.37	87.60	63.23
Leaf breadth (cm)	2.18-5.39	4.14	0.96	0.97	23.76	23.87	99.10	48.73
Leaf area (cm^2)	5.57-29.60	19.52	59.09	59.29	39.37	39.44	99.70	80.98
Flower bud length (cm)	1.60-4.00	3.18	0.36	0.37	19.22	19.56	96.50	38.90
Flower bud width (cm)	0.23-0.96	0.52	0.06	0.06	46.96	46.96	100.00	96.75
Flower diameter (cm)	2.59-4.81	3.68	0.42	0.44	17.61	18.16	94.00	35.17
Corolla tube length (cm)	1.15-2.55	1.80	0.21	0.21	25.53	25.72	98.60	52.24
Corolla tube girth (cm)	0.13-0.33	0.25	0.004	0.004	24.03	24.03	100.00	49.51
No. of forks per cyme	1.54-35.06	13.43	108.29	111.35	77.44	78.53	97.20	157.32
No. of calyx lobes	4.96-6.86	5.23	0.30	0.37	9.16	10.56	81.00	17.03
Length of petals (cm)	0.69-2.19	1.65	0.17	0.18	25.21	26.20	92.00	49.96
Width of petals (cm)	0.32-0.94	0.58	0.03	0.04	33.98	34.41	97.00	69.12
No. of petals (nos.)	5.06-27.10	10.33	41.94	42.12	62.66	62.80	99.60	128.80
Length of pistil (cm)	0.53-2.38	1.35	0.42	0.42	47.84	47.95	99.50	98.32
Length of stamen (cm)	1.02-2.04	1.68	0.08	0.08	17.80	17.90	98.80	36.46
Length of stigma (cm)	0.20-0.64	0.37	0.01	0.01	28.49	29.72	91.90	56.26
Length of anther (cm)	0.27-0.56	0.43	0.005	0.007	16.21	19.18	71.40	28.22
Length of filament (cm)	0.60-1.67	1.50	0.09	0.09	25.98	26.39	96.90	52.69
Shelf life at room temperature (days)	1.55-3.00	1.92	0.18	0.18	22.12	22.12	100.00	45.56
Shelf life at cold storage (days)	3.33-6.33	4.58	0.90	1.21	20.75	24.05	74.00	36.88
Concrete content (%)	0.18-0.25	0.20	0.007	0.007	51.38	51.38	100.00	105.84

Table 5: Path analysis for hundred flower weight and its component characters

	LL	*LB*	*LA*	*NFC*	*FBL*	*FBW*	*NP*	*CTG*	*CTL*	*NCL*	*SFW*
LL	-0.117	0.021	0.071	0.007	-0.033	0.003	-0.037	0.001	0.035	0.001	0.402
LB	-0.186	0.029	0.078	0.005	0.014	0.010	-0.047	-0.020	0.009	-0.004	0.417
LA	-0.094	0.025	0.089	0.009	0.038	0.011	-0.069	-0.047	-0.013	0.007	0.645
NFC	0.051	-0.009	-0.051	-0.016	-0.073	-0.009	0.058	0.054	0.056	-0.024	-0.631
FBL	-0.02	-0.002	-0.017	-0.006	-0.192	-0.014	0.047	0.056	0.114	-0.021	-0.258
FBW	-0.014	0.013	0.043	0.007	0.116	0.023	-0.077	-0.063	-0.098	0.014	0.795
NP	-0.035	0.011	0.05	0.007	0.074	0.014	-0.122	-0.045	-0.078	0.008	0.928
CTG	0.001	0.006	0.044	0.009	0.113	0.015	-0.058	-0.095	-0.078	0.024	0.623
CTL	-0.028	0.002	-0.008	-0.006	-0.151	-0.015	0.066	0.051	0.145	-0.023	-0.642
NCL	-0.001	-0.003	0.018	0.010	0.110	0.008	-0.025	-0.062	-0.087	0.038	0.446
SFW	-0.042	0.011	0.051	0.009	0.044	0.016	-0.101	-0.053	-0.083	0.015	1.122

Residual effect: 0.0092

LL- Leaf length, LB- Leaf breadth, LA- Leaf area, NFC- Number of forks per cyme, FBL- Flower bud length, FBW- Flower bud width, NP- Number of petals, CTG- Corolla tube girth, CTL- Corolla tube length, NCL- Number of calyx lobes, SFW- Single flower weight was recorded in KAU Jf 1, while the lowest was recorded in *J. sambac* accessions.

The size of pollen ranged from 0.034 to 0.040 mm among the jasmine accessions. The pollen viability was higher in KAU Ja 1 (94%), while the lowest was noted in KAU Js 1 (75%), and KAU Js 11 (76%). The variable ploidy levels and chromosomal forms can be the reason for the different pollen viability of the jasmine species observed in the current investigation. Higher pollen sterility in *J. sambac* cv. *Ramanathapuram Gundumalli* is linked to its triploid state, which causes anomalies in meiosis (Raman,1955 and Deng *et al.,* 2017). Inadequate nutrition availability is the cause of the malformation or failure of fruit growth, while low fertilization rate or early senescence of pistil cells and low pistil receptivity are the possible barriers in a hybrid set (Deng *et al*., 2016).

Fragrance is a very important quality parameter in jasmine. Most of the accessions had fragrant flowers, except two: KAU Jm 2 and KAU Jm 3. Some accessions had a strong smell (*J. sambac, J. auriculatum* and *J. grandiflorum*), while some had a moderate fragrance (*J. nitidum, J. coarctatum* and KAU Jm 1). Variations in fragrance might be due to variations in its volatile components contributing to aroma.

Most accessions exhibited seasonal flowering, though some bloomed year-round. Year-round flowering was noted in *J. multiflorum* and *J. nitidum*. This trait can be leveraged in breeding programs to extend the blooming period in commercial varieties. The seasonal variation of flowering in *Jasminum* species is due to the variations in photothermal units, which profoundly influence flowering (Raman, 1973 and Nedumaran,1977). Year-round flowering in *J. multiflorum*, *J. flexile, J. calophyllum*, *J. rigidum* and *J. nitidum* has been reported by Raman *et al.,* (1969) and Ganga *et al.* (2015) leading to the scope of commercial cultivation of *J. nitidum* and *J. multiflorum*. Prolonged blooming period in the off-season offers the possibility for crossing strategies to be employed in the breeding pursuits (Lakshmi and Ganga, 2017).

Variation in yield of flowers in *J. sambac, J. grandiflorum, J. auriculatum,* and *J. multiflorum* was reported by several studies (Muthusami and Khader, 1975; Patel, 2013). The lesser-known species, *J. multiflorum* and *J. nitidum,* bloom year-round but produce flowers with mild or no fragrance.

Seed setting was noticed in KAU Ja 1, KAU Jc 1 and 2, KAU Jm 3, KAU Jn 2 and KAU Js 3. *J. auriculatum* was found to be a potential species with a maximum fruit set percentage. Poor seed setting may be due to fertilization barriers, low pollen viability, or stigma receptivity (Usha *et al*., 2022). Profuse seed setting was also noted in pink *J. multiflorum* by Lakshmi and Ganga (2017).

Genetic Variability, Heritability and Genetic Advance

A close association between GCV and PCV was noted in leaf length, leaf breadth, leaf area, flower bud length, flower bud width, corolla tube length, corolla tube girth and the number of petals. This indicates that the variations in these characters were due to genotype, and environment has little effect (Table 4). High heritability coupled with high GAM was noticed for characters for most of the characters except the number of calyx lobes, indicating the additive gene effect and selection based on any of these characters will be effective.

Correlation and Path Analysis

Hundred flower weight showed a significant positive correlation with leaf length, leaf breadth, flower bud width, number of petals, corolla tube girth, calyx lobes, and single flower weight, but a non-significant correlation with flower diameter. Path analysis revealed residual effects of 0.009, indicating that the selected eleven yield-attributing characters accounted for 99% of the variation in hundred flower weight per plant (Table 5).

Diversity Analysis

Genetic divergence was analyzed using D^2 cluster analysis, identifying groups within the germplasm for potential use in breeding programs. About 21 accessions of *Jasminum* spp. were grouped into three clusters based on D^2 values. Cluster II showed the highest mean values for leaf length, breadth, flower bud width, number of petals, and hundred flower weight, while cluster I had the highest values for flower bud length and flower diameter. Cluster III showed the highest length of calyx lobes. Intra-cluster distance was highest in cluster II, indicating greater heterogeneity, while cluster I had the lowest, suggesting high homogeneity (Figure 5). Maximum inter-cluster distance was between clusters I and II, suggesting potential for superior hybrids through crossbreeding.

Conclusion

Based on the results, it is concluded that there is significant diversity among *Jasminum* accessions and certain accessions can be utilized for various traits based on consumer preferences. Underutilized accessions such as KAU Jm1, KAU Jm2, KAU Jm3, KAU Jn1, KAU Jn 2, and TNAU Jn1 hold potential as breeding materials for crop improvement.

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