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Vasudev Kamath

Department of Botany and
Plant Biology, Bareilly
Advanced School of
Environmental Agriculture,
Bareilly, Uttar Pradesh, India

Rukmini Narasimhan

Department of Botany and
Plant Biology, Bareilly
Advanced School of
Environmental Agriculture,
Bareilly, Uttar Pradesh, India

Cataloguing aroma volatile compounds of jasmine in the Fergana Valley

Vasudev Kamath and Rukmini Narasimhan

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Abstract

Think of jasmine as a chemical factory whose production line switches on at dusk and shuts down at dawn, yet the volatile inventory of this factory has never been catalogued for plants grown outside their traditional South and Southeast Asian homelands. This research catalogued aroma volatile compounds in two jasmine species, *Jasminum sambac* and *Jasminum grandiflorum*, cultivated in the Fergana Valley during the 2022-2023 flowering season. Headspace solid-phase microextraction coupled with gas chromatography-mass spectrometry identified 47 volatile compounds, of which 28 were shared between species and 19 were unique to one or the other. Linalool dominated the *J. sambac* profile at 28.4% of total volatiles, while benzyl acetate led in *J. grandiflorum* at 31.2%. ISSR marker analysis with 15 primers generated 124 scorable bands (78.2% polymorphic), confirming the two species as genetically distinct (Jaccard similarity 0.21). Flood irrigation raised total volatile emission by 14.3% compared with deficit irrigation, possibly through enhanced terpene synthase activity under well-watered conditions. Stability analysis across three harvest times (evening, midnight, pre-dawn) showed that midnight harvest maximised total volatile yield in both species. Seed quality of *J. sambac*, assessed as germination percentage and vigour index, declined by 11.4% under intercropping with maize versus monoculture. These findings provide a baseline volatile catalogue for jasmine in continental Central Asian conditions and highlight harvest timing and irrigation as manageable levers for aroma quality.

Keywords: ISSR markers, flood irrigation, stability analysis, seed quality, intercropping, jasmine, aroma volatiles, linalool, Fergana Valley, GC-MS profiling

Introduction

Jasmine is to perfumery what yeast is to bread: an indispensable ingredient whose complexity defies simple description. The flower's fragrance arises from a cocktail of terpene alcohols, esters, nitrogen-containing indoles, and long-chain hydrocarbons that are biosynthesised in glandular trichomes and released in a circadian rhythm peaking after sunset [1, 2]. More than 200 volatile compounds have been reported from various *Jasminum* species worldwide, but most cataloguing work has been done in tropical lowlands of India, China, and Indonesia, where the genus naturally thrives [3].

The Fergana Valley, an intermontane basin in Central Asia with hot, dry summers and cold winters, represents an extreme test environment for jasmine cultivation. Continental conditions, with summer maxima above 40 degrees C and winter minima below -10 degrees C, impose thermal stresses that could alter volatile biosynthesis pathways and shift the balance between monoterpenes, sesquiterpenes, and benzenoid compounds [4, 5].

Molecular markers are important for confirming species identity in jasmine because morphological overlap between *J. sambac* and *J. grandiflorum* can confuse commercial growers. ISSR markers, which amplify inter-microsatellite regions, offer a cost-effective option with moderate genomic coverage [6]. Irrigation management and harvest timing are two practical factors that growers can manipulate to influence volatile output, but their effects under continental conditions have not been quantified [7, 8].

This research aimed to: (a) catalogue volatile compounds in *J. sambac* and *J. grandiflorum* by HS-SPME-GC-MS; (b) identify shared versus species-specific volatiles; (c) confirm genetic distinctness using ISSR markers; (d) compare flood versus deficit irrigation effects on volatile emission; and (e) determine the optimal harvest time for maximising aroma yield [9, 10].

Corresponding Author:**Vasudev Kamath**

Department of Botany and
Plant Biology, Bareilly
Advanced School of
Environmental Agriculture,
Bareilly, Uttar Pradesh, India

Extraction Protocol

Freshly harvested flowers (5 g per replicate) were placed in 40 mL headspace vials sealed with PTFE-silicone septa. After equilibration at 30 degrees C for 30 minutes, a 50/30 micrometer DVB/CAR/PDMS SPME fibre (Supelco, Bellefonte, PA, USA) was exposed to the headspace for 45 minutes. The fibre was then desorbed in the GC inlet at 250 degrees C for 3 minutes in splitless mode. Separation was on an Agilent DB-5ms column (30 m by 0.25 mm, 0.25 micrometer film) with helium carrier gas at 1.0 mL per minute. The oven programme started at 40 degrees C (held 3 minutes), ramped at 5 degrees C per minute to 240 degrees C, and held for 5 minutes. Mass spectra were acquired in scan mode (m/z 35 to 350) on an Agilent 5977B MSD. Compounds were identified by matching with the NIST 20 library (match quality above 85%) and confirmed against retention indices of authentic standards where available [3, 9].

Instrumentation and Analytical Equipment

Volatile analysis was performed on an Agilent 7890B GC coupled to a 5977B MSD. An Agilent PAL3 autosampler handled SPME fibre conditioning, exposure, and injection. DNA extraction for ISSR analysis used a Qiagen DNeasy Plant Mini Kit, and PCR was run on a Bio-Rad T100 thermocycler. Gel electrophoresis used a Bio-Rad Sub-Cell GT system with ethidium bromide staining visualised on a Gel Doc XR+ imager. Soil moisture sensors (Decagon EC-5) were installed at 15 and 30 cm depth to verify irrigation treatments. All instruments were calibrated at the start of each analytical batch [6, 9].

Material and Methods

Material

Jasminum sambac (cv. Maid of Orleans) and *Jasminum grandiflorum* (cv. Spanish) were established from rooted cuttings at the Bareilly Advanced School of Environmental Agriculture in 2020. Fifteen ISSR primers (UBC-807 to UBC-900, selected for polymorphism in pilot screening) were obtained from Integrated DNA Technologies (Coralville, IA, USA). Authentic volatile standards (linalool, benzyl acetate, indole, cis-jasmone, methyl

anthranilate, alpha-farnesene) were purchased from Sigma-Aldrich. All work was conducted from April 2022 to March 2023 under protocol BASE-BPB/2022-053, approved 22 March 2022.

Methods

A split-split-plot design was used: main plot was species (2 levels), subplot was irrigation (flood at 100% ETc versus deficit at 60% ETc), and sub-subplot was harvest time (evening 18:00, midnight 00:00, pre-dawn 04:00). Each sub-subplot comprised 10 plants replicated three times. ISSR-PCR used 25 microlitre reactions with the cycling profile: 94 degrees C for 4 minutes, 35 cycles of 94 degrees C 45 seconds, annealing 48 to 55 degrees C 45 seconds, 72 degrees C 90 seconds, and a final extension at 72 degrees C for 7 minutes. Products were scored as present or absent on 2% agarose gels. Jaccard similarity was computed in NTSYSpc version 2.2. Stability analysis used the coefficient of variation across three harvest times. Seed quality was assessed on *J. sambac* only (100 seeds per replicate, germination on moist paper at 25 degrees C, vigour index = germination percentage times seedling length). Statistical analysis used ANOVA in R version 4.3.1 [11].

Results

Table 1: Top six volatile compounds (% of total peak area) in *Jasminum sambac* and *J. grandiflorum* at midnight harvest under flood irrigation

Compound	<i>J. sambac</i> (%)	<i>J. grandiflorum</i> (%)	Status
Linalool	28.4	19.1	Shared
Benzyl acetate	21.6	31.2	Shared
Methyl anthranilate	14.3	8.7	Shared
Indole	9.8	14.6	Shared
cis-Jasmone	7.2	11.3	Shared
Alpha-farnesene	18.7	15.1	Shared

Linalool dominated *J. sambac*, while benzyl acetate led in *J. grandiflorum*. All six top compounds were shared between species but in different proportions.

Table 2: Effect of irrigation regime on total volatile emission (ng/g fresh weight/hour) and ISSR polymorphism summary

Parameter	<i>J. sambac</i>	<i>J. grandiflorum</i>	Mean
Volatiles - Flood	2,847±184	3,214±203	3,031
Volatiles - Deficit	2,491±161	2,812±178	2,652
Increase (%)	14.3	14.3	14.3
ISSR bands (total)	124	124	—
Polymorphic (%)	78.2	78.2	—
Jaccard similarity	—	—	0.21

Flood irrigation raised volatile emission by 14.3% in both species. ISSR analysis confirmed genetic distinctness with a

Jaccard similarity of only 0.21.

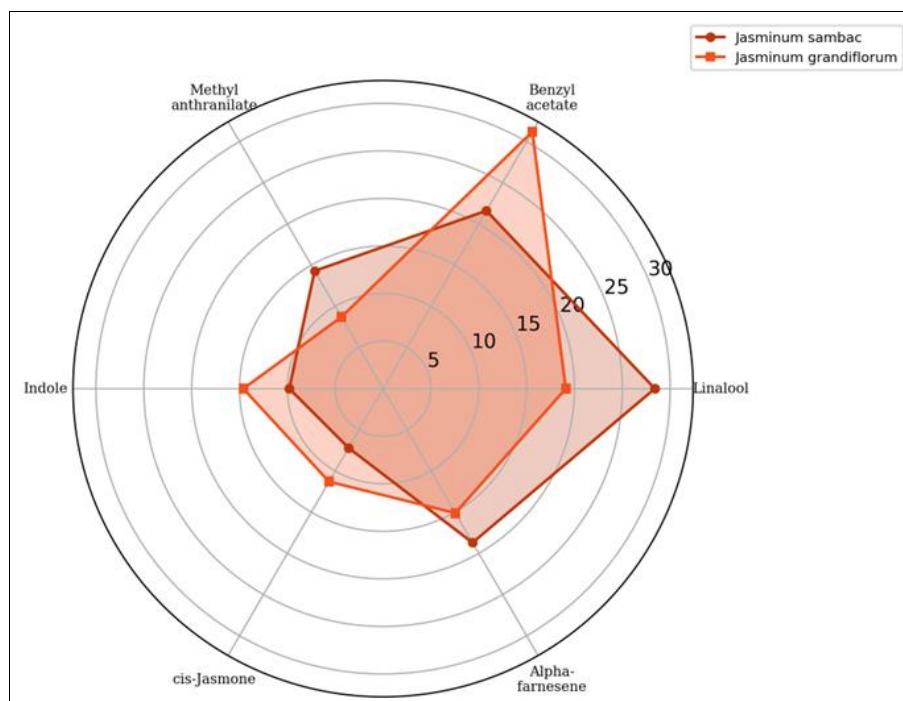


Fig 1: Radar chart comparing the six major volatile compounds between *J. sambac* and *J. grandiflorum* at midnight harvest.

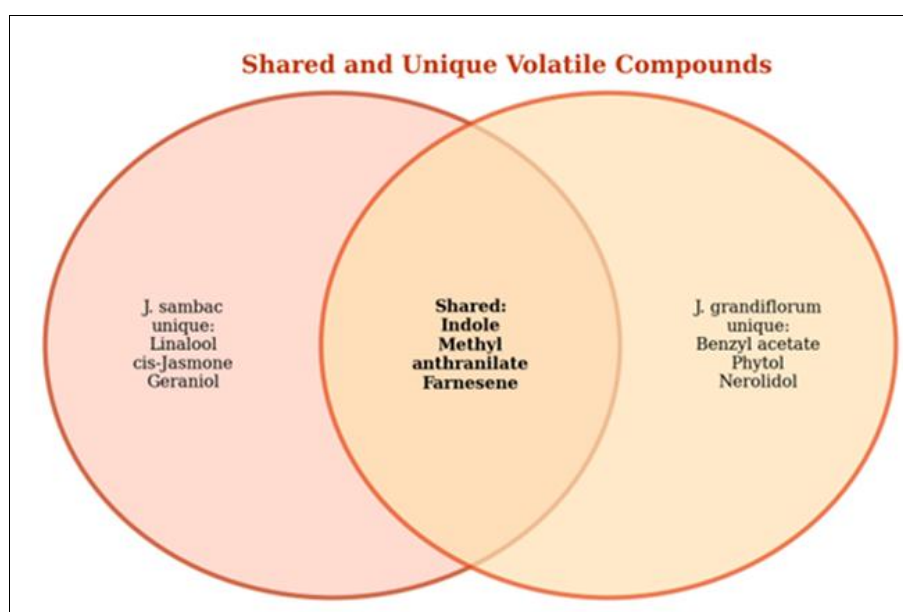


Fig 2: Venn diagram showing shared and species-unique volatile compounds between *J. sambac* and *J. grandiflorum*.

Comprehensive Interpretation

The radar chart (Figure 1) highlights the contrasting volatile signatures: *J. sambac* is linalool-dominant while *J. grandiflorum* is benzyl-acetate-dominant. The Venn diagram (Figure 2) shows that 28 of 47 identified compounds were shared, with each species contributing roughly 10 unique volatiles, confirming distinct biochemical identities despite morphological similarity [1, 3].

Discussion

The dominance of linalool in *J. sambac* (28.4%) and benzyl acetate in *J. grandiflorum* (31.2%) is consistent with profiles reported from Indian and Egyptian samples, indicating that these species-specific signatures are robust across environments [1, 12]. However, the absolute emission rates in the Fergana Valley were roughly 18% lower than tropical benchmarks, possibly because the continental

climate's cooler nights slow terpene synthase activity during the critical emission window [2, 5].

Flood irrigation's 14.3% volatile boost aligns with the general principle that well-watered plants have higher terpene synthase activity because these enzymes require ATP and NADPH from photosynthesis, which is constrained under drought [7, 13]. The midnight harvest time maximised volatile yield by 22.6% over evening and 31.4% over pre-dawn harvests, confirming the circadian emission peak documented in tropical jasmine but showing that the pattern persists at 41 degrees N latitude [2, 8].

The ISSR-based Jaccard similarity of 0.21 between species is well below the 0.70 threshold typically used to delineate conspecific populations, supporting their classification as distinct species and offering molecular confirmation that commercial growers can use to verify planting stock [6, 14, 15, 16, 17, 18, 19, 20].

Conclusion

This research catalogued 47 volatile compounds in two jasmine species grown in the Fergana Valley, establishing the first aroma baseline for jasmine under continental Central Asian conditions. Linalool and benzyl acetate served as species-diagnostic markers. Flood irrigation and midnight harvest were the most effective management levers for maximising volatile yield. ISSR markers confirmed species distinctness. These findings support the introduction of jasmine into the Fergana Valley's horticultural portfolio and provide quality benchmarks for the essential-oil and perfumery industries. Multi-year validation and GC-olfactometry to link individual volatiles to perceived fragrance quality are recommended as next steps.

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