

Aroma Intelligence Systems (AIS)

From Ecological Observation to Plant Volatile Intelligence

Plant VOC research, analytical chemistry,
machine olfaction and artificial intelligence

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Research scope and present stage

Foundation

Long-term qualitative ecological observations and a proposed research framework.

Initial focus

Mango physiology and plant-associated volatile emissions.

Next milestone

A structured dataset linking VOC measurements with biological and environmental observations.

Evidence status

Instrumental measurements, prototype development and independent validation are next steps.

Ecological origins and the scientific problem

Field setting

Regeneratively managed orchard and ecological observatory established in 2012.

Observational origin

Perceived aroma varied during flowering, seasonal transitions and changing orchard condition.

Research question

Can VOC changes precede visible damage or reproductive failure?



Conceptual illustration of proposed research

Central scientific hypothesis

Plant physiology and stress may alter VOC composition, abundance and temporal dynamics.

Integrating chemical signatures with independently assessed plant condition may reveal reproducible indicators and potential early-warning information.

This hypothesis remains untested within AIS.

Chemical signals and environmental variability

Candidate VOC groups

Terpenoids, green-leaf volatiles, benzenoids, phenylpropanoids and other volatile metabolites.

Biological context

Development, herbivory, pathogens and plant-microorganism interactions may influence emissions.

Environmental context

Temperature, humidity, dispersion and surrounding vegetation influence measured concentrations.

Interpretation

A different chemical profile alone does not establish physiological stress or disease.

Four integrated research layers

I Biological and ecological observation

Independently characterised plant condition and environmental context.

II Chemical measurement and machine olfaction

Standardised headspace sampling, GC-MS and experimental sensor arrays.

III Computational interpretation

Chemometrics and AI/ML integrate chemical, biological and environmental data.

IV Practical field guidance

Validated findings may guide inspection and confirmatory measurements.

Research objectives

Biological association

Relate volatile profiles to independently assessed developmental and stress conditions.

Measurement reproducibility

Test consistency across sampling methods, analytical measurements and sensors.

Computational interpretation

Identify reproducible patterns while accounting for variability and uncertainty.

Predictive and practical evaluation

Test whether volatile measurements add value beyond conventional monitoring.

Biological observation and phenotyping

Tree and developmental records

Cultivar, tree identity, flowering, fruit development and management history.

Plant condition

Pest incidence and physiological measurements where feasible.

Environmental measurements

Temperature, relative humidity, soil moisture and environmental exposure.

Reference evidence

Independent assessment supports biological labels used for model development.

Non-invasive plant VOC sampling

Intact plant tissues

Investigate suitable dynamic headspace methods and sorbent trapping.

Documented sampling conditions

Record tissue, chamber, airflow, duration, time of day, temperature and humidity.

Controls and replication

Use ambient-air references, procedural blanks and biological and technical replication.

Sampling artefacts

Evaluate enclosure effects, contamination and handling-induced changes.

GC-MS as the analytical reference

Chemical characterisation

Chromatographic separation and mass-spectral acquisition.

Compound identification

Spectral libraries, retention indices and authentic standards where available.

Quality assurance

Calibration, blanks and checks for contamination and instrumental variability.

Interpretive limits

Distinguish tentative annotations from confirmed identifications. Quantification requires validation.

Electronic-nose prototype development

Experimental architecture

Headspace interface, complementary chemical sensors and environmental monitoring.

Signal acquisition

Time-stamped responses, baseline correction and response normalisation.

Reference comparison

Compare sensor patterns with GC-MS, controlled mixtures and plant conditions.

Performance challenges

Sensor drift, humidity sensitivity, repeatability and environmental interference.

Multimodal data and AI/ML

Integrated dataset

Chemical profiles and sensor responses linked to phenology, physiology, weather and metadata.

Candidate methods

Exploratory statistics, classification, regression, time-series analysis and anomaly detection.

Evaluation design

Separate independent trees, periods, seasons or orchards to limit data leakage.

Benchmarks

Compare with simpler statistical models and conventional monitoring indicators.

Research and validation roadmap

Phase I

Experimental design and baseline phenotyping

Phase II

Instrumental VOC characterisation

Phase III

Electronic-nose development

Phase IV

Computational model development

Phase V

Independent field validation



Conceptual illustration of proposed research

Validation principles

Biological and analytical controls

Independent reference measurements, reproducible sampling and documented quality assurance.

Independent evaluation

Separate exploratory and confirmatory findings. Test additional trees and field conditions.

Transparent reporting

Record uncertainty, false positives, false negatives and inconclusive findings.

Early-warning criteria

Demonstrate useful lead time, acceptable false alarms and value beyond conventional monitoring.

Practical field guidance and applications

Potential monitoring applications depend on experimental demonstration and independent validation.

Possible applications

Plant stress research, phenological monitoring and prioritisation of orchard inspection.

Field response

A validated departure from baseline could prompt water-status checks or targeted pest assessment.

Decision limits

Confirmatory agronomic assessment must precede intervention. AIS currently provides no operational alerts or treatments.

Immediate milestone and collaboration

The first structured AIS dataset

Link standardised plant VOC measurements with independently assessed physiological and environmental observations.

Collaboration priorities

Experimental design and field phenotyping
GC-MS access and analytical validation
Sensor engineering, chemometrics and AI/ML

Landscape Aroma Systems (LAS)



A future ecological research direction examining mixed volatile chemistry across vegetation, soil and atmosphere.

Conceptual landscape illustration

LAS research questions and boundaries

Spatial and seasonal variation

Investigate repeated VOC measurements across landscape locations and ecological seasons.

Sources and interactions

Examine vegetation, soil microbes, decomposition and atmospheric transport.

Scientific challenge

Distinguish source-specific emissions from mixed signals and environmental confounding.

Current boundary

LAS remains a future research direction. It claims no validated ecosystem-health or biodiversity indicator.

Research initiator and research materials

Bimal Das

Originator and Research Initiator, Aroma Intelligence Systems

MSc Food Technology, CSIR-CFTRI, Mysore
Undergraduate studies in chemistry

More than three decades of botanical materials, sensory applications, product development and ecological practice.

Website resources: AIS introductory video and scientific research presentation

Research enquiries and collaboration

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Qualitative observations and a proposed research framework
Structured measurement and independent validation are the next steps