5TH INTERNATIONAL
STRAWBERRY CONGRESS

WELCOME

Connecting the dots in a complex world of strawberries

Antwerp – Belgium

17 – 20 September 2025

5TH INTERNATIONAL STRAWBERRY CONGRESS

Wednesday

Parallel Session 1: Strawberry Breeding & Physiology

AI-driven phenotyping for profiling varietal requirements in strawberry breeding programs

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Topic Session : Breeding & Physiology

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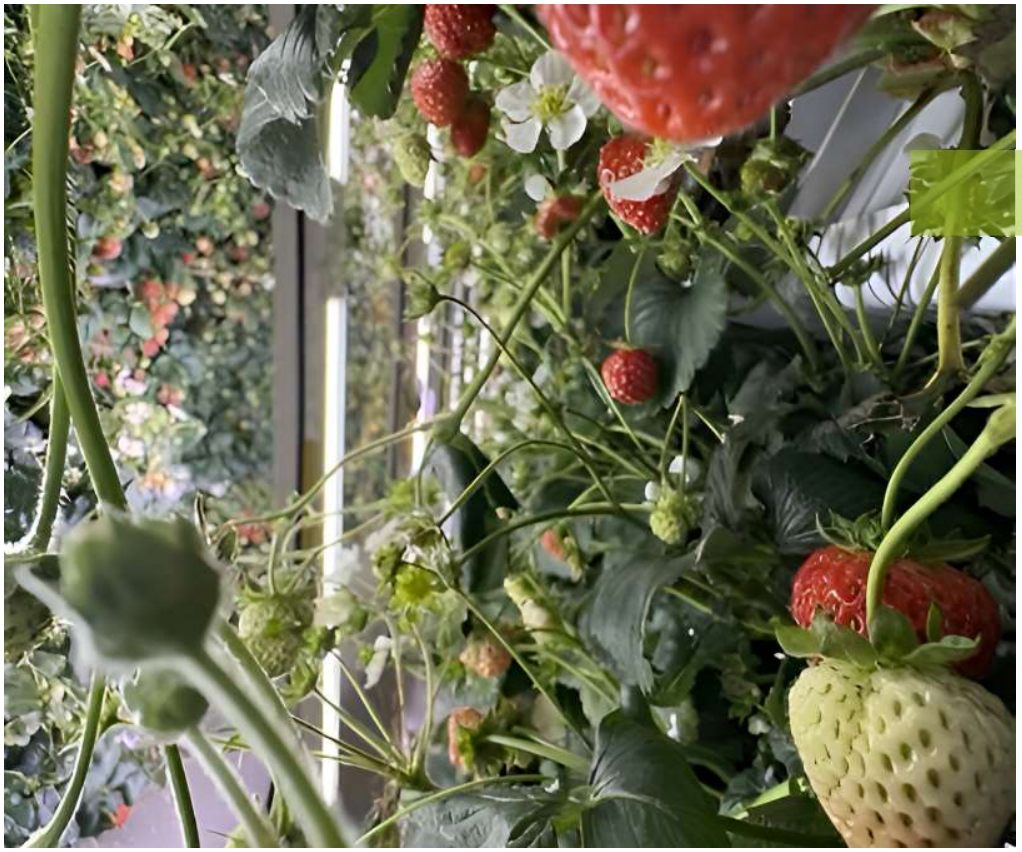
Who We Are

Farm3 is a research accelerator and innovator in plant production technologies. Through its phenotyping center, the company develops and validates optimized cultivation protocols that are implemented in its industrial-scale nurseries. The resulting plants are marketed under the Cultivar brand in Europe and North America. By integrating research, production, and commercialization, Farm3 contributes to advancing innovation, sustainability, and efficiency in modern agriculture.



Why this Project Matters

Developing resilient, high-yield strawberry varieties is traditionally slow and labor-intensive. At Farm3, we address this challenge with the Cube, a controlled aeroponic chamber that leverages AI and imaging to accelerate breeding. This approach enables faster identification of promising cultivars, generates scalable data for breeders and researchers, and has direct applications for sustainable food production.

Bottlenecks in Strawberry Selection

Manual phenotyping is slow and labor-intensive, constraining the selection of high-yielding, resilient cultivars.

Post-Breeding

New variety obtained → phenotyping needed to evaluate key traits

Current Situation

Manual observation on custom sheets

Not standardized → hard to compare/share

FARM³

Plant Automated Learning

Advantages

Live digital descriptive sheet

Saves time, ensures comparability

High-Throughput Phenotyping, Non-Invasive Trait Extraction

Automated imaging with AI enables accurate and efficient trait analysis, accelerating the development of improved strawberry cultivars.

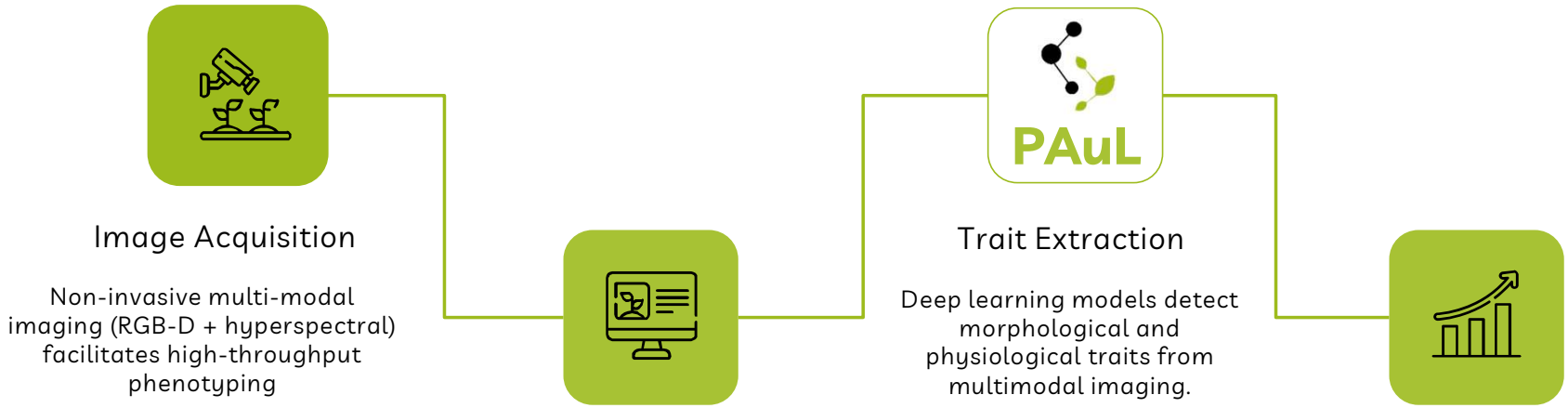


Image Acquisition

Non-invasive multi-modal imaging (RGB-D + hyperspectral) facilitates high-throughput phenotyping

Preprocessing & Alignment

Ensures data quality at scale → normalization, spectral calibration, noise reduction

Trait Extraction

Deep learning models detect morphological and physiological traits from multimodal imaging.

Trait Aggregation & Selection

Data integration → cultivar ranking
Accelerates breeding decision-making

Multi-modal Phenotyping in the **Cube**

*From a **TCEA** to **PAuL-driven** plant trait extraction*

The **Cube**, a patented vertical aeroponic chamber by Farm3, is a **TCEA** (Total Controlled Environment Agriculture) system that precisely controls temperature, humidity, light, and irrigation. Plant growth and physiology are monitored using multi-modal imaging: RGB-D cameras capture canopy structure and 3D morphology, while hyperspectral cameras measure traits such as chlorophyll content. Data are transmitted in real time to **Farm3.0** and analyzed by **PAuL**, which performs automated trait extraction for objective plant phenotyping.

Plant Material

Two short-day strawberry cultivars grown and monitored in the Cube

Haruhi (19FAG-2)

Sakura (19FAG-1)

Germination: in rock wool

Transfer: to vertical aeroponic shelves inside the Cube

Controlled environment: 19–12 °C (day/night) °C, 60–90% RH, 16 h photoperiod, precise nutrient misting

Daily imaging : RGB-D for morphological traits, hyperspectral for physiological traits

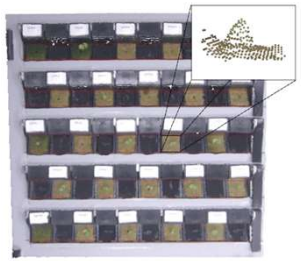
Note: Only early vegetative and physiological development was monitored, stopping prior to fruiting to focus on high-throughput phenotyping of initial plant traits.

Imaging-Based Plant Trait Acquisition

Multi-modal RGB-D and hyperspectral imaging for monitoring canopy morphology and physiology

RGB-D

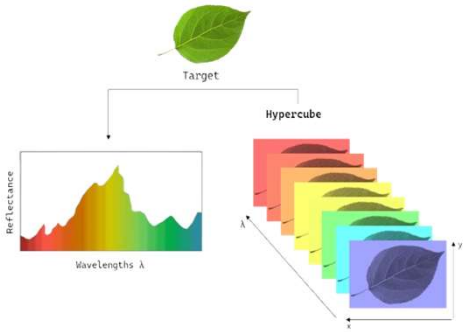
ToF camera



Point Cloud Visualization of Growth Environment

VNIR

hyperspectral camera



Visual representation of a hypercube

Leaf canopy area

Growth rate

Triangular Mesh Visualization of Leaf

NDVI → Vegetation health/density

CCI → Leaf chlorophyll content

PSRI → Leaf senescence / stress

SR → Biomass / vigor

Note: For each cultivar, Sakura and Haruhi, 39 plants were monitored.

PAuL: AI-Driven Imaging for Tracking Strawberry Plant Features

Automated measurement of canopy expansion through multimodal imaging and continuous plant tracking

Instance segmentation

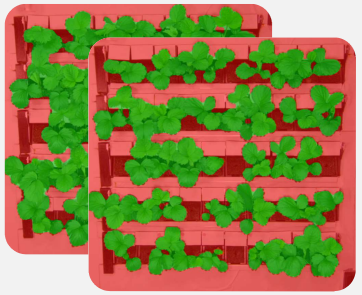
YOLOv8

Trait Extraction

Morphological → canopy area & growth rate (3D depth data)

Physiological → NDVI, CCI, SR, PSRI (hyperspectral data)

Canopy tracking



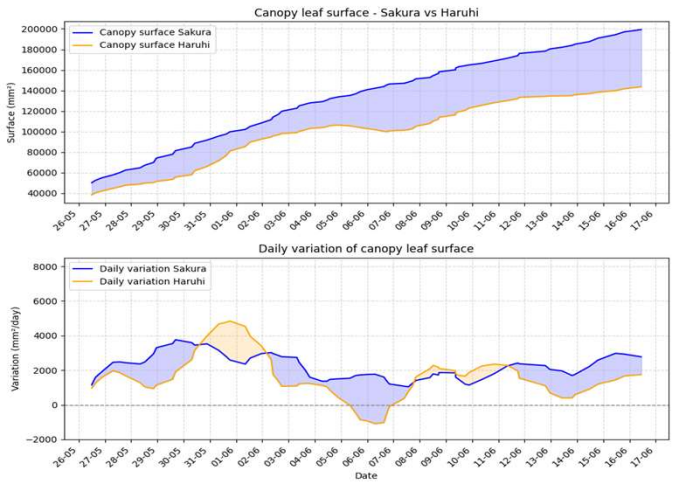
BoT-SORT

PAuL

Note: A curated dataset covering diverse cutting surface shapes and lighting conditions was annotated for training. YOLOv8 instance segmentation model was fine-tuned using pre-trained weights via transfer learning. BoT-SORT was employed with tuned motion and appearance parameters,

Key Findings I

Comparative Leaf Growth Dynamics: Sakura vs. Haruhi



Canopy area and growth rates of Sakura vs. Haruhi

📈 Visible canopy size
- Sakura's canopy ~40% larger than Haruhi's at the end

→ Sakura shows a larger and more uniform canopy

📊 Daily growth
- Sakura: stable, often >2,000 mm²/day

→ Haruhi: irregular, lower on average → Sakura keeps the lead

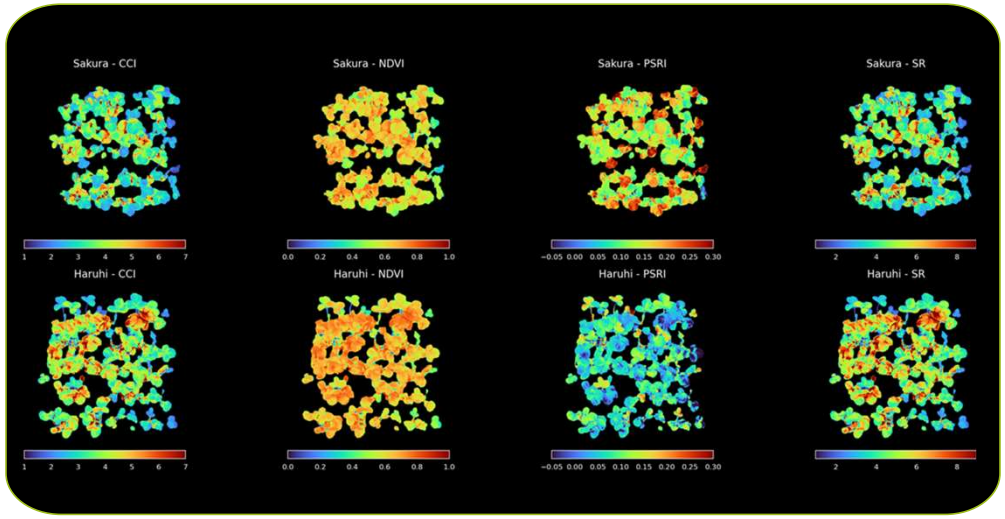
Agronomic implications
- Larger canopy → higher potential light interception
- Uniform growth may improve photosynthesis efficiency

Canopy performance summary

Note: Reported canopy measurements are based solely on projected visible leaf area, which may underestimate the actual canopy. Occasional negative daily values likely reflect temporary apparent losses caused by measurement variability and canopy structure

Key Findings II

Hyperspectral Vegetation Indices Across Strawberry Canopies – Sakura vs Haruhi



Hyperspectral indices of Sakura vs. Haruhi

📊 General patterns
- Indices reveal spatial heterogeneity within canopies
- Reflect leaf physiology & light interception

🌿 Spectral indices (CCI, NDVI, PSRI, SR)
- NDVI → Similar greenness & photosynthetic activity
- CCI → Haruhi shows higher chlorophyll content
- PSRI → Sakura shows localized pigment shifts
- SR → Haruhi shows slightly stronger structural hotspots

Agronomic implications
- Differences suggest slight cultivar-specific variations in photosynthesis efficiency and early senescence risk

Spectral index–based canopy assessment

Note: Reported canopy measurements are based solely on projected visible leaf area. Local variability may be due to occluded layers or variations in leaf angle.

Key Takeaways

- ✓ PAuL → Trait extraction → Data-driven quantification of varietal potential
- ✓ Imaging Synergy → Structural + spectral data → non-invasive, high-throughput evaluation
- ✓ Cube Advantage → Reduces environmental variability, strengthens trait–field performance link
- ✓ Next Steps → Validate in diverse conditions, integrate genomics & stress-response phenotyping

Thanks !

Do you have any questions ?

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