

CSSBoost Pilot 1 faba beans

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Reporting Period: 22/12/2024 – 10/10/2025

Crops: Faba Beans (*Vicia faba*) & Tomato (*Solanum lycopersicum*)

Field Site: 2 acres, Heraklion, Crete (what about the reference fields?)

WP Reference: WP5 – Task 5.2 – Pilot 1 Agricultural By-Product Valorisation

Section A: Soil Analysis and Preparation Phase

Prior to the establishment of the crop cycles, a comprehensive soil health assessment was conducted to evaluate the field fertility and ensure proper nutrient management planning. The designated area (2 acres) was sampled at five strategic locations, following a grid pattern, to ensure spatial representation. At each location, stratified soil samples were collected at three different depths, 10 cm, 20 cm, and 30 cm, in correlation with the known effective absorption zone of tomato root systems, which actively uptake nutrients within the top 35 cm of the soil profile, though the total rooting depth can exceed 60–100 cm.



The sampling protocol included:

- A soil auger for vertical extraction of samples
- Depth validation with a measuring tape
- A hand trowel for refinement
- A collection bucket for homogenization of composite samples

Approximately 3 kg of homogenized composite samples were transferred to an



accredited lab, for chemical and physical analysis, including organic matter content, macronutrient availability (NPK), pH, cation exchange capacity, and trace elements. These results can offer both the fertilization level and a calibration of the SmartAgroGenius system.



Section B: Faba Bean (*Vicia faba*) Cultivation

Sowing and Appearance (22/12/2024)

The sowing of faba beans took place on 22 December 2024. A total of 10 kg of certified seed was used. Faba beans were selected for their triple role within CSSBoost Pilot 1, both as a marketable fresh crop, as a nitrogen-fixing legume capable of enriching the soil organically, and a plant offering biostimulant to the soil. These form the backbone of the circular bio-input strategy outlined in Deliverable D5.2.



Early Development and Phosphorus Recommendation (01/02/2025)

By early February, the plants had been grown uniformly, with 2–3 fully leaves developed and an average height of approximately 5 cm. Given the critical role of phosphorus (P) in root system establishment, we decided to recommend



a targeted P fertilization, to stimulate early rhizogenesis and encourage strong vegetative growth.

Nutrient Uptake and Field Conditions (15/02/2025)

A follow-up visit confirmed that the phosphorus application had been completed five days earlier. Timely post-application rainfall contributed to rapid nutrient solubilization and movement into the root zone. Visual crop progress remained stable, reflecting typical latency in above-ground response to below-ground nutrient uptake processes.

Vegetative Boost Observed (20/02/2025)

Vegetative biomass had increased noticeably. Average plant height ranged between 20–30 cm, with up to 15 leaves per plant. A mechanical hoeing intervention was recommended and scheduled to suppress early weed growth, improve soil aeration, and enhance rhizospheric biological activity.

Pre-Flowering Morphology (25/02/2025)



At this stage, 25% of the population displayed visible inflorescences. The plant height had reached 30–40 cm, and most specimens had 15–20 healthy leaves. The farmer successfully executed the hoeing procedure, which had the dual effect of disrupting weed pressure and facilitating better soil moisture retention through improved pore

structure and gas exchange.



Section C: Deployment of Monitoring System and Agronomic Inputs

Significant technological support was introduced at this stage, based on Smart Irrigation and Weather Monitoring. A fully automated **electrovalve-based fertigation system** was installed and integrated with the **SmartAgroGenius platform**, enabling real-time monitoring and dynamic irrigation scheduling. Additionally, a meteorological station base was established, providing specific data on site for thermal stress monitoring and evapotranspiration estimation.



Phytosanitary and Nutritional Management

In March, the farmer had to apply a proactive spray for rust control. Phosphorus fertigation was scheduled through the automated system, followed by a balanced nutrient solution (NPK 20-20-20) ten days later. This period aligned with the critical flowering and early pod-set phases.

Section D: Green Manure Integration & Flowering Phase

Early Biomass Incorporation Design (14/03/2025)



Three rows were selected for early incorporation of green manure, made with plants at the peak of flowering (~50% blossoming), so that to valorise the faba bean's biological nitrogen fixation potential via its root nodules. This was a key CSSBoost strategy for reducing synthetic input dependency. A slowdown in vegetative expansion was noted due to rising ambient temperatures, which is physiologically expected at this phenological phase.

System Testing and Grower Training

The farmer after some initial on-site training was capable of using the SmartAgroGenius system alone. The platform successfully recorded microclimate and soil parameters, enabling data-driven irrigation adjustments.

Incorporation (24/03/2025)

Green biomass from the flowering rows was incorporated into the soil. The biochemical contribution of the decomposing biomass was expected to increase soil nitrogen levels via microbial mineralization, thus preparing the field for the high-demand tomato crop to follow.



Section E: Harvest and Soil

Reconditioning

Sensor Maintenance and First Harvest (14/04/2025)

Sensor 1, positioned in the control plot, was repaired. Plants had transitioned into the reproductive phase, with pod development occurring uniformly. Vegetative growth had ceased. The first round of harvesting was successfully completed.

Pod Quality and Successive Harvests (22/04/2025)

The crop showed a high harvest index with clean, well-formed pods. Smaller pods were progressing and set the stage for staggered harvesting, ensuring a continuous yield window.

Final Harvest & Residue Management (08/05/2025)

Final yield reached **2.5 tonnes of green faba bean pods**, from only 10 kg of seed, confirming excellent input/output efficiency. On 10 May, all above-ground residues were incorporated via mechanical plowing, returning biomass to the soil for organic matter enhancement.

Second Tillage & Post-Crop Sampling (29/05/2025)

A second plowing was performed to ensure full decomposition of fibrous residues. Soil samples were collected from three differentiated zones (flower-incorporated, harvested, and control) for comparative nutrient profiling before initiating the tomato cycle.







Section F: Tomato (*Solanum lycopersicum*) Cultivation Cycle

Planting Date: 6 June 2025

Total Plants: 1,500

Cumulative Harvest (as of 10 October 2025): 9 tonnes

Irrigation & Monitoring: SmartAgroGenius + Automated Electrovalve Fertigation

Transplanting and Soil Conditioning



On 6 June 2025, following the successful faba bean cycle and residue incorporation, the tomato transplants were established across the same 2-acres area. The soil, enriched with faba bean biomass, displayed improved structure and organic matter content, ensuring enhanced root aeration and microbial activity. The planting operation was carried out under controlled soil moisture conditions to minimize transplant stress.

To maintain uniform plant spacing, each seedling was transplanted manually using GPS-guided row alignment to support even irrigation distribution and facilitate SmartAgroGenius sensor accuracy.

Post-transplant, the irrigation system was recalibrated to accommodate the tomato crop's evapotranspiration rates and nutrient requirements.

Early Fertigation and Root Development (Days 10–20)





The first two fertigation events were scheduled on **Day 10 (16 June)** and **Day 20 (26 June)** following planting. These fertigation rounds were formulated with a balanced nutrient solution optimized for root induction and early vegetative vigor. The root-zone sensors of the SmartAgroGenius platform ensured that soil moisture and electrical conductivity remained within optimal thresholds.

The purpose of these early interventions was to:

- Encourage robust **root proliferation and branching**,
- Stabilize osmotic potential under early summer heat stress, and
- Enhance nutrient uptake efficiency before flowering onset.

No incidence of shock due to planting or water stress was recorded during this period, validating the precision irrigation system's performance.

Transition to Flowering Stage (01/07/2025)

Approximately 25 days post-planting, the crop had transitioned smoothly into the **flowering stage**. Vegetative growth was vigorous and uniform, with an average canopy height of 65–70 cm and dense, well-developed foliage.

A targeted **nutrient enrichment program** was implemented:

- **Fertigation 1:** NPK 20-20-20 to sustain balanced macro-element availability.
- **Fertigation 2 (7 days later):** NPK 20-20-20 + Ca + Mg + B, formulated to strengthen cell walls, optimize photosynthetic activity, and promote pollen viability.

At this stage, SmartAgroGenius data recorded daily temperature peaks of 32–34°C, relative humidity levels between 55–60%, and consistent volumetric soil moisture averaging 75%. These metrics were critical in maintaining an optimal reproductive environment.

Flowering, Fruit Set, and First Harvest (15/07/2025)

By mid-July, the plants exhibited an abundant and synchronized flowering pattern. Fruit set was highly successful, with visible initial formation at multiple nodes. No pest or disease pressure was observed during this period, confirming the success of proactive field hygiene and integrated pest management measures.

On **15 July 2025**, the **first tomato harvest** was conducted, yielding high-quality fruit characterized by:

- Uniform size and coloration
- Average fruit weight between 180–220 grams
- No deformation or cracking
- Excellent firmness and Brix levels within optimal market range (5.8–6.5°Bx)

The quality parameters indicated both efficient nutrient management and balanced soil fertility inherited from the previous legume crop cycle.

Continuous Fertigation Regime and Crop Health (19/07/2025 – 24/07/2025)

During the second half of July, the crop entered its **peak reproductive phase**. A weekly fertigation protocol was maintained, focusing on **Ca + Mg + B supplementation** to prevent blossom end rot and sustain vegetable uniformity. SmartAgroGenius data indicated steady soil moisture at 70–75% of field capacity, and average daily irrigation volumes ranged from 5–7 L per plant, modulated by temperature and evapotranspiration data.

The precision platform provided alerts on potential heat stress conditions (temperatures above 35°C) between 20–24 July. In response, irrigation frequency was increased by 15%, maintaining crop transpiration and avoiding yield loss.

Minor **leaf curling** was observed — a reversible physiological response to transient heat stress rather than nutrient deficiency.

Vegetable Development and Maturation (06/08/2025)

By early August, the crop reached the **maturation stage**, with approximately 50% of total biomass dedicated to vegetable structures. The plants preserved excellent vigor, healthy canopy retention, and sustained vegetable load per cluster (average 6–8 tomatoes per truss). Continuous monitoring confirmed optimal photosynthetic activity (SPAD index 49–52) and absence of foliar diseases.

Visual and data-based assessment indicated an equilibrium between vegetative and reproductive phases — an essential indicator of nutrient management balance and irrigation precision.

Second and Third Harvests (August–September 2025)

Between 15 August and 20 September, **successive harvests** were carried out. Each collection maintained consistent vegetable quality parameters. Regular leaf pruning was applied to optimize light penetration and air circulation.

The SmartAgroGenius system continued scheduling based on local climatic feedback, ensuring minimal water loss and sustained soil moisture levels.

Weekly fertigation continued with trace element supplementation to preserve vegetable quality and post-harvest firmness.

No biotic stressors (fungal, bacterial, or insect-related) were recorded throughout the cycle, emphasizing the effectiveness of preventive soil health management inherited from faba bean residues.

Final Harvest and Results

By October 2025, the tomatoes cultivation yield had reached 9 tonnes, confirming high productivity from the relatively small pilot field (2 acres). This corresponds to 4.5 tonnes per acre, which is above the local average for open-field cultivation under similar climatic conditions.

Crop uniformity, sustained fertility, and minimal disease incidences can support the technical hypothesis of CSSBoost Pilot 1, namely, that integrating leguminous green manure cycles with precision fertigation systems enhances both yield and sustainability of farming.

Section G: Scientific Assessment and CSSBoost Implications

1. Soil Health and Nutrient Cycling

Post-harvest analyses revealed measurable improvements in organic carbon content (+0.4%) and total nitrogen levels (+0.15%) compared to baseline samples. The faba bean residues contributed significantly to biological nitrogen fixation and improved soil aggregation. These findings validate CSSBoost's **bio-stimulant and bio-fertilization** objectives for Pilot 1.

2. Circular Bioeconomy Integration

This dual-crop rotation (legume → tomato) exemplifies a circular agroecosystem where **biomass residues** are incorporated into the soil, reducing the need for chemical fertilizers by ~30% and improving water-use efficiency. Such outcomes align directly with the **CSSBoost Deliverable D5.2**, targeting waste valorisation and nutrient cycling.

3. Smart Agriculture Validation

The **SmartAgroGenius system** proved critical in data acquisition and decision support. Real-time monitoring of irrigation, soil conductivity, and climatic parameters demonstrated measurable input savings (~20% reduction in water

use, compared to conventional practices) and enhanced resource allocation efficiency.

4. Farmer Engagement and Training

The participating farmer was successfully trained to operate the smart monitoring system, which a positive step toward **technology adoption in small Mediterranean farms**. Continuous mentoring ensured accurate sensor interpretation and responsive management actions.

Summary

Parameter	Faba Bean	Tomato
Planting Date	22/12/2024	06/06/2025
Ending of Harvest Date	08/05/2025	10/10/2025
Area	2 acres	2 acres
Yield	2.5 tonnes faba beans	9 tonnes tomatoes
Smart Monitoring	SmartAgroGenius	SmartAgroGenius
Soil Nitrogen Enrichment	+0.15%	Retained and utilized
Fertilizer Reduction	30%	Maintained
Farmer Training	Completed	Completed

Concluding Remarks

During the field implementation of the **CSSBoost Pilot 1 in Crete**, we demonstrated that integrating **legume-based green manure systems** with **smart precision irrigation** significantly improves soil health, reduces external input dependency, and enhances both environmental and economic sustainability.

These results can support the employment of this methodology across Mediterranean agroecosystems and will feed directly into **Deliverable D5.2: Integrated Pilot 1 Activities Report** and the overall **WP5 impact assessment**.









