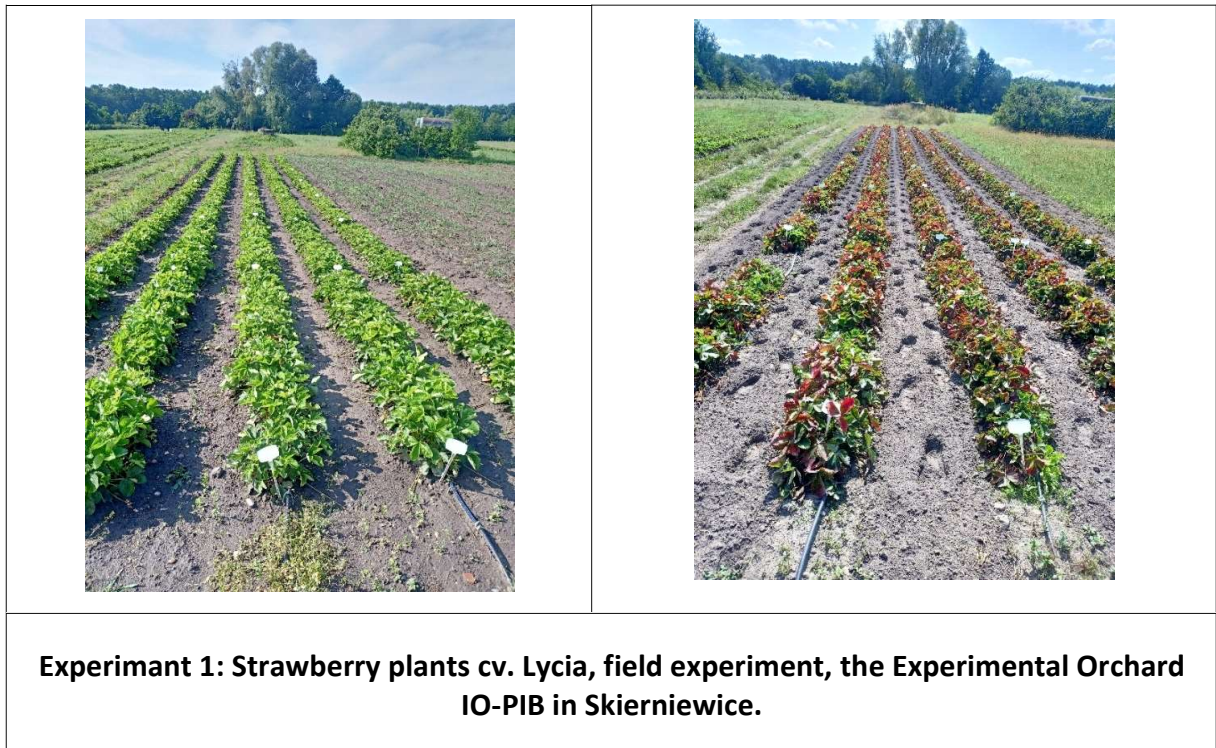


**INHORT Demonstration site**  
**Updated Report — April 2026**

**Experiment I : STRAWBERRY PLANTS**

A field experiment with strawberry plants cv. Lycia was established in May 2023 at the Experimental Orchard of the National Institute of Horticulture in Skierniewice (INHORT). Frigo class A seedlings were used for the experiment establishment. Prior to setting up the experiment, biochar was applied at a rate of 2L/plot (15 plants), mixed with the topsoil layer, and poultry manure (granulated) at a rate of 200 g/plot was also applied. Strawberry plants were planted with a spacing of 0.9 m x 0.2 m.



**Experiment II: CUCUMBER PLANTS**

A field experiment with cucumber plants cv. Octopus was established at the Experimental Orchard of the National Institute of Horticulture in Skierniewice (INHORT). Cucumber seeds were sown in May 2023, 2024 and 2025. Prior to setting up the experiment, biochar was applied at a rate of 2L/plot (2 m<sup>2</sup>), mixed with the topsoil layer and Kurzak (granulated chicken manure) at a rate of 200 g/plot (2 m<sup>2</sup>) was also applied. Each plot constituted an experimental unit, where 14 seeds were sown with a spacing of 0.3 m within the row and 1 m between rows.



**Experiment II: Cucumber plants cv. Octopus, field experiment, the Experimental Orchard IO-PIB in Skierniewice.**

**Experiment III: APPLE TREES**

For the field experiment with apple trees, 4-year-old trees cv. Gold Milenium grafted on M9 rootstock, located in the Experimental Orchard of the National Institute of Horticulture in Skierniewice in Dąbrowice (INHORT), were selected. In spring, the apple trees were fertilized with poultry manure at a rate 300 g/tree and biochar - 2L/tree. Biochar fertilizer was applied to the soil in a ring around the tree trunk and mixed with the topsoil layer. The trees were planted with a spacing of 2 m x 4 m.



**Experiment III: Gold Milenium of apple trees grafted on M9 rootstock, located at the Experimental Orchard IO-PIB in Dąbrowice.**

## Conclusion

The results of field experiments conducted between 2023 and 2025 clearly demonstrate that the use of biochar and microbial consortia, either individually or in combination, has a significant positive impact on the growth, physiological activity, yield, and overall health of apple trees ('Gold Milenium'), strawberries ('Lycia'), and cucumbers ('Octopus'). Among the treatments used, Consortium 2 consistently increased apple yield, while the combination of biochar and microbial consortia improved photosynthetic efficiency, as reflected in improved FV/FM,  $\Phi$ PSII, qp, ETR, FV/F0, and Rfd parameters. In the case of strawberries and cucumbers, these methods increased chlorophyll content, fruit number, and total yield, demonstrating their broad applicability across a variety of crops.

The key mechanism for these benefits is increased root colonization by arbuscular mycorrhizal fungi (AMF) and increased AMF spore abundance in the rhizosphere soil. This symbiotic interaction facilitates nutrient uptake, particularly macro- and micronutrients, leading to improved plant growth. The highest AMF spore abundance was observed in the rhizosphere of apple trees, highlighting crop-specific responses and suggesting that the application of microbial consortia, particularly in fruit tree crops (apple orchards), benefits their growth. Molecular analyses also confirmed the presence of beneficial bacteria, such as *Priestia* spp., in soils treated with Consortium 3 and biochar, indicating additional positive effects on soil microbial diversity and overall soil health.

The use of biochar and microbial consortia also improved soil fertility by increasing organic matter content and the availability of macro- and micronutrients, particularly in strawberry cultivation. The increased content of leaf nutrients, including iron and zinc, contributed to improved plant nutritional status and higher photosynthetic efficiency. These changes translated directly into increased yield, fruit number, and average fruit weight in all species studied. The combined use of biochar and microbial consortia consistently produced the most pronounced benefits, suggesting a synergistic effect of organic soil amendments and beneficial microorganisms. From a practical agricultural perspective, the results indicate that incorporating biochar and selected microbial consortia into the production cycle of fruit and vegetable plants can significantly increase yield and fruit quality, while simultaneously improving soil fertility. For fruit and vegetable growers, these treatments offer an effective, environmentally friendly strategy for improving crop productivity, reducing the use of synthetic fertilizers, and strengthening plant resistance to environmental stress. In particular, the use of Consortium 2 and its combination with biochar is recommended for apple orchards, while the combination of biochar with 3 examined microbial consortia is recommended for strawberries and cucumbers to maximize fruit yield and quality.

Overall, the results of these multi-season experiments (2023-2025) support the use of biochar and microbial consortia as practical tools in modern, sustainable horticulture, delivering tangible benefits in plant growth, yield, nutrient uptake, and soil microbial health. Their consistent positive impact on multiple crop species over several growing seasons underscores their potential for widespread application in organic and sustainable fruit and vegetable production systems.

INHORT has developed consortia of microorganisms and bio-based products to reduce greenhouse gas emissions in greenhouse and field crops. INHORT was conducting field trials to evaluate the use of specific microbial consortia (Streptomyces and Pseudomonas) to accelerate composting and increase nutrient content and bioavailability, reducing N and P losses by 30 to 80%. Elaborated new Consortia 1, 2 and 3 of microorganisms was selected from the SYMBIO BANK, INHORT:

Selected bacterial consortium for compost enrichment

Consortium 1 – TES10B3 *Bacillus licheniformis*, TES5B21 *Bacillus licheniformis*, GOS5B1 *Streptomyces* sp., GOS10B9 *Bacillus licheniformis*.

Selected bacterial consortia to increase the uptake of nitrogen and phosphorus by plants

Consortium 2 - Pi22B *Pseudomonas* sp., Pi25C *Pseudomonas* sp., NAzot2 *Klebsiella* sp.

Consortium 3 - TES5B10C *Priestia* sp., GOS5B22 *Priestia* sp., GOS10B151 *Bacillus licheniformis*.

Technology for optimization of composting of agricultural waste is based on newly developed, innovative microbiological consortia. Selected strains of microorganisms have properties of accelerating the degradation process of organic matter during composting. Consortium of beneficial microorganisms for biodegradation of organic matter, containing the following strains was developed: *Priestia* sp., *Bacillus* spp., *Streptomyces* sp. Newly developed consortia contain selected and never before used strains of microorganisms. The strains of beneficial microorganisms isolated from the soil around plant roots and from the rhizosphere soil of horticultural and agricultural plants were inoculated on specific agar-based growth media. Cultures were tested on presence of potential mechanisms responsible for stimulation of vegetative growth of plants (phosphate solubilization, siderophore production, nitrogen fixation, production of indole acetic acid).

Recommendation for cultivation

- Biochar enriched microbiologically is recommended for growing cucumber, strawberry plants, apple trees, other horticultural crops.
- Soil application of biochar, at the beginning of vegetative growth, 5-10 t/ha, ones in the season.
- Microbial consortia are recommended to be used 2-3 times during the season, at 2-week intervals.
- The biochar should be used in combination with soil fertilization with a nitrogen fertilizer or a biofertilizer.
- It is recommended to use the biochar together with foliar fertilization with an organic fertilizer.