



MICROBIAL CONSORTIA AS COMPONENTS OF BIOPREPARATIONS STIMULATING PLANT GROWTH, YIELDING AND REDUCING LOSSES OF MINERAL NUTRIENTS TO THE SOIL, WATERS AND AIR - ECONUTRI PROJECT

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INTRODUCTION

The EcoNutri research project developed and implemented innovative technologies for horticulture and agriculture crop, in order to reduce soil, water and air pollution resulting from excessive use of mineral fertilizers and chemical plant protection products. The objective of ECONUTRI is to optimize, validate and demonstrate nature-based novel solutions adapted into a holistic concept, which contribute to reduction of NO₃-N and P leaching, control of N losses through ammonia volatilization and mitigation of GHG emissions originating from the agricultural sector, including both plant and animal production.

The effect of three newly developed microbial consortia applied to the soil separately or in combination with biochar on the growth and yield of strawberry, cucumber and apple trees was assessed.



MATERIALS AND METHODS

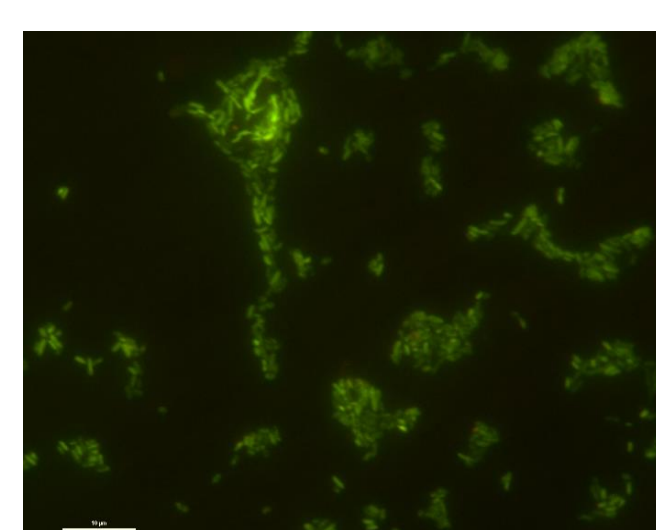
Three consortia of microorganisms deposited in SYMBIO BANK of The National Institute of Horticultural Research in Skierniewice (INHORT) were selected for experiments with strawberry, cucumber and apple plants:

- Consortium 1 - TE510B3 *Bacillus* sp., TE55B21 *Bacillus* sp., GOS5B1 *Streptomyces* sp., GOS10B9 *Bacillus* sp.
- Consortium 2 - Pi22B *Pseudomonas* sp., Pi25C *Pseudomonas* sp., NAzot2 *Klebsiella* sp.
- Consortium 3 - TE55B10C *Priestia* sp., GOS5B22 *Priestia* sp., GOS10B151 *Bacillus* sp.

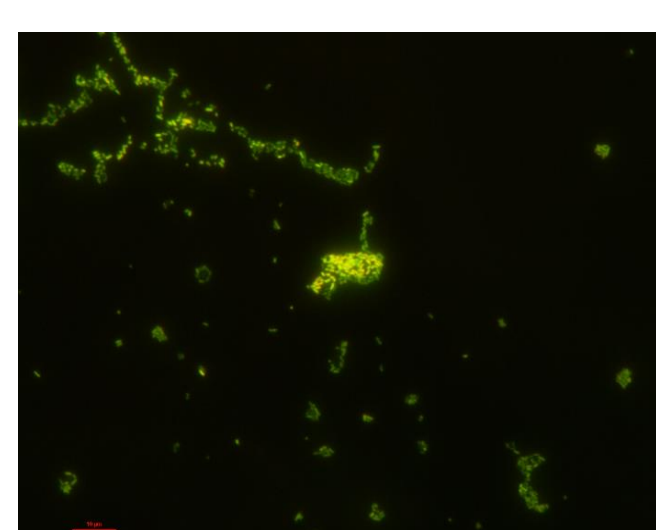
Experiments on the effect of biochar and consortia of beneficial microorganisms on the growth and yield of strawberry cv. Lycia, cucumber cv. Octopus plants and apple trees cv. Gold Millennium were carried out in 2023 under field conditions. Experimental combinations:

1. Control; 2. Biochar; 3. Consortium of microorganisms I; 4. Consortium of microorganisms II; 5. Consortium of microorganisms III; 6. Biochar + Consortium of microorganisms I; 7. Biochar + Consortium of microorganisms II; 8. Biochar + Consortium of microorganisms III.

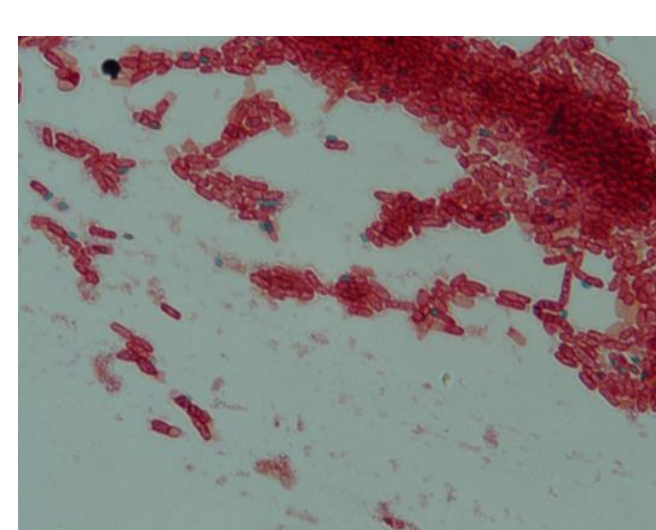
The consortia of microorganisms were applied to all examined plant species, 2 times in the season (beginning of April, in the middle of June), thorough abundant soil spraying. The following measurements were conducted: plant height (cm/plant); number of fruits (pcs/plant); average weight of one fruit (g/plant); total yield (g/plant). The degree of colonization of plant roots by arbuscular mycorrhizal fungi, the photosynthetic efficiency and the chlorophyll content in leaves were also assessed.



Pseudomonas sp.



Klebsiella sp.



Priestia megaterium

SUMMARY

1. Microbiological plant cultivation technologies have been developed, using innovative biofertilizers containing selected strains of beneficial bacteria of the genera: *Bacillus*, *Priestia*, *Klebsiella*, *Streptomyces* and *Pseudomonas*, stimulating growth and yield of strawberry, cucumber and apple trees and increasing the absorption of nitrogen, potassium, phosphorus and other macro- and microelements by plants.
2. The application of newly developed biofertilizers reduces the loss of minerals from the soil to surface waters, groundwater and the atmosphere.
3. Innovative microbiological technologies will contribute to reducing soil, water and air pollution by improving the efficiency of the use of minerals by plants and reducing soil and water contamination with organic biomass waste from agriculture.

RESULTS

Biochar application on its own and application of biochar with 3 microbial consortia increased the yield and average fruit weight of cucumber plants. In comparison to the control, total yield, the number of cucumber fruits and the average weight of fruits was increased by biochar application and biochar microbiologically enriched with 3 consortia.

The use of biochar in combination with microbial consortia had a positive effect on the efficiency of photosynthesis in photosystem II (PS II) expressed by improved parameters of FV/FM, ΦPSII, qp, ETR, FV/F0, Rfd.

The use of biochar or consortia of beneficial microorganisms, as well as their combined application with biochar, increased the degree of colonization of cucumber, strawberry and apple roots by arbuscular mycorrhizal fungi. A beneficial effect was found, after combined application of microbial consortia and biochar on the formation and occurrence of AMF spores in the rhizosphere soil of strawberry, cucumber and apple plants.

Table 1. Effect of biochar and consortia of microorganisms on chlorophyll content in leaves, yield, number of fruits and average weight of 1 fruit of cucumber 'Octopus' plants

Combination	Chlorophyll content in leaves [SPAD/plant]	Yield [g/plant]	Number of fruits [no./plant]	Average weight of 1 fruit [g]
Control	104,5 a	1589,9 a	26,5 a	59,98 a
Biochar	107,6 a	1814,2 a	28,4 a	63,89 ab
Consortium 1	106,0 a	1540,4 a	25,8 a	59,74 ab
Consortium 2	106,6 a	1729,7 a	27,8 a	62,05 ab
Consortium 3	109,0 a	1581,1 a	27,1 a	58,42 a
Biochar + Consortium 1	107,0 a	1846,7 a	28,0 a	65,85 ab
Biochar + Consortium 2	105,7 a	1854,1 a	27,8 a	66,58 b
Biochar + Consortium 3	108,0 a	1809,0 a	28,8 a	62,95 ab

- An increase in the green color of leaves was observed after application of Consortium 3 or Consortium 3 with biochar.
- The highest yield was obtained after treatment with biochar, biochar with Consortium 2 or biochar with Consortium 1.
- A larger number of cucumber fruits was obtained after the application of biochar, biochar with Consortium 3 and biochar with Consortium 1.
- The highest average fruit weight was recorded after the application of biochar and Consortium 2.

Table 2. The effect of biochar and consortia of microorganisms on chlorophyll content in strawberry leaves, the height of strawberry plants cv. Lycia and the fruit yield of apple trees cv. Gold Millennium

Combination	Chlorophyll content in strawberry leaves [SPAD/plant]	The height of strawberry plants [cm]	The fruit yield of apple 'Gold Millennium' [kg/plant]
Control	36,8 a	22,6 a	28,22 a
Biochar	37,5 a	23,4 a	24,78 a
Consortium 1	38,3 a	24,0 a	26,23 a
Consortium 2	36,6 a	23,2 a	31,17 a
Consortium 3	39,3 a	22,0 a	25,85 a
Biochar + Consortium 1	38,3 a	23,2 a	25,40 a
Biochar + Consortium 2	39,1 a	23,9 a	29,65 a
Biochar + Consortium 3	39,1 a	20,8 a	25,23 a

- An increase in chlorophyll content in strawberry leaves was recorded after the application of Consortium 3, Biochar with Consortium 2 or Biochar with Consortium 3.
- The application of Consortium 1 had the greatest impact on the height of strawberry plants.
- The most positive effect on the height of strawberry plants was after the application of Consortium 1.
- An increase of apple fruit yield was recorded after the application of Consortium 2.

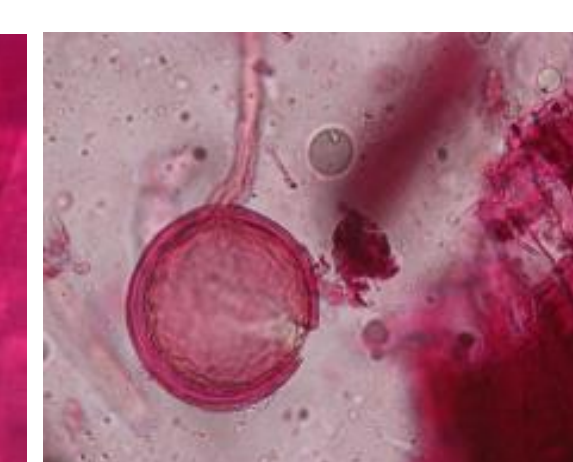
Table 3. The effect of treatment of apple trees with biopreparations on the colonization of roots by arbuscular mycorrhizal fungi

Treatment	F%	M%	m%	
Control	12,2 a	0,99 a	8,0 a	
Biochar	26,0 b	2,2 a-c	9,0 a	
Beneficial microorganisms	Consortium 1	42,2 c	3,0 bc	7,0 a
	Consortium 2	40,0 c	3,2 c	8,0 a
	Consortium 3	28,0 b	2,0 a-c	7,0 a
Beneficial microorganisms + Biochar	Consortium 1	23,3 a	1,3 ab	9,0 a
	Consortium 2	40,0 c	3,0 bc	7,0 a
	Consortium 3	28,0 b	2,2 a-c	7,9 a

- The results of microscopic observations indicate that the application of Consortium 1 in the cultivation of apple trees resulted in a significant increase in the occurrence of arbuscular mycorrhizal fungi (AMF) in the roots of these plants.
- The application of Consortium 2 increased the intensity of colonization of apple tree roots by AMF.



Mycelium of arbuscular mycorrhizal fungi in apple tree roots treated with biochar together with Consortium 2.



Mycorrhizal fungus spore in the root of apple trees after application of Consortium 1.



AMF mycelium in apple root treated with Consortium 2.

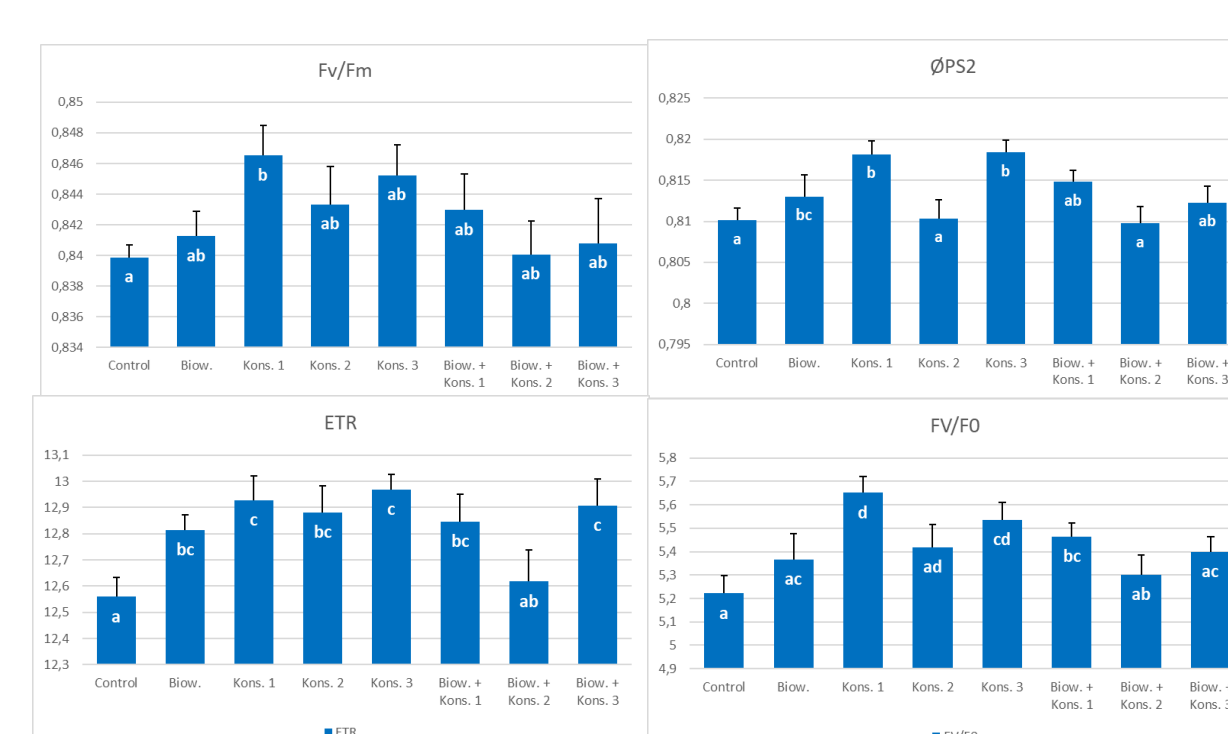


Fig. 1. Chlorophyll fluorescence in apple leaves

- Application of biochar and consortia alone or together increased the photosynthetic efficiency in apple leaves.
- The most effective increased of photosynthetic efficiency in apple leaves was observed after treatment with Consortium 1 and Consortium 3 applied alone and together with biochar

