Effect of bioproducts on root growth and the occurrence of arbuscular mycorrhizal fungi in the rhizosphere of strawberry plants cv. 'Elsanta' and 'Elkat' in field conditions

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Abstract

The aim of the study was to determine the effect of biofertilizers on the growth of strawberry roots and their colonization by mycorrhizal arbuscular fungi. Plants of two strawberry cultivars, 'Elkat' and 'Elsanta', were planted in May 2010 in an experimental orchard in Dąbrowice. The experiment was set up in a randomised block design in four replications. Each replication consisted of a plot of 20 strawberry plants planted 0.25 m apart with a 1-metre-wide gap between the rows. The experiment included 10 combinations: Control 0 (no fertilization), Control NPK, manure, Micosat + manure, Humus UP, Humus Active + Aktywit PM, BF Quality + manure, BF Amin + manure, manure + Tytanit, Vinassa + manure. In June 2011, the roots of the plants were collected for a laboratory assessment of mycorrhizal frequency. Regardless of the cultivar, the applied biopreparations had a positive effect on the colonization of the roots of strawberry plants cv. 'Elkat' and 'Elsanta' by arbuscular mycorrhizal fungi. The combined application of the preparation Micosat + manure caused a 6-fold increase in mycorrhizal frequency in the roots of strawberry cv. 'Elkat' in relation to the control fertilized with NPK. Mineral NPK fertilization caused a reduction in mycorrhizal frequency in the roots of strawberry plants of the two strawberry cultivars.

Keywords: strawberry, arbuscular mycorrhizal fungi (AMF), mycorrhizal frequency

Introduction

The study, carried out within the framework of a project aimed at developing new products and technologies for organic fruit production in Poland, evaluated the effect of new organic fertilizers and amendments on root growth and mycorrhizal abundance and biodiversity in the rhizosphere of strawberry plants 'Elsanta' and 'Elkat'. The influence of organic amendments on the development of mycorrhizal fungi has been reported by several authors. The technologies rely on the use of these bioproducts as they are or in a form enriched with beneficial soil microorganisms (Malusà *et al.*, 2007; Derkowska *et al.* 2008; Günes *et al.* 2009; Kirad *et al.* 2009). Several organic fertilizers and amendments have been recently tested and introduced, which are also acting as natural stimulators of plant growth and development (Chelariu & Ionel, 2005; Gousterova *et al.*, 2008; Khan *et al.*, 2009; Chelariu *et al.*, 2009; Meszka & Bielenin, 2009; Spinelli *et al.* 2010). These are preparations of natural (plant or animal) origin, harmless to humans and the environment, which contain nutrient elements and biologically active substances (i.e. plant hormone-like substances, enzymes) as well as other compounds that stimulate plant growth, yield, quality or tolerance to biotic and abiotic stresses. Enrichment of organic bioproducts with beneficial soil bacteria and mycorrhizal fungi could enhance the effectiveness of the organic products in plant growth stimulation and fruit production.

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Material and Methods

Plants of two strawberry cultivars 'Elkat' and 'Elsanta' were planted in May 2010 in an experimental orchard in Dąbrowice. The experiment was set up in a randomised block design in four replications. Each replication consisted of a plot of 20 strawberry plants planted 0.25 m apart with a 1-metre-wide gap between the rows. In June 2011, the roots of the plants were collected for a laboratory assessment of mycorrhizal frequency.

The following experimental treatments were applied:

1) Control (no-treatment) (organic matter 1.5%, P 51 mg P kg^{-1}, K 158 mg K kg^{-1}, pH 5.5).

2) Standard NPK soil fertilization: 4 g NH_4NO_3 $plant^{-1}$, 3 g triple superphosphate and 6 g K_2SO_4 per rhizobox.

3) Dry granulated bovine manure for organic farming (Doktor O'grodnik) – 1 g per rhizobox.

4) Micosat (CCS Aosta s.r.l.) – a mixture of AM fungi: *Glomus* species, *Trichoderma viride* and rhizosphere bacteria species (*Bacillus subtilis, Pseudomonas fluorescens, Streptomyces* spp.) – 10 g + 0.5 g manure per rhizobox.

5) Humus UP (Ekodarpol) – an extract from a vermicompost – 2% solution to the soil per rhizobox.

6) Humus Active + Aktywit PM (Ekodarpol) – Humus Active is a soil improver with active humus and a population of beneficial microorganisms – 2% solution of Humus Active and 1% solution of Aktywit PM to the soil per rhizobox.

7) BioFeed Quality (Agrobio Products B.V.) – an extract from several seaweed species reinforced with humic and fulvic acids – 0.5% solution + 0.5 g manure to the soil per rhizobox.

8) BioFeed Amin (Agrobio Products B.V.) – an extract of 100% vegetal amino-acids – 0.5% solution + 0.5 g manure to the soil per rhizobox.

9) Tytanit (Intermag) – titanium (Ti) 0.8% (5 g Ti in 1 l of working solution), pH 3.4, containing 3163 mg kg^{-1} Ti – 0.05% solution + 1 g manure to the soil per rhizobox.

10) Vinassa – molasses residue from yeast production – 0.5% solution + 0.5 g manure to the soil per rhizobox.

Determination of mycorrhizal frequency:

- Roots were cold-stained using the Phillips & Hayman method (1970).
- Microscopic analysis of the roots – Trouvelot's method (1986).
- Mycorrhizal frequency (F%), mycorrhizal intensity (both relative – M%, and absolute – m%), abundance of arbuscules (both relative – A%, and absolute – a%) were assessed in each root segment.
- The mycorrhizal parameters were calculated using the Mycocalc software: http://www2.dijon.inra.fr.mychintec/Mycocalc-pgr/download.html

All the results were statistically evaluated with analysis of variance. Comparisons of means were at $p \leq 0.05$ with the Duncan test.

Results

The highest mycorrhizal frequency was recorded in the roots of plants cv. 'Elkat' (F = 38.89%) in the combination Micosat + manure. Relative mycorrhizal intensity was the highest in the roots of plants cv. 'Elkat' (M = 2.26%) in the combination BF Amin + manure. The highest abundance of arbuscules was recorded in the roots of plants cv. 'Elkat' (A = 0.03%) in the combination with manure. The lowest values of mycorrhizal frequency,

mycorrhizal intensity and abundance of arbuscules were observed in the control combination fertilized with NPK (‘Elsanta’: F = 4.44%, ‘Elkat’: F = 6.67%).

Table 1. Comparison of mycorrhizal frequency (F%), relative mycorrhizal intensity (M%), intensity of the mycorrhizal colonisation in the root fragments (m%), arbuscule abundance in mycorrhizal parts of root fragments (a%) and relative abundance of arbuscules (A%) in the roots of strawberry plants cv. ‘Elsanta’ and ‘Elkat’ (Dąbrowice, 2011) (on the left – ‘Elsanta’, on the right – ‘Elkat’).

‘Elsanta’

Treatments	F%	M%	m%	a%	A%
Control	8.89	0	1	0	0
NPK Control	4.44	0.04	1	0	0
Manure	27.78	0.45	1.59	0	0
Micosat + manure	34.44	1.02	3.01	0	0
Humus UP	18.89	0.78	4.3	0	0
Humus Active + Aktywit PM	22.22	0.47	1.83	0	0
BF Quality + manure	24.44	1.2	4.7	0	0
BF Amin + manure	20	0.88	4.35	0	0
Manure + Tytanit	18.89	0.6	3.1	0.93	0
Vinassa + manure	18.89	0.32	1.71	0.93	0

‘Elkat’

Treatments	F%	M%	m%	a%	A%
Control	14.44	0.28	1.8	0	0
NPK Control	6.67	0.58	2.33	0	0
Manure	27.78	1.88	6.89	3.21	0.03
Micosat + manure	38.89	0.79	2.03	0	0
Humus UP	33.33	0.69	2.11	0	0
Humus Active + Aktywit PM	23.33	0.63	2.71	0	0
BF Quality + manure	12.22	0.21	1.67	0	0
BF Amin + manure	16.67	2.26	1.53	0	0
Manure + Tytanit	23.33	1.05	4.94	0	0
Vinassa + manure	20	1.07	4.85	0	0

The observed mycorrhizal structures:

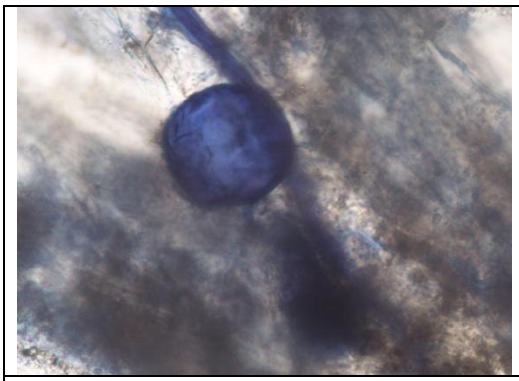

Photo 1. A spore in the roots of strawberry plants cv. ‘Elsanta’ (Dąbrowice, 2011)

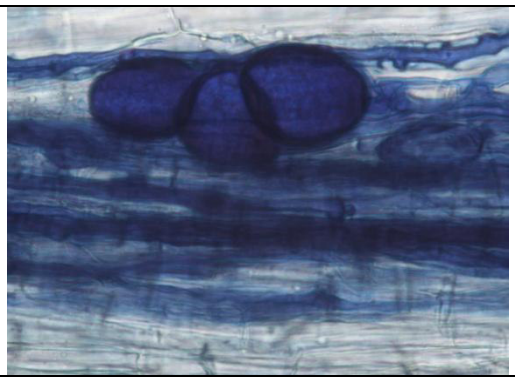

Photo 2. Vesicles in the roots of strawberry plants cv. ‘Elkat’ (Dąbrowice, 2011)

The combined application of the preparation Micosat + manure caused a 6-fold increase in mycorrhizal frequency in the roots of strawberry cv. ‘Elkat’ in relation to the control fertilized with NPK. Mineral NPK fertilization caused a reduction in mycorrhizal frequency in the roots of strawberry plants of the strawberry cultivars.

Regardless of the cultivar, the applied biopreparations had a positive effect on the colonization of the roots of strawberry plants cv. 'Elkat' and 'Elsanta' by arbuscular mycorrhizal fungi.

Discussion and conclusions

The influence of different types of products of biological origin on plant growth and fruit quality has been widely reported by many authors (Żurawicz *et al*. 2006, Frąc *et al.* 2009*;* Roussos *et al*. 2009). Also, the occurrence of AMF in plant roots and the rhizosphere affected by these products has been observed by many authors in different kinds of plants (Celik *et al*. 2004; Kuwada *et al.* 2006b).

The beneficial influence of products of seaweed origin on the presence of arbuscular mycorrhizal fungi was observed in our experiment and was reported earlier by Kuwada *et al.* (2005; 2006a) for *Gigaspora margarita*. The positive influence of manure application was observed by Harinikumar & Bagyaraj (1989) in cropping sequence with maize, sunflower and other plants. The higher percentage of mycorrhizal colonization of dry bean (*Phaseolus vulgaris* L. cv. Viva) in manure-treated soil was observed by Tarkalson *et al.* (1998). In some cases increased amounts of manure can decrease the positive effect of AMF on plant growth parameters (Brechelt 1990). The results of our study revealed that NPK fertilization significantly decreases the number of mycorrhizal structures in strawberry roots due to the lowest percentage of mycorrhizal associations in the roots of NPK-fertilized plants. Other researchers have also reported the harmful influence of synthetic NPK fertilizers on mycorrhizas (Harinikumar & Bagyaraj 1989; Plenchette 1989). The results of this field experiment showed that mycorrhization has a positive effect on root colonization with arbuscular mycorrhizal fungi, which is in agreement with the previous studies conducted in various environmental conditions (Varma & Schuepp 1996; Vosatka *et al.* 2000).

Our results revealed that the highest mycorrhizal frequency was recorded in the roots of strawberry plants cv. 'Elkat' in the combination of Micosat + manure. The highest abundance of arbuscules was recorded in the roots of plants cv. 'Elkat' fertilized with manure. The combined application of the preparation Micosat + manure caused a 6-fold increase in mycorrhizal frequency in the roots of strawberry cv. 'Elkat' in relation to the control fertilized with NPK.

Mycorrhization and application of bioproducts can be recommended as an alternative to standard NPK fertilization, for use in strawberry cultivation, due to its positive influence on plant growth, development and higher colonization of strawberry roots with mycorrhiza (Sas Paszt *et al.* 2011).

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