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Effect of application of mycorrhizal fungi on apple tree growth after planting

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Abstract

The effect of mycorrhizal fungi on the rooting and growth of apple trees was evaluated in experimental plantings in Research and Breeding Institute of Pomology at location Holovousy, district Jičín, Czech Republic. Product Symbivit that contains five species of mycorrhizal fungi (Symbiom company, Lanškroun, Czech Republic) was applied during planting on apple cultivars 'Angold', 'Antopa', 'Idapaz', 'Meteor' and 'Topaz' on M9 rootstocks. Trees were planted in the spring in 2022. The planting was without drip irrigation. Mycorrhizal fungi were applied during planting directly to the roots. Differences in the diameter of tree stems in the experimental variants were compared with control variants. Measurements were done after planting, in fall 2022 and 2023. In the first year of cultivation a significant difference in growth was noted in trees treated with the product compared to control. The diameter of tree trunk with the application of mycorrhiza was 1.8 mm while in the control without application 1.4 mm in the first year, respective 4.5 mm and 4.1 mm after the second year of cultivation.

Keywords: *Malus* × *domestica* Borkh.; symbiotic relationships; fruit cultivation; tree growth, rootstocks

Introduction

Mycorrhizal symbiosis represents one of the most widespread symbiotic relationships on the planet. Green photosynthesizing plant supplies the mycorrhizal fungus with carbonaceous substances in the form of simple sugars (glucose or fructose) and the fibrous fungus colonizes the root of the host plant, from which it penetrates the surrounding soil, obtains water and mineral nutrients, and subsequently transports them to the colonized plant. Mycorrhizae colonize plant roots extracellularly (ectomycorrhiza) and intracellularly (endomycorrhiza). Ectomycorrhizal fungi form a net in the outer cell wall layers of plant roots, without invading plant cells. Arbuscular mycorrhizal fungi (AMF) are the most important endophytic fungi. AMF also interact with most crop plants including cereals, vegetables, and fruit trees. Therefore, they receive increasing attention for their potential use in sustainable agriculture. Fungal hyphae grow not only through the intercellular spaces, but also get inside the cells, where they form characteristic richly branched formations - arbuscules looking like bush-like formations that enable transfer of nutrients (MacLean *et al*., 2017). However, the fungal fiber does not only grow inside the tissue of the root, but also outside in the soil. The fungus thus ensures the creation of a surface large enough to receive water and minerals for itself and for the host plant.

Material and Methods

The effect of mycorrhiza fungi on the rooting and growth of apple trees after planting was evaluated in an experimental orchard at location Holovousy, district Jičín, Czech Republic. The commercial product Symbivit (Symbiom company, Lanškroun, Czech Republic)

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containing five species of AMF (*Glomus* species) was tested on the cultivars ‘Angold’, ‘Antopa’, ‘Idapaz’, ‘Meteor’ and ‘Topaz’ on M9 rootstock. The orchard was planted in spring of 2020. The planting was not provided with drip irrigation. Mycorrhizal product was applied during planting directly to the tree root system by spreading from each side of the tree. The total dose for one tree was 120 g of the product. Variants with application of the mycorrhizal product and control without application were evaluated in randomized blocks (10 trees from each cultivar) with 5 repetitions for the purpose of eliminating the influence of microhabitat. The soil was medium loam sandy with rather deep cultivated layer on gravel substrate. Climatic conditions of location Holovousy are characterized by an average annual temperature of 8.1 °C and an average annual precipitation of 655 mm. The trial planting is located at an altitude of 310 m above sea level. The tree strips were mechanically cultivated, the intermediate alleys were regularly mulched. Effect of mycorrhiza was evaluated on the growth of trees. The diameters of the trunk at a height of 60 cm above grafting site were measured. Obtained data were statistically processed by an analysis of variance by STATISTICA software (version 12, Stat Soft). All data were statistically processed by an analysis of variance (ANOVA) and Tuckey´s test (α=0.05) by STATISTICA software (version 12, Stat Soft).

Results

Measurements were carried out in spring of 2022 and at the end of the growing season in autumn 2022 and autumn 2023. The measurement results are processed in table 1 and figure 1. Differences in the increase of the trunk diameter were evaluated and compared to untreated control trees. In the first year of cultivation, a significant difference was noted between treated trees and control trees. The difference in increases was from 1.2 mm (cultivar Angold) up to 2.5 mm (cultivar Meteor) in the variants with the application and 1.0 mm (cultivars Angold and Idapaz) up to 1.8 mm (Meteor) in the untreated control in the year 2022. Moreover, in the second year of cultivation, higher increases were observed in trees with the application of mycorrhizal fungi (from 1.9 up to 5.0 mm) compared to control trees (from 1.8 up to 4.5 mm). The total difference for variants with mycorrhiza after two years of cultivation was from 2.9 up to 7.2 mm and 2.8 up to 6.3 mm for the controls. Since high soil humidity intensifies AMF roots colonization, favourable weather conditions with a rainy period after planting contributed to the colonization of mycorrhizal fungi, when 22 mm of precipitation was recorded in April 2022 and 69 mm in May 2022 (figure 2).

Table 1: Records of difference in trunk diameter increases in variants in years 2022, 2023 (in mm)

Year	2022		2023		Total 2022 - 2023	
Cultivar	Mycorrhiza application	Control	Mycorrhiza application	Control	Mycorrhiza application	Control
Angold	1.2ab	1.0b	3.8cde	3.0abc	4.7cde	3.8abcd
Antopa	1.8a	1.5a	2.1ab	1.8a	3.3abc	3.1abc
Idapaz	1.3a	1.0b	1.9a	1.8a	2.9ab	2.8a
Meteor	2.5c	1.8ac	5.0e	4.5de	7.2f	6.3ef
Topaz	1.9ac	1.6ab	3.5bcd	3.0abc	5.0de	4.5bcd
Total	1.8a	1.4b	3.1a	2.8a	4.5a	4.1a

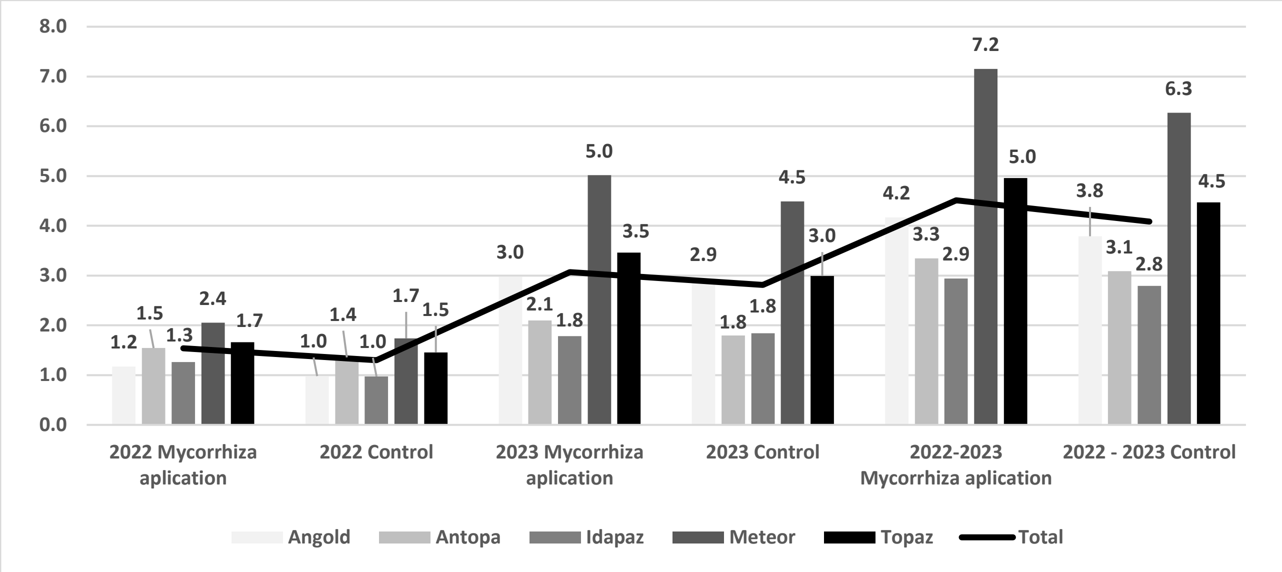

Figure 1: Effect of AMF product on apple tree growth expressed as difference in trunk diameter increases (in mm)

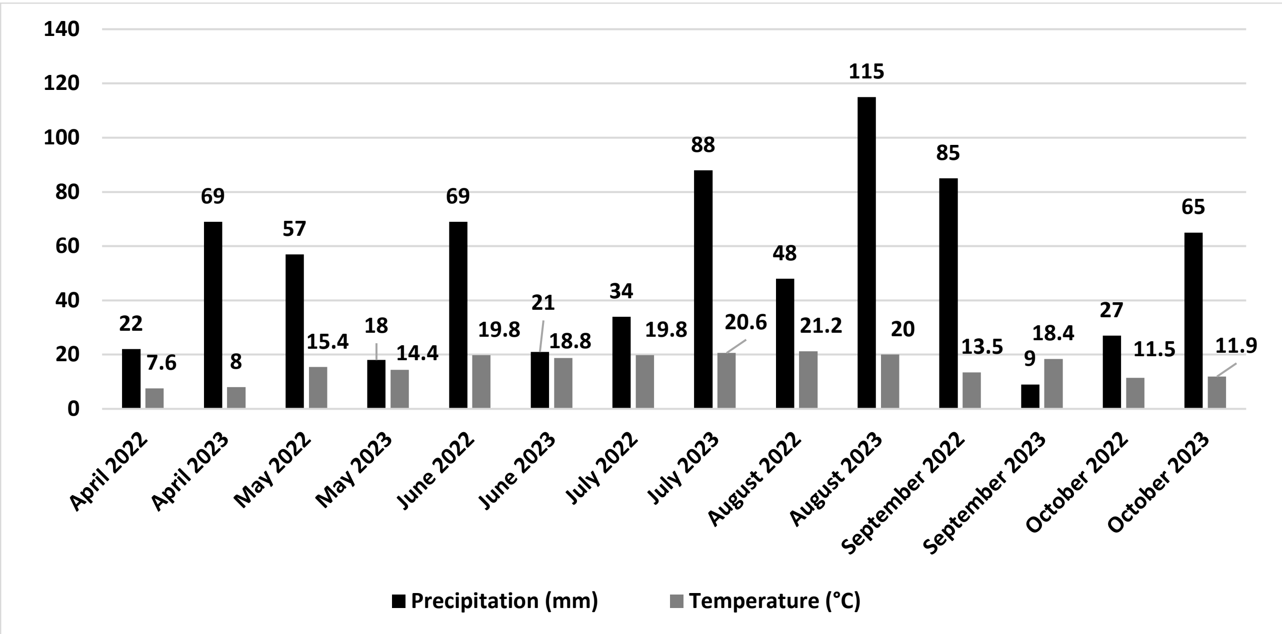

Figure 2: Weather conditions in location Holovousy in years 2022 and 2023

Discussion

Obtained results are consistent with the assessment of AMF colonization on rootstock GF305 observed by Garcin *et al*. (2020). How much a plant benefits from AM fungal colonization depends to a large degree on the environmental conditions. High soil humidity intensifies AMF roots colonization. One month is required for establishing symbiosis. After two months, plants can benefit from AMF symbiosis. In most natural environments, which are characterized by mineral nutrient deficiency and various abiotic stress conditions, mycorrhizal plants are thought to have a selective advantage over non-mycorrhizal individuals of the same species (Chen *et al*., 2018). In conclusion, supply of commercial AMF product could improve plant growth. Mycorrhizal colonization lasts for the whole life-span of plants. Inoculation is necessary only once during the tree life. The best physiological responses and the highest economic benefits are achieved by early application during tree planting.

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