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EFFECTS OF MYCORRHIZAL FUNGI *GLOMUS MOSSEAE* ON THE YIELD FORMATION OF TOMATOES

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Summary: Arbuscular mycorrhizal fungi (AMF) are symbiotic soil fungi that colonize roots of the majority of vascular plants. So these fungi are important in agriculture too, because they improve plant water relations and increase mineral uptake, which reduces the use of fertilizers. The aim of our study was to assess the influence of arbuscular mycorrhizal fungi *Glomus mosseae* isolate LL1 on the growth and yield of tomatoes, as well as on soil biological activity. Plants from the cultivars 'Taifun', 'Sultan'and 'Jantar' were grown from seeds. The fungus preparation was added under seeds during sowing. The control variant was without inoculation with mycorrhizal fungi. At the 2nd true leaf stage seedlings were planted in 10 L vegetation pots with peat substratum. Plants were grown in a greenhouse and fertilized every week with Yara-Kristalon (18-18-18+3). Fresh and dry weights were measured during plant growth. The biological activity of substratum was also determined. Results showed that *Glomus mosseae* stimulated seedling growth. The effect of inoculation with *Glomus mosseae* depended on the tomato cultivar. Among the tested cultivars, cv. 'Jantar' was most sensitive to mycorrhization. Mycorrhization of plants prolonged the period of harvesting and mitigated fluctuations of substratum biological activity.

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Keywords: Arbuscular mycorrhiza; *Glomus mosseae*; tomatoes.

INTRODUCTION

Tomatoes are important vegetables grown conventionally and biologically. Tomatoes are one of the most popular vegetables grown in greenhouse conditions over the world as well as in Latvia. Soil quality and optimal growth conditions are essential for high-quality yield production. Organic fertilizers and microbial preparations are used to optimize the crop growing conditions, to improve plant nutrition and increase resistance to various diseases.

Soil microbiological activity depends on plant-microbe interactions. Plants are

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able to influence the composition and activity of the microbial communities around their root systems through the selective exudation of specific carbohydrates, carboxylic and amino acids, and these microbial communities can be cultivar-specific. Rhizobacteria can themselves induce root exudation responses in plants or initiate changes in root biochemistry (Parmar and Dardarwal, 1999; Sturz and Christie, 2003). Plant-bounded carbon enters the soil as plant litter and root exudates, and is released as CO_2 by the respiration of roots and soil microorganisms. As much as 50% of soil CO_2 efflux is root derived, another part is coming directly from respiration of microorganisms (Cavagnaro et al., 2008).

The arbuscular mycorrhizal fungi (AMF) that colonize the roots of most terrestrial plant species can influence soil carbon processes in a variety of ways and at a range of scales from the individual plant to the ecosystem (Rillig, 2004). Many researches have shown that AMF are an important component of rhizosphere. The effect of mycorrhization depends on plant species and cultivar, plant root age and chemical content of root excudates (Sood, 2003; Tawaraya et al., 2007). Arbuscular mycorrhizal fungi are important in agriculture because they improve plant water relations, increase mineral uptake, which reduces the use of fertilizers, increase the drought resistance of host plants and improve disease control. Endomycorrhizal associations often result in greater yields of crop plants such as rice, tomato, onion and bell pepper (Poss et al., 1985; Ruiz-Lozano et al., 1996)

Most data on mycorrhizal dependence of plant cultivars are available for different host-plants (Vierheilig and Ocampo, 1991). Root exudates may influence microbiological activity in the root zone. Root exudates from mycorrhizal tomato plants showed a higher attraction effect on plant-growth-promoting bacteria, such as *Azotobacter chroococcum* and *Pseudomonas fluorescens*, compared to root exudates from non-mycorrhizal tomato plants (Vierheilig, 2004).

Despite the fact that tomatoes are one of the most popular vegetables grown in protected areas in Latvia, there are no studies on the impact of mycorrhizal fungi on tomato growth, development and yield formation. Mycorrhizal preparations are offered in Latvian market and farmers' interest in them is growing, but there are no local studies about the effects of mycorrhizal fungi on the growth of tomatoes.

The aim of the present study was to investigate the effect of *Glomus mosseae* isolate LL1 on the biological activity of soil as well as on the growth and yield formation of tomatoes.

MATERIALS AND METHODS

Experiments were carried out in 2013 and 2014 in the polycarbonate greenhouse of the Institute of Soil and Plant Sciences, Latvia University of Agriculture.

Seeds of the tomatoes cvrs. 'Taifun', 'Sultan' 'Jantar' were sown in 1 L pots containing the commercial peat substrate pH_{KCl} 5.5±0.5, N 100-140 mg L^{-1}, P_2O_5 110-170 mg L^{-1}, K_2O 190-290 mg L^{-1} with Ca, Mg, S and microelements (Fe, Mn, Mo, Zn, Cu and B). The AMF *Glomus mosseae* (indigenous isolate LL1) preparation was added under seeds during sowing. *Glomus mosseae* strain was isolated from sandy soil by the scientists of Latvia University.

The preparation contained 100 propagules per g and was added 50 g per 1L vegetation pot. Control was without the preparation.

At the stage of 2nd true leaf, plants were placed in 10 L plastic pots containing the same type of peat substratum and grown until the end of the experiment. Based on conventional recommendations after transplantation plants were fertilized weekly with Yara-Kristalon NPK - 18-18-18+3, with Mg and microelements at a dose of 5 g per m^{-2}. Plants were watered daily with tap water.

Plant length and weight before transplantation, the number of leaves and yield formation during plant growth were determined.

Soil biological activity was characterized by the intensity of soil basal respiration. Respiration intensity was determined by the measurement of emitted carbon dioxide using the titration method. 50 g field moisture soil was placed into 500 mL sealed jars containing a beaker with 5 mL of 0.1 M KOH solutions and incubated for 24 h in the dark at 30°C. Then, the KOH solution was removed and titrated with 0.1 M HCl to determine the amount of CO_2 evolved with the soil microbial respiration (Pell et al., 2005).

The obtained data were analyzed with ANOVA analyses using Microsoft Excel and treatment means were compared using LSD test.

RESULTS AND DISCUSSION

At the early developmental stages no significant differences between the variants were observed. Plant length at the stage of 2nd true leaf varied between 10-12 cm, and weight between 12-18 g. Although significant differences between the treatments were not found, the effect of the cultivar was observed. Plants of cv 'Taifun' were responsive to mycorrhization and in average were by 7.4 % heavier than the control (Fig. 1).

The number of leaves during the vegetation period differed between cultivars, but no effect of mycorrhization was observed. Several authors reported the effect of AMF to promote plant growth (Estaun et al., 2010; Ortas, 2010), but in other studies no growth effects as a result of mycorrhization were found (Steinkellner et al., 2012)

The yield and yielding period mostly depended on the cultivar. The highest yield was harvested from cv. 'Sultan',

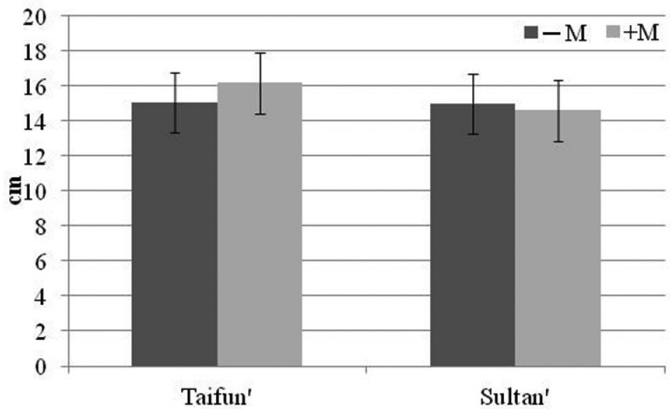

Figure 1. Plant weight at the second true leaf stage. –M - without treatment, +M - treated with *Glomus mosseae* isolate LL1.

in average 16.1 kg per 5 plants. It was significantly more compared with the other two cultivars 'Taifun' and 'Jantar' (12.9 and 9.6 kg, respectively). The effect of inoculation with *Glomus mosseae* depended on the cultivar (Fig. 2). No significant effect of inoculation of tomato plants of cv. 'Taifun' was found during 30 days of harvest. During the first 20 days of harvest of fruits from cv. 'Sultan', a significant negative effect of mycorrhization was observed. An opposite result was obtained for cv. 'Jantar' where during the whole experimental period higher yield was harvested from the mycorrhized plants. Our data corresponded

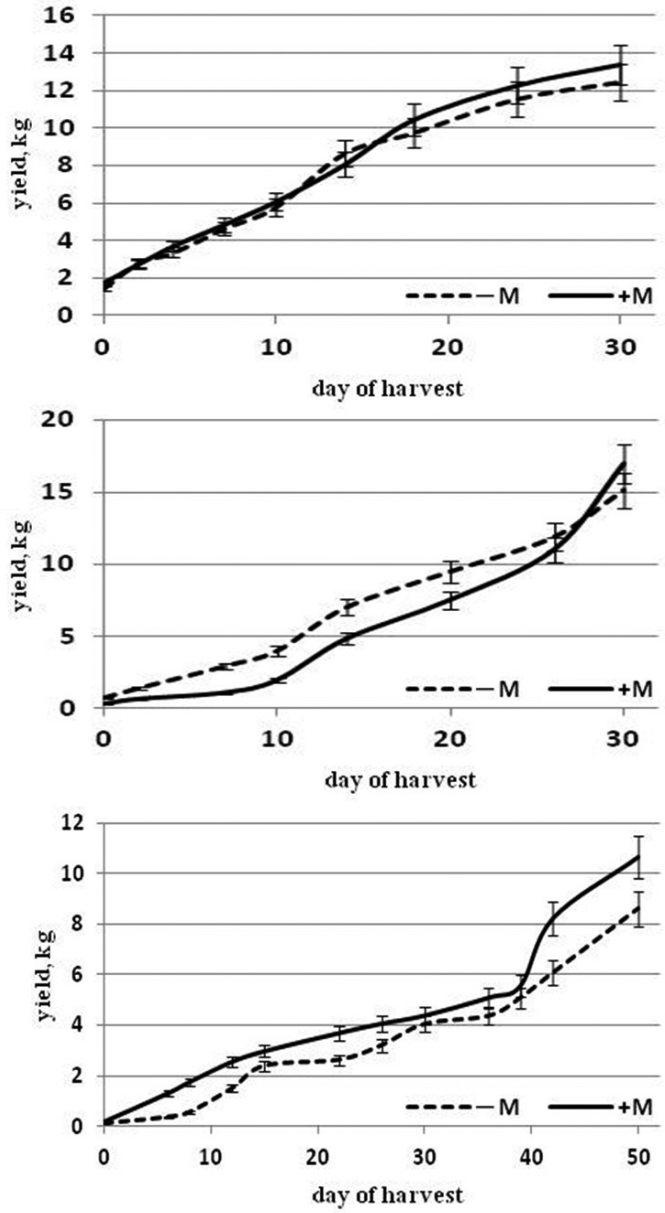

Figure 2. Yield of tomatoes (5 plants). A – cv. 'Taifun', B – cv. 'Sultan', C – cv.'Jantar'; -M - without treatment, +M - treated with *Glomus mosseae* isolate LL1.

to the results of other researchers showing that the effect of mycorrhyzal fungi varied in the interaction between host plants and even plant cultivars (Estaun et al., 2010, Steinkellner et al., 2012). A positive effect of mycorhization was observed at the later period of harvest. This result corresponded to data reported by other researchers (Shinde and Vaidya, 2014), who pointed out that the 2nd and 3rd yield from unmycorrhized tomato plants was significantly less in comparison with treated ones. In opposite to Salvioly et al (2008) in our experiments no effect on the yield earliness as a result of mycorrhization was detected.

The number of fruits correlated with tomato yield (Figs. 2, 3). Fruit weight depended on the cultivar. No effect of mycorrhization on tomato fruits weight was observed. A tendency that fruits of tomatoes treated with *Glomus moseae* had higher dry matter content was observed, but it was not statistically approved (Fig. 4).

Respiration intensity of peat substratum during the vegetation period in untreated plants significantly decreased, but in the treated variants it was continuous (Fig. 5). This result indicated sustainability of the symbiotic system that can improve growing conditions and yielding period. Literature data pointed out that qualitative and quantitative changes in the population

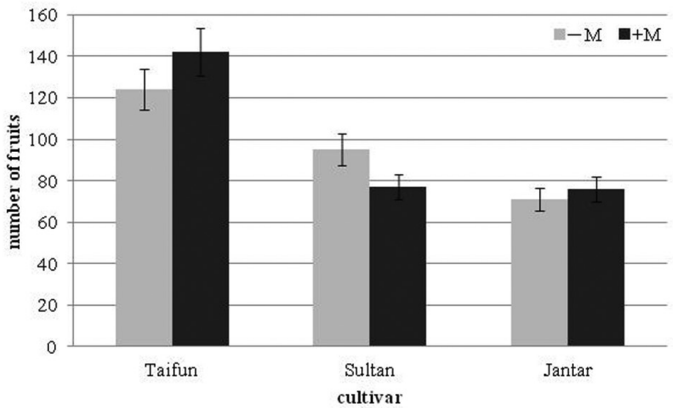

Figure 3. Total number of fruits from 5 plants. –M - without treatment, +M - treated with *Glomus mosseae* isolate LL1.

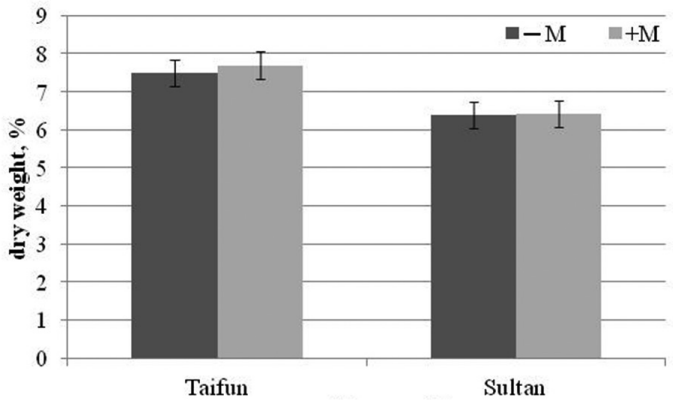

Figure 4. Content of dry matter in tomato fruits. –M - without treatment, +M - treated with *Glomus mosseae* isolate LL1.

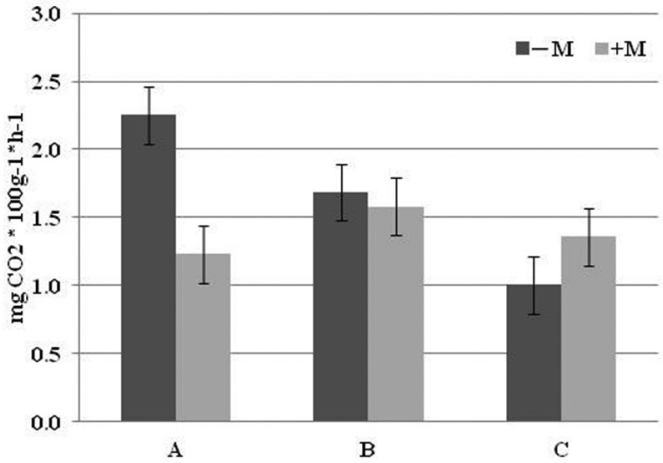

Figure 5. Respiration intensity of substratum during the experiment: A – 2 weeks after planting in 10 L pots, B – 6 weeks after planting in 10 L pots, C – end of the experiment. –M - without treatment, +M - treated with *Glomus mosseae* isolate LL1.

of soil microorganisms reflect the changes in soil quality. Plant cultivation practices affect the soil microbial community in various ways, with possible consequences for nitrogen (N) losses, plant growth and soil organic carbon (C) decomposition. Soil microorganisms are involved in biochemical processes that include decomposition of plant residues, transformations of organic matter, affect mineralization of plant available nutrients, and influence the efficiency of nutrient cycles. Mikanova et al. (2009) pointed that soil biological activity and particularly activity of microorganisms was a significant indicator of soil quality and fertility. The activity of soil respiration can be a sensitive indicator of the changes in soil biological activity and fertility in response to various plant cultivation practices.

Literature data as well as results obtained in our experiments give evidence that the use of *Glomus moseae* can mitigate fluctuations of substratum biological activity, thereby providing sustainability of tomato production and a prolonged harvesting period.

Our data showed that there were no significant differences in tomato production at the beginning of the harvest period. Approximately 20-30 days after the start of harvest, an increase of productivity was observed in the variants treated with *Glomus moseae* in comparison with the control indicating that the production period was prolonged and yield was increased due to sustainability of the symbiotic plant-fungus system.

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