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THE EFFECT OF ARBUSCULAR MYCORRHIZA ON THE YIELD OF DIFFERENT WINTER WHEAT VARIETIES AT FOUR NUTRIENT LEVELS

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Abstract: The examination of mycorrhizae is a very important research topic nowadays, as it is known for its many positive effects and can be found on almost all soil types. They are able to form a symbiotic relationship with the majority of terrestrial plants, with almost 90% of them. They increase the nutrient and water absorption of the host plant, increase the resistance of the plant against diseases and help improve the quality of the soil. In return, the fungus receives organic matter, vitamins and growth-stimulating substances from the plant. However, few studies deal with the mycorrhiza-wheat relationship under field conditions. In our research, we focused on this, where we created four different nutrient levels and treated four varieties of winter wheat (GK Déva, GK Petur, Cellule, MV Nádor) with a biological seedcoating product that contain mycorrhiza. The experiment was set up in Szeged-Öthalom, in the 2021/2022 growing season, on 10 m2 plots in four replicates, using random block arrangement. Our goal was to determine the effectiveness of mycorrhizal treatments in addition to traditional field cultivation. To do this, we measured the yield amounts and examined different yield elements (stem weight, spike weight, spike length). Then the results of the treated and control plants were compared and evaluated using the SPSS statistical system. Based on the one-year results, we observed that mycorrhizal treatments had a positive effect on the yield of winter wheat varieties at all nutrient levels.

Keywords: wheat, arbuscular mycorrhiza, seed inoculation, yield

1. Introduction

The extreme climatic conditions due to climate change, the heavy metal contamination of soils, and the difficulties caused by the increasing amount of chemicals make the pursuit of sustainable farming more and more urgent. Therefore, the importance of biological, soil-improving, environment-friendly and plant-growth-stimulating microorganisms is being appreciated nowadays (Egamberdieva et al. 2017).

During agricultural production, one of the main goals is to achieve a high crop yield, and for this purpose, we spread a significant amount of artificial fertilizers and chemical preparations. And these can have harmful effects on both the environment and health. From the point of view of sustainable farming, an important goal is to find some alternative in order to reduce chemicals. Mycorrhizal fungi, which are useful living organisms that can be found in almost all field and natural ecosystems, can serve as a solution for this (Pellegrino et al. 2015). They are able to form a symbiotic relationship with 70-90% of terrestrial plants. It is known to have several beneficial effects, the extraradical hyphae originating from the plant's root form a mycelium network in the soil, thus increasing the absorption surface of the root and helps absorb nutrients and water from the soil (McGonigle 1988, Lekberg and Koide 2005). It also increases the host plant's resistance to biotic and abiotic stresses. The glomalin produced by mycorrhizal fungi promotes the adhesion of soil particles, so it plays a significant role in the formation of the appropriate soil structure. In return, the fungus receives photosynthetic products, vitamins and growth-promoting substances from the plant (Smith and Read 2008).

The relationship between the plant and the fungus, the resulting root colonization and its extent are influenced by a number of biotic and abiotic factors (Vierheilig et al. 2008). Among the previously mentioned effects, the physical and chemical properties of the soil, such as soil pH, it is influenced by its phosphorus and organic matter content, the taxonomic affiliation of the host plant and the AM fungal species forming or participating in active root colonization (Sasvári et al. 2012). The development and maintenance of the symbiosis is under the joint control of the two partners, so if one of the parties usually the plant does not need the connection, then it is not created (Parkinske 2008). Arbuscular mycorrhizal fungal species form relationships with plants and genotypes to a different degree. One of the reasons for this may be that AM fungal species have different carbohydrate needs (Vierheilig et al. 2008, Hetrick et al. 1996).

The decrease in the number of plant diversifications (e.g. monoculture, wheat-maize crop rotation), the regular disturbance of the soil, the use of artificial fertilizers, and the use of various fungicides all lead to a decrease in the number and activity of AM fungi (Bakonyi and Csitári 2018). Most of the research on arbuscular mycorrhizae is done in culture pot experiments. And in these, the above-mentioned problems do not prevail or not to such an extent. In our experiment, we investigated the effects of mycorrhiza under traditional tillage under field conditions.

2. Materials and methods

Table 1: Fertilization levels of the Öthalom winter wheat monoculture experiment

NPK kg/ha	N	P	K
A	60	0	0
B	90	30	30
C	120	60	60
D	150	60	60

Source: Author's own editing.

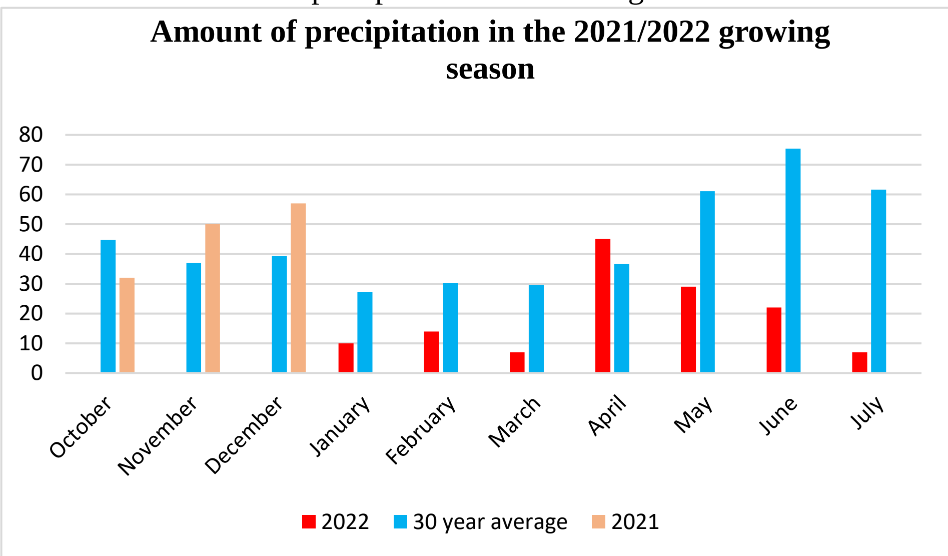
The experiment was set up in Öthalom in the 2021/2022 growing season, on 10 m^2 plots in four replicates, in random block design. Öthalom is located in the south-eastern part of Hungary, near Szeged, and its main soil type is meadow chernozem. The experiment was placed in a longterm field wheat monoculture experiment that has been operating since 1994, where four nutrient levels are separated according to *Table 1*.

2.1 Soil and nutrient management

At the end of September 2020, the basic fertilizer was spread on all four nutrient levels. The following day, plowing and rolling. Immediately before sowing, combinatoring was carried out, in order to develop the appropriate soil structure. Sowing took place on October 18, followed by rolling. 2021 At the beginning of March, we spread the Nitrogen Phosphorus and Potassium fertilizer on the experimental area during the tillering. At the end of April at stem extension, level D received a new Nitrogen head fertilizer. At the beginning of July, the harvest took place, and then the crop quantities were measured.

Under the four different nutrients level treatments consists of arbuscular mycorrhiza seed inoculant which contains mycorrhizal spores of Glomus mossae, Glomus intraradices and fungal spores of Trichoderma Atroviride, and control without any seed adjustments. Glomus mossae and G. intraradices species can be found on almost all soil types and establish a good mycorrhizal relationship with most herbaceous plants. The task of the added trichoderma fungus is to destroy pathogenic fungal species from the root zone.

Figure 1: Rainfall in the 2021/2022 growing season. This chart shows the monthly amount of precipitation from sowing to harvest.



Source: ksh.hu and metnet.hu. [1][2]

During the experiment four wheat varieties were used: GK Déva, GK Petur, Cellule, MV Nádor. The nutrient response of Cellule is outstanding, the nutrient response of Petur is average/good, and that these two varieties were already used in the monoculture experiment.GK Déva is a new variety that has good resistance against diseases and excellent bread-making quality. MV Nádort was already grown by István Bakonyi and Gábor Csitári in a mycorrhizal field experiment in 2018, and the obtained results proved that the variety builds a good mycorrhizal relationship, and they also experienced an increase in yield.

During the 2021/2022 growing season, the amount of precipitation was extremely low. And its distribution is even more critical, *Figure 1* also shows that in the first three months of 2022, the total amount of precipitation was 31 mm. In 2022, April is the only month when precipitation exceeded the 30-year average, but after that the drought continued.

3. Results

When examining the results, it needs to take into account the fact that the year 2022 was an extremely dry year (*Figure 1*). Due to the limited amount of water, the plants were probably less able to utilize the applied nutrients. However, this weather made it possible to draw conclusions about how the relationship established during symbiosis increases the drought tolerance of the host plant.

The results showed that the mycorrhizal treatments can cause a measurable difference in the yield of the examined winter wheat varieties. After all, the treated varieties had a positive influence on the yield of wheat compared to the control at all nutrient levels (*Figure 2*). In most cases, the difference was significant, except for these three cases: Petur variety at D level, Cellule variety at A level, Nádor variety at A level. The largest increase was 40%, while the smallest was 8% (*Table 2*).

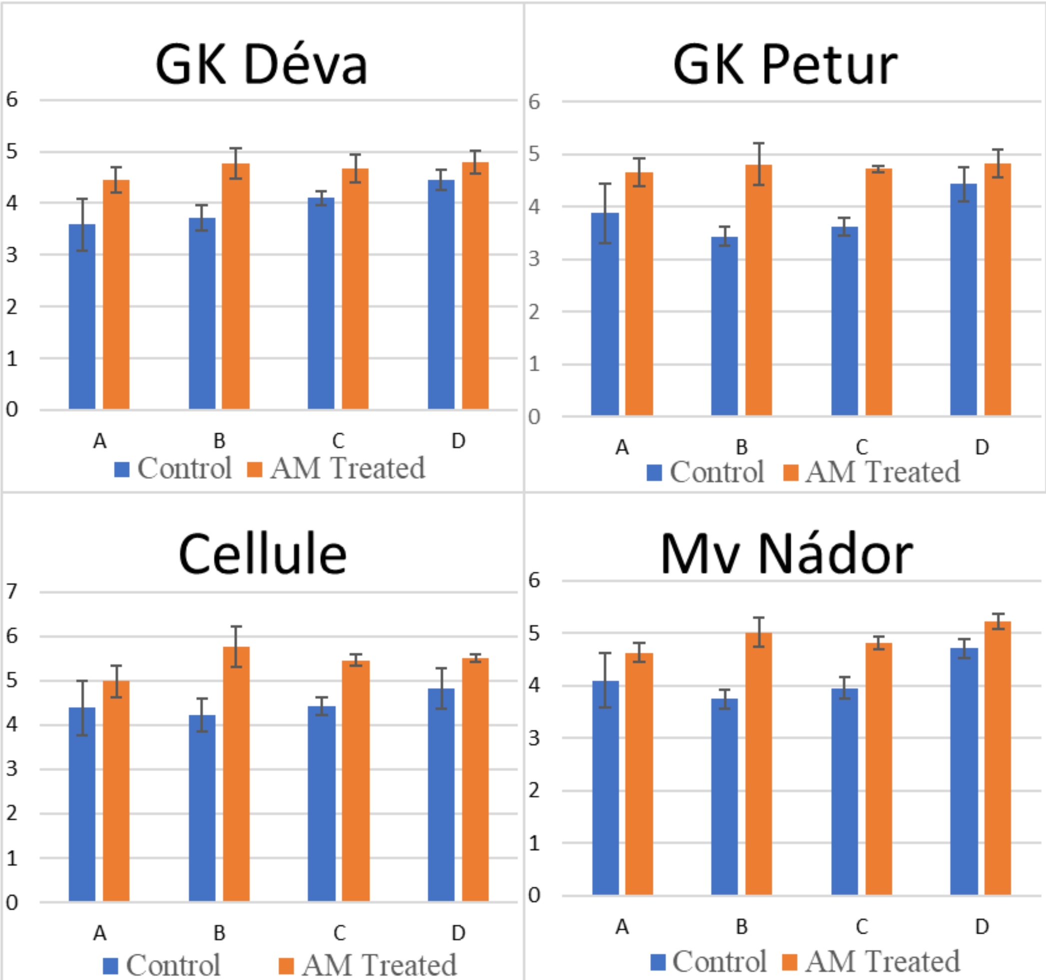
Table 2: increase in the yield of the wheat varieties used in the experiment after the treatments (in percent)

Fertilization level	Significance level	Yield increase %	Variety
A	0,02	124,27	GK Déva
B	0,00	128,26	GK Déva
C	0,01	113,78	GK Déva
D	0,05	108,00	GK Déva
A	0,05	120,31	GK Petur
B	0,00	140,17	GK Petur
C	0,00	130,71	GK Petur
D	0,11	109,02	GK Petur
A	0,14	113,80	Cellule
B	0,00	136,77	Cellule
C	0,00	123,53	Cellule
D	0,03	114,11	Cellule
A	0,10	112,94	Mv Nádor
B	0,00	133,96	Mv Nádor
C	0,00	121,90	Mv Nádor
D	0,01	110,95	Mv Nádor

Source: Author's own editing.

The highest yield was measured at cellule 5.765 t/ha. The percentage yield increase compared to the yield results measured on the control plots was the highest at nutrient level B (135%) and the lowest at nutrient level D (110%). Comparing the four varieties, Petur had the largest increase among the treatments. It is likely that this variety develops a symbiotic relationship with the mycorrhizal fungus to a greater extent.

Figure 2: The yield difference between control and treated plots for the four wheat varieties depending on the fertilization level. The values on the Y axis are in t/ha and the X axis shows the four fertilization level.



Source: Author's own editing.

4. Discussion

During the evaluation of crop yields, we found that the mycorrhizal treatments also have a measurable effect during traditional tillage, and we measured a significant increase in all four nutrient levels for the winter wheat varieties used in the experiment (Bakonyi and Csitári 2018). The increase in yield due to seedcoating with mycorrhiza proves that today's modern varieties are also able to form symbiosis with mycorrhizal fungi (Bakonyi and Csitári 2018, Lehmann et al. 2012). However, the finding that high nutrient supplementation reduces the activity of mycorrhizae is not entirely clear in our present experiment. After all, the highest nutrient level D had the smallest increase of 110%, but this was followed by level A with 118%, then C with 122%, and the highest valuable yield increase was at level B with 135%. This can be explained by the fact that in the wheat monoculture experiment set up nearly 30 years ago, the nutrient levels are located in the same area every year and level A does not receive phosphorus. Therefore, the level of soil phosphorus here can be so low that the host plant cannot absorb more phosphorus even through the fungal relationship.

However, we cannot draw long-term conclusions from the results of one growing season. Despite this based on the results of the first year, it is worth conducting further experiments on the subject.

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