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Agricultural Use of Beneficial Microorganisms in the Aspect of Environmental Protection Project
2020-1-FR01-KA202-079874

Module 2: Practical aspects and advantages of using mycorrhiza

Balıkesir University, TR

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It has been determined that there are more than 150 species of mycorrhizal fungi worldwide in the soil. The two most common classes of mycorrhizal fungi are known as ***ectomycorrhizae*** and ***endomycorrhizae***. There are six main types of mycorrhizae. These are ectomycorrhizae (EM), arbuscular (AM), monotropoid, arbutoid, orchid, and ericoid mycorrhizae. Among them, farmers know better and focus on AM and EM. However, AM fungi are most common in soils.

Mycorrhizas may be more beneficial for crops grown in nutrient-poor soils. Inoculation of AM confers tolerance to host plants against various abiotic stressful situations such as climate change, excessive use of chemical fertilizers and pesticides, salinity and heavy metals.

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Agroecological Production in Europe

Overview of organic production in Europe:

The total agricultural land area of the European Union under organic production corresponds to 8.5% of the total used agricultural area of the EU-27, with 343,858 producers and an organic retail market of 41.5 billion Euros in 2019. Four member states, Spain, France, Italy and Germany, accounted for more than half of all organically grown land in the European Union in 2019. These countries had 57.1% of the total organic farming areas in the EU-27.

The European Commission recently published two new strategies:

1. the **Biodiversity Strategy,**
2. and the **Farm to Fork** (F2F) **Strategy**.

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The European Commission's Farm-to-Fork Strategy highlights organic food as a key sector for achieving the food targets of the ***European Green Deal***. The Commission has also published the ***Organic Action Plan 2021-2027***. The main objective of the Farm to Fork strategy to transform EU agriculture is to increase organic food and farming to 25% by 2030.

Mycorrhizas have a significant impact on plant physiology and safe food production. This relationship between the plant and mycorrhiza is also important for human health.

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Current use of mycorrhiza in certified productions

The use of easily soluble fertilizers is prohibited in the organic farming regulation. The main prohibited activities in organic farming are:

- Use of ***synthetic fertilizers***,
- Chemical ***pesticide*** use,
- Use of genetically modified organisms (***GMOs***).

Establishing a highly active soil microbial population is one of the central paradigms of organic and other low-input farming systems. Mycorrhizas can be a very important and useful source of ***biofertilizers/microbial fertilizers*** for organic farming and organic production. Mycorrhizae are also an important environmental tool for sustainability, helping to reduce carbon emissions, enabling us to survive on the planet.

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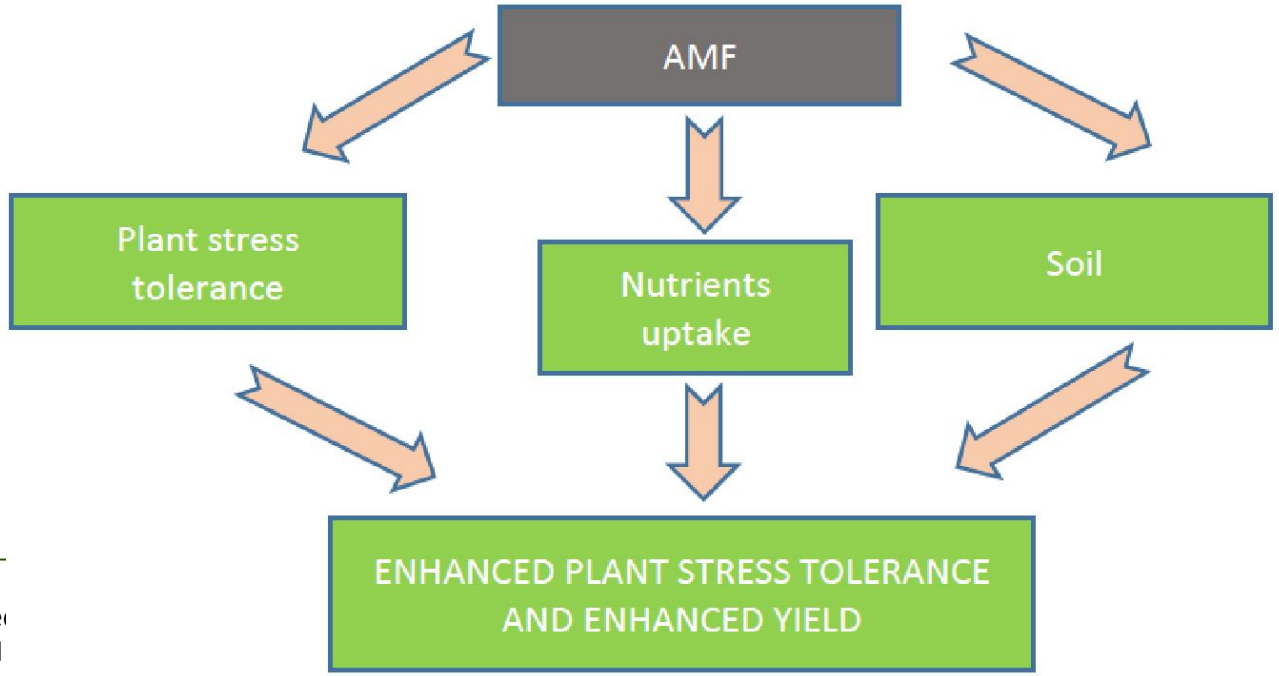
Benefits Mycorrhizal fungi to the soil

Mycorrhizal fungi need plants for sugars. Fungi bind soil particles, increase biomass, increase soil water holding capacity, replace harmful chemicals, increase the uptake of phosphorus, zinc and other nutrients, increase drought and salinity tolerance, trap carbon in the soil, and protect the plant from nematodes and other pests.



Soil improvement, compared to chemical fertilizer

- Benefits of mycorrhizae to the soil

Mycorrhizal fungi play an important role in soil aggregation through the hyphae network and production of glomalin, a hydrophobic glycoprotein. Glomalin is very resistant to microbial decay and accumulates in the soil. AM cells secrete various organic acids that dissolve minerals in the soil rhizosphere and make them available to the plant. The presence of mycorrhizae in the soil is essential for maintaining the physical properties of the soil. A better soil structure has these benefits:

- More water infiltration and water holding capacity,
- More air permeability,
- Better root development,
- Better resistance to surface sealing, erosion and compression,
-Higher microbial activity and nutrient cycling.

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The role of mycorrhizae compared to chemical/synthetic fertilizers for soil improvement

- Mycorrhizal fungi as biofertilizer

Scientific results from studies have shown the effectiveness of mycorrhizal fungi compared to other synthetic or chemical fertilizers under stressful conditions for the soil and plant. The benefits of AM are for plants, ecosystems and humans. For plants, AM is very useful for increasing nutrient uptake, especially elemental phosphorus. The rate of entry of phosphorus nutrients into AM hyphae can be up to 6 times faster in the roots of AM-infected plants compared to non-AM-infected plants. Plants need AM to facilitate the conversion of organic matter after chemical fertilization.

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Benefits Mycorrhizal fungi to the plants

Crop improvement, compared to chemical fertilizer

- Benefits of mycorrhiza for plant nutrition

Mycorrhizae take nutrients and water from the soil, form a large root network and nourish the plant. Mycorrhizal root systems and hyphae can increase the absorptive surface of the roots 10 to 1000 times. This greatly improves the plants' ability to use the soil resource. AM fungi can absorb and transfer essential macro and micronutrients for plant growth, especially phosphate. AM can also increase the level of nodulation and atmospheric nitrogen fixation capacity in legumes. AM has a direct effect on soil structure. Because the host plant transfers 20% of all fixed carbon to its fungal partner, AM can produce substantial biomass in soils.

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Mycorrhizae compared to chemical fertilizer for crop improvement

Chemical fertilizers will help plants grow faster, but the plants will not be healthy and often do not have enough time to mature to develop good root growth, strong stems, or quality fruits and vegetables. It is clear that the use of chemical fertilizers will kill beneficial insects, fungi and bacteria in the soil, which are called ***soil-friendly microorganisms***.

As a result, chemical fertilizers threaten plant, soil, environment, animal and human health. Organic fertilizers are the best solution to prevent soil pollution, many other threats to the environment and life. The adverse effects of synthetic chemicals on human health and the environment can only be reduced or eliminated by adopting new agricultural technological practices such as ***organic inputs***, ***biofertilizers, biopesticides, slow release fertilizers and nanofertilizers***.

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Benefits of Mycorrhizal fungi to the environment

Comparison of environmental impact of chemical fertilizer and mycorrhiza

Mycorrhizal fungi are of great importance to our planet and society. Mycorrhizas play an important role in the formation and maintenance of global ecosystems by forming mutual symbiosis with the vast majority of land plants. They also have great potential to be used to facilitate various sustainability programs in agriculture, soil conservation and agro/forestland/pasture restoration, especially in the context of global climate change and natural resource depletion.

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Environmental impact of chemical fertilizer

The main problems caused by using too much chemical fertilizers are:

1) As a result of the use of high levels of ***nitrogen*** fertilizer, the amount of nitrate in drinking water and rivers may increase.

2) The amount of ***phosphate*** in drinking water and rivers may increase as a result of the transport of phosphorus fertilizer by surface flow.

3) A high rate of ***nitrogen*** fertilizer is used in plants grown in the soil. It consists of ***carcinogenic*** substances such as ***nitrosamines***. Especially plants such as lettuce and spinach are important in this context.

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Environmental impact of mycorrhiza

Mycorrhiza is a green alternative to mineral fertilizers. The ability of mycorrhizal fungi to accumulate heavy metals and radionuclides makes them possible candidates for the restoration and remediation of contaminated soil and the environment. As a useful bio-stimulant for agriculture, mycorrhizal fungi can contribute to better crop quality and higher yields with less fertilizer. These fungi contribute to plant roots uptake of nutrients from a much larger soil volume. This, in turn, can help prevent nutrients from leaking into groundwater and the environment.

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Economic Benefits of Mycorrhizal fungi

Economic balance sheet, cost savings, comparative production cost

-Mycorrhizal inoculants as bio-inoculants and commercial use

Many active or dormant bacterial or fungal strains or combinations called ***bio-inoculant/bio-fertilizer*** are used to increase crop yield. These biofertilizers are safe to use and only small amounts are required as they have the ability to multiply rapidly.

The European market represents one of the leading markets for mycorrhizal biostimulants. The multiple benefits of AM have increased opportunities for its commercial applications. As a result, AM-related markets have grown significantly in recent years with an increasing number of actors, products and market volumes.

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Mycorrhiza inoculations;

The first advantage is that it helps plants be more efficient at uptake of nutrients. Mycorrhizas can store nutrients during times of surplus and make them available during times of plant need, shortage or stress.

The second advantage of mycorrhiza is the improvement of water extraction from the rhizosphere. Mycorrhizas can store water when there is excess water and make it available to the plant during drought. Mycorrhizae act as a buffer, regulating the flow of water to the plant.

The benefits of mycorrhiza inoculants include:

- Reduced nutritional deficiencies,
- Potential reduction in fertilizer use,
- Delayed wilting,
- Resistance to salt toxicity and surprise shock,
- Reduced root disease attack,
- Improved growth and increased yield.

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The main problems with economically using of the inoculants are:

- ***Little success***,
- ***Expense***,
- ***Certification of brands, and guarantee*** of their effectiveness.

These disadvantages deter farmers from purchasing these inoculants. Because farmers cannot be sure that a particular formulation will work on their land. Alternative commercial products include those designed to encourage local AM to be more effective. Productivity and/or profitability is the only way to get an idea of the economic benefits of AM. Where AM fungi contribute to phosphorus uptake, the benefit can be measured in terms of savings in phosphate fertilizer. Little attention is paid to potential savings in nitrogen fertilizers. However, the close links between the phosphate and nitrogen cycles make mycorrhizal inoculants important.

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A simple way to make an estimation of the economic benefits of mycorrhizal inoculants is to estimate the value of crop production with and without mycorrhizae. Risk minimization strategies can be considered to deal with some or all of the factors that hinder realistic economic evaluation of mycorrhizae.

As a result, the benefits obtained from the increased nutrient uptake in plants with the use of inoculants should be taken into account when calculating the cost economy in the use of mycorrhizal inoculants.

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