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Original article

Effects of Arbuscular Mycorrhizal Fungi on the Growth of Wheat Plant

Himedah Fheel Alboom[1], Mabroukah Khalleefah[2]*, Najat Mansour[2], Abdulmunem Abounqab[2]

[1]Faculty of Education, University of Zawia, Zawia City, Libya
[2]Faculty of Dentistry, University of Zawia, Zawia City, Libya

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Corresponding Email. m.khalleefah@zu.edu.ly

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ABSTRACT

Mycorrhiza is a symbiotic association between a green plant and a fungus. The current study was conducted to assess the effect of inoculation with Arbuscular Mycorrhizal Fungi (AMF) on the growth of seeds of the wheat plant. Triticum aestivum, which is one of the plants that host the fungus, was studied by calculating the wet weight and dry weight of both the root system and the shoot system. In this experiment, roots colonized with AMF were used as a source of injection. Wheat seeds were injected with these roots and compared with other seeds without control injection. The injected plants and uninfected plants were allowed to grow for a period of 75 days. During this period, the plants were harvested over three periods 25, 50, and 75 days. Through this experiment, it was found that AMF have a high efficacy on the growth of the wheat crop, through a positive effect on the growth of the seeds of this host plant. Such studies on AMF are still rare in Libya, so we tried to follow up the previous studies, so we studied this kind of coexistence with this economically important agricultural crop in Libya and the world.

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INTRODUCTION

Mycorrhizal fungi form a type of symbiosis between them and the roots of most plants, as mycorrhizal fungi are associated with the roots of most plants found on the surface of the earth [1,2]. The symbiosis between fungal hyphae and plant roots is one of the most common types of symbiosis [3,4]. Plants that are colonized by mycorrhizal fungi are called host plants. These plants include herbs, economic crops, and some trees, especially fruit trees and shrubs. Plants that are not colonized by these fungi are called non-host plants (Non host plants) [5]. These fungi cannot complete their life cycle in the absence of a host plant, and therefore cannot be grown or isolated in artificial environments in the laboratory without a host plant, unlike some types of mycorrhizae that can be grown on nutrient media [6,7].

Seven types of mycorrhizae have been identified to date, and the fungi that form this relationship belong to the Ascomycotina, Basidiomycotina, and Glomeromycotina fungi. The most important type of mycorrhizal fungi is the Arbuscular Mycorrhizal Fungi (AMF), which has been highlighted for its effectiveness on the growth of wheat seedlings [8,9].

AMF are the most common and widespread type in nature, as they enter into a symbiotic relationship with more than 80% of vascular plants. These fungi belong to an independent division, Glomeromycota, and are characterized by the formation of both (Vesicles) and (Arbuscules) within the cells of the cortex in the roots of host plant [10]. The fungal hyphae are not divided by transverse barriers, and penetrate the roots of the host by mechanical pressure or secretion of enzymes on the cell wall of the root cells of the host plant, and enter the epidermal cells where they extend between the cells in the intercellular spaces, and form fungal structures in the form of arbuscules, which are dendritic branches found inside the cells of the host plant [11]. It is believed that these dendritic branches are the main place where food exchange takes place between the plant and the fungus, due to the large surface area in them, in addition to the formation of swellings known as vesicles inside the roots, and they are formed immediately after the formation of arbuscules[12] Vesicles are fungal hyphae in the form of swellings inside the cells or in the intercellular spaces of the cortex layer, and they are used to store food materials inside the root cells, and they are also considered reproductive organs as they produce spores that remain inside the roots or are transferred to the soil [13]. These spores are characterized by their tolerance to difficult environmental conditions such as high or low temperatures and increased salinity. AMF are composed of Also from the fungal threads (Hyphae) extending in the soil, they are in the form of a dense network of thin and branched fungal threads [14]. These external fungal threads act as channels that are believed to absorb nutrients necessary for plant growth, such as phosphorus, as it is present in an insoluble form, and therefore the roots cannot absorb it directly. These threads have the ability to absorb it. The external fungal threads also increase the area of the root's absorbent surface [6,15].

Mycorrhizal fungi play an important and vital role in feeding plants, thus increasing their growth, and providing water to the plant [16]. These fungi are important in improving and increasing the effectiveness of plant absorption of nutrients in poor soil for some important elements for the plant such as phosphorus (P), nitrogen (N), sulfur (S), zinc (Zn), calcium (Ca), manganese (Mn), copper (Cu), magnesium (Mg), iron (Fe), and potassium (K). Many studies have indicated an increase in the amount of these elements absorbed by the roots of plants associated with mycorrhizal fungi, as these studies have proven a high concentration of these nutrients in plants associated with AMF compared to those plants free of AMF [17].

Mycorrhizal fungi change the shape and structure of the root, and cause hormonal changes in the host plant [18]. These changes improve the plant's absorption of water through the roots, and thus plants that coexist with AMF show a better ability to survive and continue than plants without AMF, as the presence of the mycelium network spread in the soil gives greater penetration and spread to the roots of the host plant, and thus the area of root activity increases. Several previous studies have proven the relationship between the plant, AMF and water, and the role of mycorrhizal in providing water to the plant, as AMF increase water absorption, and also increase drought tolerance in several types of plants, and the rate of increase in water absorption in the plant is linked to the extent of phosphorus availability in the plant, and AMF increase the percentage of phosphorus, and thus increase the plant's absorption of water, AMF contribute to the transfer of water from soil containing small amounts of water to plant roots, through fungal threads present in the soil [19,20]. AMF also play a role in improving soil structure and assembling soil particles together, as fungal hyphae in the soil form the basic structure that binds soil particles together. There are several studies that show the effectiveness of AMF in soil composition. The results of these studies indicate the effect of AMF on soil pores and the aggregation of soil particles, which in turn increases the fixation of plant roots in the sand, as fungal hyphae act as a network that connects soil particles together, thus improving soil structure and its water retention capacity, and increasing its resistance to erosion. An earlier study on AMF and soil aggregation, found that aggregating soil particles is necessary to maintain the physical properties of the soil, and fungal hyphae AMF help in aggregating soil, as they found that there is a positive correlation between AMF hyphae and the overall stability of natural systems [21].

Given the importance of AMF and their role in increasing the growth of host plants, and increasing the fertility of soil that suffers from a deficiency in plant nutrients, the aim of this research was to know the effect of these fungi and test their efficiency in improving the growth of wheat seedlings, and to know the extent of this plant's response to these fungi, where a vaccine of AMF is prepared, and the soil is injected with these fungi by using herbal roots associated with these fungi, after which this soil is planted with the host plant.

MATERIALS AND METHODS

Assembling a source of AMF inoculum

From April to July 2023, a small amount of the roots of the flycatcher *Conyza bonarieusis*, herbaceous plant that is a host to AMF, was collected to use its roots colonized by the fungus as a source of inoculum for these fungi. After confirming the presence of AMF, the same site was returned to uproot a large amount of this herbaceous plant, estimated at about 20 plants. Then the roots were separated from the rest of the plant parts, and they were cut into small pieces about half a centimeter long. These small pieces were collected and used as a source of inoculum.

Soil preparation

Sandy soil was collected from the same farm where the plant was found as a source of inoculum with the AMF fungus, and it was 6 kg, and it was mixed with about 3 kg of wire soil, after it was sieved and sterilized in the express autoclave sterilizer for 15 minutes at a temperature of 121^{0}C and under a pressure of 15 pounds/inch, to kill all living organisms present in the soil, and to obtain sterile soil.

Preparation of pots

In this experiment, special plastic pots were used for cultivation, and a mark was placed on each pot to distinguish between them. The mark M was placed on the first pot to indicate the presence of the AMF inoculum, and the mark NM was placed on the second pot to indicate the absence of the inoculum in this pot. Then, the soil was distributed in the first pot M into two layers, between which there was a layer of roots prepared as inoculum for the fungus. As for the second pot NM, only soil was placed.

Germination of seeds

Wheat seeds were placed in 9 cm Petri dishes on wet filter papers inside the greenhouse prepared for the cultivation process in the city of Zawiya. After the germination period, the seeds were transferred to the pots prepared for the cultivation process, at a rate of 50 seeds in each pot, and they were watered with a nutrient solution at a rate of three times a week.

Table 1. Components of the nutrient solution

Rorison's nutrient solution-P	Values
Ca(NO3)2.4H2O Calcium Nitrate Tetrahydrate	**47.61g / 100 ml**
K2HPO4.3H2O Potassium Phosphate Trihydrate	**23.07g / 100 ml**
MgSO4.7H2O Hydrated magnesium sulfate	**24.8 g /100 ml**
(NH4)2SO4 Ammonium sulfate	**26.56 g /100 ml**

Harvesting process

The plants were harvested randomly in three periods. The first harvest was 25 days after planting, the second harvest was 50 days after planting, and the third harvest was 75 days after planting. The number of samples was 10 plants in each harvest period.

Weight and drying

During each harvest period, the samples are washed with water, then the root system is separated from the vegetative system, and each is weighed separately, until the wet weight of both is known. Then they are dried in a special oven for the thinning process, then the samples are weighed with a sensitive balance and the weights are recorded. In special tables.

RESULTS

Growth of wheat plants in the presence and absence of AMF fungi

A complete examination of wheat plants at the last harvest showed that wheat plants grown in soil mixed with the roots of plants associated with AMF responded significantly to AMF, as plant growth increased at a higher rate than those plants that grew in the absence of AMF. Differences were found. Significant differences between plants that grew in the presence of AMF and those that grew in the absence of AMF. These differences appeared in the second and third harvests, and this was evident in the wet weight and dry weight of the root system and the shoot total of the plants. Table 2 shows the results of these weights after (25, 50, 75) days from planting the seeds, where 10 plants were harvested during these three periods, and the results of the arithmetic average of the weights of ten plants were as shown in the following tables and figures.

Table 2. Results of the arithmetic mean of the wet and dry weight of the root and shoot system of wheat plants in the presence and absence of AMF during the three growth periods

Variables	Results of the first harvest after 25 days		Results of the second harvest after 50 days		Results of the third harvest after 75 days	
	M	NM	M	NM	M	NM
Wet weight of shoot system	0.1405	0.1681	0.5601	0.2910	1.0301	0.6150
Dry weight of shoot system	0.030	0.032	0.091	0.055	0.14	0.082
Wet weight of root system	0.038	0.0495	0.0975	0.080	0.3151	0.129
Dry weight of root system	0.0020	0.0023	0.0095	0.007	0.049	0.0209

Table 3. Statistical analysis of wheat plants in wet weight and dry weight of the root system and shoots in the first, second and third harvests when AMF are present and when they are not present.

Harvest periods	Plant weight		Type	Sample size	The arithmetic mean	The difference between the two means	Significance level
The first harvest	Root system	Wet weight	M	10	0.038	-.0115	**.000**
			NM	10	50.049		
		Dry weight	M	10	0.0020	.0003-	**.000**
			NM	10	0.0023		
	Shoot system	Wet weight	M	10	050.14	.0276-	**.000**
			NM	10	810.16		
		Dry weight	M	10	300.0	.002-	**.000**
			NM	10	320.0		
The second harvest	Root system	Wet weight	M	10	50.097	.0175	**.000**
			NM	10	800.0		
		Dry weight	M	10	50.009	.0025	**.000**
			NM	10	70.00		
	Shoot system	Wet weight	M	10	6010.5	.2691	**.000**
			NM	10	9100.2		
		Dry weight	M	10	910.0	.036	**.000**
			NM	10	550.0		
The third harvest	Root system	Wet weight	M	10	1510.3	.1231	**.000**
			NM	10	0.192		
		Dry weight	M	10	90.04	.0281	**.000**
			NM	10	2090.0		
	Shoot system	Wet weight	M	10	3011.0	.4151	**.000**
			NM	10	500.61		
		Dry weight	M	10	0.14	058.	**.000**
			NM	10	820.0		

DISCUSSION

The study presented in this research aimed to test the hypothesis of the positive effect of AMF fungi on the growth of wheat plants. Through all the results obtained, it was shown that AMF fungi have a positive effect on the growth of this host plant. The results shown in Table 2&3 confirm that wheat was a host plant for AMF fungi, through the wet weight and dry weight of the vegetative group and the root group, as the weights were high in the plants grown in (M) soil injected with AMF fungi compared to the weights of the plants grown in (NM) soil free of AMF fungi. In all three harvest periods, especially in (the third harvest), where the weights were high and with clear significant differences compared to the plants grown in (NM) soil, as the total weight of the wheat plant after 75 days of planting in (M) soil was about 1.3253 grams, compared to the weights of the plants grown in (NM) soil free of fungi. AMF was estimated at about 0.6280 grams.

The study demonstrated the ability of mycorrhizal fungi AMF to enhance the growth of the host wheat plant and increase the dry weight of the plant. The results of some similar studies revealed that injecting wheat plants with AMF fungi can improve the absorption of phosphorus and potassium at a higher rate than plants not injected with the fungus under water stress conditions [22-24]. The results obtained in this research are consistent with what was indicated by previous studies [24-26].

CONCLUSION

Through the results of this study, the following conclusions and recommendations were reached: Conclusions: AMF mycorrhizal fungi play an effective role in increasing the growth of wheat plants compared to their growth in the absence of AMF fungi. Through the results of this study, it was shown that AMF fungi work to increase the surface area of the root absorption system, which increases the efficiency of the plant in absorbing water and the elements necessary for plant growth. Recommendations: The study of this symbiosis between mycorrhizal fungi and plants is almost non-existent in Libya, and this study is a first step to shed light on the importance of mycorrhizal fungi for host plants. Based on the results reached, one of the most important main recommendations for maximum benefit from mycorrhizal fungi is to use mycorrhizal fungi in agriculture as a biofertilizer due to their importance in improving soil fertility and improving plant growth, thus increasing the amount of the crop.

REFERENCES

1. Harley J, Smith S, Mycorrhizal symbiosis. Academic Press, London, UK. 1983;22(1):80.
2. Jincai S, Wang E, Mycorrhizal Symbiosis in Plant Growth and Stress Adaptation: From Genes to Ecosystems. Annual Review of Plant Biology. 2023;74(22):607–569.
3. Smith S, Read D, Mycorrhizal symbiosis, 3rd edn. Academic, London Smith SE, Soil Science Society of America Journal,2008;73(2):587
4. Waill A, Elkhateeb T, Paul W, Ghoson M. Mycorrhiza and lichens as two models of fungal symbiosis. The Journal of Microbiology, Biotechnology and Food Sciences. 2021;11(3):1-10.
5. Raul S, Lavado V, Symbiosis of Plants with Mycorrhizal and Endophytic Fungi. Plants. 2023;12(8):1688.
6. Smith E, Read D, Mycorrhizal symbiosis. San Diego, California, Academic Press Inc.1997.
7. Bitao L, Fei H, Xing A, Zed R, The Response of Plants and Mycorrhizal Fungi to Nutritionally-Heterogeneous Environments Are Regulated by Nutrient Types and Plant Functional Groups. Frontiers in Plant Science. 2021;12.
8. Schussler A, Schwarzott D, Walker C. A new fungal phylum, the Glomeromycota, phylogeny and evolution. Mycol. Res,2001; 105(12):1413-1421.
9. Brundrett M. Mycorrhizal associations and other means of nutrition of vascular plants: understanding the global diversity of host plants by resolving conflicting information and developing reliable means of diagnosis. Plant and Soil. 2009;320:37–77.
10. Wang Y, He X, Non-host plants: are they mycorrhizal networks players, Plant Div. 2022; 44(2):127–134.
11. Mnasri M, Janouškova M, Rydlova J, Abdelly C, Ghnaya T. Comparison of arbuscular mycorrhizal fungal effects on the heavy metal uptake of a host and a non-host plant species in contact with extraradical mycelial network. Chemosphere. 2017; 171:476–484.
12. Kumar S, Adholeya A. Analysis of express sequence tags from Arbuscular Mycorrhizal fungi (AMF) express during the pre-symbiotic stage of the fungus, Research Journal of Biotechnology. 2023;18(11):89-95.
13. Elizabeth M, Daniel Salgad B, Juan M, Martinez A, Ruben D, Cadena N, Meritxell R. Nanosized extracellular vesicles released by Neurospora crassa hyphae. bioRxiv. 2022;1-25.
14. Thabiso E, Emma T, Extracellular Vesicles in Teasing Apart Complex Plant-Microbiota Links: Implications for Microbiome-Based Biotechnology. 2021;31:6(4): 0073421.
15. Patricia F, Rafaela F, Lysangela R, Marcio L. Extracellular vesicles as vehicles for the delivery of biologically active fungal molecules. Current Protein & Peptide Science, 2019; 20 (10):1027–1036.
16. Manoj P, Kumar C, Ram H, Asha K, Gopal T, Kiran R, et al. Role of AMF in growth promotion of high-value crops. 2022;121-144.
17. Moiseev A. Role of Endophytic Microorganisms in Phosphate Solubilization and Phytoremediation of Degraded Soils, Journal Microorganisms for Sustainability Plant Microbiome for Plant Productivity and Sustainable Agriculture. 2023;387-400.
18. Debasis M, Keyvan V, Priya C, Janki R, Mahapatra S, Hanane B, et al. Involvement of strigolactone hormone in root development, influence and interaction with mycorrhizal fungi in plant: Mini-review. 2021;2:100026,.
19. Allen M. Water dynamics of mycorrhizas in arid soils. Published by Cambridge University Press. British Mycological Society. 2006;74- 94.
20. David P, Michael B, Jana R, Jan J. Facilitation of plant water uptake by an arbuscular mycorrhizal fungus: a Gordian knot of roots and hyphae, Mycorrhiza. 2020;30(2-3):299-313.
21. Sylvia DM. Distribution, structure, and function of external hyphae of vesicular-arbuscular mycorrhizal fungi. InRhizosphere dynamics 2019 Jun 4 (pp. 144-167). CRC Press.

22. Baylis G, Effect of vesicular-arbuscular mycorrhizas on growth of Griselinia littoralis (Cornaceae). New Phytol. 1959;58(3):274-280.
23. Gerdemann J. Vesicular-arbuscular mycorrhizae and plant growth. Ann Rev Phytopathol. 1968; 6: 397–418.
24. Hayman D, Mosse B, Plant growth responses to vesicular arbuscular mycorrhiza. III. Increased uptake of labile P from soil. New Phytol. 1972;71(1):41–47.
25. Copeman R, Martin C, Stutz J, Tomato Growth in Response to Salinity and Mycorrhizal Fungi from Saline or Nonsaline Soils. Hort Science. 1996;31(3):341–344.
26. Smith S, Chen B, Zhu Y, Duan J, Xiao X. Effects of the arbuscular mycorrhizal fungus Glomus mosseae on growth and metal uptake by four plant species in copper mine tailings. Environ Pollut. 2007;147(2):374–380.
27. James B, Rodel D, Lorett U, Reynaldo E, Tariq H. Effect of vesicular arbuscular mycorrhiza (VAM) fungi inoculation on coppicing ability and drought resistance of senna spectabilis. Pak J Bot. 2008;40(5):2217-2224.

تاثير فطريات الميكوريزا الشجيرية علي نمو نبات القمح

حميدة فحيل البوم[1]، مبروكة خليفة[2]*، نجاة منصور[2]، عبدالمنعم ابونقاب[2]

[1]كلية التربية، جامعة الزاوية، مدينة الزاوية، ليبيا
[2]كلية طب الأسنان، جامعة الزاوية، مدينة الزاوية، ليبيا

المستخلص

تم دراسة تأثير التسميد بفطريات الميكوريزا الشجرية على نمو بذور نبات القمح وهو أحد النباتات التي تتعايش مع الفطر وذلك من خلال حساب الوزن الرطب والوزن الجاف لكل من المجموع الجذري والمجموع الخضري حيث أجريت تجربة أصص داخل البيت الزجاجي في مدينة الزاوية وفي هذه التجربة تم استخدام الجذور المستعمرة بفطريات الميكوريزا كمصدر للحقن وتم حقن بذور القمح بهذه الجذور ومقارنتها ببذور أخرى بدون حقن وتركت النباتات المحقونة والنباتات غير المحقونة تنمو لمدة (75) يوماً وخلال هذه الفترة تم حصاد النباتات على ثلاث فترات (25، 50، 75) يوماً ومن خلال هذه التجربة وجد أن فطريات الميكوريزا لها فاعلية عالية على نمو محصول القمح وذلك من خلال التأثير الإيجابي على نمو بذور هذا النبات العائل. إن مثل هذه الدراسات على فطريات الميكوريزا لا تزال نادرة في ليبيا، لذلك حاولنا متابعة الدراسات السابقة، فدرسنا هذا النوع من التعايش مع هذا المحصول الزراعي المهم اقتصاديا في ليبيا والعالم.

الكلمات الدالة. فطريات الميكورايزا الشجرية، التعايش، نمو النباتات، القمح، حقل التربة.