Sustainability and Biodiversity Conservation

A review of mycorrhizal fungi and its effect on medicinal plants

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Abstract
Medicinal plants have existed in Iran's agricultural systems since ancient times. These plants were used as traditional medicine in Iranian medicine. However, medicinal plants have always been affected by ecological factors, and their active ingredients and yields have undergone changes, and secondary metabolites have increased in some plants under environmental stress conditions and decreased in other plants. There are strategies to deal with these stresses in the natural and cultivated ecosystem of medicinal plants in the environment, such as using beneficial microorganisms, such as arbuscular mycorrhizal fungi in the soil, and this research was done for this purpose. In this study, the results showed that mycorrhizal fungi are soil organisms that can create an excellent physiological relationship with the plant by coexisting with the roots of plants. Mycorrhizal fungi are soil organisms that can create an excellent physiological relationship with the plant by coexisting with the roots of plants. During environmental stress, the colonization of mycorrhizal fungi with plant roots leads to an increase in plant secondary metabolites such as flavonoids and essential oils, and by changing the antioxidant activity (increasing superoxide dismutase, peroxidase) and increasing the amount of phosphorus, the plant strengthens.

Keywords: Essential oil, Flavonoids, Medicinal plants, Mycorrhizal fungi, Secondary metabolites

Introduction
There are problems in producing medicinal plants, such as a lack of awareness of planting and reactions of this plant to ecological factors, which are the challenges of medicinal plants (Rahimi, 2017). One of these challenges is the stress of water deficiency, and the harmful effects

of this stress can be moderated through the use of mycorrhizal fungi (Rahimi et al., 2023). Most plants can establish a symbiotic relationship with mycorrhizal fungi, and soil indicators for nutrient and carbon cycles. In addition, the structure and function of the soil ecosystem are affected by these fungi. The supply of nitrogen and phosphorus to the plant, as well as the growth and survival of many plants, is provided through mycorrhizal fungi. Mycorrhizal symbiosis exists between 250,000 plants and 50,000 fungi (Marcel et al., 2015). Medicinal plants have active ingredients or secondary metabolites that were used to deal with diseases in the past, and the relationship between these plants and living soil microorganisms (endophyte or symbiotic) is very significant. Among these microorganisms are arbuscular mycorrhizal fungi that establish a symbiotic relationship with more than 70% of vascular plants and lead to an increase in plant yield, growth, and development, as well as an increase in the secondary metabolites of plants, these active ingredients have therapeutic uses for humans (Zhao et al., 2022). Humans in all parts of the planet have used medicinal plants from the past centuries until today. Herbal medicines, cosmetics, and health products from the said plants have been provided, and Humans even use medicinal plants in the food industry. The demand for essential oils (active ingredients of these plants) has caused to become important the cultivation of medicinal plants important. Nevertheless, the planting, growth, development, quality, and productivity of medicinal plants are affected by environmental factors and stresses, which environmental stresses such as drought, salinity, pollution, etc., which are caused by acute ecological and environmental changes. There are strategies to deal with these stresses in the natural and cultivated ecosystem of medicinal plants in the environment, such as using beneficial microorganisms, such as arbuscular mycorrhizal fungi in the soil. Improving the growth and yield of these plants is dependent on the presence of these useful soil fungi in conditions of environmental stress, which, as a result, increases the range of plant tolerance in harsh environmental conditions (Israel et al., 2022). Environmental factors such as drought have important effects on medicinal plants, while mycorrhizal fungi can reduce water stress leading to drought and improve the performance of medicinal plants. Of course, environmental studies have shown that the coexistence of mycorrhizal fungi with the plant has affected the physiological and ecological conditions related to the plant. With this mechanism, they have caused the plant's resistance by avoiding stress in drought conditions and water shortage crises (Rahimi et al, 2017). Under environmental stress, plants can increase their growth and yield through the symbiosis of their roots with mycorrhizal fungi. In conditions of environmental stress, such as water shortage stress, salinity, and heavy metal toxicity, mycorrhizal fungi help the plant facilitate the absorption of water and soil minerals such as phosphorus and ultimately increase the resistance of the plant. Also, this symbiosis causes the hormonal activity, antioxidant, and osmotic potentials of plants to be physiologically activated in environmental stress, and the phenomenon of photosynthesis is improved, and during drought stress, the performance of the plant should not be damaged. ways, they affect the structure of the soil, accelerate the cycle of nutrients and the phenomenon of carbon deposition, and in these ways, can help the flexibility and stability of the ecosystem. However, this stability depends on the plant species and the ecological environment. In harsh ecological conditions, the biochemical activity of the plant changes, and mycorrhizal fungi have a useful role in this change, and facilitate the absorption of water and nutrients for the plant and increase the biochemical activity and growth of the plant in this way, they significantly increase the resistance and tolerance of the plant during environmental stress. Therefore, in harsh environmental conditions, the colonization of mycorrhizal fungi with the roots of plants leads to the stimulation to receive the stress signal at first. With the support of the fungi is activated the hormonal and physiological activity of the plant and the number of secondary metabolites of the plant such as essential oils increases By changing the antioxidant activity (increasing superoxide dismutase, peroxidase, etc.) and increasing the amount of phosphorus in the plant, they lead to the strengthening of the plant during environmental stresses caused by ecological and climatic changes in sustainable agricultural and natural systems, which lead to better production and productivity is higher in agricultural systems (Wahab et al., 2023). In a study conducted in China, out of a total of 3230 species of medicinal plants, nearly 1321 species had mycorrhizal status, and the most common type of mycorrhiza was arbuscular mycorrhiza, which had symbiotic relationships with 842 species of medicinal plants. Also, 926 species had obligatory symbiotic relationships with mycorrhizal fungi (Zhang et al., 2022). Mycorrhizal fungus (Glomus mosseae and Glomus intraradices) was able to moderate the negative effects of drought stress and increase the traits (flower phosphorus, flower yield, biological yield and water use efficiency in Borage) on irrigation levels after 60, 90, 120 and 150 mm of water evaporation from the evaporation pan, and based on the results of this study, irrigation treatment after 90 mm of water evaporation from the evaporation pan + the use of Glomus mosseae mycorrhizal fungi recommended (Rahimi et al., 2023). In the management systems of medicinal plants, to use mycorrhizal fungi, information such as the type of mycorrhiza and the condition of the plant species in the region is needed to determine what type of mycorrhiza can have a symbiotic relationship with the indigenous medicinal plants of the region, that based on this information, it is possible to increase the yield and accumulation of effective substances in the plantation systems of medicinal plants and lead to better management and more profit of medicinal plants. On the other hand, the increasing importance, position, and role of medicinal plants in sustainable management, especially in the macro dimensions of economic, environmental, health (medicinal self-sufficiency), employment, food security, and genetic resources in the national and global arena, is such that it can be done today (Rahimi et al., 2018). Therefore, considering the above causes and reasons and the importance of medicinal plants as well as the effects of mycorrhizal fungi in increasing the quality of medicinal plants, first, mycorrhizal fungi and their structure, then their role, importance, and effect on plant secondary metabolites were investigated, respectively. In this study, the authors searched the main related keywords of medicinal plants in the main biological data centers, e.g., Web of Science, Scopus, and Google Scholar. Then, the authors classified articles and only discussed the valid full papers in different categories.

Structure and mechanism of action of mycorrhizal fungi

The word mycorrhiza is derived from the two Greek words miko, meaning fungus, and rhiza, meaning root (Ianson and Smeenk, 2010), which refers to the cooperation between fungi and plant roots. In this cooperation, unlike when pathogenic fungi attack plants, no disease symptoms are observed, but by creating favorable relationships between them, they also benefit from each other. According to the research, some fungi penetrate the tissues of the root of the host plant, and by sending the sucking organ into and between the host cells, they get some of the organic substances they need and in turn, absorb water and minerals, dissolve insoluble substances. Furthermore, mineralizing the organic matter of the soil around the root and absorbing it by the root and biosynthesis of some hormones and their transfer to the host plant help (Ianson and Smeenk, 2010). The formation of mycorrhizal communities in the root parts is different. for example, mycorrhizal symbiosis is not formed at the end of the root, because there has been no report on intracellular inoculation in the tissue of the root end, but anyway, there is a region in the root where inoculation or formation takes place in it and this region, which has less resistance to inoculation, is located behind the apical region and also in front of the region where the primary cortex is destroyed after the initiation of root maturation (Ianson and Smeenk, 2010). Fungi are different, and this difference is due to their location on the roots of plants. In (Fig. 1, right part), inside the roots of all angiosperms, ferns, and mosses penetrate and then have a symbiotic relationship (a), as endomycorrhizal fungi. While in another type of fungi (Figure 1, left part), there are ectomycorrhizal fungi (b), which establish symbiosis with the roots of all kinds of trees, bushes, and sometimes herbaceous plants, and by increasing the absorption level, it increases the tolerance of the host plant to drought, especially in dry areas (Ianson and Smeenk, 2010). The leading indicators determining the *mycorrhizal* formation in the root system have close relations to the *mycorrhizal* functions, as well as one of the most widely distributed structural traits of AM *Arbuscular mycorrhiza* (AM) (Tian et al., 2013). In the same sample, observing different ages of *arbuscules* is common. Vesicles may last longer in the root than in the *arbuscules,* which are storage structures formed in the terminal part of the hyphae (Luis-Alaya et al., 2023) (Figure 2, portion a). For capturing soil nutrients, the mycelium is extended on the external root (Luis-Alaya et al., 2023) (Figure 2, portion b). The presence of mycorrhizal symbiosis and its functionality was shown in the three plantations, where colonization of cocoa with *mycorrhizal* colonization had active mycorrhiza between 59 and 63%, which were similar values (68–86%) statistically. families Glomeraceae, Acaulosporaceae, and Paraglomeraceae, and auxiliary cells from the family Gigasporaceae, as shown in Figure 3, which are some of the morphotypes of the Glomeromycota fungi in the cocoa plantations (Luis-Alaya et al., 2023). In Figure 4, root fragments of fennel dyed and showed colonization of *arbuscular mycorrhizae* as microscopic images (F. mosseae) (Rasouli et al., 2023). The colonization and activating of *mycorrhizal*, *arbuscular mycorrhizal* structures and GRSP-EE content in the roots of cocoa plants are shown in Table 1 (Rasouli et al., 2023), also (Rasouli et al., 2023). There is a symbiotic relation between tropical, subtropical, temperate, boreal forests and host EM mushrooms of Caesalpiniaceae, Pinaceae, Fagaceae, and Dipterocarpaceae (Smith and Read, 2010). Ectomycorrhizal plants are also more conservative of nitrogen than arbuscular plants in northern and tropical ecosystems. However, differences in phosphorus use are less evident outside temperate latitudes. The relevance of plant mycorrhizae is related to the evolution of plant nutrient economic strategies. In ectomycorrhizal fungi, the thin filaments of the fungus enter only into the intercellular space of the first few layers of the root bark (Bonfante and Genre, 2010), resulting in the Hartig net structure (Ediriweera et al., 2022) (Figure 5).

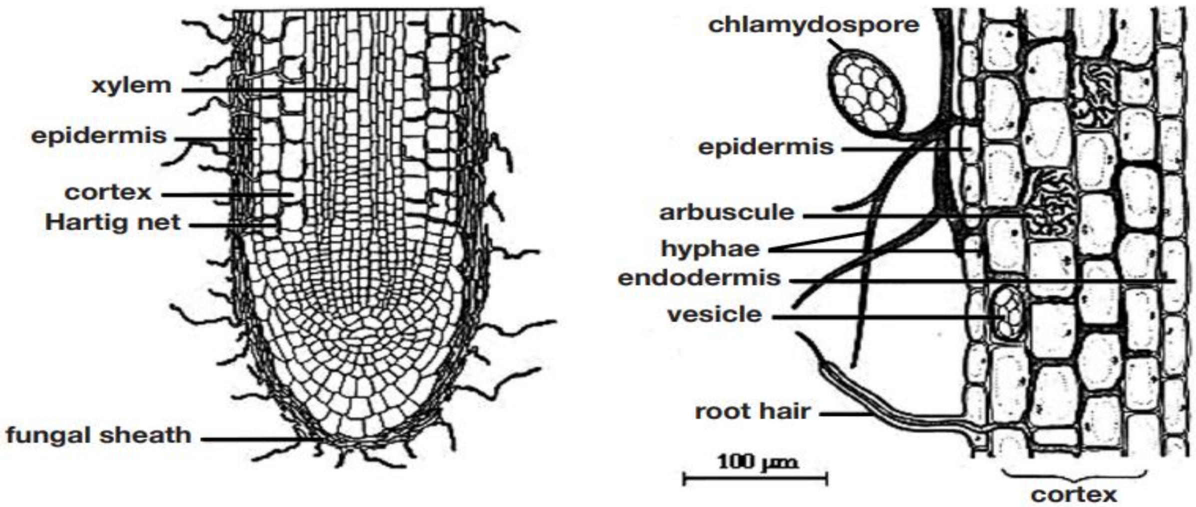

Fig 1. Ectomycorrhize (left) and Arbuscular mycorrhize (right) (Ianson and Smeenk, 2010)

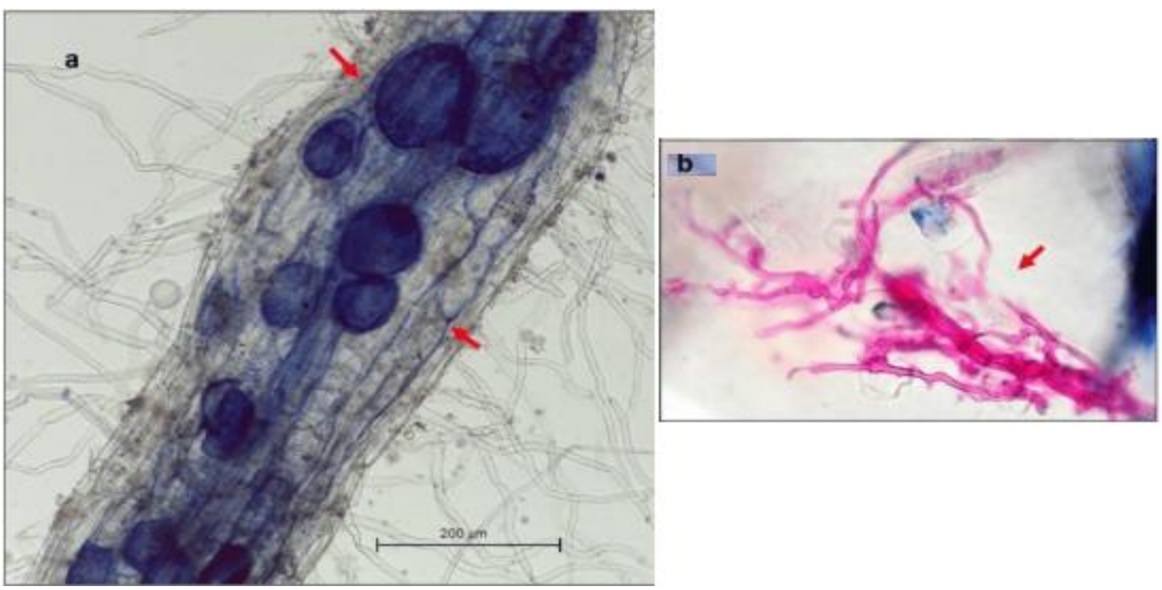

Fig 2. Different ages of arbuscules, a: Vesicles may last longer in the root than in the arbuscules which are storage structures formed in the terminal part of the hyphae. b: For capturing soil nutrients the mycelium is extended to the external root (Luis-Alaya et al., 2023).

Table 1. The traits of mycorrhizal colonization in the roots of cocoa plants (Rasouli et al., 2023)

Cocoa Field	Number of Spores/100 g Dry Soil	Number of Inactive Hyphae	Number of Active Hyphae	Number of Coils	Number of Active Arbuscules	Number of Vesicles	Total Active Mycorrhizal Colonization (%)	Total Mycorrhizal Colonization (%)	GRSP-EE Content (mg/g Dry Soil)	GRSP-T Content (mg/g Dry Soil)
3 years	131.8 [a]	30 [a]	13 [a]	9 *	19 [a]	0	59 [a]	77 [a]	8.30 [a]	9.58 [a]
9 years	65.6 [b]	33 [a]	18 [a]	13 *	33 [a]	9 *	61 [a]	86 [a]	8.70 [a]	13.75 [b]
10 years	13.4 [b]	21 [a]	19 [a]	4 *	28 [a]	0	63 [a]	68 [a]	7.67 [a]	12.83 [b]

The data represent the mean of three independent replicates with three repetitions each. Means in each column followed by the same letters are not significantly different between fields ($p < 0.05$, Duncan). * Does not have three repetitions (Rasouli et al., 2023).

Fig 3. a (Paraglomeraceae spore), b (Glomeraceae spore). c, d (spores belonging to the families Paraglomeraceae) The portion of e (Glomeraceae spore), f (Claroideoglomeraceae spore), and g (auxiliary cells of Gigasporaceae) (red arrow) all of them are some Glomeromycota morphotypes from the cocoa in fields studied were shown (Luis-Alaya et al., 2023).

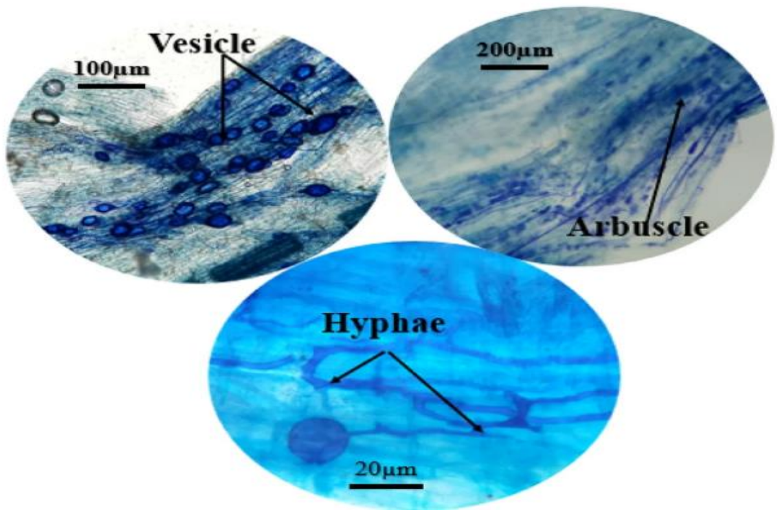

Figure 4. F. mosseae in the root of the medicinal plant of fennel (Rasouli et al., 2023)

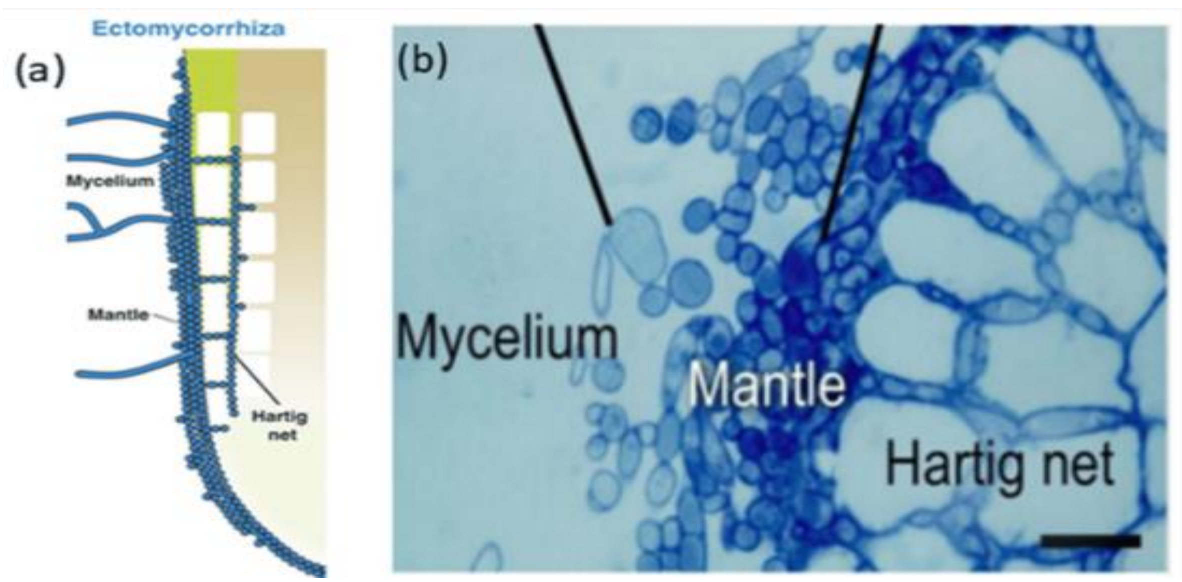

Fig 5. (**a**) *ectomycorrhizal in root* (**b**) the root and Hartig net of EM fungi (Bonfante and Genre, 2010). Symbiosis between the plant and fungi (Ediriweera et al., 2022).

Importance and function of the mycorrhizal

Mycorrhizal fungi are obligate symbionts of more than 80% of plant families and support the survival and growth of the host plant under stressful conditions (Koucheki et al., 2011). The hyphae of mycorrhizal fungi can enter tiny pores that even the filaments cannot penetrate and cause an increase in water absorption (Tisdall, 1991). Symbiotic fungi receive carbohydrate materials mainly in the form of sucrose from the plant and provide nutrients (mainly phosphorus) to the plant (Merulanda and Barea, 2009). In this way, nutrients from the arbuscule membrane are actively provided to the plant through membrane carriers, which act with the proton gradient, and carbohydrate materials in the phloem vessel of the plant are first converted to glucose by the fungus. Fructose is converted and then absorbed by carriers (Smith and Read, 2010). The plant fungal, bacterial, and nematode diseases are controlled by applying AMF, as the mechanisms of resistance to diseases are called biological control potential. The exact mechanism AMF and beneficial microorganisms prevent plant diseases that shown in Figure 6. The symbiosis of mycorrhizal (AMF) with plants caused biological control mechanisms shown in Figure 7. Via increasing the root branch and lignifying of cell walls, AMF mycelium acts as a barrier in the external level of the root is called the epidermis, causes of plant disease connected to the cell wall by AMF, soil structure is better, the material exudates by root and killed pathogens and growth, development and reproduction of beneficial microorganisms improved via AMF for absorption of nutrients and water by plants when competing with pathogens (Wenfeng, 2022).

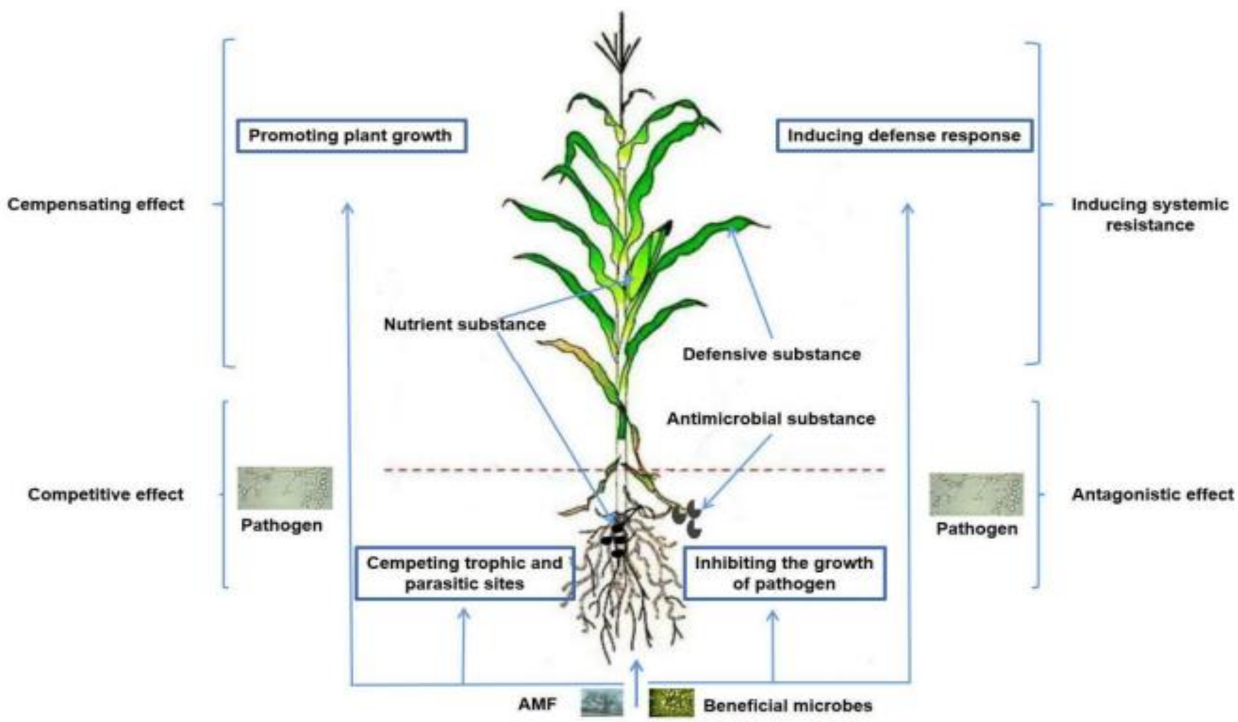

Fig 6. The same mechanism AMF and beneficial microorganisms (Wenfeng, 2022)

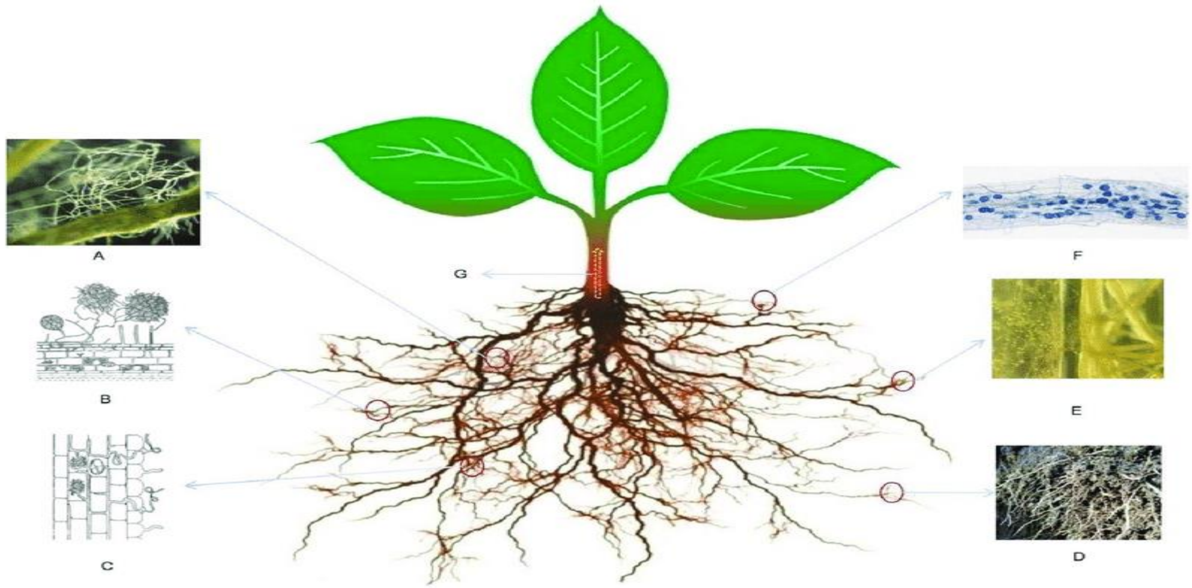

Fig 7. The symbiosis *mycorrhizal fungi* (AMF) with plants causes biological control mechanisms (A) via increasing root branches and lignifying of cell walls; (B) AMF mycelium's acts as a barrier in external level of root is called epidermis; (C) causes of plant disease connected to the cell wall by AMF; (D) soil structure is better; (E) the material exudates by root and killed pathogens and growth; (F) development and reproduction of beneficial microorganisms. (G) improved via AMF for the absorption of nutrients and water by plants when competing with pathogens (Wenfeng, 2022).

Arbuscular mycorrhizal and active ingredients in Medicinal plants

Medicinal plants have been significant in various fields of human life for a long ago and have been widely used in traditional medicine. Of course, the benefits of medicinal plants are due to the presence of their secondary metabolites. On the other hand, the secondary metabolites of these plants can be affected by microorganisms called mycorrhizal fungi and increase, and although essential experiments related to the accumulation of effective substances in medicinal plants by Mycorrhizal fungi have shown that the secondary metabolites, which are critical medicinal substances, have increased by about 27% by inoculation with mycorrhizal fungi. Also, there was a significant increase in flavonoids (68%) and terpenoids (53%), and in addition, the active substances of medicinal plants increased much more in the underground organs (32%) than in the aerial organs (18%). Of course, the mycorrhizal fungus of the genus Rhizophagus has increased the effective substances of medicinal plants in aerial and underground organs to more than 50%, and subsequently, chlorophyll, stomatal conductance, and photosynthesis have improved under the influence of mycorrhizal mushroom inoculation [26]. In this regard, the growth characteristics and the amount of essential oil production of the basil medicinal plant (*Ocimum basilicum*) were tested under the influence of mycorrhizal fungi G. mosseae, G. fasciculatum, and G. intraradices. The inoculation of Basil with the mentioned mycorrhizal fungi caused an increase in essential oil compounds and essential oil yield compared to control plants without inoculation. G. mosseae and G. fasciculatum mushrooms showed a better and higher effect than other treatments in increasing the essential oil content of the plant. However, the fresh weight of the root showed a good increase by all the fungi used in the experiment, while the dry weight of the root did not show such a reaction against all three fungi, and only G. intraradices and G. fasciculatum increased the dry weight of the root. Of course, the important compounds of Basil essential oil, such as linalool and chavicol methane, showed a significant increase using mycorrhizal fungi (Zolfaghari, 2013). Therefore, it can be understood that mycorrhizal fungi can have a significant effect in increasing the quantitative characteristics of plants, especially plants that are used in the pharmaceutical industry, which are vital. The results of another investigation showed that the interaction of irrigation and mycorrhiza fungi on leaf chlorophyll, phosphorus of flowers and seeds, seed oil, flower mucilage percentage, flower phenol, leaf area index, flower and seed yield, biological yield, and water use efficiency of Borage were significant. At irrigation levels after 90-, 120- and 150-mm water evaporation from the evaporation pan, that caused water shortage stress for borage, application of fungi G. mosseae and G. intraradices than non-application of fungi respectively (43.33% and 41.66%), (75.55% and 24.44%) and (54.23% and 11.11%) caused a significant increase in total chlorophyll of Borage. Also, the application of mycorrhiza in these levels of irrigation increased the phosphorus of flowers, seeds, phenol flower, and leaf area index of Borage. Biological yield and water use efficiency and decreasing proline and soluble sugar content of Borage at irrigation levels after 60, 90, 120 and 150 mm water evaporation from evaporation pan caused significant increase in conditions of presence of mycorrhizal fungus than non-application of fungi, also in these levels of irrigation, application of mycorrhizal fungi than the absence of fungi increased the yield of flowering plants (30.44% and 27.35%), (92.29% and 98.90%), (94.1% and 93.21%) and (81.73% and 78.86%) respectively. Significant increase in the percentage of mucilage of plants (19.65% and 14.1%) and (62.22% and 57.28%) was observed in the presence of G. mosseae and G. intraradices in comparison with the absence of *mycorrhizal fungi* at irrigation levels after 120- and 150-mm evaporation water from the evaporation pan, also the application of mycorrhiza fungus at these irrigation levels increased the amount of borage seed oil. Flower yield, phenol, seed oil, mucilage percentage, and borage phosphorus had a significant positive correlation with leaf area index, relative water content, and chlorophyll indicating the increase of the mentioned traits due to the increase of leaf area index, relative water content and chlorophyll of borage, However, these traits showed a significant negative correlation with proline and soluble sugar, indicating a decrease in these traits due to the increase in proline and sugar content of Borage. According to the results of this study, irrigation treatment after 90 mm water evaporation from the evaporation pan and the use of fungi mycorrhiza G. mosseae is recommended (Rahimi, 2017). Of course, in a study, the symbiotic relationship and positive effect of mycorrhizal fungi on the medicinal plant Indian Borage (*Plectranthus amboinicus*), indicating about 92% colonization of mycorrhizal fungi on the roots of this plant, and the increase in the yield of Indian Borage (Hemalatha and Selvaraj, 2003). The hyphae of mycorrhizal fungi can enter microscopic pores that even the filaments cannot penetrate and cause an increase in water absorption (Tisdall, 1991). Symbiotic fungi receive carbohydrate materials mainly in the form of sucrose from the plant and provide nutrients (mainly phosphorus) to the plant (Merulanda and Barea, 2009). In this way, nutrients from the arbuscular membrane are actively provided to the plant through membrane carriers, which act with the proton gradient, and carbohydrate materials in the phloem vessel of the plant are first converted to glucose by the fungus and fructose is converted and then absorbed by carriers that the mechanism of action of mycorrhizal fungus in the above research has improved the quantitative and qualitative traits and active ingredients of different medicinal plants (Smith et al., 2010). The plant *Eclipta prostrata* L. has a critical role in human life due to its effective substances and secondary plant metabolites. In this sense, it is essential in a survey, the results showed that in different stages of growth of the plant *Eclipta prostrata* L. that the intensity of stress was different; the coexistence of mycorrhizal fungi with the roots of this plant caused changes in the phenol contents of the plant. In conditions where salinity stress was applied at a moderate level on the plant, mycorrhizal fungi increased the tolerance of this medicinal plant. In the later stages of the plant's growth, when the salinity stress had increased, the researchers saw more accumulation of phenol content in the plant body. Therefore, mycorrhiza is one of the biological microorganisms of the soil ecosystem, which can increase secondary metabolites such as phenols in plants when inoculated with medicinal plants during various environmental stresses, including soil salinity (Duc et al., 2021). Medicinal plants are significant in traditional medicine, pharmaceutics, and human treatment due to the high amount of active medicinal substances and secondary metabolites that are natural and do not harm humans. Compounds such as paclitaxel, camptothecin, and vincristine play a leading role in the production of drugs, and for this reason, they are the most widely used in the world. However, the indiscriminate harvesting of medicinal plants from nature has caused these important plants to be exposed to damage and extinction, and the life and survival of medicinal plants are in great danger. The rhizosphere of medicinal plants can have vital fungi, such as mycorrhizal fungi, through which a common life called symbiosis between plant roots and mycorrhizal fungi is established. The environment and absorption of nutrients and water supply play a vital role. The results of various experiments have clearly shown that an increase in the absorption of nutrients and the growth of plants has been achieved in the conditions of inoculation with mycorrhizal fungi. Also, it has helped the plant in conditions of temperature stress, salinity, and drought, and has increased the power of the plant. Mycorrhizal fungi, such as *Piriformospora indica*, which were discovered by researchers, had effects similar to other mycorrhizal fungi. In the conditions of laboratory and artificial cultivation of medicinal plants, they can provide new mechanical pathways in conditions of high demand in the international market (Sun et al., 2021). Quantitative traits, antioxidant changes, essential oil content, and tissue elements of fennel medicinal plants under the influence of mycorrhizal fungi (AMF), foliar spraying of seaweed extract (SWE), and their mutual effects were investigated in an experiment. The application of AMF, in both non-inoculated and inoculated conditions at the rate of 5 g/kg, and foliar spraying with concentrations of 0, 0.5, 1.5, and 3 g/l of SWE from the tested factors were on this medicinal plant. The application of AMF + 3 grams per liter of SWE was one of the most important interaction effects or combined treatment that could increase the number of osmotic regulators (total soluble carbohydrates and soluble protein), antioxidant activity, and essential oil amount, and therefore obtain the maximum number of photosynthetic pigments and on the other hand increase the concentration of nutrients (N, P, K, Fe, Zn, and Mn) in the plant tissue. Also, the essential compounds of the fennel plant (E-anatol, fencone, limonene, methyl chavicol, and beta-ocemon), which were the main components of the plant, among which, E - E-anatol and fencone compounds from the treatment of AMF+SWE were obtained in high amounts. Therefore, the achievement and output of such experiments, which are related to the effect of biofertilizers such as mycorrhizal fungi, indicate a significant increase in the important compounds of medicinal plants such as antioxidants, an increase in the main compounds of essential oils, an increase in osmotic regulators, and finally because it is possible to increase the quantity and quality of medicinal plants, including fennel. It can be seen that during the cultivation of medicinal plants, biological fertilizers such as AMF + SWE should be used instead of chemical fertilizers in order to avoid environmental pollution, let us witness the increase of secondary metabolites of healthy and high-quality medicinal plants for the medical sector and pharmaceutical industry (Rasouli et al, 2023). Helping the health of the heart and blood vessels, helping to expand blood vessels, helping to maintain normal blood pressure, creating beneficial effects on the heart and blood vessels by diluting and reducing blood clotting, strengthening and improving blood circulation are some of the benefits of using the root and rhizome of medicinal plant *Salvia miltiorrhiza*. Since arbuscular mycorrhizal fungi have been able to increase the yield and secondary metabolites in many plant species, accordingly, the medicinal plant *Salvia miltiorrhiza* was inoculated with mycorrhizal fungi (G. mosseae, G. aggregatum, G. versiforme, G. intraradices) was placed. In all *Salvia miltiorrhiza* plants that were inoculated with mycorrhizal fungi, the colonization structure of mycorrhizal fungi was evident in their roots, and the increase of mycelium of the fungus was clearly evident in the roots, and this inoculation, plant quantitative traits such as in height, leaf size, and leaflets significantly increased the length and diameter of the roots and the biological function of the plant, and on the other hand, It also increased the concentration of elements in plant tissue increased (Yang et al., 2017). Of course, mycorrhizal fungi G. v and G. i increased the amount of tanshinones in plant in order to stimulate the increase of salvianolic acid, also these two fungi were able to increase plant growth, as well as fungi G. m and G. i were increased effective and active plant ingredients.

Conclusion

There are strategies to deal with these stresses in the natural and cultivated ecosystem of medicinal plants in the environment, such as using beneficial microorganisms such as arbuscular mycorrhizal fungi in the soil, and this research was done for this purpose. In this study, the results showed that mycorrhizal fungi are soil organisms that can create an excellent physiological relationship with the plant by coexisting with the roots of plants. Mycorrhizal fungi are soil organisms that can create an excellent physiological relationship with the plant by coexisting with the roots of plants. During environmental stress, the colonization of mycorrhizal fungi with plant roots leads to an increase in plant secondary metabolites such as flavonoids, and essential oils, and by changing the antioxidant activity (increasing superoxide dismutase, peroxidase) and increasing the amount of phosphorus, the plant strengthens.

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