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Efficacity of Arbuscular Mycorrhizal Inoculations on Tree Species Germination and Growth

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Researchers are very concerned about addressing or managing the growing problem of global warming or climate change. Global warming is caused by greenhouse gases, of which carbon dioxide (CO_2) alone contributes 60%. By absorbing carbon dioxide (CO_2) during photosynthesis and naturally storing it as biomass, trees serve as a sink for CO_2 because trees have the ability to store carbon and can lessen the effects of climate change and global warming, planting trees or restoring forests may be a solution to this growing problem. This review paper can be helpful since it

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discusses the interaction between arbuscular mycorrhizal fungi (AMF) and the roots of trees, which benefits the plant for better germination and growth. dormancy of seeds or a delay in growth can be identified as a disadvantage in a plantation program. With the hope that this information would advance the field of research, we have concentrated on mycorrhizal association and its impact on different species of trees in this work. It can be useful for tree species that have lower biomass or slower growth.

Keywords: Global warming; photosynthesis; arbuscular mycorrhizal fungi (AMF); dormancy and biomass.

1. INTRODUCTION

Seed dormancy, a physiological phenomenon in plants that can be brought on by internal or external stimuli, prevents seeds from sprouting even under ideal circumstances. Hard seed coats, underdeveloped embryos, primitive embryos, and inhibitory compounds can all contribute to seed dormancy [1]. Some species' seeds cannot fully germinate because the embryo is restricted by the structures in its environment. Embryos removed from these seeds are not dormant; this phenomenon is known as seed coat augmented dormancy or physical dormancy. In seeds of other species with underdeveloped embryos, a second kind of dormancy known as morphophysiological dormancy is also present, but it also has a physiological component. As a result, these seeds need a treatment to break their dormancy, such as a specific mix of warm and/or cold stratification [2]. Large-scale cultivation is hampered in forestry and home garden plantation initiatives by delayed nursery development and deprived seed germination [3-5].

Bonner [6] stated that germination is defined as “the resumption of active growth in an embryo which results in its emergence from the seed and development of those structures essential for plant development”. It is the culminating event of seed maturation, the establishment of the seedling [7]. Pre-sowing treatments of seed are crucial for constructing a nursery of a specific species in order to forecast the largest number of high-quality seedlings with the least amount of money, time, and labor [8]. To overcome this dormancy in forest seeds, various pre-sowing seed treatments are used.

One of the soil microorganisms that makes up the fundamental components of a good soil-plant connection is the arbuscular mycorrhizal fungus (AMF). By reducing stresses through symbiosis, the mycorrhizal fungus is an essential part of the soil microbial community that promotes plant growth and survival [9]. The advantages that these fungi provide their host include improved phosphorus uptake [10], increased nitrogen absorption [11], the production of plant growth hormones [12], root defense against soil-borne diseases [13], and improved plant growth and productivity [14].

The ability of the AM fungus to colonize roots and act as a biofertilizer and bioprotectant to protect plants against parasitic nematodes and fungi as well as to boost plant development and yield has been demonstrated [15]. (Wei et al., 2016). AMF is a form of symbiotic soil fungi that colonizes the roots of about 80% of vascular plants, according to Vierheirlig 16]. It is one of the essential soil microbes that contribute to a balanced soil-plant system [17]. They improve plant fitness and soil quality [18]. Since it has been demonstrated that the AMF colonizes its roots in prodigious quantities, the neem tree species is extremely dependent on mycorrhizal fungus [19]. In order to lessen the negative effects of slow growth and low germination rates in tree species, this review will analyze the benefits, drawbacks, and role of seed treatment with arbuscular mycorrhizal fungi. It will also consider potential AMF that may be applied through seed treatment or inoculation for better growth.

2. EFFECT OF MYCORRHIZA ON GROWTH AND GERMINATION OF DIFFERENT TREE SPECIES

Although arbuscular mycorrhiza fungi are naturally present in the roots of higher tree species, this literature includes the effect of some AM fungi on the growth and germination of tree species (Table 1). Khaiper et al. [20] conducted an experiment on Melia azedarach, in which she treated seeds with different pre-sowing treatments and then sow these seeds into soils inoculated with *Glomus mosseae* and reported that seeds showed maximum seed germination percentage in seeds treated with cow dung slurry for 6 days within the soil inoculated with Glomus mosseae as compared to control. Shukla et al. [21] investigated the effect of AM fungi (*Glomus cerebriforme* and *Acaulospora scrobiculata*) on two multipurpose tree species i.e., Eucalyptus tereticornis and Albizia procera and found that shoot length, dry weight and nutrient uptake increased significantly after inoculations with AM fungi. The best results were obtained with *G. cerebriforme* in both the tree species than other inoculants.

Muthukumar et al. [22] concluded that the seedlings of Casuarina equisetifolia inoculated with Glomus aggregatum and Acaulospora scrobiculata had significantly higher plant growth and nutrient parameters measured. Nevertheless, the response was higher for seedlings inoculated with *G. aggregatum* compared to those inoculated with *A. scrobiculata*.

Basumatary et al. [23] reported that an increase in length, diameter, circumference and biomass yield along with nutrient availability in the rhizosphere i.e. Nitrogen, Phosphorus, Potassium and carbon in Rubber tree (*Havea brasiliensis*) seedlings inoculation with Acaulospora sp. and Glomus sp. over control.

Singh et al. [24] revealed that the maximum biomass accumulation, phosphorous and nitrogen content in Acacia nilotica seedlings were achieved under soil treated with *Glomus mosseae* along with phosphate and nitrogenous fertilizers.

Reena and Bagyaraj [25] conducted an experiment on effect of 13 different VAM fungi on the seedlings of *Acacia nilotica* and *Calliandra calothyrsus* and reported that inoculated plants had greater plant height, leaf number, stem girth, biomass and phosphorus and zinc content. They also had more mycorrhizal root colonization, spores and external hyphae in soil. *A. nilotica* seedlings responded best at inoculation with *G. mosseae* followed by *G. caledonicum* whereas, *C. calothyrsus* responded best with *G. velum* and *G. merredum*.

Herrmann et al. [26] revealed that the management of Arbuscular mycorrhizal fungi (AMF) would contribute to maintaining or restoring soil fertility, leading to a better tree growth and optimized latex yield of Rubber trees (*Hevea brasiliensis*).

Chen et al. [27] reported that Liqurice (*Glycyrrhiza uralensis*) plant inoculated with *G. mosseae* improved the features of the root system and increased in photosynthetic efficiency. The uptake of P and K in plant was also increased when inoculated with *G. mosseae*.

Filho et al. [28] found that the application of *Rhizofagus clarum* and *Glomus etunicatum* in soil grown with star fruit (*Averrhoa carrambola* L), provided increments of 49% in height, 99% in dry matter production and 86, 129 and 108% in the content of N, K and calcium respectively, in relation to the control.

Jamaluddin and Shukla [29] conducted a laboratory experiment with three treatments *viz.,* AM fungi (*Glomus mosseae*, *Acaulospora* sp. and *Gigaspora* sp.) + root exudates, AM fungi alone and root exudates alone. Out of which the treatment containing AM fungi + root exudates showed maximum colonization, phosphatase enzyme activity, phosphorus uptake and leaf protein as compared with control and other treatments under studied.

Hamidi et al. [30] studied the effect of endomycorrhizae *i.e.Glomus etunicatum* on the seedlings of cork oak plants (*Quercus suber*) and observed that plants inoculated with mycorrhizae showed the stimulatory effect on aerial part, aerial part weight, average root length and average fresh weight and the leaves number as compared to control.

Jha et al. [31] studied the effect of AM fungi namely *Glomus fascicualtum, Glomus aggregatum*, *Glomus cerebriforme, Glomus diaphanum* and *Glomus etunicatum* on *Dalbergia sissoo, Acacia procera* and *Acacia nilotica* seedlings and revealed that the application of AM fungi improves the uptake of phosphorus, minor elements and water and enhances plant growth and resistance to root diseases as compared to non-mycorrhizal plants.

An experiment conducted by Young [32] showed the effect of single and mixed inoculations with phosphorus solubilizing bacteria and VAM fungi on the growth of *Leucaena leucocephala, Acacia confuse, A. mangium* and *Liquidamber formosana*. Growth of *L. leucocephala* tree increased by 22-99% with VAM fungal inoculation. The growth of *Acacia confuse* (14-63%), *A. mangium* (7-88%) and *Liquidamber formosana* (24-280%) promoted by mixed inoculants.

Sumana and Bagyaraj [33] conducted a experiment and used eight different VAM fungi (*Acaulospora laevis, Gigaspora margarita, Glomus caleldonicum, Glomus fasciculatum, Glomus intraradices, Glomus lepototichum, Glomus macrocarpum* and *Glomus mosseae*) for selecting best symbiont for *Dalbergia latifolia* and reported that inoculated plants had greater plant height, stem girth, dry weight and phosphorus content when compared to non-inoculated plants. *D. latifolia* responded best to inoculation with *Glomus leptotichum* as well as *Glomus fasciculatum* as compared to the other AM fungi.

Youpensuk et al. [34] conducted an experiment on Seedlings of *Macaranga denticulate* inoculated with spores of fungi (*Glomus* species, *Glomus fasciculatum, Acaulospora* species and mixed species of AM fungi) in pot and concluded that Nutrient contents (N, P and K) of plant inoculated with *Acaulospora* species or mixed species of AM fungi were higher than plants inoculated with *Glomus* spp. and *G. fasciculatum*.

Table 1. Effect of mycorrhizal treatment on germination and growth of different tree species

S. No.	Tree spp.	Mycorrhizal spp.	Description	Reference
	Melia azedarach	*Glomus mosseae*	The germination percentage (75.87) and other such as mean daily germination, germination value and speed of germination were recorded highest in treatment with cow dung slurry for 6 days + *Glomus mosseae*.	Khaiper et al. [20]
	Eucalyptus tereticornis and *Albizia procera*	*Glomus cerebriforme* and *Acaulospora scrobiculata*	Shoot length, dry weight and nutrient uptake increased significantly after inoculations with AM fungi. Best results were obtained with *G. cerebriforme* in both the tree species then other inoculants	Shukla et al. [21]
	Azadirachta indica	*G. intraradices* and *G. gegosporum*	Neem (*Azadirachta indica*) seedlings and inoculate with *G. intraradices* and *G. gegosporum* have increase mycorrhizal colonization, greater plant height, leaf area and number of root, biomass, phosphorus, nitrogen, collar diameter and potassium content and seedling quality.	Muthukumar et al. [22]
	Casuarina equisetifolia	*Glomus aggregatum* and *Acaulospora scrobiculata*	Higher plant growth and nutrient parameters measured. Nevertheless, the response was higher for seedlings inoculated with *G. aggregatum* compared to those inoculated with *A. scrobiculata*.	Muthukumar et al. [35]
	Havea brasiliensis	*Acaulospora* sp. and *Glomus* sp.	Increase in length, diameter, circumference and biomass yield along with nutrient's availability in rhizosphere *i.e.* Nitrogen, Phosphorus, Potassium and carbon in seedlings inoculated with *Acaulospora* sp. and *Glomus* sp. over control.	Basumatary et al. [23]
	Acacia nilotica	*Glomus mosseae*	Maximum biomass accumulation, phosphorous and nitrogen content in seedlings were achieved under	Singh et al. [24]

S. No.	Tree spp.	Mycorrhizal spp.	Description	Reference
			soil treated with *Glomus mosseae* along with phosphate and nitrogenous fertilizers.	
	Hevea brasiliensis	Arbuscular mycorrhizal fungi	Arbuscular mycorrhizal fungi (AMF) would contribute to maintaining or restoring soil fertility, leading to a better tree growth and optimized latex yield of Rubber trees (*Hevea brasiliensis*).	Herrmann et al. [26]
	Glycyrrhiza uralensis	*G. mosseae*	Plant inoculated with *G. mosseae* improved the features of the root system and increased in photosynthetic efficiency. The uptake of P and K in plant was also increased when inoculated with *G. mosseae*.	Chen et al. [27]
	Averrhoa carrambola L	*Rhizofagus clarum* and *Glomus etunicatum*	Increments of 49% in height, 99% in dry matter production and 86, 129 and 108% in the content of N, K and calcium respectively, in relation to the control.	Filho et al. [28]
.	*Quercus suber*	*Glomus etunicatum*	Plants inoculated with mycorrhizae showed the stimulatory effect on aerial part, aerial part weight, average root length and average fresh weight and the leaves number as compared to control.	Hamidi et al. [30]

3. CONCLUSION

Trees act as a sink for carbon dioxide (CO2) by absorbing it during photosynthesis and naturally storing it as biomass, which helps to mitigate the consequences of climate change and global warming. the relationship that develops between arbuscular mycorrhizal fungus (AMF) and tree roots, enabling the plant to germinate and grow more successfully. A disadvantage in a plantation program can be the dormancy of seeds or a delay in growth. We have focused on mycorrhizal association and its effects on several tree species in this work with the aim that this information would progress the field of research for tree species with lower biomass or slower growth.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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