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Bioprospection Of Arbuscular Mycorrhizal Fungi (Amf) And Mycorrhizal Helping Bacteria (Mhb) For Rejuvenation Of Degraded Land- A Up To Date Review

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Abstract: Degraded land is land which has been damaged by either human-caused activities or has been devoid of any human activity resulting in low productivity and low economic potential unless special restoration measures are used. The aim of the study is to develop scientifically based proposals for identification of land degradation in order to classify and evaluate land degradation in Latvia and to develop the sequence of gradual prevention measures of this process. This review covers the aspects related to the specificity and mechanisms of action of MHB, which positively impact the formation and functioning of AMF in mycorrhizal symbiosis, and the need to advocate MHB as AMF bioenhancers towards their inclusion in integrated nutrient management practices in sustainable agriculture.

Keywords: Halophyte, Arbuscular Mycorrhizal Fungi, Plant Growth Promoting Rhizobacteria, Morphological Characteristics; Photosynthesis; Soil Enzymes.

I. INTRODUCTION

Forest soils are extremely complex ecosystems, as it is well known that soil bacteria have a big impact on plant variety and production [1]. Mycorrhizas are root-fungus partnerships that most trees create with diverse filamentous fungi in a variety of mutualistic relationships. Improved nutrient uptake & greater disease resistance are benefits of mycorrhizal symbiosis, while the fungus receives carbohydrate from its host plant. Numerous elements of plant physiology are impacted by the development of mycorrhizas, and the nutritional and physical characteristics of the soil are also altered. Bacteria are present in the mycorrhizas and external mycelia of symbiotic fungi, which together make up the mycorrhizosphere. These bacteria may effectively affect the development of outside fungal mycelia or the colonisation of mycorrhizal roots. For example, MHB, encourage the development of mycorrhizas. In both arbuscular or ectomycorrhizal symbioses, a number of bacterial strains from a wide variety of major clades have been demonstrated to have MHB-type functions [2].

Mycorrhization may be aided by bacteria in a number of ways. In many instances, their capacity to trigger a quick increase of the fungal mycelium, like in [3], is what produces the beneficial effects. Other important processes include the reduction of soil-mediated stress, for example, and the promotion of lateral root growth to create more broad plant-fungus interactions. However, MHB can show fungal specificity in fostering symbioses and do not always have favorable impacts on mycorrhiza development. While substantial in vitro research has been done on the effects of MHB on mycorrhizal fungi, little attention has been paid to the effect of the fungi on MHB.

The rest of the paer is organized as ;Section II shows the Arbuscular Mycorrhizai fungi ;Section III shows the MHB;Section IV gives the literature survey ;and lastly section V shows the conclusion of the paper.

II. Arbuscular Mycorrhizal Fungi

AMF are a group of organisms that are members of the phylum Glomeromycota, which includes ten of the eleven individuals listed below: Acaulosporaceae, Ambisporaceae,Archaesporacea, laroidoglomeraceae, Diversisporaceae, Gigasporaceae, Glomeraceae, Pacisporaceae, Paraglomeraceae, and Sacculosporaceae (http://www). The AMF life cycle cannot be completed without host plants because they are obligate biotrophs. In the asymbiotic phase that precedes this one, spores germinate in response to environmental conditions such moisture, temperature, and pH to produce hyphae with a finite lifespan [4]. In the existence of root exudates from host plants, a differential morphogenesis of hyphae takes place, with germling hyphae shifting their direction of elongation as well as starting a differential branching pattern [5]: this pre-symbiotic phase is then followed by physical contact among AMF hyphae as well as host roots, with the differentiation of appressoria giving rise to hyphae developing intercellularly within the root cortex, ultimately penetrating in The primary components of mycorrhizal symbioses are arbuscules, where nutrient transfers among the two partners take place. AMF obtains lipids or carbon from the host plant (up to 20% of plant photosynthates), whereas ERM releases minerals it has received and transported.

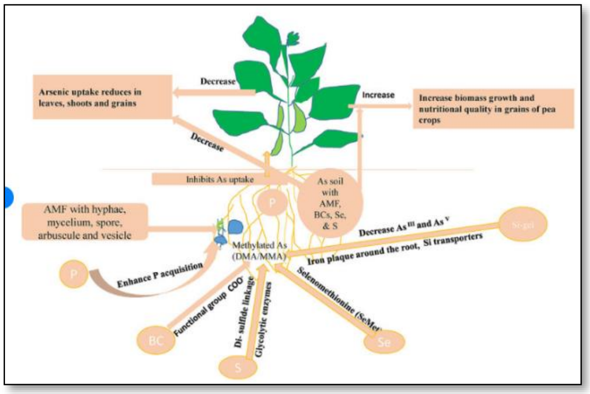

Figure 1: Role of arbuscular mycorrhizal fungi, selenium, silica, sulfur and biochar on As uptake and biomass growth in pea.

Arum-type or Paris-type root colonisation have both been identified. The AM symbiont forms terminal arbuscules on intracellular hyphal branches as it spreads intercellularly among cortical root cells in the Arum-type. In the Paris-type, the fungus develops intracellular hyphal coils and intercalary arbuscules along the coils as it grows straight from cell to cell within the cortex. The majority of information on AMF comes from research on Arum-type mycorrhizal symbioses, which are common in agricultural or natural ecosystems. Some AMF species also create intraradical vesicles, which are spore-like containers that store lipids, in addition to arbuscules. After getting carbon from the plant that is the host, the fungal symbiont has the capacity to develop extraradical, colonize adjacent soil, take in mineral nutrients to be sent to the host plant, communicate with the rhizosphere as well as soil microbes, colonise the roots of other nearby plants (even those belonging to species, genera, and families different from their host), as well as translocations minerals nutrients from one host to another. The life cycle is completed by the production of asexual spores by ERM, which are essential to the preservation of the soil's high mycorrhizal potential and, as a result, the biological fertility of the soil (Figure 2).

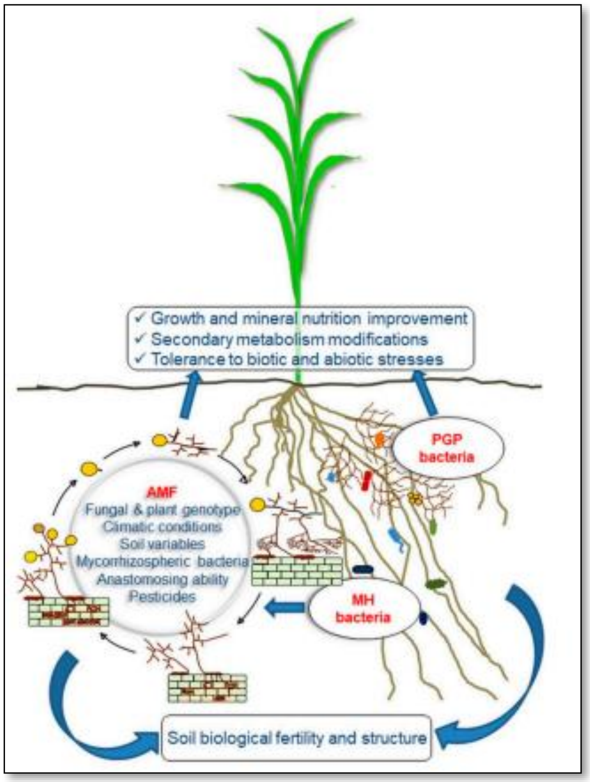

Figure 2. Schematic drawing representing the impacts of arbuscular mycorrhizal fungi (AMF) and beneficial bacteria on plant performance and soil fertility[6]

Table 1: List of various transporters involved in carbon transfer from the host plant cell to AMF arbuscule

III. Mycorrhiza Helper Bacteria

The third party in this complex organization, an assortment of bacteria known as mycorrhiza helper microbes (MHB), has an impact on the symbiotic association of AMF with plant roots. MHB may promote root colonization, spore germination, hyphal growth, as well as the metabolic fitness of AMF. Pseudomonas fuorescens BBc6 was identified as the first clinical demonstration of the so-called help bacteria, which led to the creation of the general name, mycorrhiza helper bacteria (MHB) [7]. Mycorrhiza helper bacteria affect the operation of a previously established AMF symbiosis, and MHB encourage the establishment of a symbiotic relationship of AMF with host plant roots. The researchers later divided MHB into two classes based on their method of work. Both groups fall under the umbrella name "MHB," although they can be distinguished by the environments where they naturally thrive. MHB may be separated from several AMF habitats, including the hyphosphere, mycorrhizosphere, or sporocarps. Since the discovery of AMF-associated MHB in the endomycorrhizal fungus Rhizophagus (Glomus) [8], other bacteria that promote AMF symbiotic have been identified

(Table 1). Being mycorrhizosphere residents, MHB are not specifically adapted to their plant hosts but instead have varying degrees of specify in relation to the fungus [9]. The MHB identified thus far may be categorized into Gram-negative Proteobacteria (Agrobacterium, Azospirillum, Azotobacter, Burkholderia, Bradyrhizobium, Enterobacter, Pseudomonas, Klebsiella, as well as Rhizobium), Gram-positive Actinobacteria (Rhodococcus, Streptomyces, and Arthrobacter), as well as Firmicutes (Bacillus, Brevibacillus, and Paenibacillus). Some MHB use quite specifc mechanisms of In contrast with other types of MHB that promote mycorrhiza development less specifically, certain MHB use fairly specific modes of contact that have co-evolved with their fungi companions. Yet, numerous studies have also shown that MHB has plant growth-promoting (PGP) properties. As a result, the positive effects of MHB may not necessarily be restricted to the development and operation of mycorrhizal connections.

Table 1: Observed responses of plants to the inoculation application of AMF on host species exposed to various abiotic stress treatments.

Stress	Host species	Fungus species	Observed responses	References
Drought	Glycine max L	AMF	Enhanced leaf proline, photosynthesis, leaf area index, relative growth rate, fresh weight, and dry weight of seeds	Pavithra and Yapa (2018)/[19]
High temperature	Zea mays	Rhizophagus intraradices, Funneliformis mosseae, F. geosporum	Increased leaf length, plant height, leaf number, chlorophyll a, photosynthetic rate, stomatal conductance, and transpiration rate	Mathur et al.,(2016)/[20]
Salinity	Cucumis sativus L	Glomus etunicatum,	Increased biomass,	Hashem et al.,(2018)/[21]

		Glomus intraradices, Glomus mosseae	photosynthetic pigment synthesis, and enhanced antioxidant enzymes	
Salinity-alkali	Leymus chinensis	Glomus mosseae	Increased colonization rate, seedling weight, water contents, and both P and N.	Jixiang et al.,(2017)/[22]
Salinity	Solanum lycopersicum L	Rhizophagus irregularis	Enhanced shoot FW, leaf area, leaf number, root FW, and levels of growth hormones.	Khalloufi et al.,(2017)/[23]
Drought	Olea europaea	AMF	Alleviated drought impact and increased turgor potential (Ψp) and mineral uptake	Sara et al.,(2018)/[24]
Drought	Poncirus trifoliate	Funneliformis mosseae, Paraglomus occultum	Increased hyphal length, hyphal water absorption rate, and leaf water potential	Zhang et al. (2018)/[25]

IV. LITERATURE SURVEY

Dimitri et al.,(2020) examined the effects of repeated inoculations with a Proteobacteria consortium on the productivity of plants and the AMF assemblages found in the roots or rhizosphere of four plant species grown in either naturally occurring soil free of petroleum hydrocarbon contamination or in sediments polluted with the same substance. Authors evaluated the AMF community structures in the roots or rhizosphere of plants growing on contaminated and uncontaminated substrates using MiSeq amplicon sequencing, targeting the 18S rRNA gene. Additionally, looked into how the linked AMF assemblages were shaped by plant identity or biotope (plant roots and rhizospheric soil). As a consequence of inoculation, AMF community underwent a considerable shift, however suggested findings revealed that substrate contamination had a far greater impact on the communities' structure than did the biotope and plant identity, which had a smaller effect. Additionally, inoculation significantly boosted plant biomass output and was linked to a reduced dissipation of petroleum hydrocarbons in the polluted soil [10].

MariaLuiza et al.,(2022) performed a global meta-analysis of 193 independent results in order to comprehend the general effect of using AMF as a restoration strategy and to assess sources of variance in the effects of AMF inoculation on the growth of plants in mining-damaged regions. Our findings highlight the significant potential for using AMF to promote plant development in the restoration of mined areas, with greater consequences when combined with the use of organic matter and other soil microorganisms [11].

Higo et al.,(2019) An Illumine MiSeq arranging inquiry within a 30-km radius around the Fukushima-Daiichi NPP in 2013 and 2014 looked at the community motion of indigenous AMF colonizing roots of napiergrass in two different 137Cs-contaminated land-use felds . The nine AMF families that we discovered in the roots included Glomeraceae, Gigasporaceae, Paraglomeraceae, Claroideoglomeraceae, Acaulosporaceae, and uncultured Glomeromycotina. Glomeraceae or Paraglomeraceae were the two plant families that were most prevalent in both grassland or paddy field. In comparison to 2013, there was a greater diversity of AMF in grassland and paddy fields in 2014. Furthermore, the sample year or land-use type had an effect on the AMF community structure. Over the course of the two-year experiment, the land use type and year had an important effect on the AMF community structures colonizing napiergrass roots. Our findings, to our knowledge, are the first to describe the indigenous AMF community dynamics in the 137Cs-contaminated felds near NPP [12].

Mengistu et al.,(2018) Calculated the impact of decades-long, locally-based soil and water conservation practices on the density of arbuscular mycorrhizal fungus, the colonisation of woody plant roots, and soil nutrients. Four important genera of AMF, including Glomus, Acaulospora, Gigaspora, Scutellospora, and Entrophospora, were identified as a result of the study. The most numerous genera were discovered to be Glomus, which accounted for (52%) of the overall spore density and was followed by Acaulospora (18%). Additionally, enclosures had the highest overall spore density (60%) followed by stone terraces (23%), while the open shared grazing meadows had the lowest spore density (17%). From 48.6% in the open communal grazing lands to 68.7% in the enclosure with terraces, total root colonization varied among the treatments. Arbuscular and vesicular colonization were lower than hyphal colonization. In terms of overall colonization, terraced enclosure was followed by enclosure alone, terraces, or non-conserved community grazing lands [13].

Andrade et al.,(2017) introduces a method that enables the automatic counting of those fungi spores in slide images. Because specialists still use manual counting today, the technique helps them complete their work more quickly. To automatically identify patterns, created a database of spore images and ran each one through an ANN Using the same database, authors compared the outcomes of our Perceptron Artificial Neural Network-based counting model and the Fuzzy Morphology technique. The agreement of the proposed counting model with the manual counting had been better than that of Fuzzy Morphology [14].

Ronnie et al.,(2023) In order to determine the ideal concentration of Glomus spp., three hybrid evolutionary or bio-inspired optimization models the genetic termite colony (GTC), the genetic bacterial foraging, and the genetic sperm swarm were constructed. When subjected to a salty environment after 15 and 30 days of sowing, AMF inoculant to stimulate papaya var. Sinta F1 developed the plants as a function of root or stem lengths, stem thickness, leaf count, or total leaf chlorophyll. Control or mycorrhizal with doses of five, ten, and fifteen mg/L were two of the four therapies used. Utilizing NaCl solution, salinity was kept at 6 dS/m. Stem length (Ls) was identified as the most important trait with the highest community using variance-based factor analyses. For Ls fitness function, a 4-gene genetic programming model was created. With the best possible outcomes, GTC advised using 11.149 mg/L, which produced improvements in the non-mycorrhizal plant's root and stem lengths, stem thickness, leaf count, & total leaf chlorophyll of 1937.5%, 388.43%, 650%, 480%, and 238.889%, respectively. Glycophyte resistance to high salinity has been enhanced by this recognized protocol [15].

Crossay et al.,(2017) demonstrated that proteomic-based biotyping using matrix-assisted laser desorption ionization time of flight mass spectrometry is a highly effective method for AMF identification. By using MALDI biotyping at the species level, 19 isolates from 14 species, 7 genera, or 4 families could be distinguished well, with most of them achieving intraspecies differentiation. AMF identification using MALDI biotyping may be very beneficial for research as well as environmental & agricultural uses. In comparison to traditional morphological & molecular approaches for AMF identification, MALDI-TOF-MS offers quick, accurate, affordable molecular mass determination and the potential for automation [16].

Alejandro et al.,(2017) The mycorrhizal fungus Rhizophagus irregulars & the rhizobacterial bacterium Pseudomonas putida KT2440 were (co)inoculated with two wheat cultivars that differed in their capacity to establish mycorrhiza. In comparison to the cultivar with poor mycorrhizal reliability, the cultivar that had excellent compatibility supported greater amounts of rhizobacterial colonization. Mycorrhizal infection increased these amounts. However, mycorrhizal arbuscule production decreased rhizobacterial colonization of the poor compatibility cultivar. Both cultivars responded differently to single inoculations with R. irregularis or P. putida in terms of growth. Furthermore, only the cultivar that had superior mycorrhizal integration demonstrated a synergistic boost in callose adaptability following co-inoculation with both microbes, even though both cultivars constructed systemic preparation of chitosan-induced callose after single inoculations with R. irregulars or P. putida. The suggested findings demonstrate the potential for synergistic impacts from multilateral interactions among roots, mycorrhizal fungi, or PGPR on wheat growth or systemic priming [17].

Madhulika et al.,(2022) need a reliable framework that can keep track of as well as manage all of these adverse impacts on plants, and AMF is one of the best ways to build a foundation for agriculture that is permanent. Higher plant roots and mycorrhizal symbionts collaborate to absorb minerals and nutrients, enhancing plant growth and yield even in adverse environmental conditions. These symbionts acquire carbohydrates in exchange for the ability to complete their life cycle. By improving the stability of ecosystems and soil health, AMF's function as a bio-fertilizer could enhance agricultural plant quality. The effect of various abiotic stress variables on the development of plants, the function of AMF in managing those stresses, its effects as well as impact on plant growth as well as yield, its use as a bio-fertilizer in fields of agriculture, and its interactions with other living things are all topics covered in this review [18].

V. CONCLUSION

Environmental pollution brought on by crude oil & its byproducts is a growing issue that calls for quick and decisive action. The quantity of resources being mined, transported, and maintained has dramatically increased in response to the higher demand for hydrocarbon. Mechanical, chemical, and biological techniques are the three basic categories of elimination. Plant health and soil fertility are mostly determined by advantageous plant-microbe interactions in the rhizosphere. Most of plants' most significant microbial symbioses are arbuscular mycorrhizas, which have an impact on plant community growth, nutrient intake, water relations, or above-ground production in P-limited environments. Additionally, they serve as bioprotectants from infections and harmful stressors. The article provides an introduction to AMF or MHB as well as a review of the literature that will be used in subsequent research activities.

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