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Role of Rhizosphere Fungi Associated With Commercially Explored Medicinal and Aromatic Plants: A Review

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Abstract

The study of rhizospheric microbial flora for the enhancement of aroma compounds is well recognized. The rhizosphere microbes also play very important role in improving medicinal values of plants. Rhizospheric microbes affect the plant physiology by imparting several useful effects such as nitrogen fixation, nutrient uptake, and production of secondary metabolites in the medicinal and aromatic plants. Recent days there are increasing the interests in the research of the relation between rhizosphere microbes associated with medicinal plant for the improvement of quality of medicinal plants. A large variety of fungi and bacteria is recognized in the rhizosphere soil of medicinal plants that showed significant effect in secondary metabolite alteration and uptake of plant nutrient. There are reports that rhizosphere fungi not only enhanced the growth parameters in plants but also considerably modulated essential oil's quality. This study highlighted the researches performed on active role of rhizosphere fungi on explored medicinal and aromatic plants. As the use of organic material is one of the constituents of good agricultural practices (GAPs). Therefore, this review also investigates the environmental concerns reducing the use harmful chemicals as well as recommendation for utilization of biological and organics in agriculture. Therefore, a proper understanding of role of rhizosphere mycoflora associated with the medicinal plants is essential.

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Introduction

The beginning of medicinal and aromatic plants (MAPs) production, as a cultivation of plant materials is lost in olden times. It mainly began at or near the time of the first pain and the detection that smelling, chewing, and eating some plant materials could provide relief from pain, nausea and other physical or mental ailments. Those plants containing the distinctive compounds with pleasant aromas, increased food flavors were well-known and much important by early man[1]. Therefore, the extracts from the plants recognized as medicinal

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and aromatic became an important source for medicines, colorings, preservatives, seasonings, and etc. According to the World Health Organization[2] "a medicinal plant" is any plant, having substances that can be used for the healing purposes and are precursors for the synthesis of useful medicines. The medicinal properties of plants could be based on the antimicrobial, antipyretic and antioxidant activity of the biological active compounds in them[3]. Based on World Health Organization (WHO), medicinal plants would be the best resource to obtain a variety of drugs. Medicinal plants are very important and rich source of biological active compounds[4], and these are said to be safe and environment friendly compared to the synthetic drugs for the healing of many diseases[5]. Currently total number of the plant species in the world is 0.4 million out of 47,513 known to India[6]. India has been blessed with large number of valuable medicinal and aromatic plant species. In India, medicinal and aromatic plants have been used from ancient time for their therapeutic properties. Over 9,500 plant species have documented for their importance in the drug designing industry by the Ministry of Environment and Forests Government of India. Among these, about 65 plants have enormous demand in the world market. About 2,000 native plant species have therapeutic properties and 1,300 species are identified for their aromatics[7]. In the other hand India produces only limited quantities of these drugs. In terms of market share in manufacture significance, India is on 6th place with only 7 percent share. India is still importing around 10 types of essential oils at the rate of 8,000 tonnes per annum[8]. Therefore, such plants should be studied to better understand their properties, efficacy and safety[9].

Medicinal and aromatic plants are from a large group of economically important plants. There are increasing demand for drugs and pharmaceuticals, aroma chemicals and essential oils in the world market since two decades. There is need to fulfill the demand of oil and aroma compounds but pests, diseases, nutrient supply etc are the few factor which decreasing the production quality of medicinal and aromatic plants. For controlling such type of loss, unnecessary use of pesticides and chemical fertilizers creates severe problems and it may deteriorate the quality of medicinal and aromatic plant products. Therefore, growth of modern technologies and uses of bio-fertilizers for farming of medicinal and aromatic plants is required. The inoculation of the rhizosphere fungi is an emerging approach to improved therapeutic properties, aroma content and production of such screened plants. The inoculation of rhizosphere fungi is useful method to improve the quality and quantity of the medicinal plant components. The medicinal plants forming a healthy association with different microorganisms can be express as biofertiliser and biocontrol device. Therefore, it is very important to identify, characterize and use of rhizosphe fungi associated with medicinal plants[10]. Meager work has been done in area of role of rhizosphere fungi associated with commercially important medicinal and aromatic.

Rhizosphere Fungal Diversity and their Effects on Medicinal and Aromatic Plants

Lorenz Hiltner, was the first scientist mentioned the concept rhizosphere, as the soil compartment influenced by plant roots[11]. Rhizosphere is a narrow zone around the root is interconnected to the root exudates (proteins and sugars), respiration and biogeochemical reactions[12]. Rhizosphere is having high microbial diversity which showed critical link between plants and soil[13,14] observed that fungal abundance is 10–20 times more in the zone of rhizosphere than in the rhizoplane soil. Rhizosphere fungi have more potential of spreading through the soil than rhizobacteria[15]. The root exudates in the zone of rhizosphere may control disease and play important role in nutrient cycling. The various bioactive compounds secreted by plant roots into the rhizosphere soil carry out several functions. A broad range of important organic compounds secreted by plant roots in the rhizosphere acts as a nutrient source for microbes enhancing microbial population and activity in the rhizosphere compared to the rhizoplane[16].

Fungal abundance in the medicinal and aromatic plants has been reported broadly[17] investigated rhizosphere fungal population in the roots surrounding area of *Abutilon indicum, Argemone maxicana, Aloe vera, Amaranthus polygamus* and *Achyranthus aspera*. All these five species found to cultivate in wild and northern plains of India. Total 37 species of fungi were observed and isolated. A large number of fungi were also found in rhizosphere region as compared to the non-rhizosphere area. These specious were

Abutilon indicum (11) followed by *Achyranthus aspera* (9), *Aloe vera* (9), *Amaranthus polygamus* (8) and *Argemone maxicana* (7)[18] reported *Fusarium* sp. and *Verticillium* sp. in *Dioscorea zingiberensis, Atractylodes lancea, Euphorbia pekinensis, Pinellia ternate* and *Ophiopogon platyphyllum. Acaulospora scrobiculata* and *Glomus aggregatum* reported in *Andrographis paniculata*[19].

[20]recorded 11 species of rhizosphere fungi isolated from *Santalum album.* Out of 11 species 10 species were belongs to Class Hyphomycetes namely *Aspergillus fumigatus, Aspergillus niger, Aspergillus funiculosus, Aspergillus flavus, Aspergillus restrictus, Aspergillus terricola, Fusarium oxyporum, Aspergillus flavipes, Aspergillus terreus, Penicillium* spp. and one species *i.e. Mycelia sterilia* belongs to Basidomycetes. During the investigation *Aspergillus niger, Aspergillus terricola* and *Penicillium* spp. were frequently observed and recorded.

[21]isolated and identified the rhizosphere fungi of local aromatic rice varieties namely Basmati 370, Jiri, Ambemohar Tambda, Ambemohar 157, Indrayani, and Raibhog. The fungi were *Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus Aspergillus terreus, Alternaria tenuous, Curvularia lunata, Trichoderma* viride*, Rhizopus oryzae, Trichoderma lignorum, Rhizopus nigricans, Curvularia inaequalis, Mucor racemosus, Nigrospora oryzae, Fusarium oxyporum* and *Phoma* spp. were predominant in most of the varieties.

Rhizosphere of the medicinal plants viz. *Ocimum sanctum* and *Centella asiatica* showed 16–17 species of fungi[22,23] isolated and identified 2-Acetyl-1-Pyrroline (major basmati aroma compound) in the culture of *Aspergillus oryzae* TISTR 3232 and *Aspergillus oryzae* TISTR 3088. *Acremonium nigricans* and *Aspergillus awamori* reported to produce 2AP (2.08 mg/l and 1.11 mg/l respectively) isolated from rhizosphere of scented rice seedlings.

Rhizosphere of fourteen varieties of tree peony (*Paeonia suffruticosa*) was colonized by AM fungi[24,25] studied AM fungi *viz*, *Glomus intraradices* and *Glomus mosseae* have improved salinity and plant growth parameters by different process in *Bacopa monnieri*, an economically explored medicinal plant. Seventeen species of AM fungi and fungal colonization structures (hyphae, hyphal coils and vesicles) were found to present in roots of *Huangshan magnolia*[26]. The species were from the genera *Glomus* (8 species), *Acaulospora* (6 species), *Scutellospora* (2 species) and *Gigaspora* (1 species)[27] reported around 21 AM fungal species in roots of the important medicinal plants such as *Indigofera aspalathoides, Eclipta prostrata* and *Indigofera tinctoria*. Five genera of AM fungi were identified in the rhizosphere soil of 3 different medicinal plant species namely, *Withania coagulans, Mitragyna parvifolia* and *Leptadenia reticulata*[28].

There was an enormous difference in the AM fungal population and root colonization in the rhizosphere soil of ten medicinal plant species i.e. *Aloe barbadensis, Emblica officinalis, Mimosa pudica, Rauvolfia tetraphylla, Centella asiatica, Sapindus trifoliatus, Euphoria longan, Rauwolfia serpentina, Smilax* sp. and *Trachyspermum copticum*, inspite of their growth in the similar environment[29,30] reported a whole of 445 actinomycete isolated from 16 important medicinal plant rhizosphere soils. The rhizosphere soil of *Phellodendron amurense* showed three different groups of AM fungi namely *Glomus, Hyponectria* and *Scutellospora* sp. respectively[31].

Effect of Rhizosphere Fungi on Medicinal and Aromatic Plants

Rhizosphere microflora is known as the economic, organic and sustainable inputs for increasing the productivity of many crops[16]. Rhizosphere fungal isolates *i.e. Penicillium pinophilum*, *Aspergillus niger* and *A. fumigatus*, isolated and identified in the different plants, can efficiently solubilise Tricalcium phosphate or Rockphosphate[32] and increase the uptake of phosphorus (P) by the growth of plants. AM fungi could help to increase the functional variability, nutrient uptake and activity of microorganisms in the rhizosphere soil of *Atractylodes lancea*, medicinal plant and affect the constituents of the organic matter in *A. lancea*, but not to the quality[33]. Jdm2 (*Bacillus subtilis*), a rhizobacterial strain isolated from the rhizosphere soil of the old Chinese medicinal plant *Trichosanthes kirilowii* increase plant growth and suppress the activity of nematode and has the capability to be a safe, effective and environmental friendly microbial pesticide[34].

There are three main categories of plants secondary metabolites namely terpenoids, phenolics and alkaloids used for pharmacological and medicinal purposes. Essential oils generally consisting of monoterpenes, phenylpropanoids and sesquiterpenes are used as antimicrobials, fragrances and flavours and antioxidants[35,36] studied that *Pseudomonas fluorescens, Trichoderma viride* and *Bacillus megaterium* in alone and combined treatments showed maximum enhancement (22.27%) of essential oil as compared to untreated plant in *Ocimum tenuiflorum*.

Rhizosphere fungi isolated from aromatic rice varieties namely, *Aspergillus terreus, Asprgillus niger, Aspergillus flavus, Aspergillus fumigatus, Rhizopus oryzae, Alternaria tenuous, Trichoderma viride, Rhizopus nigricans, Nigrospora oryzae, Trichoderma lignorum, Mucor racemosus, Curvularia lunata, Curvularia inaequalis, Phoma* spp. and *Fusarium oxyporum*, were found to synthesize 2-acetyl-1-pyrroline[21].

[37]reported 8 rhizosphere fungal strains isolated from Basmati rice varieties were synthesizing 2-acetyl-1-pyrroline. Among the 2-acetyl-1-pyrroline synthesizing strains, *Aspergillus niger* was found to synthesize maximum amount (70.86 µg/kg 2-acetyl-1-pyrroline) on malt extract broth medium. [23]isolated and identified 2-acetyl-1-pyrroline in the culture of *Aspergillus oryzae* TISTR 3232 and *Aspergillus oryzae* TISTR 3088. *Acremonium nigricans* and *Aspergillus awamori* reported to produce 2-acetyl-1-pyrroline (2.08mg/l and 1.11mg/l respectively) isolated from rhizosphere of scented rice seedlings[38]. A total 62 fungal isolates were identified from the rhizosphere of *C. citratus*. Out of 62 isolates *Trichoderma viride* was found to synthesize Citral, in potato dextrose broth which was supplemented with 2 g/L geranyl pyrophosphate (GPP) as a universal precursor of monoterpenes[39]. Besides citral, the two other important compounds were isolated include 1, 2-Benzenediol and 2,6-Octadien-1-ol, 3,7-dimethyl-, (Z)- respectively.

Therefore, a proper understanding of role of rhizosphere mycoflora associated with commercially important medicinal plants is essential.

Conclusion

The quality of medicinal plants (bioactive compounds) is mostly affected by biotic and abiotic factors of the rhizosphere. The rhizosphere fungi play a significant role in enhancing medicinal properties of medicinal plants. Nowadays, there are increasing research interests in the area of relation between medicinal plant and their rhizosphere fungi for the enhancing the quality of medicinal plants. A large variety of fungal including arbuscular mycorrhizal fungi is known in the rhizosphere of medicinal plants that have importance in plant nutrient uptake and secondary metabolite production. The inoculation of rhizosphere fungi or AM fungi is an advance technique to enhance the quantity and quality of the medicinal plant secondary metabolites. However, selecting and inoculating efficient rhizosphere fungi for a specific plant are necessary for the cultivation of medicinal plants with respect to get good quality secondary plant metabolites. Therefore, additional research is required on rhizosphere fungi associated with commercially important medicinal plants.

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