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The Potential Use of Arbuscular Mycorrhiza in the Cultivation of Medicinal Plants in Barak Valley, Assam: A Review

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ABSTRACT

AM fungi are widespread and are found from arctic to tropics in most agricultural and natural ecosystems. They play an important role in plant growth, health and productivity. They increase seedling tolerance to drought, high temperatures, toxic heavy metals, high or low pH and even extreme soil acidity. The cultivation of medicinal and herbal plants has assumed greater importance in recent years due to their tremendous potential in modern and traditional medicine. They are also used as raw materials for pharmaceutical, cosmetic and fragrance industries. Indian system of medicine (ISM) uses 25,000 species belonging to more than 1000 genera. About 25% species are used by the industries. The Barak Valley is the southernmost part of the Assam and consists of three districts namely Cachar, Karimganj and Hailakandi. Different tribes staying here are directly using of medicinal plants for the treatments of different ailments. Comparatively very less attention has been given for the conservation of some of these rare and endangered medicinal plants which are extensively used by the tribes of Assam. So, AM fungi can play an effective role in the conservation of some valuable medicinal plants where *Glomus* sp. was found to be widely used for the increase yield of important medicinal plants. This review summarizes the data from recent studies to elucidate the potential use of AM fungi for promoting growth and disease resistance in medicinal plants found in southern part of Assam, which in turn provide a natural enhancer for the commercial production of traditional drugs from various important plants.

Key words: Arbuscular mycorrhiza; Medicinal plants; Traditional drugs, Barak Valley, Bioremediation.

INTRODUCTION

Arbuscular Mycorrhizal(AM) fungi interact either directly with other soil organisms or they may influence these organisms indirectly by affecting host physiology that could change root morphology, physiology and patterns of exudation into the mycorrhizosphere. Mycorrhizae form mutualistic symbiotic relationships with plant roots of more than 80% of land plants including many important crops and forest tree species [1, 2]. Seven kinds of mycorrhiza: arbutoid mycorrhiza, ectomycorrhiza, endomycorrhiza or arbuscular mycorrhiza, ectendomycorrhiza, ericoid mycorrhiza, monotropoid mycorrhiza, and orchidoid mycorrhiza have been recognized [3-5]. However, AM fungi are most commonly found in the rhizosphere roots of a wide range of herbaceous and woody plants [6].

The plant roots provide substances for the fungi and the fungi transfer nutrients and water to the plant roots [7, 8]. Endomycorrhizal fungi are inter and intracellular and penetrate the root cortical cells and form finger like branched structures called arbuscule and vesicles to be known as vesicular arbuscular mycorrhiza (VAM). In some cases no vesicles

are formed and they are known as arbuscular mycorrhiza (AM) [9] .Arbuscular Mycorrhiza (AM) mycobionts forming symbiosis with approximately 90% (>200000) of the terrestrial plant communities. They are essential components of soil biota and are found in almost all ecological situations particularly those supporting plant communities with high species diversity [10] .So far more than 170 species of AM fungi have been recorded and described [11].AM fungi belong to nine genera: *Acaulospora*, *Archaeospora*, *Enterophospora*, *Gerdemannia*, *Geosiphon*, *Gigaspora*, *Glomus*, *Paraglomus*, and *Scutellospora* [12, 13].

Benefits of AM fungi with the host plant

AM fungi are a widespread group and are found from the arctic to tropics and are present in most agricultural and natural ecosystems. They play an important role in plant growth, health and productivity [14]. AM fungi help plants to absorb nutrients, especially the less available mineral nutrients such as copper, molybdenum, phosphorus and zinc [15].They increase seedling tolerance to drought, high temperatures, toxic heavy metals, high or low pH and even extreme soil acidity [8, 16]. AM fungi can reduce the severity of soil-borne pathogens and enhance resistance in roots against root rot disease [17, 18] . Competition between mycorrhizal fungi and pathogenic fungi of the same root tissues and production of fungistatic compounds results in protection of mycorrhizal seedlings [19, 20]. AM fungi have been shown to have benefits to host plants by increasing herbivore tolerance, pollination, soil stability, and heavy metal tolerance. The use of AM fungi as biofertilizers is not new, they have been produced for the use in agriculture, horticulture, landscape restoration, and soil remediation for almost two decades [21]. Mass production of AM fungi has been achieved with several species such as *Acaulospora laevis*, *Glomus*. *clarum*, *G*. *etunicatum*, *G*. *intraradices*, *G*. *mosseae*, *Gigaspora ramisporophora and Gigaspora rosea* but *Glomus intraradices* is the most common inoculum of endomycorrhizae products [22]..Effective management of AM fungi involves increasing population of propagules such as spores, colonized root fragments and hyphae using host plants and also by adoption soil management techniques [1, 23].

The traditional medicinal plants and the use of AM fungi

The cultivation of medicinal and herbal plants has assumed greater importance in recent years due to their tremendous potential in modern and traditional medicine. They are also used as raw materials for pharmaceutical, cosmetic and fragrance industries. Indian system of medicine (ISM) uses 25,000 species belonging to more than 1000 genera. About 25% species are used by the industries .The criteria for selecting AM fungi will depend on the climate soil and host medicinal plants. The AM fungi must 1) colonize roots rapidly after inoculation, 2) absorb phosphate from the soil, 3) transfer phosphorus to the plant, 4) increase plant growth, 5) persist in soil and reestablish mycorrhizal symbiosis during the following seasons and 6) form propagules that remain viable during and after inoculum production [24].

Inoculation of AM fungi during an early stage of acclimatization process has become an alternative strategy for better establishment by improving the plant growth. The AM fungal association had not only enhanced the growth of medicinal plants but also improved the productivity of medicinal compounds. Hence, there is a need for research in improving the quality and quantity of drugs produced from native medicinal plants in relatively shorter period and at lower expense by using AM fungi [25]. AM fungi are also responsible for enhanced uptake of mineral nutrients especially phosphorus from the soil by the host plants and thereby enhancing vigor [26].

Traditional herbal medicines are increasingly being used not only by the developing countries but also by the developed countries in their primary health care system. A bulk of our rural population relies on the drug resources of plant origin. Thus, the cultivation of medicinal plants is increasing steadily to maintain a regular supply and to support their increasing demand. But corresponding research works on the occurrence of AM fungi and their associations in medicinal plants have received very little attention as compared to the studies on forest species and field crops. Out of 150 naturally growing and frequently used medicinal plants, 24 plant species have been found to be on extinction due to over-exploitation for medicinal purposes, particularly

used by local tribes of Barak Valley. Among various medicinal plants, *Cassia fistula*, *C. tora*, *Caeselpinea pulcherima, Melastoma malabatricum, Acacia nilotica, Shorea robusta, Artocarpus sp., Tectona grandis, Dillenia pentagyna ,Albezzia lebbeck* are very important medicinal plants which are necessary to conserve for their various traditional as well as commercial medicinal values (Table 1) [27]. Thus,it is essential to have a proper use of AM fungi in the cultivation of medicinal plants and thus to develop a protocol for traditional drugs in pharmaceutical, cosmetic and fragrance industries.

Interaction of AM fungi with the Medicinal Plants

Mycorrhizal colonization resulted in increased accumulation of nutrients, chlorophyll, carotenoids, sugars and proteins. This was further confirmed from the presence of spores belonging to different VAM fungal species in the rhizosphere soils. VAM inoculation significantly increased the uptake of N, P and, but most markedly increased of P uptake. The effects of inoculation with vesicular arbuscular mycorrhizal (VAM) fungus *Glomus fasciculatum* on the root colonization, growth, essential oil yield and nutrient acquisition in three cultivars of menthol mint

Table 1: Traditional uses of some Medicinal important plants of Barak Valley[27]

Plant	Family	Uses
Achyranthes aspera	Amaranthaceae	Leaf juice extract used internally in otorrh ea, young twig paste used as bandage in external wounds and injury.
Cassia fistula	Fabaceae	The leaves are employed there for erysipelas, malaria, rheumatism, and ulcers. In Brazilian herbal medicine, the seeds are used as a laxative and the leaves and bark is used for pain and inflammation.
Caesalpinia pulcherrima	Caesalpiniaceae	Plant pacifies vitiated kapha, pitta, fever, jaundice, colic, flatulence, malignant tumors. It is a proven anti-cancerous drug.
Acacia nilotica	Fabaceae	Acts as an astringent and It is used to treat diarrhoea, dysentery, and leprosy. Bark and root decoction, said to impart courage, even aphrodisia, and the root is said to cure impotence. The bruised leaves are poultice and used to treat ulcers.
Dillenia pentagyna	Dilleniaceae	Plants are used in the treatment of anal fistula, wounds, diabetes, diabetic carbuncle, neuritis, pleurisy, pneumonia, and burning sensation.
Tectona grandis	Verbenaceae	Plants are used for inflammation, burning sensation, skin diseases, diabetes, stomatitis, ulcers, hemorrhages, urinary retention, kidney diseases, urinary calculi and arthritis.
Melastoma melabatrricum	Melastomaceae	The seeds are used to produce a black dye, the roots, a pink dye Traditionally, Leaves are used to treat diarrhoea and dysentery wash for ulcers, to prevent scarring from smallpox and to treat piles.
Terminalia arjuna	Combretaceae	Bark,young stem & leaf extract is used as cardiotonic, in high blood pressure and liver complaints.
Rauvolfia serpentina	Apocynaceae	Leaf juice is used for curing and controlling high blood pressure.
Artocarpus chama	Moraceae	Bark extract used in jaundice; dried fruit powder is used in stomach troubles.

(*Mentha arvensis*); Kalka, Shivalik and Gomti was found significantly higher as observed by different workers [28].

It was clearly evident from the data as discussed by different workers that the root systems of all medicinal plant species grown in both control and VAM fungus infested soils were invariably found to harbour VAM association. The VAM colonization and growth response of *G. fasciculatum* was observed in all the four medicinal plants .In the VAM inoculated plants, the percentage of VAM associations were observed significantly higher than the control one. In the inoculated plants, the percent VAM association were significantly higher from 10 to 65; 20 to 85%, 12 to 58%; 15 to 75% in the tested plants *O.Sanctum*, *Catharanthus roseus*; *Coleus forskholii* and *Cympbopogon flexuosus* respectively [25]. The Mycorrhizal root intensity of Vesicles and arbuscules were also recorded higher in the inoculated plants than the control ones (Table 2) [29,30].

Medicinal plants inoculated with VAM fungus have shown improved growth and development as compared to control plants. The significant increase was observed not only in AM colonization but also in biomass production (dry wt. of root and shoot) due to inoculation with *Glomus fasciculatum* in all the four medicinal plants. The root and shoot

Table 2: Intensity of VAM formation of some medicinal plants with *Glomus fasciculatum* [25]

Plant	VAM status					
	Control plants			VAM inoculated plants		
	% VAM association	Intensity % of formation		% VAM association	Intensity % of formation	
		Vesicles	Arbuscules		Vesicles	Arbuscules
Ocimum sanctum	10±1.5	12±0.75	10±1.0	65±1.0	60±1.5	40±2.0
Catharanthus roseus	20±1.5	20±0.5	12±0.5	85±2.5	70±1.5	30±1.5
Coleus forskholii	12±0.5	10±0.5	8±1.5	58±1.5	58±1.5	42±2.5
Cympbopogon flexuosus	15±1.0	19±0.5	11±0.5	75±3.5	65±1.5	35±2.5

Values are mean of three replicates ± SD.

Table 3: Effect of *G. fasciculatum* inoculation on the shoot and root weight dry protein content and total chlorophyll of medicinal plants[25]

Plant	VAM status							
	Control Plants				VAM inoculated plants			
	Shoot dry wt(g/plant)	Root dry wt (g/plant)	PC (mg/g of plant)	TCC (mg /g plant)	Shoot dry wt(g/plant)	Root dry wt(g/plant)	PC (mg/ g plant)	TCC (mg /g plant)
Ocimum sanctum	12.44	7.64	60.40	1.20	18.44	11.04	80.20	2.20
Catharanthus roseus	15.66	8.44	70.66	1.90	25.22	14.98	94.00	3.40
Coleus forskholii	8.00	5.66	53.40	1.00	15.91	10.00	79.27	1.96
Cympbopogon flexuosus	13.00	8.00	65.20	1.50	20.10	15.20	84.00	2.60
CD (p=0.05)	1.52	1.64	3.56	0.34	1.58	1.54	4.24	0.34
SD	0.74	0.84	7.92	0.96	3.64	3.72	8.72	0.98

PC = Protein content, TCC =Total chlorophyll content, CD = Critical differences, SD = Standard deviation.

biomass of the inoculated plants were found to be maximum and significant than that of control in all the four medicinal plant species. The reason may be due to the formation of external mycelium around the roots by VAM fungi. Similar improved growth response was also observed in 10 medicinal plants when inoculated with three AM fungal species (*G. mossae, G. fasciculatum and G. monosporum*) for their efficiency [31].

The inoculation with *G. fasciculatum* resulted in increased total chlorophyll content and protein content in all the four medicinal plants over control plant. The highest chlorophyll and protein content was recorded in *C. roseus*, followed by *C. flexuosus, O. sanctum* and *C. forskholii*. The increase in total chlorophyll content and protein content in inoculated plants may be due to increased uptake of phosphorus, which will increase the photosynthetic activity of the plants and ultimately the chlorophyll content in plants. Similar findings were reported already by different workers who found that plants inoculated with mycorrhiza showed significant increase in the growth over non-mycorrhizal plants and also had higher percent of phosphorus over non-mycorrhizal plants after six months field survey [32-36]. Earlier studies also showed such a trend for medicinal plants subjected to AM inoculation with significant increase in growth and production of active secondary metabolites in some medicinal plants *viz*. *Hemidesmus indicus, Gymnema sylvestris, Andrographis paniculata, A. alaba and Clerodendrum phlomidis* [9, 37-39]. *Glomus aggregatum* and *Glomus fasciculatum* were predominantly present and associated with all the *Ocimum* species. Among the seven AM fungal treatments, Pre-inoculation with *Glomus fasciculatum* improved the total seedling biomass, and nutrition uptake better in some medicinal plants also observed and reported by different workers [40-44]. So, the application of AM inoculum will play a very effective role for the commercial production as well as cultivation of medicinal plants which are rare, native to the Southern part of NE of Barak valley.

CONCLUSION

The following conclusions can be drawn from the above discussion

1. Medicinal plants are used as Traditional herbal medicines and are increasingly being used by people for primary health care system. Thus, the cultivation of medicinal plants should be increased to maintain a regular supply and to support their increasing demand by the use of Mycorrhizal fungi for sustainable medicinal plants productivity.
2. The beneficial role of rhizosphere AM fungi is to enhance the tolerance to various biotic and abiotic stresses, thereby increase the growth of medicinal plants. Mycorrhiza inoculated plants showed significant increase in growth and production of active secondary metabolites in some traditional medicinal plants. In order to develop a successful and sustainable protocol, the inoculum of AM fungi could be of great use for promoting growth and disease resistance in medicinal plants specifically found in Barak Valley, Assam for their great medicinal values by local tribes as well as for future commercial production.
3. In improving the socio-economic and cultural status of native people for collection of medicinal plants and their mycobionts like AM inoculum to increase the yield of medicinal plants along with their secondary metabolites to utilize these natural resources on a sustainable basis as a traditional and herbal medicine for the human welfare.

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