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A review on role of vesicular arbuscular mycorrhiza (VAM) in medicinal and aromatic plants with special reference to *Plectranthus barbatus* Andrew

Pooja G Pawar and Yuvraj D KengarDOI: <https://www.doi.org/10.22271/phyto.2025.v14.i6b.15644>**Abstract**

Vesicular Arbuscular Mycorrhizal (VAM) fungi represent a vital symbiotic association between soil fungi and the roots of higher plants. This mutualism significantly enhances plant nutrient acquisition, particularly phosphorus, while improving tolerance to biotic and abiotic stresses. Medicinal and aromatic plants benefit from VAM colonization through improved growth, nutrient efficiency, and enhanced biosynthesis of secondary metabolites responsible for therapeutic efficacy. Among these, *Plectranthus barbatus* (syn. *Coleus forskohlii*), a well-known medicinal species, shows remarkable response to VAM inoculation, resulted in increased biomass and forskolin yield. This review summarizes the mechanisms of VAM colonization, its influence on plant physiology and metabolite accumulation, and its potential applications in sustainable cultivation practices for medicinal and aromatic plants.

Keywords: VAM fungi, *Plectranthus barbatus*, nutrient uptake, secondary metabolites, mycorrhizal symbiosis, medicinal plants

Introduction

Medicinal and aromatic plants (MAPs) have been widely used in traditional and modern medicine to their bioactive compounds. Their cultivation often depends on soil fertility and microbial interactions that influence plant growth and metabolite production. Vesicular Arbuscular Mycorrhizal (VAM) fungi, belonging to the phylum Glomeromycota, form symbiotic relationships with approximately 80% of terrestrial plant species (Smith and Read, 2008) [1].

These fungi colonize plant roots, forming arbuscules and vesicles that aid in nutrient exchange. Such associations are known to enhance nutrient uptake efficiency, improve plant vigor, and regulate secondary metabolism key aspects for medicinal plants like *Plectranthus barbatus*. Understanding the mechanisms of VAM action provides a foundation for developing sustainable biofertilization and phytochemical enhancement strategies.

Mechanism of VAM Colonization

VAM colonization begins when fungal spores germinate in response to signaling molecules exuded by plant roots, such as strigolactones and flavonoids. The germinating hyphae grow toward the root surface, forming an appressorium through which they penetrate the epidermal and cortical cells. Within the cortical cells, branched structures called arbuscules are formed, serving as sites for nutrient transfer between the symbionts. Vesicles, which act as storage organs, develop within or between cells. Extraradical hyphae extend into the soil matrix, improving nutrient absorption, especially immobile elements like phosphorus and zinc. This complex colonization ensures a steady nutrient flow and establishes a functional mycorrhizal network that benefits the host plant (Giovannetti and Mosse, 1980) [2].

Role of VAM in Growth and Nutrient Uptake

VAM fungi play a central role in improving plant nutrition, particularly under nutrient-limited conditions. They enhance the uptake of phosphorus, nitrogen, potassium, and micronutrients such as iron, copper, and zinc. The external hyphae increase the effective absorptive area of roots, thereby improving soil exploration and nutrient solubilization (Bolan, 1991) [3].

In *Plectranthus barbatus*, mycorrhizal inoculation has been shown to increase dry biomass and phosphorus concentration significantly (Bhattacharya *et al.*, 2004) [5]. This improvement in nutrient status also promotes chlorophyll synthesis, protein accumulation, and overall photosynthetic efficiency, contributing to enhanced plant productivity.

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Influence of VAM on Secondary Metabolite Production

The production of secondary metabolites in medicinal plants is highly sensitive to physiological and environmental factors. Mycorrhizal associations can alter the biosynthetic pathways of alkaloids, terpenoids, phenolics, and essential oils. By improving nutrient uptake and inducing plant defense mechanisms, VAM fungi upregulate key enzymes involved in secondary metabolism. In *Coleus forskohlii*, VAM inoculation enhanced forskolin concentration, while in *Ocimum sanctum* and *Withania somnifera*, essential oil and withanolide levels were also elevated (Kapoor *et al.*, 2002; Singh *et al.*, 2015)^[4, 7]. These effects demonstrate the potential of mycorrhizal biotechnology to improve the pharmacological value of medicinal plants without the use of synthetic fertilizers.

VAM and Stress Tolerance

Apart from nutritional benefits, VAM fungi provide resilience to plants against several environmental stresses. They improve water absorption, enhance antioxidant enzyme activity, and regulate osmolyte accumulation under drought and salinity conditions (Ruiz-Lozano *et al.*, 2012)^[10]. In medicinal plants, this protection maintains steady growth and consistent secondary metabolite synthesis even under suboptimal conditions. Such stress mitigation is particularly beneficial for crops like *Plectranthus barbatus* grown in marginal soils.

Conclusion

Vesicular Arbuscular Mycorrhizal fungi significantly enhance plant growth, nutrient uptake, and bioactive compound synthesis in medicinal and aromatic plants. (Barea *et al.*, 2005; Kapoor *et al.*, 2008; Sharma *et al.*, 2009)^[4].

For *Plectranthus barbatus*, this symbiosis not only promotes biomass accumulation but also elevates forskolin yield, offering an efficient and sustainable approach to medicinal crop management. (Pandey *et al.*, 2006; Nisha and Rajeshkumar, 2014)^[11, 12].

The integration of VAM biotechnology into cultivation systems could therefore play a crucial role in improving the quality and yield of medicinal plants while preserving soil fertility and ecological balance. (Kapoor *et al.*, 2002; Akiyama *et al.*, 2005)^[4]

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