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Research Article

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Effects of arbuscular mycorrhizal (AM) fungi on growth and nutrients uptake in *Coleus aromaticus* Benth.

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Abstract The effect of arbuscular mycorrhizal (AM) fungi on root colonization, growth and nutrient content of (*Coleus aromaticus*) was investigated as complete randomized design with 4 treatments and 4 replications. Fungi inoculation treatments consisted: Gf (*Glomus fasciculatum*), Glomus margarita and NM (non-mycorrhizal). The results showed mycorrhizal plants significantly had higher shoot and root dry weight, as well as N, P, K, Ca, Fe, Cu and Mg concentration compared to non-inoculated plants. The effect of AM fungi inoculation on the root colonization, growth parameters dry weight of *Coleus aromaticus* are more pronounced with *G. fasciculatum* than other AM fungi. It is concluded that *G. fasciculatum* was more effective than other species, which may indicate effective symbiotic potential of this strain with *Coleus* roots.

Keywords *Arbuscular mycorrhiza*, *Coleus aromaticus*, dry weight, nutrients.

Introduction

Medicinal herbs are known as sources of phytochemicals, or active compounds that are widely sought after worldwide for their natural properties. In India, Tamil Nadu is under strategic geographical location and possesses an invaluable treasure of medicinal plants holding a major share in cultivation and export of more than fifty medicinal plant species including Coleus aromaticus Benth. Medicinal plants in Tamil Nadu are cultivated in isolated patches each being grown in its favourable soil and agro-climatic conditions [1]. Soil is a living entity which posses a number of organism. The microbes present in the soil are responsible for the living nature of the soil. The microbial activity is enhanced due to application of organic manures like cattle manure, green manure and oil cakes, etc., to the soil. The soil microbes play a very important role in the supply of nutrients to plants by fixation, solubilization and mobilization etc., from atmosphere and soil. But the continuous use of chemical inputs like chemical fertilizers, pesticides, insecticides, fungicides and weedicides, etc., in the soil, has eradicated these beneficial microbes, which are very essential for plant growth, yield and quality. The microbial population and activity determine the soil fertility or soil health, which lead to crop productivity.

In recent years, "biofertilizers" and plant growth promoting rhizo microorganisms (PGPRs) have emerged as an important component of integrated nutrient supply system and hold a promise for reducing the production costs, improve the crop yields, quality, nutrient supplies and sustaining the productivity over a longer period [2]. The biofertilizers and PGPRs may be of immense use in the cultivation of medicinal plants and have the potential to replace part of the requirement of nitrogen and phosphate fertilizers in the field and thus reduce the costs of plantation establishment [3]. With the growing interest on the application of biofertilizers world over, the future is bright for large-scale utilization. Biofertilizers have proved that their application will increase the productivity of a wide range of crops. Its potential can be best exploited in medicinal crops where the inoculum needed would be

less and there is reduction in time to produce seedlings suitable for transplanting is slow growing medicinal and aromatic crops [4-6].

Plant roots provide an ecological niche for many of the microorganisms that about in soil [7]. They play an important role in soil fertility, not only because of their ability to induce biochemical transformation, but also because of their importance as a source and store-house for mineral nutrients. Several groups of microorganisms have the potential to enhance growth and to improve the health of the plants of the various microorganisms colonizing the rhizosphere, mycorhizae, the mutualistic symbiont play an important role in mobilizing phosphorus from the deeper layers of the soil and supplying it to the host lands [8].

The success of mycorrhizal evolution has been attributed to the role that mycorrhizal fungi play in the capture of nutrients from the soil of all ecosystems [9]. Literally, "Mycorrhiza" means fungus root and is derived from the Greek word "Mykes" meaning fungus and "Rhizo" meaning root [10]. This term was first used by Frank, a German Plant Pathologist in 1855 to describe the symbiotic relationship between plant roots and fungi. The symbiosis is characterized by the exchange of nutrients where carbon in the form of hexose sugars flows to the fungus and inorganic nutrients are passed to the plant, thereby providing a linkage between the plant root and the soil [11]. Mycorrhizal fungi provide inorganic nutrients mainly phosphorus and other complex compounds to the plant through the extensive network of their hyphae that forage for soil nutrients more effectively than plant roots. For this association to occur there must be a host plant (the phycobiont), an ecological habitat (the soil) and a suitable fungus (the mycobiont). Mycorrhizal fungi differ from other plant-fungus associations because of their ability to create an interface for nutrient exchange which occurs within living cells of the plant [12].

The objective of this paper is comparative analysis of the effects induced by two AM fungi *Glomus fasciculatum* (Gf), and *Gigaspora margarita* (Gm) on plant growth and development and nutrient content of *Coleus aromaticus*.

Materials and Methods

Experimental Design and Plant Culture

This study was performed on a loamy sandy soil. To assess the indigenous AM fungi from rhizosphere soils of *Coleus aromaticus* which were collected from Three different sites Karmangudi, Valliyam and Devankudi (located at latitude 11.46'N Longitude 79o48'E. The altitude is 4.6 m MSL) Vriddhachalam taluk, Cuddalore district of Tamil Nadu, India (Fig. 1).

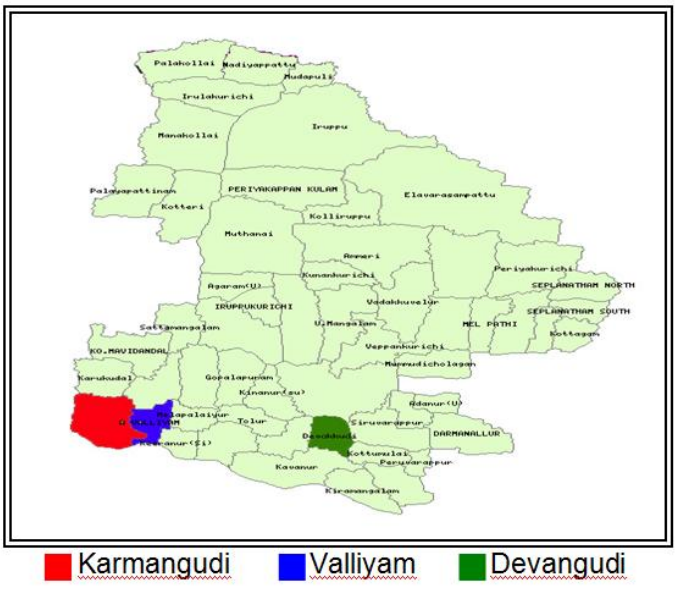

Figure 1: Map showing Soil sampling site

Soil samples were collected from the field at the flowering stage of the plant. Soil samples of about 1kg were collected from the root zone (rhizosphere) of the plant species with the help of soil user at the depth of 10-15 cm. near the root zone. The soil samples were collected in sterile polythene bags and brought to the laboratory for analysis. The samples were kept at ambient temperature in clearing room and used as per the need for further analysis.

Soil properties were: pH (1:5 H2O) 7.2, EC 0.45 dS m-1, CaCO3 7.2%, organic matter 13 g kg-1, P 9.65 mg kg-1, K 165 mg kg-1 and the DTPA (Diethylenetriamine pentaacetate)-extractable Zn, Fe, Mn and Cu were 0.80, 1.80, 2.2 and 1.1 mg kg-1, respectively.

Factor	**Study sites** S_1 **Sandy loam**
Soil pH	7.2 ± 0.04
Moisture (%)	8.0 ± 0.05
Organic carbon (%)	8.0 ± 0.05
Available nitrogen (mg kg^{-1})	460 ± 6.5
Available phosphorus (mg kg^{-1})	1.2 ± 0.02
Available potassium (mg kg^{-1})	220 ± 6.2
Copper (ppm)	1.1 ± 0.04
Zinc (ppm)	1.2 ± 0.02
Manganese (ppm)	3.2 ± 0.02
Iron (ppm)	60.2 ± 0.2

Treatments

The field experiment was carried out in a complete randomized design with 4 replicates. Four treatments were considered: Control plants or non-mycorrhizal (NM), plants inoculated with *Glomus fasciculatum* (Gf), *Gigaspora margarita* (Gm) and *G. fasciculatum* (Gf) + *G. margarita* (Gm).

Cultivation Method

The experimental fields were prepared as per usual method for Coleus cultivation. The fertilizers input was applied as half on N (20 kg), whole of P_2O_5 (30 kg) and K_2O (25 Kg) were applied as a basal dose followed by the remaining ½N at 30 days after planting as top dressing in addition to Farm yard manure 4 ton per acre. The crop was propagated through terminal and cuttings were planted in well prepared nursery beds under shade and AMF inoculants was applied to plants as per the treatments by following standard method, after about a month's time it was transplanted to main field. The field was divided into plots of convenient sizes which were prepared into ridges and furrows at a spacing of 60 cm and the rooted cuttings were planted at 30 cm apart within the row. The first irrigation was given immediately after transplanting. During the first two weeks after planting, the crop was irrigated once in three days and there after weekly irrigation was given. In order to obtain economic yield frequent weeding during the early growth period was done. Plant protection was done by following standard method. The crop was ready for harvest after about 130-150 days of planting. The crop was harvested manually by uprooting the individual plants. The tubers were separated, cleaned chopped into pieces and shade dried to bring about 12 per cent moisture.

After 150 days growth, the plants were harvested and the following parameters including shoot dry weight (SDW) and root dry weight (RDW), number of leaves, and plant height were measured by standard methods. Furthermore, macro and microelement content in shoot dry matter were determined at the end of experiment.

Results and Discussion

Results showed that mycorrhizal plants had significantly higher shoot and root dry weight and plant height (Table 1). Moreover, all mycorrhizal plants showed a higher degree of shoot branching, while root and shoot weight was lower in control plants (Table 1). Increased growth and development in AM plants, compared to non-mycorrhizal ones, was reported for many different species [13-14].

For instance, shoot dry weight in plants inoculated with Gf was increased 39.33 more than Gm and non-mycorrhizal treatments, respectively. The similar results were observed in other growth indices when inoculated with G. fasciculatum (Table 1).

Table 1: Effect of native AM fungi on dry weight (g) of *Coleus aromaticus* Benth

Treatments	Sampling Days (120)
Control	30.63
G. fasciculatum	39.33
G. margarita	32.80

Plants inoculated with different mycorrhizal fungal species showed higher nutrient acquisition. The contents of N, P, K, Ca, Mg, Fe, Cu and Mn in shoots of host plant were higher in mycorrhizal treatments compared to control ones (Table 2).

Table 2: Effect of native AM fungi on macro and micro nutrient content (ppm) of *Coleus aromaticus* Benth

Treatments	Sampling Day (120)							
	N	**P**	**K**	**Ca**	**Cu**	**Fe**	**Mg**	**Zn**
Control	4.68	2.035	0.718	4.603	0.86	4.55	5.68	0.98
G. fasciculatum	8.18	3.852	1.215	7.332	1.92	7.80	7.80	1.80
G. margarita	6.64	2.631	0.986	5.451	1.18	5.62	6.78	1.14

The mycorrhiza G. fasciculatum induced significant increase in shoot nutrient contents rather than other fungal species. Phosphorus content in non-mycorrhizal, Gm treatments was 2.035, 2.631 ppm respectively, lower than that of Gf inoculated (3.852) plants (Table 2). A similar finding was reported for white ash and black walnut plants inoculated with *G. fasciculatum* [15]. This higher nutrient uptake in mycorrhizal plants might be attributed to the contribution of fungal external mycelia which explore a large volume of soil and thus absorb more nutrients [13]. Previous works have shown that arbuscular mycorrhizal fungi increase plant uptake of phosphate [15], micronutrients [16], nitrogen [17] and act as antagonists against some plant pathogens [18]. Moreover, it has been demonstrated that plants inoculated with Arbuscular mycorrhizal fungi utilize more soluble phosphate from rock phosphate than noninoculatedplants [19]. The main explanation is that mycorrhizas developed an extrametrical mycelium, which increased the root phosphate absorbing sites [15].

Conclusion

Nutrients uptake were high in mycorrhizal plants particularly in G. f*asciculatum* treatments. Among studied fungus species, inoculation of *Coleus aromaticus* with Gf resulted in significant increase in growth indices and nutrient contents in comparison with other AM fungal species. Colonization rate of roots with *G. fasciculatum* was higher than other species, which may indicate efficient symbiotic potential of this species with basil roots. It is concluded that *G. fasciculatum* extensively colonized *Coleus aromaticus* roots and considerably improved growth parameters as well as nutrient uptake.

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