RESEARCH ARTICLE

EVALUATE THE ASSOCIATION OF ARBUSCULAR MYCORRHIZAL FUNGI IN SOME MEDICINAL PLANTS GROWN IN NOYAL RIVER BED, TIRUPPUR DISTRICT, TAMIL NADU

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ABSTRACT
To evaluate the rhizosphere soils and ten medicinal herbs polluted soils were tested for the association of arbuscular mycorrhizal fungi and determined the impact of the physico chemical factors in relation to the quantitative and qualitative assessment of AM fungi in polluted soils. Forty species of AMF belonging to five genera such as *Glomus*, *Acaulospora*, *Gigaspora*, *Sclerocystis* and *Scutellospora* were recorded and identified. *Glomus fistulosum* was noticed as the moist dominant in the polluted. In the non-polluted soils, all the plant species were colonized with AM fungi. Where as in polluted soils, eight herb species only were colonized and the percentage of root colonization was less.

Keywords: Arbuscular mycorrhizal fungi (AMF), Polluted soils, AMF root colonization, *Glomus fistulosum*

1. INTRODUCTION
Arbuscular mycorrhizal fungi are a natural constituent of the soil of most ecosystems. They interact with the root of more than 80% of terrestrial plants and can be considered functional extensions of plant roots considerably enlarging the volume for nutrient uptake. Arbuscular mycorrhizal (AM) fungi provide an attractive system to advance plant-based environmental cleanup. During symbiotic interaction the hyphal network functionally extends the root systems of their hosts. AM fungi occur in the soil of most ecosystems including polluted soils by acquiring phosphate micronutrients and water and delivering a proportion to their hosts they enhance the nutrition state of their hosts. Identifying the most sustainable disposal route an important issue in almost all industrialised countries due to a range of legislative, environmental and economic and social drivers (Awotoye, et al., 2009).

Noyyal River is a seasonal river and it flows through the two urbanized and well known industrial cities namely Coimbatore and Tirupur before it reaches River Cauvery as a tributary. More than 6250 textile dyeing and bleaching units are situated in Tirupur region across the river basin release partially or untreated effluents into Noyyal River (Udayakumar et al., 2011). Most of the industries dump their liquid waste in streams and river producing changes in physicochemical and biological conditions of water and soil. Major industrial pollution sources in the country are mills of textiles, leather, dyes, chemicals and number of other industries, in addition to municipal and domestic waste effluents. Textile industry in one of the foreign exchange earner in India. Total annual discharge of waste water is 9,420,000 m³ (Jogdand, 1995) and is disposed into river and on land. In order to find out the potential use of the tannery effluent, an experiment was conducted at polluted soils where the textile liquid wastes mixed with the Noyal river bed, Tirupur District, Tamil Nadu.

Heavy metals (HMs) occur naturally in the environment and constitute a potential hazard for waters, soils, plants and sediments. Numerous studies have indicated that agroecosystems receive inputs of HMs from the increased use of agrochemicals, the application of metal-containing wastes such as sewage sludge, pig manure, coal and wood ashes to soils, and from atmospheric deposition (Mhatre and Pankhurst, 1997). Although some of these metals are essential plant micronutrients and are required or are beneficial for plant growth and development (Zn, Cu, Fe, Mn, Ni, Mo, Co), high contents and/or long-term presence of HMs, in soils, are generally considered a matter of concern to society as they may adversely affect the quality of soil and water, and compromise sustainable food production (Pandolfini et al., 1997; Keller et al., 2002; Voegelin et al., 2003; Kabata-Pendias and Mukherjee, 2007). Arbuscular mycorrhizal fungi (AMF) are one of the important endophytic fungi living in the roots of most terrestrial plants. This symbiosis confers benefits directly to the host plant’s growth and development through the acquisition of phosphorus and other mineral nutrients from the soil by the fungus. In addition, they may also enhance the plant’s resistance to biotic and abiotic stresses (Harrier and Sawczak, 2000).
Now a day, it has been shown that improvement of the interactions between beneficial rhizosphere microorganisms and plants can significantly lower the stress placed on plants by the presence of HMs, increase the availability of metal for plant uptake and subsequently are considered to be an important tool for phytoremediation technology (Glick, 2003, 2010).

2. MATERIALS AND METHODS

2.1. Study area

Tirupur is located at 11.1075°N 77.3398°E. It has an average elevation of 295 metres (967 feet). Tirupur is situated at the banks of Noyyal River, helping the textile business to grow well. As a textile city Tirupur is full of Dyings and Garments. Its location as a center of other cities like Erode, Coimbatore makes it easier to get cotton and other stuffs for the business to be done. The Noyyal River runs through the city and forms the southern boundary of corporation. The cities fast development leads to growth to its status as Tirupur district (Figure-1). The southern part of the city enjoys more rainfall Due to the surrounding of Western Ghats of the city. The mean maximum and minimum temperatures for Tirupur city during summer and winter vary between 35 to 22 °C (95 to 72 °F). The alternative perspective of historical geography is used to understand how Tirupur’s industry is an outcome of processes liking work and investment across sectors in a form of regional industrialization based on small town.

2.2. Experimental soil

The physicochemical characteristics of the soil used for experiment were tested in Department Soil Science testing laboratories at Tamil Nadu Agricultural University, Coimbatore, Tamilnadu, India.

2.3. Rhizosphere effect in soil (Subbarao, 2000)

The quantitative rhizosphere effect of the plants was calculated using the formula:

\[ R/S = \frac{\text{Number of microorganism per gram of rhizosphere soil}}{\text{Number of microorganism per gram of non-rhizosphere soil}} \]

2.4. Mycorrhizal status in plant roots

Results were processed using Phillips et al., technique to study the percent of root colonization. Arbuscular mycorrhizal fungal spores were isolated by wet sieving and decanting method (Gerdemann and Nicolson, 1963).

2.5. Phosphorus content

The phosphorus content in the shoots was determined by the vanado-molybdate phosphoric acid yellow color method outlined by (Jackson, 1973).

3. RESULTS AND DISCUSSION

The contamination of nature compartments by heavy metals has become a serious environmental problem. The worldwide release of heavy metals has reached 1,350,000 tons Zn in 2002 (Singh et al., 2003). This AMF-induced plant nutrient uptake is of more importance in alkaline and calcareous soils of arid semiarid regions in which the bioavailability of P and most of the cationic micronutrients is limited. Calcareous soils have also lower water holding capacity due to the presence of carbonates (Khodaverdiloo et al., 2011). Furthermore, (Khodaverdiloo and Homae, 2008 and Davari et al., 2010) reported a significant reduction in plant transpiration with an increase in soil HM concentration. It has been suggested that heavy metals, such as Cd, can affect root hydraulic conductivity by multiple mechanisms operating on the apoplastic and the symplastic pathway (Shah et al., 2010). Physico-chemical properties of soil samples of both the study sites were presented in (Table-1). Both the control and polluted soils of sandy clay loam and the pH of the non-polluted soil ranged from 7.3 - 7.2 while that of the polluted soils ranged from 6.2-5.4. Both study sites were deficient in phosphorus and nitrogen.

Phytoremediation cannot be done alone by the plant, just as there is always a close interaction between the microorganisms in the rhizosphere and the plant which leads to an increased activity related
Arbuscular mycorrhizal fungi (AMF) are one of the important endophytic fungi living in the roots of most terrestrial plants. This symbiosis confers benefits directly to the host plant's growth and development through the acquisition of phosphorous and other mineral nutrients from the soil by the fungus. In addition, they may also enhance the plant's resistance to biotic and abiotic stresses (Harrier and Sawczak, 2000). Potential roles of AMF associations have repeatedly been demonstrated to alleviate metal stress of plants (Hildebrandt et al., 2002).

Microorganisms in the soil are responsible for nitrogen fixation, assimilation, and degradation of organic residues to release nutrients. When HMs is retained in the soil by repeated and uncontrolled additions, they interfere with these key biochemical processes which alter ecological balance. Toxic effects of HMs on microorganisms manifests in numerous ways such as decrease in litter decomposition and nitrogen fixation, less efficient nutrient cycling. The soil microbial community is thought to be a sensitive bioindicator of metal pollution effects on bioavailability and biogeochemical processes. It has been shown that HMs at certain concentrations can have long-term toxic effects within ecosystems and have a clear negative influence on biologically mediated soil processes (Lee et al., 2002).

In all forty AM fungal species were observed in the rhizosphere soils of both non-polluted and polluted sites. The AM fungal species isolated from the study sites belonging to five genera viz., *Acaulospora*, *Glomus*, *Gigaspora*, *Sclerocystis*, and *Scutellospora* (Table 2). The number of AM spores in the root-zone soils ranged from 0-912. The non-polluted soils were rich both in AM spore number and species abundant whereas in polluted soils were less. This is an agreement with earlier findings of (Ramapulla Reddy and Manoharachary, 1990). There was an impact of season on the distribution of AM spores in polluted and non-polluted soil sites (Jagpal et al., 1988). The numbers of AM spores were more in monsoon and summer. There was a certain degree of specificity among the different species in both non-polluted and polluted sites. There are previous reports of such specificity in root zone soils (Mosse, 1981) and the occurrence of forty species of AM fungi in polluted habitats in the present study is a report as (Gildon and Tinker, 1981) have isolated only one species of effluent tolerant AM fungi. In present study, *Glomus fistulosum* was noticed the most dominant effluent tolerant strain of AM fungi in polluted sites.

All the test plant species in non-polluted soil sites examined exhibited AM colonization whereas in soil polluted with effluent sites, eight plant species were positive for AM colonization and one plant species were nonmycorrhizal, results indicated that mycorrhizal condition is the rule and nonmycorrhizal condition is the exception and agrees with the widespread association of AM reported in natural ecosystem (John and Coleman, 1983). The presence of AM colonization in plants of industrially polluted habitats have earlier been reported (Gildon and Tinker, 1981). The percent root colonization was comparatively more in nonpolluted soil grasses than polluted soil plants (Table 2) and (Figure 2&3). The minimum and maximum per cent root colonization was observed in *Aerva lanata* (Amaranthaceae) (45%) and *Phyllanths amarus* (Euphorbiaceae) (76%) respectively in non-polluted sites and in polluted sites the minimum was in *Datura stromonion* (Solanaceae) (22%) and maximum in *Leucas aspera* (Lamiaceae) (96%) (Table 2). The percentage root colonization was high in summer season of plant species in polluted soil sites in the per cent study as supported by (Ramapulla Reddy and Manoharachary, 1990) in industrially polluted soil sites plant species (Table 2). The number of AM spores were more in monsoon and summer seasons in nonpolluted soils and less in polluted with effluents may be due to dilution of nutrients or accumulation of nutrients and optimum moisture level or water stress and increased level of carbon, zinc and iron were noticed in soil polluted with effluents may be caused reduction in the number of AM propagules, as supported by (Ramapulla Reddy and Manoharachary, 1990).

These results suggested that the variation in soil pH, temperature and effluent pollution seems to be the decisive factors in tropical soils influencing distribution of AM fungi. The physico-chemical data revealed that the polluted soil was acidic to neutral with more of carbon. Zinc, Iron and other nutrients in the present study. It can be concluded that tannery effluents significantly alter the occurrence of native AM fungi both quantitatively and qualitatively. The variation in spore population which was generally more or less in effluent site may be attributed to the season, soil edaphic characters particularly to the acidity, high moisture and organic carbon in soil.
Table 1. Physico-chemical characteristics of polluted and non-polluted soils of three different sites in polluted soils in Noyal river bed, Tirupur District, Tamil Nadu

| S.No. | Study Sites | pH    | Organic matter | N     | P     | K     | Zn    | Cu    | Mn    | Fe    |
|-------|-------------|-------|----------------|-------|-------|-------|-------|-------|-------|-------|
|       |             |       |                |       |       |       |       |       |       |       |
|       | Polluted sites |       |                |       |       |       |       |       |       |       |
| 1.    | Site I      | 6.26±0.20 | 5.4±0.4        | 96.8±4.2 | 24.2±4.2 | 348±12.0 | 2.4±0.2 | 1.7±0.12 | 2.04±1.2 | 30.56±4.2 |
| 2.    | Site II     | 5.93±1.24 | 4.6±0.2        | 89.0±4.6 | 26.4±2.4 | 293±10.0 | 2.98±0.4 | 1.8±0.12 | 1.92±1.2 | 21.58±4.2 |
| 3.    | Site III    | 5.4±0.57  | 3.2±0.4        | 87.8±4.2 | 28.4±2.2 | 24.2±10.20 | 1.74±0.3 | 1.9±0.13 | 1.93±1.0 | 20.14±4.2 |
|       | Non-Polluted sites |       |                |       |       |       |       |       |       |       |
| 1.    | Site I      | 7.30±0.41 | 2.2±0.02       | 92.8±12.1 | 21.3±12.1 | 121.0±17.0 | 2.4±0.2 | 2.1±0.1 | 5.6±1.2 | 1.2±0.1 |
| 2.    | Site II     | 6.56±0.57 | 2.8±0.2        | 89.4±14.0 | 28.4±11.4 | 135.4±15.2 | 2.7±0.1 | 1.9±0.2 | 5.4±1.3 | 1.2±0.1 |
| 3.    | Site III    | 7.21±0.58 | 2.4±0.02       | 77.4±12.0 | 34.0±10.4 | 140.0±26.0 | 2.1±0.4 | 1.8±0.1 | 4.2±1.1 | 1.3±0.1 |

NPS-Non-Polluted Soil. PS-Polluted soil.

General nutrient Status of the soil.

- **Low**: N <140, P_2O_3 <24.2, K_2O <140.7
- **Medium**: N 141-280, P_2O_3 24.3-32.2, K_2O 140.8-281.6
- **High**: N >280, P_2O_3 >32.3, K_2O >281.6
Table 2. Present root colonization spore count and AM fungal species associated in the root zone soil it plants in polluted and non-polluted sites at Noyal river

| S.No. | Family and Botanical name | Study Sites | % of root Colonization | AMF Spores Population/100g Soil | AMF Spores Associated |
|-------|---------------------------|-------------|------------------------|---------------------------------|-----------------------|
|       |                           |             | PS  NPS                | PS  NPS                         | PS  NPS               |
| 1.    | Amaranthaceae *Aerva lanata* L. | S I         | 45  66                 | 224  534                        | Acaulospora sporocarpa Glomus citricola |
|       |                           | S II        | 32  45                 | 135  463                        | Glomus fasciculatum Glomus fistulosum |
|       |                           | S III       | 25  33                 | 334  765                        | Glomus delhiense Glomus multicaulis |
|       |                           |             |                        |                                 | Glomus hoi Glomus occultum |
|       |                           |             |                        |                                 | Glomus canadense Glomus multisubtensum |
|       |                           |             |                        |                                 | Glomus austral Glomus segmentatum |
|       |                           |             |                        |                                 | Acaulospora denticulatam Acaulospora thomii |
| 2.    | Solanaceae *Datura stromonium* L. | S I         | 33  69                 | 210  345                        | Acaulospora denticulatum Glomus microcarpum |
|       |                           | S II        | 22  53                 | 325  657                        | Glomus fistulosum Glomus multisubtensum |
|       |                           | S III       | 33  79                 | 132  432                        | Glomus multicaulis Glomus mososporum |
|       |                           |             |                        |                                 | Acaulospora denticulatum Acaulospora thomii |
|       |                           |             |                        |                                 | Acaulospora thomii Glomus claroids |
| 3.    | Lamiaceae *Leucas aspera* L. | S I         | 56  89                 | 215  765                        | Glomus hoi Glomus geosporum |
|       |                           | S II        | 26  78                 | 453  876                        | Glomus muticaulis Glomus flavisporum |
|       |                           | S III       | 41  95                 | 312  675                        | Scutellospora verrucosa Glomus claroids |
|       |                           |             |                        |                                 | Sclerocystis paecaulis Glomus etunicatum |
|       |                           |             |                        |                                 | Glomus hoi Glomus geosporum |
|       |                           |             |                        |                                 | Acaulospora apendicula Glomus claroids |
| 4.    | Euphorbiaceae             | S I         | 38  73                 | 343  745                        | Glomus fistulosum Glomus geosporum |
|       |                           |             |                        |                                 | Single spore of dimorphicum Acaulospora apendicula |
|       |                           |             |                        |                                 | Glomus manihot Glomus claroids |
|       |                           |             |                        |                                 | Glomus panihalos Acaulospora thomii |
|       |                           |             |                        |                                 | Glomus austral Glomus manihot |
|       |                           |             |                        |                                 | Acaulospora rehmii Acaulospora thomii |

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| Family                  | Genus              | Species                  | Spore Size | 1 | 2 | 3 |
|------------------------|--------------------|--------------------------|------------|---|---|---|
| 5. Euphorbiaceae       | *Phyllanthus*      | *madraspatensis* L.      |            |   |   |   |
|                        |                    |                          |            | S II 25 | 55 | 225 | 564 |
|                        |                    |                          |            | S III 22 | 76 | 143 | 688 |
|                        | *Scutellispora*    | *heterograma*             |            | Acaulospora thomii |
|                        | *Acaulospora*      | *gdanskensis*             |            | Glomus geosporum |
|                        |                    | *dimorphicum*             |            | Glomus magnicaule |
|                        |                    | *microaggregatum*         |            | Glomus claroids |
|                        |                    | *versiforme*              |            | Glomus claroids |
|                        |                    | *heterograma*             |            | Glomus claroids |
|                        | *Glomus*           | *microaggregatum*         |            | Glomus claroids |
|                        | *Glomus*           | *versiforme*              |            | Glomus claroids |
|                        | *Scutellispora*    | *heterograma*             |            | Glomus claroids |
|                        | *Acaulospora*      | *sporocarpa*              |            | Glomus claroids |
|                        | *Acaulospora*      | *thomii*                  |            | Glomus claroids |
|                        | *Glomus*           | *parsifalos*              |            | Glomus claroids |
|                        | *Glomus*           | *canadense*               |            | Glomus claroids |
|                        | *Glomus*           | *aural*                   |            | Glomus claroids |
|                        | *Glomus*           | *multiplex*               |            | Glomus claroids |
|                        | *Acaulospora*      | *reihmi*                  |            | Glomus claroids |
|                        | *Glomus*           | *multisubtensum*          |            | Glomus claroids |
|                        | *Glomus*           | *microcarpum*             |            | Glomus claroids |
|                        | *Glomus*           | *mososporum*              |            | Glomus claroids |
|                        | *Acaulospora*      | *sporocarpa*              |            | Glomus claroids |
|                        | *Glomus*           | *fasciculatum*            |            | Glomus claroids |
|                        | *Acaulospora*      | *thomii*                  |            | Glomus claroids |
|                        | *Scutellispora*    | *scutata*                 |            | Glomus claroids |
|                        | *Glomus*           | *citricola*               |            | Glomus claroids |
|                        | *Glomus*           | *multicauilis*            |            | Glomus claroids |
|                        | *Glomus*           | *manihot*                 |            | Glomus claroids |
|                        | *Glomus*           | *arboreense*              |            | Glomus claroids |
|                        | *Scutellispora*    | *heterograma*             |            | Glomus claroids |
|                        | *Glomus*           | *flavisporum*             |            | Glomus claroids |
|                        | *Glomus*           | *fistulosum*              |            | Glomus claroids |
| 6. Malvaceae           | *Sida acuta*       | Burm.                    |            |            |   |   |
|                        |                    |                          |            | S I 31   | 66 | 233 | 543 |
|                        |                    |                          |            | S II 45   | 75 | 153 | 456 |
|                        |                    |                          |            | S III 32  | 56 | 122 | 698 |
|                        | *Acaulospora*      | *sporocarpa*              |            | Glomus claroids |
|                        | *Acaulospora*      | *thomii*                  |            | Glomus claroids |
|                        | *Glomus*           | *parsifalos*              |            | Glomus claroids |
|                        | *Glomus*           | *canadense*               |            | Glomus claroids |
|                        | *Glomus*           | *aural*                   |            | Glomus claroids |
|                        | *Glomus*           | *aural*                   |            | Glomus claroids |
|                        | *Glomus*           | *muticaulis*              |            | Glomus claroids |
|                        | *Acaulospora*      | *reihmi*                  |            | Glomus claroids |
|                        | *Glomus*           | *multisubtensum*          |            | Glomus claroids |
|                        | *Glomus*           | *microcarpum*             |            | Glomus claroids |
|                        | *Glomus*           | *mososporum*              |            | Glomus claroids |
|                        | *Acaulospora*      | *sporocarpa*              |            | Glomus claroids |
|                        | *Glomus*           | *fasciculatum*            |            | Glomus claroids |
|                        | *Acaulospora*      | *thomii*                  |            | Glomus claroids |
|                        | *Scutellispora*    | *scutata*                 |            | Glomus claroids |
|                        | *Glomus*           | *citricola*               |            | Glomus claroids |
|                        | *Glomus*           | *multicauilis*            |            | Glomus claroids |
|                        | *Glomus*           | *manihot*                 |            | Glomus claroids |
|                        | *Glomus*           | *arboreense*              |            | Glomus claroids |
|                        | *Scutellispora*    | *heterograma*             |            | Glomus claroids |
|                        | *Glomus*           | *flavisporum*             |            | Glomus claroids |
|                        | *Glomus*           | *fistulosum*              |            | Glomus claroids |
| 7. Tiliaceae           | *Corchorus*        | aestuans L.               |            |            |   |   |
|                        |                    |                          |            | S I 42   | 81 | 314 | 543 |
|                        |                    |                          |            | S II 21   | 78 | 110 | 876 |
|                        |                    |                          |            | S III 43  | 69 | 143 | 765 |
|                        | *Acaulospora*      | *gdanskensis*             |            | Glomus claroids |
|                        | *Glomus*           | *citricola*               |            | Glomus claroids |
|                        | *Glomus*           | *multicauilis*            |            | Glomus claroids |
|                        | *Glomus*           | *manihot*                 |            | Glomus claroids |
|                        | *Glomus*           | *arboreense*              |            | Glomus claroids |
|                        | *Scutellispora*    | *heterograma*             |            | Glomus claroids |
|                        | *Glomus*           | *flavisporum*             |            | Glomus claroids |
|                        | *Glomus*           | *fistulosum*              |            | Glomus claroids |
| 8. | Oxalidaceae  
*Oxalis corniculata* L. | S I | 55 | 93 | 322 | 869 | *Glomus austral*  
*Glomus muticaulis*  
*Acaulospora rehmii*  
*Sclerocystis paecaulis*  
*Glomus etunicatum*  
*Acaulospora gdanskensis*  
*Glomus magnicaule*  
*Acaulospora thomii*  
*Glomus dimorphicum*  
*Glomus fistulosum*  
*Glomus microcarpum*  
S II | 46 | 88 | 309 | 896 |  
S III | 43 | 80 | 259 | 798 |  
9. | Fabaceae  
*Cassia occidentalis* L. | S I | 12 | 66 | 103 | 659 | *Glomus geosporum*  
*Glomus geosporum*  
*Scutellispora heterograma*  
*Glomus maculosum*  
*Acaulospora apendicula*  
*Glomus rubiformis*  
S II | 44 | 83 | 215 | 765 |  
S III | 23 | 78 | 453 | 876 |  
10. | Mimosaceae  
*Mimosa pudica* L. | S I | 36 | 87 | 312 | 675 | *Glomus fistulosum*  
*Glomus canadense*  
*Glomus invermeyanum*  
*Glomus manihot*  
*Glomus arborens*  
*Glomus macrocarpum*  
S II | 45 | 66 | 343 | 745 |  
S III | 32 | 45 | 233 | 543 |  

**NPS**-Non-Polluted Soil. **PS**-Polluted soil.
soils that were substantially polluted with toxic metals. In order to utilize native plants for revegetation of metal polluted soils, more detailed investigations are needed to improve our understanding of plant adaptation. It is also essential to identify the potential role of indigenous AM fungi in phytostabilization of toxic metals in contaminated environments, and also in stimulating plant growth so that optimum use can be made of both the plant and fungal symbionts for successful revegetation.

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