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STUDY OF MYCORRHIZAL ALLIANCE WITH PLANTS UNDER STRESSFUL CONDITION OF OVERBURDEN DUMPS IN JHARIA COALFIELDS, INDIA

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INTRODUCTION

The majority (probably 70-80%) of terrestrial plants are capable of interacting with arbuscular mycorrhizal (AM) fungi in nature. AM fungi and plant roots are closely integrated as a result of co-evolution over at least 450 million years (Smith & Read, 2008). The beneficial effects of AM fungal symbiotic association on the growth of plants are well known, like improving uptake of macro- and micronutrient, increasing plant resistance against biotic and abiotic stress, and beneficial alternations of plant growth regulators (Smith & Smith, 1996; Liu & Li, 2000; Govindarajulu *et al.*, 2005; Kung'u *et al*., 2008; Smith & Read, 2008).There are several studies reporting the role of mycorrhizae in stressed habitats. The mycorrhizae are very common in disturbed areas which indicate their positive role in establishing and building the plant community. Also, the mycorrhizal associations are essential to the colonization of nutrient-deficient soil heaps left after mining.

Mycorrhizae is found naturally in soil but not in coal polluted soil (Bureau of Mines, 1990). The hyphal network established by mycorrhizal fungi breaks when soils are initially moved and stockpiled (Gould et al. 1996). However, AM is now widely being used for environmental reclamation to limit the application of agrochemicals (Johansson et al., 2004).

2. METHODOLOGY

2.1 Study area

The study site was located in Bastacola, Jharia coalfield of Jharkhand (23°39'30" and 24°48' 20" N latitude and between 86º 11' 30" and 86°27' E longitude). It has an average elevation of 77 m; the climate is tropical monsoon with annual average rainfall is 1169 mm. The mean monthly maximum and minimum temperature during study period (April 2010-July 2011) were, 19.8-45 °C in summer, 8.5-33.5 °C in winter and 24-37.8 °C in monsoon season. The relative humidity varied from 15 – 98 %.

2.2. Experimental design

The saplings of five plant species grown in the mixed plantation were *Azardirachta indica* (Neem), *Dendrocalamus strictus* (Bamboo), *Emblica officinalis* (Amla), *Ficus religiosa* (Peepal) and *Saraca asoca* (Ashok). The plants were two months old at the time of plantation. The mine spoils were collected from Bastacola

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Opencast Mines, Jharia. This mine spoil was freshly dumped because of opencast mining, hence devoid of arbuscular mycorrhizal fungi. Then it was transported to the Experimental Garden where control and treatment plots were made. Vesicular arbuscular mycorrhiza was introduced as tablets procured from KCP Sugar and Industries, Vuyurru, Andhra Pradesh. The tablets contained mycorrhiza of *Glomus* genus. The composition of control and treatment plots is given in Table 1. All the analyses for physico-chemical parameters of the soil were done according to Jackson (1973).

Table 1: Summary about control and treatment plots

Plot Name	Remarks
Over Burden spoil as Control	Mine spoil, seedlings of five plant species, no amendments
Over Burden Spoil + VAM	Mine spoil, seedlings of five plant species, treatment with vesicular arbuscular mycorrhizae (VAM)

2.3. Mycorrhizal Infection:

The plants after one year of infection were taken for the study. The plants were uprooted and dried at 60 °C for 48 Hours and transported to KCP sugar and Industries where the infection study was done. The roots were softened with 10% KOH and stained with Trypan Blue and observed under microscope for Hypahe, Arbuscules and Vesicles in the roots. The percentage of root length colonization was calculated using the Biermann and Linderman (1981) method (frequency distribution method). The roots were observed under Olympus microscope.

3. RESULTS

3.1. Baseline data of the overburden dump soil

The dump was new, devoid of vegetation having the typical heterogeneous characteristics of mine spoil which is clear in Table 2, the impoverished soil conditions depicts poor organic carbon and essential macro nutrients like NPK. The mine-soil is fresh and contains approximately 73% sand, 21% silt, 6% clay and a low concentration of nutrients.

VAM Root Infection

There was no infection found in the control plot as expected. In the treatment plots VAM infection in *Azardirachta indica* (Neem), *Dendrocalamus strictus* (Bamboo), *Emblica officinalis* (Amla), *Ficus religiosa* (Peepal) and *Saraca asoca* (Ashok) was 16%, 32%, 16%, 40% and 10% respectively. Arbuscules, vesicles and hyphae were observed in *D. strictus* (Table 3).

Table 2: Physico-chemical charateristics of the overburden soil.

Parameters	Mine Spoil (Avg ± Sd)
pH	5.67±1.36
Electrical Conductivity (mmhos/cm)	0.07±0.34
Bulk Density(g/cc)	1.45±0.02
Moisture Content (%)	2.07±1.30
Water Holding Capacity (%)	16.28±4.25
Organic Carbon (%)	1.66±0.92
Organic Matter(%)	2.87±1.60
Nitrogen (μg/g)	16.67±9.20
Phosphorus (μg/g)	1.80±0.47
Magnesium(μg/g)	8.22±4.91
Calcium (μg/g)	191.95±8.34
Sodium (μg/g)	32.15±2.66
Potassium (μg/g)	49.63±7.03
CEC(meq/100g)	6.89±1.76
%Sand (<2 -mm and > 0.05 mm)	73±6.20
%Silt (0.05 mm to 0.002mm)	21.4±3.66
%Clay(<0.002 mm)	6±2.17

Table 3: Percent root infection of VAM with the five plant species

S.No	Name of the plants	% of root length colonized	Remarks
1	*Azardirachta indica*	16	Vesicles and hypha are observed.
2	*Dendrocalamus strictus*	32	Hyphae, Vesicles and Arbuscules were observed.
3	*Emblica officinalis*	16	Hyphae were observed.
4	*Ficus religiosa*	40	Hyphae were observed.
5	*Saraca asoca*	10	Hyphae have been observed.

4. DISCUSSION

Maiti (2013) collected spores in restored dumps of Jharia coalmines and found *Glomus* species to dominate. Thus, in our study *Glomus* species have been used which imitates the natural occurrence in restored mines. Similar studies have been done by Kumar et al., (2003) on Jayant Coalmines, Madhya Pradesh. They found high percent colonization of *A. indica* (about 70%) which does not match with our findings. Kumar et al., (2010) found low percent infection in *A. indica* in another study which support our findings. Similarly we found moderate infection for *D. strictus* which corroborates the research of Kumar et al., (2003). Bamboo's root infection by vesicular arbuscular mycorrhiza (VAM) has also been studied by Jiang et al., (2013). Rajeshkumar et al (2012) found 45 % root colonization in *S. asoca*. *S. asoca* failed to survive vigorously which may be correlated to its poor association with VAM. Research on Ashoka's infection studies by VAM are rare in India. Therefore our finding may be fruitful in this aspect.

The presence of arbuscules (Smith & Gianinazzi- Pearson 1988) is normally used to designate VAM association. However, the presence of hyphae or vesicles alone has also been used as evidence for these associations. Arbuscules are ephemeral structures which may be absent if samples are collected when roots are inactive, whereas vesicles are considered as storage organ produced in the older region of infection. The condition indicates that roots of majority of the plants colonized are not mature.

Gould *et al*. (1996) have reported that mycorrhizal inocula in spoil during the first year following dumping chiefly consisted of spores and following the first spring after reclamation other forms of mycorrhizal inocula were enhanced in a revegetating coal mine spoil. As the succession commences at distressed site, there is an increase in VAM inoculums level and as plant root system matures and expands the association also increases. The plants were young so high association at this stage is not expected. Association also varies from soil to soil. In forest *E. officinalis* root infection was found as high as 64% (Pindi, 2011). The impoverished soil condition is potential cause for slow root development of the plants and hence colonization. *F. religiosa* showed good root growth which may be boosted up by its association with the VAM. Thus *F. religiosa* and *D. strictus* can be promoted as good growers in such stressed sites of Jharia Coalfields.

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