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Reclamation of coalmine overburden dump through environmental friendly method



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Abstract Coal mine spoils (-the previous overburden of coal seams, inevitable by-product in the mining process) which are usually unfavorable for plant growth have different properties according to dumping years. The reclamation of overburden dumps (OBDs) through plantation by using efficient microbes with suitable bio-inoculants is an environmental friendly microbial technique for significant improvement in fertility status and biological activities of the OBD soil. A systematic greenhouse pot experiment program followed by field trial was conducted to investigate the influence of *arbuscular mycorrhizal* (AM) and NFB on the performance of plant growth which have resulted in the development of environmental friendly bio-inoculant package for soil reclamation of abandoned mine land by revegetation.

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1. Introduction

Coal (-the most abundant fossil fuel resource) provides around 30% of global primary energy needs, generates 41% of the world's electricity and is used in the production of 70% of the world's steel (<http://www.worldcoal.org/>). During open-cast mining, the overlying soil is removed and the fragmented rock is heaped in the form of overburden dumps (Ghosh, 2002). These dump materials are left over the land, occupy a large amount of land, which loses its original use and generally

gets soil qualities degraded (Barapanda et al., 2001). As the dump materials are generally loose, fine particles from it become highly prone to blowing by wind. These get spread over the surrounding fertile land plants; disturb their natural quality, and growth of fresh leaves. It has been found that overburden dump top materials are usually deficient in major nutrients. Hence, most of the OBD do not support plantation. The physico-chemical properties of OBD materials are site specific and differ from one dump to another due to different geological deposits of rocks (Lovesan et al., 1998). Thus, the open-cast coal mining particularly releases a huge amount of mining wastes to the upper part of the land surface as OBD materials which raises a number of environmental challenges, including soil erosion, dust, water pollution, loss of nutrient qualities and microbial activities of the soil system, and ultimately impacts on local floral diversity.

The soil reclamation of abandoned mine has been focused in several studies (see Sheoran et al., 2010) since, the

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physic-chemical properties of OBD materials are site specific (Lovesan et al., 1998). In the present study, the reclamation of coalmine OBD was undertaken through environmental friendly method in order to select the efficient photosynthetic and soil conserver plant species suitable for growing on OBD with the ability to grow on poor and dry soils and develop the vegetation cover in a short time and to accumulate biomass rapidly. Further, the plant should have ability to bind soil for arresting soil/water erosion and checking nutrient loss/water runoff, and improvement of the soil organic matter status and soil microbial biomass, thereby enhancing the supply of available nutrients for plants.

2. Materials and methods

The study site (ECL, Coal field, Lalmatia, Jharkhand, India) was surveyed in order to collect the data on general topography, meteorological data, enumeration and documentation of native vegetation, and quantitative structures (density and frequency) of plant community in core zone. 5, 10 and 15 year (yrs) old OBDs were selected. The soil samples along with fine feeder roots were collected for assessment of physico-chemical characteristics (i.e. pH of OBD soil, water holding capacity, bulk density, porosity, soil texture, available minerals (phosphorous, potassium, nitrogen), organic carbon, and rhizosphere microflora (VAM spore population, VAM root colonization, estimation of N_2 -fixing bacteria i.e. isolation of Rhizobia from root nodules, isolation of *Azospirillum*, and estimation of phosphate solubilizing bacteria). VAM spores were isolated by wet sieving and decanting techniques (Gerdemann and Nicolson, 1963), the spores were filtered in a line grid marked filter paper. The number of spores per 5 g soil sample was identified following the key manual (Schenck and Perez, 1987). Maize plants were used as a host for the mass multiplication of bio-inoculants (i.e. VAM fungi, *Rhizobium* and *Azospirillum*).

The collected OBD soil was sterilized. A total number of 10 plant species viz. *Acacia mangium*, *Acacia cracicarpa*, *Cassia siamia*, *Dendrocalamus strictus*, *Dalbergia sissoo*, *G. sepium*, *Pterocarpus santalinum*, *Sesbania grandiflora*, *Stylo hamata* and *Stylo scabra* were selected for the evaluation of growth performance in pot and filed condition. The seeds were also surface sterilized by immersing them into 1% $HgCl_2$ solution for 1 h and were subsequently washed with sterilized tap water followed with sterilized distilled water for 5–6 times. The seeds were then allowed to germinate on to sterilized OBD soil. The surface disinfectant seeds were left in the germination chamber for 36 h maintaining optimum temperature and humidity for their sprouting. The very next day after the emergence of radicle and plumule, saplings were transferred to the polybags (22×30 cm) containing admixture of sterilized OBD soil and vermicompost along with 10 g VAM infected chopped root bits or N_2 FB carrier medium separately or in combination. A total number of nine different treatments including control { T_1 – OBD soil (Control), T_2 – OBD soil (1 KG) and vermicompost (1 KG), T_3 – OBD soil (2 KG) and vermicompost (1 KG), T_4 – OBD soil (1 KG) and vermicompost (1 KG) + VAM, T_5 – OBD soil (2 KG) and vermicompost (1 KG) + VAM, T_6 – OBD soil (1 KG) and vermicompost (1 KG) + VAM, + N_2 FB, T_7 – OBD soil (2 KG) and vermicompost (1 KG) + VAM + N_2 FB, T_8 – OBD soil (1 KG) + VAM,

T_9 – OBD soil (1 KG) + N_2 FB} were set in poly bags meant for assessment of their effect on growth performance of raised plants under green house condition. The population of bio-inoculants used for each experiment set was also observed. The growth parameters in terms of shoot height and number of branches were recorded at an interval of 30 days till the saplings attained an age of 3 months.

After the evaluation of growth parameters in green house, all the plants were shifted to the OBD site taking utmost care in transportation. The pits of 1.5ft in depth and 2ft in diameter were dug out keeping 2 m distance between them. The poly bags were removed with care and finally all the test plant species were transplanted on the OBD site (80×80 m²) keeping their natural habit in consideration i.e. big tree plants were at the inner row, herbs at outer making a circular row and the bushy at outer most circle. Irrigation at the time of plantation and thereafter at the interval of 15 days till three months was done to maintain the optimum moisture of the rhizoplane. Growth parameters in terms of plants height and number of branches were also observed till one year at an interval of three months.

2.1. Statistical analysis

All the results were mean of the five replicates. Data were analyzed {standard error (SE), Critical Difference (CD) and *F*-ratio at 5% and 1% of significant level} statistically using MS Excel. ANOVA (analysis of variance) and two way mean value were also calculated for the evaluation of growth performance, treatment and time factors.

3. Results and discussion

3.1. Plant community and quantitative structures

The composition (diversity, density and frequency) of native vegetation growing on coalmine waste (OBD soil) of study site was studied. The results as depicted in Tables 1 and 2 clearly reveal that altogether 102 (belonging to 37 families, 53 herbaceous, 11 shrubs and 38 trees; Fig. 1) angiospermic plants of diverse nature were found to grow in core and periphery zone. Herbaceous plants were more prevalent in the core zone due to settlement of new soil with changed microbial niche. However, density of flora varied with the age of the OBD. 10 and 15 year old OBDs showed the highest number of plants (61) of different habits whereas 5 year old overburden dump was found to cover only herbaceous plants species viz. *Saccharum spontaneum*, *Croton bonaplanadium*, *Xanthium strumarium*, *Alternanthera sessilis*, *Launea nudicaulis*, *Cyandon dactylon* and *Chrysopogon asciculatus*. While *D. sissoo*, *Tectona grandis*, *Acacia nilotica*, *Acacia angustifolia*, *Terminalia alba*, *Alstonia scholaris*, *Agele marmelous*, *Artocarpus lachoa*, *Semicarpus anacardium*, *Terminalia bilarica*, *Sterculia urens*, *Ficus bengalensis*, *Ficus glomerata*, *Ficus religiosa*, *Madhuca latifolia*, *Bombex cieba*, *Bauhinia variegata*, *Butea monosperma*, *Holarhanea pubescence*, *Shorea robusta*, etc. were observed as sparse vegetation (natural or by plantation) in the periphery zone of the mining wasteland, *Ficus benghalensis*, *A. sessilis*, *Artocarpus lakoocha*, *T. grandis*, *S. robusta* and *Mangifera indica* constitute dominant flora in the periphery zone.

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