DIVERSITY OF ARBUSCULAR MYCORRHIZAL (AM) FUNGAL SPECIES FROM IRON ORE MINE WASTELANDS IN GOA

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Introduction

Mining activity is an unavoidable destructive process. Though there are problems of mine wastes in terms of erosion, environmental pollution, damage to adjoining agricultural fields, forests etc., many a time they are exaggerated. These hazards are within measurable limits and can be easily be ameliorated to a significant extent by extensive research and proper planning. Damage to the environment by mining activity has been caused by reject dumps, pumping out of muddy water from the working pits, increasing water levels and slimes from the beneficiation plant.

Revegetation of the mining sites is to achieve vegetation cover within a few years, so that succession may take place at a rapid pace. Hence, it is obvious that one must look for useful treatments and management strategy so that useful vegetation can be established quickly and economically leading to a self-sustaining ecosystem.

Arbuscular Mycorrhizal (AM) fungi, by virtue of their symbiotic association with roots of virtually all vascular plants, are among the most significant microbes in terrestrial ecosystems. Mycorrhizae are not only more efficient in utilization of available nutrients from the soil but also involved in transfer of nutrients from components of soil minerals and organic residues to solution and in nutrient cycling in an ecosystem. Currently, there are opportunities to apply the ectomycorrhizal technology to reclamation programmes. Endomycorrhizae are sometimes reported to be an important associate of many pioneer plants which may require endomycorrhizal infection in order to survive on disturbed land (Jehne and Thompson, 1981). They are particularly useful in detoxifying heavy minerals by chelation (Lamont, 1978).

The present investigation was carried out to study the colonization and diversity of native arbuscular mycorrhizal species in the rhizosphere soils of iron ore mine sites in Goa State.

Material and Methods

Soil pH was measured in 0.01 M $CaCl_2$. Electrical conductivity and Cation exchange concentrations were determined in 1 : 1 water : waste extracts. Cation concentrations were measured by Atomic Absorption Spectrophotometer. Mineral (available) Nitrogen was determined after extraction in 2M KCl (Bremner, 1965a) and total nitrogen determined after acid-Kjeldahl digestion (Bremner, 1965b). Phosphorus was determined by using Olsen and Dean's (1965) method. Total water-soluble sulphate-sulphur was measured turbidimetrically (Anon., 1981). All analysis were carried on air-dried material but results are expressed on an oven-dried (105°C) weight basis after correction for moisture content.

Rhizosphere soils from 15 different plant species found growing on fairly established mine sites were collected from the degraded mining sites during different seasons. Spores were isolated by Flotation Adhesion Technique (Sutton and Burron, 1972) and Wet Sieving and Decanting method (Gerdemann and Nicolson, 1963). Spores were mounted in PVGL and observed under light microscope. For spore identification, the Manual for the identification of V A mycorrhizal fungi by Schenck and Perez (1987) was followed.

Root samples of all the species studied were collected. The roots were freed from adhering soil, gently washed and cut into 1 cm segments. The degree of colonization was calculated by using the slide method (Giovannetti and Mosse, 1980). Colonization was determined after clearing the roots with 10% KOH and staining with Trypan blue (Phillips and Hayman, 1970).

Results and Discussion

The pH of the reject dumps was found to be 6.02 (0.18) with an EC value of 0.051 (0.012) mS/cm. All the plant macro-and micro-nutrients analysed were in very low levels (Table 1).

Chemical analysis of the mine rejects revealed that the mine rejects show acute deficiency of Nitrogen, Phosphorus, Potassium and other essential macro-and micro-nutrients. Electrical conductivity (EC) is very low indicating that there is no likelihood of salinity problems for plant growth.

Table 1

Some properties of iron ore mine rejects

Properties	Mean (S.D.)
pH	6.02 (0.18)
EC (mS/cm)	0.051 (0.012)
Total N	93.2* (N.A.)
Available N	3.8* (N.A.)
P	1.5 (N.A.)
SO_4^{-*}	>0.1 (N.A.)
Ca	1.76 (0.80)
Mg	0.92 (0.55)
K	0.76 (0.26)
Na	2.60 (0.54)
Cu	>0.05 (N.A.)
Fe	>0.01 (N.A.)

Concentrations in $\mu.g^{-1}$ oven dry spoil.
N.A. = Not applicable
S.D. = Standard deviation
E.C. = Electrical conductivity
* = Mean of two replicates taken from bulked samples.

It was observed that the number of spores were very low with fewer than 50 spores/100g. However, the adjacent soil covered with natural vegetation and unaltered by mining activities which was taken as a control showed as high as 384 spores/100 g (Table 2).

Arbuscular mycorrhizal colonization was recorded in all the species taken up for the study. Maximum mycorrhizal infection was observed in *Tephrosia purpurea* (99%),

Table 2

Spore density on mine reject dumps and adjacent vegetation

	Spore density/100g*
Reject dumps	50
Undisturbed areas adjacent to the mining dump	384

*Mean of three readings.

while minimum mycorrhizal infection was recorded in *Spermacoce hispida* (37%). Rest of the plant species showed moderate to heavy infection. (Table 3).

Twenty-seven AM species identified belong to four genera viz. *Glomus* (16), *Gigaspora* (3), *Acaulospora* (7), and *Scutellospora* (1) with number of species given in parenthesis. Maximum AM species diversity was recorded in *Blumea mollis* which showed the presence of seven AM

Table 3

Degree of root colonization and AM species diversity in some plant species found growing on iron ore mine rejects

Plant species	Degree of root colonization (%)	AM species
Spermacoce hispida L.	37	Gm, Gf, Goc, Al
Striga asiatica (L.) Kuntze	93	Gm, Gf, Gr, Gc, Gra, Af
Impatiens klenii W. & A.	81	Gf, Ge, Ga, Gmo, Galb, Amo
Blumea mollis (D.Don) Merr.	87	Gm, Gf, Gau, Gh, Gcan, As, An
Merremia tridentata (L.) Hallier f.	96	Gf, Gca, Gd, Gr, As
Lindernia crustaceae (L.) F. Muell.	90	Gf, Gg, Ggl
Lindernia parviflora (Roxb) Haines	60	Gf, Gd, Gma, Sg
Ischaemum semisagittatum Roxb.	67	Gm, Gf, Ab, Gal, Am
Ziziphus rugosa Lam.	96	Gm, Gf, Gd, Ab, As
Eugenia corymbosa Lamk	95	Gm, Gf, Ab
Carissa carandas L.	94	Gm, Gf, Gd, Gma, Ab
Psidium guajava L.	93	Gf, Gd, Gma, Ab, Af
Mimosa pudica L.	87	Gf, Gd, Gma, As
Smithia sensitiva Ait.	98	As, Ab, Af
Tephrosia purpurea (L.) Pers	99	Gm, Gf, Gd

Legend: Gf = *Glomus fasciculatum*; Gm = *Glomus mosseae*; Gr = *Glomus reticulatum*; Ga = *Glomus aggregatum*; Gal = *Glomus albidium*; Gau = *Glomus australe*; Gc = *Glomus caledonium*; Gca = *Glomus clarum*; Goc = *Glomus constrictum*; Gd = *Glomus deserticola*; Ge = *Glomus etunicatum*; Gg = *Glomus geosporum*; Ggl = *Glomus globiferum*; Gh = *Glomus hoi*; Gmo = *Glomus monosporum*; Gra = *Glomus radiatum*; Galb = *Gigaspora albida*; Gma = *Gigaspora margarita*; Gcan = *Gigaspora candida*; Ab = *Acaulospora bireticulata*; Af = *Acaulospora foveata*; As = *Acaulospora spinosa*; Al = *Acaulospora laevis*; Am = *Acaulospora mallea*; An = *Acaulospora nicolsonii*; Amo = *Acaulospora morrowae* and Sg = *Scutellospora gilmorei*.

fungal species, while minimum AM species diversity was recorded in *Lindernia crustacea, Eugenia corymbosa, Smithia sensitiva* and *Tephrosia purpurea* each of which showed the presence of three AM species.

Endomycorrhizae are important associates of pioneers as many plants may require endo-mycorrhizal infection in order to survive on disturbed land. Arbuscular mycorrhizae seems to provide a primary mechanism of phosphorus uptake from soil and may thus perform an important function in mineral cycling (Fogel, 1980). Soil microflora is a crucial factor in plant nutrient availability and uptake, either by organic matter decomposition of mineral weathering. While there is little evidence of decomposition activity by AM fungi, they may absorb nutrients directly from decomposing organic matter and thus prevent nutrient losses through leaching (Went and Strak, 1968), plant composition and secondary succession following land disturbance (Jones, 1979).

The importance of introducing AM fungal inoculum into soil respired and reclaimed land has been recognized (Allen and Allen, 1980, White *et al.*, 1985). Introduction of AM fungi would decrease the amount of fertilizer required in the establishment phase.

The fairly established mine rejects showed rich diversity of AM species. Further studies involved preparation of pure culture inoculum and its application in the plantation programmes would help to give extra tolerance and ecological support for the plants to survive, grow and perpetuate in the adverse soil conditions of the mines. The present study shows promise for using AM technology in future revegetation programme of iron ore mine wastelands in the State.

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SUMMARY

The use of AM fungi in afforestation is gaining importance. It is known to increase the uptake of phosphorus, carbon sources and indirectly helps to increase biomass and productivity of the host plants. The aim is the present investigation was to isolate and identify the AM species found in the rhizosphere soils of 15 plant species growing on fairly established iron ore mine dumps. The pH of the reject dumps was found to be 6.02 (0.18) with an EC value of 0.051 (0.012) mS/cm. All the plant macro-and micro-nutrients analysed were in very low levels. Chemical analysis of the mine rejects revealed that the mine rejects show acute deficiency of Nitrogen, Phosphorus, Potassium and other essential macro-and micro-nutrients. Electrical conductivity (EC) is very low indicating that there is no likelihood of salinity problems for plant growth. Of the 27 identified species, most frequently occurring species include *Glomus fasciculatum, Glomus mosseae, Glomus deserticola, Acaulospora bireticulata, Acaulospora spinosa, Gigaspora margarita* and *Acaulospora foveata* in that order. The present study reveals that there is rich diversity of AM fungi in the fairly established iron ore mine sites, thereby showing promise towards future revegetation programme of the iron ore mine wastelands in Goa State.

गोआ की लोह अयस्क निकालने से निकृष्ट बनी भूमियों से आर्बुसकुलर कवकमूलता वाली कवक जातियों की विविधता

बी०एफ० राड्रिग्स

सारांश

आर्बुसकुलर कवकों का उपयोग वनीकरण कार्य में महत्वपूर्ण बनता जा रहा है । यह पता ही है कि इनसे फास्फोरस और कार्बन स्रोतों का ग्रहण किया जाना बढ़ जाता है और परीक्षत: पोषी पादपों के जैवपुंज और उत्पादकता की वृद्धि होने में भी इससे सहायता मिलती है । प्रस्तुत गवेषणा का उद्देश्य लोह अयस्क निकाले जाने पर वहां बन गए ढहों पर भलीभांति स्थापित हो चुकी और उग रही 15 कवक जातियों की राइजोमण्डल मृदाओं में मिलने वाली आर्बुसकुलर कवक मूलता वाली कवक जातियां ज्ञात करके उन्हें पहचान लेना था । परिव्यक्त ढूहों का पीएच 6.02 (0.18) पाया गया जिसकी विद्युतचालकता अर्हा 0.051 (0.012) mS / सेमी पाई गई । विश्लेषित सभी बड़े और छोटे पोष्याहार अत्यल्प मात्रा में पाए गए । खनिज क्षेप्यों का रासायनिक विश्लेषण करने पर उनमें नाइट्रोजन, फास्फोरस, पोटाशियम तथा अन्य बड़े व छोटे पोष्याहारों की अत्यधिक कमी पाई गई । विद्युतचालकता भी बहुत कम है जिससे यह सूचित होता है कि इन पर पादप वृद्धि होने में लवणता समस्याएं उठने की कोई संभावनाएं नहीं हैं । पहचानी गई 27 जातियों में अधिक मात्रा में मिलने वाली जातियां क्रम अनुसार *ग्लोमस फेसिकुलेटम, ग्लो० मौसेई, ग्लो० डेजर्टिकोला, एकाउलोस्पोरा बाइरेटिकुलेटा, एकाउ० स्पाइनोसा, गीगास्पोरा मार्गरिटा* व *एकाउ० फीविएटा* हैं । प्रस्तुत अध्ययन बताता है कि भली-भांति स्थापित हो चुका लोह अयस्क परित्यक्त भूमियों में आर्बुसकुलर कवकमूलता वाली कवक जातियों की अच्छी सम्पन्नता है जिससे इस बात की संभावना बनती है कि इस राज्य में लोह अयस्क निकाली गई परित्यक्त खनिज भूमियों में पादप पुनर्जनन कराया जा सकेगा ।

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