ASSOCIATION AND ACTIVITY OF ARBUSCULAR MYCORRHIZAE OF TEAK (*TECTONA GRANDIS*) IN CENTRAL INDIA

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Introduction

Arbuscular mycorrhizal (AM) fungi belong to lower group of fungi and are widely distributed throughout the world. These fungi are present in all types of soil and form symbiotic association with higher plants. AM fungi are very common in tropical forests while ectomycorrhizae dominates in temperate and coniferous forests. About 95% of tree species of tropical region are reported to be endomycorrhizal. AM fungi infect fine feeder roots and colonize the cortical region from where they extend their mycelia in rhizosphere soil. These mycelia go beyond the depletion zone and help the host plant in nutrient uptake specially phosphorus. Besides this these fungi also protect the host plants from root pathogens and enhance drought resistance (Michelsen and Rosendahal, 1990; Verma and Jamaluddin, 1994).

Teak (*Tectona grandis* L.) is the most important forestry species and extensively grown in Central India. Raman and Gopinathans (1992) studied association and activity of AM fungi in some tropical trees including teak in Tamil Nadu, India. Reena and Bagyaraj (1990) studied growth stimulation of *Tamarindus indica* by selected VAM fungi. Mohankumar and Mahadevan (1987) studied ecological distribution of AM fungi in a tropical forest of Southern India. Thapar and Khan (1973) studied endomycorrhizae of some forest species. The present paper deals with AM colonization of teak at different sites and age, AM mycoflora and effect of AM fungi on growth and biomass production of teak seedlings in nursery.

Materials and Methods

Soil samples along with fine feeder roots were collected from rhizosphere of teak trees and nursery beds. About 500 g soil samples were carried to laboratory from each site. The root bits were sieved out and a portion of it used for assessment of per cent root infection while the rest mixed with 200 g soil of the same sample for multiplication of AM spores. Three replication of the soil samples each of 100 g were made for isolation of AM spores. The spores of AM fungi were isolated by centrifugation and sucrose floatation technique (Walker *et al.*, 1982). AM fungi were multiplied in ploypots containing 1.5 kg sterilized, sand, soil and vermiculite in 1:1:1 ratio under maize cover. The AM spores were also isolated from pots substrate after multiplication (75 days). The spores obtained from natural soil as well as multiplied under maize cover were studied microscopically. The slides were prepared

Table 1

Occurrence and per cent root infection of Arbuscular Mycorhizal fungi of teak at different sites in Madhya Pradesh.

Date of study	Locality	Nursery/ plantation	% root colonization	Type of infection	AM Species recovered from soil
1	2	3	4	5	6
05.10.91	Kanger, Jagdalpur	Plantation	81.5	V/A	*Glomus aggregatum, G. etumicatum, G. macrocarpum Acaulospora scrobiculata, Scbrocystis coremioides*
06.10.91	Geedam, Jagdalpur	Nursery	68.7	V/A	*Glomus aggregatum, G. mosseae, G. etunicatum, Acaulospora scorbiculata, Scultellospora* sp. 1 & 3 *Scbrocystis coremioides*
08.02.94	Seoni	Nursery	65.0	V/A	*Glomus etunicatum, G.mosseae, G. macrocaspum, Acaulospora scrobiculata, Gigaspora* sp. 2.
10.02.94	Rookhad	Nursery	72.0	V/A	*Glomus etunicatum, G. intraradices, G. mosseae, Acaulospora scrobiculata, Scutellospora* sp. 2, *Gigaspora* sp. 1
03.10.94	Jabalpur	Nursery	58.0	V/A	*Glomus intrardices, G. mosseae, G. etunicatum, Gigaspora* sp. 1, *Acaulospora scrobiculata, Scutellospora* sp. 2
08.02.94	Rookhad, Compt, 81 (C 6)	Plantation plus tree	70.0	V	*Glomus etunicatum, G. intraradiaces, G. mosseae, Acaulospora scrobiculata, Scutellospora* sp. 1.
08.02.94	—do— (C 8)	—do—	60.0	V/A	*Glomus etunicatum, G. intraradiaces, G. mosseae, Acaulospora scrobiculata, Scutellospora* sp. 3.
08.02.94	Rookhad, Comot, 205 (PT 48)	—do—	95.0	V/A	*Glomus etunicatum, G. intraradices, G. caledonium, G. mosseae, Acaulospora* sp., *A. scrobiculata, Scutellospora* sp. 2.
08.02.94	—do— (C 5)	—do—	55.0	V/A	*Glomus etunicatum, G. intraradices, G. caleddonium. G. mosseae, Acaulospora* sp., *A. scrobiculata, Scutellospora* sp. 1.

(Contd...)

1	2	3	4	5	6
08.02.94	TSO, Kurai Range (Rookhad (C 19)	TSO	75.0	V/A	*Glomus etunicatum, G. mosseae, G.intraradices, Acaulospora* sp., *Scutellospora* sp. 1 & 2.
08.02.94	—do—	—do—	50.0	V	*Glomus caledonium, G. intraradices, G. mosseae, Acaulospora* sp. *A. scrobiculata, Gigaspora* sp. 2.
08.02.94	—do—	—do—	45.0	V	*Glomus intraradices, G. mosseae, G. etunicatum, Acaulospora* sp. *A. scrobiculata*
10.02.94	Rookhad (IPT, Mysore)	Plantation	65.0	V/A	*Glomus etunicatum, G. intraradices, G. mosseae, Acaulospora* sp. *A. scrobiculata, Gigaspora* sp. 1.
10.02.94	Rookhad (IPT Loas)	Plantation	35.0	V	*Glomus etunicatum, G. aggregatum, G. microcarpum Acaluspora* sp. *Gigaspora* sp. 2.
10.02.94	Rookhad (IPT, Thailand)	Plantation	30.0	V	*Glomus etunicatum , G. mosseae, Acaulospora* sp. *Gigaspora* sp. *G. intraradices, Acaulospora* sp.
10.02.94	Rookhad (IPT, Indonesia)	Plantation	40.0	V/A	*Glomus mosseae, G. etunicatum, Gigaspora* sp. 2, *Scutellospora* sp.1 *Acaulospora* sp.
10.02.94	T.S.O. Beharai (C 19)	TSO	45.0	V	*Glomus etunicatum, G. aggregatum, G.intraradices, G. marcocarpum, Acaulospora* sp. *A. scrobiculata*
10.02.94	Beharai, Seoni	TSO	30.0	V	*Glomus etunicatum, G. intraradices, G. mosseae Acaulospora* sp. *A. scrobiculata, Scutellospora* sp. 3.
10.02.94	Beharai, Seoni	TSO	25.0	V	*Glomus etunicatum, G. celadonium, G. macrocarpum, Acaulospora* sp. *A. scrobiculata, Gigaspora* sp. 2.
10.02.94	Beharai, Seoni	TSO	30.0	V/A	*Glomus etunicatum, G. microcarpum, G. mosseae, Acaulospora* sp., *Scutellospora* sp. 1 & 2.

IPT = International Provenance trial, TSO = Teak seed orchard.

in PVLG and Melzer's reagent + PVLG in 1:1 ratio separately. The spores were identified with the help of published literature and manual (Schenck and Perez, 1990). For study of effect of AM fungi on growth of teak seedlings, the experiment was conducted in sterilized soil + sand in 1:1 ratio in polyethylene bags. Finer roots were removed from root shoot of teak seedling washed with sterile water, and planted in polyethylene bags containing 1.5 kg potting mixture. Ten gramme of AM inoculum was given to each seedling individually. The experimental seedling were kept on polyethylene sheet in groups of 10 in each replication and watered regularly with tube well water. After 7 months the seedlings were uprooted by removing the polyethylene and washing the roots carefully. Height collar diameter, fresh weight were recorded, some fine feeder roots were kept from each replication for assessment of per cent root infection. Dry weight were recorded after oven drying the same at 75°C till a constant weight. For assessment of per cent infection, the slides were prepared by method of Phillips and Hayman (1970). One hundred root segments were examined for presence of vesicles and arbuscules. Per cent root infection was assessed by method of Giovannetti and Mosse (1980).

The data was statistically analysed using general linear model ANOVA and a simple correlations between different parameter studied was worked out.

Results

AM fungi recovered from soil samples collected from different sites with per cent root infection, type of infection are presented in Table 1. Maximum root colonization was observed in a plus tree of Rookhad (Compt 205), 95 % followed by Kanger, Jagdalpur (81.5 %) while minimum root colonization was in Teak Seed Orchard (TSO) Beharai, Seoni (25 %). AM fungi isolated from different sites are presented in Table 2 with their frequencies of occurrence.

Table 2

Arbuscular mycorrhizal fungi associated with teak and their frequencies of occurrence at 20 different sites in Madhya Pradesh

AM Species	Frequency
Acaulospora scrobiculata Trappe	17
Acaulospora sp.	06
Gigaspora sp. 1 (Pale-brown)	05
Gigaspora sp. 2 (Pale-hyaline)	03
Glmous aggregatum Schenck & Smith emend Koske	03
G. caledonium (Nicol. & Gerd.) Trappe & Gerd	02
G. etunicatum Becker & Gerd.	19
G. fasciculatum (Thaxter) Gerd. & Trappe emend Walker & Koske	01
G. intraradices Schenck & Smith	13
G. macrocarpum Tulasne & Tulasne	04
G. microcarpum Tulasne & Tulasne	02
G. mosseae (Nicol & Gerd.) Gerd. & Trappe	16
Scutellospora 1 (Pale)	07
Scutellospora 2 (Red)	05
Scutellospora 3 (Whitish)	03
Sclerocystis coremioides Berk. & Broome	02

The data recorded on growth, biomass and per cent root infection of AM treated and control seedlings are presented in Table 3. A simple correlation between these parameters was computed and presented in Table 4.

Table 3

Effect of arbuscular mycorrhizal fungi on growth, biomass and % root infection of teak seedling after 7 months of inoculation

Treatment	Height (cm)	Collar diam.(cm)	Fresh wt. (g)		Dry weight (g)		% root infection
			Shoot	Root	Shoot	Root	
Glomus fasciculatum	13.8	0.54	11.4	17.7	3.5	4.8	33.3
Mixed AM	14.7	0.65	11.8	28.8	4.2	7.5	41.7
Control	13.3	0.51	10.2	14.9	2.3	4.0	20.0
CD at 5 %	NS	NS	NS	NS	1.8	3.4	12.4

NS = Not significant.

Table 4

Simple correlations between different parameters of teak seedlings studied

	Collar (diam.)	Root (FW)	Shoot (FW)	Root (DW)	Shoot (DW)	% root infection
Height	0.24	0.56	0.35	0.59	0.41	0.29
Collar diam.	1.00	0.25	0.17	0.24	0.57	0.20
Root FW	0.25	1.00	0.69	0.99	0.72	0.44
Shoot FW	0.17	0.69	1.00	0.72	0.86	0.03
Root DW	0.24	0.99	0.72	1.00	0.73	0.38
Shoot DW	0.57	0.72	0.86	0.73	1.00	0.12
% infection	0.20	0.44	0.03	0.38	0.12	1.00

FW = Fresh weight, DW = Dry weight.

Discussion

Per cent root colonization, type of infection and AM fungi differs from site to site. It also differs with genetic variability of teak trees. Maximum per cent root colonization (95 %) was recorded in a plus tree (PT 48) at Rookhad Compt. 205, followed by natural forest tree of Kanger, Jagdalpur 81.5% with vesicular arbuscular type of infection. While minimum root infection was found in TSO, Beharai, Seoni trees which ranges between 25-45%. Low infection in TSO is probably due to removal of grasses, weeds and other cultural operations around teak trees which were regularly performed in TSO. All the plus trees of Rookhad forest are heavily infected with AM fungi (55-95%). Per cent root infection in plantation was found to be more than nursery seedlings in Jagdalpur (Table 1). It is clear from the above observations that per cent root colonization depends on site quality as well as genetic variability and age of the plant. The trees with better genome from silvicultural point of view (plus trees) were also found to be better adapted with AM fungi and hence showed more per cent root infection than other normal trees. Raman and Gopinathans (1992) studies association and activity of vesicular arbuscular mycorrhizae of some

tropical trees including teak from Southern India and reported maximum root colonization (84 %) in summer followed by late winter (62%) season and minimum colonization in winter (25 %) followed by rainy season (70 %). They also concluded that per cent root colonization depend on soil quality. Some other studies also revealed that low nutrient status of the soil enhance the rate of infection (Hass and Menge, 1990; Boerner, 1990).

On study of root colonization among international provenance trial it was found that provenances from other Asian countries show less root colonization with native AM fungi. For example, provenance from Laos shows 35 %, Thailand 30 % and Indonesia 40 % compared to provenance from Mysore, India 65 % root colonization, which are planted at same site in Rookhad. This observation reveals that the native AM fungi are better adapted to Indian provenance (Mysore) than the provenances introduced from outside the country (Table 1).

Sixteen different species of AM fungi belonging to 5 genera of Glomales were isolated from teak rhizosphere soil sample. Among these *Glomus entunicatum* and *Acaulospora scrobiculeta* are the most widely distributed species followed by *G. mosseae* and *G. intraradices* while *G. fasciculatum* was the rarest species (Table 2). According to Dr. C. Walker, Forestry Commision, Roslin, U.K. *G. etunicatum* is the most widely distributed and *G. fasciculatum* is the rarest species in the world (personal communication). The present findings also confirm his views. Raman and Gopinathans (1992) also reported 14 species of different AM species from Southern tropical forest.

Inoculation of teak seedlings with mixed species of AM fungi significantly enhanced shoot and root dry biomass and per cent root infection (Table 3). Per cent infection is positively correlated with biomass production (Table 4). Use of single species of AM fungi *G. fasciculatum* enhanced height growth (6.2 %), collar diameter (5.8 %), fresh weight (shoot, 12 %; root, 19%), dry weight (shoot, 25 %; root, 20 %) and per cent infection (60%). But these parameters except per cent root infection could not differ significantly with the control, probably due to low root infection of experimental seedlings. Therefore it is concluded that mixed inoculum of AM fungi is more effective to boost the growth and biomass of teak seedling.

SUMMARY

Arbuscular mycorrhizal (AM) fungi of *Tectona grandis* isolated from 20 different sites, including nursery, plantation and natural forests their root colonization and effect of inoculation of AM fungi on growth of teak seedlings were studied. The per cent root colonization ranges between 25-95 at different sites. Genetically superior (plus trees) showed heavy root colonization as compared to other normal trees. Sixteen different AM fungi were isolated and identified belonging to 5 genera of Glomales namely *Acaulospora, Gigaspora, Glomus, Scutellospora* and *Sclerocystis*. Among these *Glomus etunicatum* and *Acaulospora scrobiculata* were found most widely distributed species followed by *Glomus indraradices* and *G. mosseae* while *G. fasciculatum*, was found least frequent. Inoculation of teak seedling with *G. fasciculatum* and mix AM fungi separately showed better height growth, biomass and per cent root infection in nursery compare to uninoculated (control) seedlings. The mix AM inoculum is found more effective to boost the growth and biomass.

मध्य भारत में सागौन (*टैक्टोना ग्रांडिस*) से आर्बुस्कुलर कवक मूलों का संबन्ध और सक्रियता

आर०के० वर्मा व जमालुद्धीन

सारांश

20 विभिन्न स्थानों से, जिनमें रोपणी, रोपवन और प्राकृतिक वन आ जाते हैं, पृथक किए गये *टैक्टोना ग्रांडिस* की जड़ों में आर्बुस्कुलर कवक मूलों के उपनिवेशीकरण और सागौन के पौधों में उनका टीका लगाने के प्रभाव का अध्ययन किया गया है । जड़ों में उनके उपनिवेशीकरण का प्रतिशत विभिन्न स्थानों में 25-95 के बीच में रहा । सामान्य वृक्षों की तुलना में आनुवंशिक दृष्टि से श्रेष्ठतर वृक्षों की जड़ों में उनका भारी उपनिवेशीकरण पाया गया । ग्लोमेल वंश की विभिन्न प्रजातियों अर्थात् *एकौलोस्पोरा, गिगास्पोरा, ग्लोमस, स्कुटेल्लोस्पोरा* और *स्क्लेरोसिस्टिस* । इनमें *ग्लो० एटुनिकेटम* और *एकौलोस्पोटा स्कोरोबिकुलाटा* के सोलह विभिन्न आबांलस्कुलर कवक पृथक करके पहचाने गए जिनकी *ग्लोमस इंड्ररेडिसेस* और *ग्लो० मोसी* जातियाँ विस्तार से फैली हैं तथा *ग्लो० फैस्सीकुलेटम* जाति कम फैली है । बिना टीका लगाए (नियामक) पौधों के मुकाबले में सागौन के पौधों में *ग्लो० फैस्सीकुलेटम* का अन्य आर्बुस्कुलर कवकों के साथ मिलाकर टीका लगाने से रोपणी अवस्था में वृद्धि, जैवपुंज और जड़ों में कवकों का संक्रमण अच्छा होता पाया गया । वृद्धि में त्वरा लाने और जैवपुंज बढ़ाने के लिए आर्बुस्कुलर कवकों का मिला-जुला टीका लगाना अधिक प्रभावकारी पाया गया ।

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