Annals of Arid Zone 46(1): 31-36, 20007

Effect of Intercropping on Inoculum Potential of Arbuscular Mycorrhizal Fungi in Agroforestry Systems

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Abstract: To access the effect of intercropping on inoculum potential of arbuscular mycorrhizal fungi in agroforestry systems, root and/or soil samples collected from *Albizzia procera* (safed siris)-based, *Emblica officinalis* (aonla)-based and *Eucalyptus teriticornis* (eucalyptus)-based agroforestry systems were analyzed. Results on safed siris based agroforestry system indicated that intercropping in its plantation increased the inoculum potential of AM fungi, under and outside tree canopy. Among tested treatments, maximum inoculum potential was recorded in crop rotation of black gram + wheat (agroforestry plot), followed by green gram + mustard (agroforestry plot) and pure plantation of safed siris. In aonla-based agroforestry system, wheat as an inter-crop increased AM activity in aonla rhizosphere during crop period. The colonization index was significantly superior in aonla plants with wheat (28.4%) than in aonla plants grown without wheat (20.2%) during crop period and it was at par in both treatments, i.e. with (22.5%, 23.7%) and without wheat (25.6%, 24.3%) during pre-crop and post-crop periods. AM species composition did not show any qualitative changes in these observations, however quantitative changes were recorded. Similarly, colonization index of eucalyptus roots was significantly more in agroforestry plots (29.7%) than in pure plantation (13.7%). The observations are important for management of indigenous populations of AM fungi in agroforestry systems.

Key words: Agroforestry systems, AM fungi, inoculum potential, intercropping.

Arbuscular mycorrhizal (AM) fungi form symbiotic association with most economically important plants. These fungi improve plant growth under low fertility conditions, confer tolerance against plant pathogens, improve water uptake by plants, contribute to the formation of soil structure and also help plants to establish in new area (Panwar and Vyas, 2002). They are obligate symbionts and are non-specific in their selection of hosts (Bonfate-Fasolo, 1987).

Agroforestry is an intensive land use management system that maximizes production, gives supplement food and fodder, improves soil, utilizes waste and degraded lands, provides employment opportunities, minimizes adverse effect of climatic factors, aids industrial growth and improves environment. Looking to the importance of agroforestry in sustainable agriculture and role of AM fungi, present study was conducted to assess the effect of intercropping on inoculum potential of AM-fungi in agroforestry systems.

Materials and Methods

The study was conducted at National Research Centre for Agroforestry, Jhansi (25°27-N latitude, 78°35-E longitude and at about 271 m above msl), which lies in the hot semi-arid zone with three distinct

Table 1. Effect of intercropping on propagules of AM fungi in siris (Albizzia procera)-based agroforestry system

Month of sampling	Sampling location	Number of infective propagules of AM fungi per 100 g soil in intercrop			Mean	Pooled mean
		Black-gram+ wheat (agroforestry plot)	Green-gram+ mustard (agroforestry plot)	Siris		
July 2005	Under tree canopy	416.8*	557.6	201.8	392.1	275.1
	Outside tree canopy	416.8	529.6	180.8	375.7	248.0
	Mean	416.8	543.6	191.3	383.9	
August 2005	Under tree canopy	304.8	86.2	65.2	152.1	
	Outside tree canopy	217.0	92.4	51.6	120.3	
	Mean	260.9	89.3	58.3	136.2	
	Pooled mean	338.8	316.4	124.8		

	S.Em±	CD (0.05%)
Month of sampling	22.0	63.0
Tree crop combination	27.0	77.2
Sampling location	22.0	NS
Month of sampling * tree crop combination	38.2	109.1
Month of sampling * sampling location	31.2	NS
Tree crop combination * sampling location	38.2	NS
Month of sampling * tree crop combination * sampling location	54.0	NS

*Average of four replications.

seasons. The area receives annual rainfall between 700-1150 mm mostly during monsoon period (Mid June-September). The mean maximum temperature varies form 23°C (January) to 42°C (May). Corresponding mean minimum temperature varies form 5°C (January) to 26°C (May).

Results and Discussion

According to Sieverding (1991), indications about soil inoculum of AM fungi can be obtained by using data on spore enumeration, AM fungal mycelium biomass, root infection ratings, most probable number and the mycorrhizal inoculum potential. In the present study, observations on most probable number, root infection rating and spore enumeration were utilized for the purpose. Root and/or soil samples were collected from safed siris (*Albizzia procera*)-based, aonla (*Emblica officinalis*)-based and on eucalyptus (*Eucalyptus tereticornis*)-based agroforestry systems. In safed siris field, soil samples for most probable number analysis were collected from two locations (under and 5 m outside tree canopy) and three intercrop treatments, viz., black gram + wheat (agroforestry plot), green gram + mustard (agroforestry plot) and control (pure tree plantation) during July 2005 and August 2005. The trees were planted in 1998 and intercrops were being grown regularly in the experimental plots. In aonla field, root and soil samples from rhizosphere of aonla, with and without wheat as intercrop, were

Table 2. Colonization index and spore count of AM fungi in rhizophere of aonla variety NA-7 with and without wheat as intercrop

Date of sampling	Colonization index in aonla (%)			AM spore count per 100 g soil in rhizosphere of aonla		
	With wheat	Without wheat	Mean	With wheat	Without wheat	Mean
Pre-crop period:						
July 2003	27.8* (31.8)#	27.5 (31.6)	27.7 (31.7)	22.5*	12.5	17.5
August 2003	17.6 (24.8)	23.8 (29.2)	20.7 (27.0)	8.8	10.0	9.4
October 2003	10.8 (20.1)	12.5 (20.7)	12.2 (20.4)	37.5	38.0	37.8
Mean	18.7 (25.6)	20.9 (27.2)		22.9	20.2	
Crop period:						
December 2003	36.6 (37.2)	22.2 (28.1)	29.2 (32.7)	19.0	12.8	15.9
March 2004	40.2 (39.3)	26.9 (31.2)	33.4 (35.3)	2.5	2.5	2.5
Mean	38.4 (38.3)	24.6 (29.7)		10.8	7.6	
Post-crop period:						
June 2004	23.0 (28.6)	26.4 (30.9)	24.7 (29.8)	35.5	29.5	32.5
August 2004	31.0 (33.8)	22.4 (28.2)	26.6 (31.0)	17.8	21.0	19.4
September 2004	23.1 (28.7)	28.3 (32.1)	25.6 (30.4)	8.5	8.5	8.5
October 2004	18.4 (25.4)	20.4 (26.8)	19.4 (26.1)	12.5	15.5	14.0
Mean	23.7 (29.1)	24.3 (29.5)		18.6	18.6	
			S.Em±	CD (0.05%)	S.Em±	CD (0.05%)
Pre-crop period:						
Treatment			1.8	NS	3.7	NS
Date of sampling			2.2	6.7	4.6	13.6
Interaction			3.2	NS	6.5	NS
Crop period:						
Treatment			2.4	7.5	1.8	NS
Date of sampling			2.4	NS	1.8	5.5
Interaction			3.5	NS	2.5	NS
Post-crop period:						
Treatment			2.3	NS	2.2	NS
Date of sampling			3.2	NS	3.0	8.9
Interaction			4.5	NS	4.3	NS

* Average of four replications; # Figures in parenthesis indicate angular transformation values.

Table 3. AM species composition of aonla rhizophere with and without wheat as an intercrop during December 2003

AM species	Spore count per 100 g soil in aonla rhizosphere		
	With wheat	Without wheat	Mean
Glomus sp. I	6.5*	2.8	4.7
Glomus sp. II	0.8	3.3	2.1
Acaulospora sp.	0.3	0.5	0.4
Gigaspora sp.	0.3	2.0	1.2
Others	4.8	1.8	3.3
Total	12.5	10.3	

* Average of four observations.

collected from July 2003 to October 2004, for analysis of root colonization index, AM spore count and AM species composition. Aonla plants were seven years old and the wheat was grown in the agroforestry plots only during rabi 2003-2004. Root samples of *Eucalyptus* from pure plantation and agroforestry plots (crop rotation: black gram + wheat) were collected during April 2005 and June 2005 for observations on colonization index. The plantation was two years old and the intercrops are being grown in agroforestry plots on regular basis.

Number of infective propagules of AM fungi in soil samples were estimated by using most probable number method of Porter (1979). Mycorrihzal colonization percentage was determined by grid line intersection after clearing and staining root samples (Phillip and Hayman, 1970). Spores were isolated from soil according to the method of Geredmann and Nicolson (1963) and counted. The data were statistically analyzed by ANOVA and the differences among means were tested by using critical difference (CD) values at 5% level of probability.

Results on safed siris (*Albizzia procera*)-based agroforestry system indicated that intercropping in its plantation increased the inoculum potential of AM fungi under and outside tree canopy. Among treatments, maximum inoculum potential was recorded in black gram + wheat-agroforestry plot (338.8 propagules/100 g soil) followed by green gram + mustard-agrorofrestry plot (316.4 propagules/100 g soil), which were at par. Lowest inoculum potential was observed in pure plantation of safed siris (124.8 propagules/100 g soil). The inoculum potential was significantly more in July 2005 (383.9 propagules/100 g soil) than in August 2005 (136.2 infective propagules/100 g soil). The values were at par under (275.1 propagules/100 g soil) and outside (248.0 propagules/100 g soil) tree canopy (Table 1). In aonla plants, colonization index was significantly superior with wheat (28.4%) than in aonla plants grown without wheat (20.2%) during crop period. While during pre-crop and post-crop periods, it was at par in both treatments, i.e. with (22.5%, 23.7%) and without wheat (25.6%, 24.3%). The observed differences can be explained on the basis of better moisture availability in agroforestry plot, as the intercrop was irrigated. The observations on AM spore counts per 100 g soil from rhizosphere of aonla plants grown with wheat were at par

with respective observations on aonla plants grown without wheat, during all above mentioned crop periods (Table 2). AM species composition did not show any qualitative changes in these observations, however quantitative changes were recorded (Table 3). Thus, the results showed that wheat as an inter-crop increased AM activity in aonla rhizosphere during crop period. Similarly, colonization index of *Eucalyptus* roots was significantly more in agroforestry plots (29.7%) than in pure plantation (13.7%). Differences among these values for April 2005 (20.7%) and June 2005 (20.5%) were non-significant.

Fallowing has been reported by many workers to reduce soil population of AM fungi (Barbara and Hetrick, 1984). Therefore, more extensive green cover and biological diversity in agroforestry systems as compared to pure block plantation may enrich the AM flora. Though AM fungi are obligate symbionts, but these are non-specific in their selection of host (Bonfante and Fasolo, 1987). Thus, possibility of cross infectivity among tree and crop components of a given agroforestry system exists, which is likely to improve soil AM microflora. Reid and Bowen (1979) have reported that maximum AM colonization of *Medicago* plants occurred at field capacity and it reduced under conditions, which were either too wet or too dry. Thus, the improved moisture conditions of agroforestry systems with irrigated intercrops like wheat may increase the population of AM fungi in soil compared to dry soils of pure plantation. Sieverding (1991) has reported that small phosphate applications may generally improve AM fungal activities on infertile soils and their population benefits from N application probably due to longer maintenance of photosynthetic leaf area. In selected experimental fields in present study, the fertilizers were applied to intercrops and not to tree. So tree component must be receiving these at sub optimal level, which might have improved the AM flora under tree canopy. Similar observations have been made by Rajshekhara *et al.* (1989) in agroforestry system. They studied the effect of cropping system on AM development in red gram and sunflower and reported that colonization and sporulation of AM fungi increased with decreasing distance from the tree (*Dalbergia sissoo*, *Dendrocalamus strictus*, *Tectona grandis*, *Leucaena leucocephala* and *Casurina equistifolia*). *L. leucocephala* supported the highest mycorrhizal development in both crops.

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