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Role of VA mycorrhiza in the development of agroforestry model and other floristic vegetation in the Degraded land

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Abstract

Chhattisgarh region of India has adequate forest area, unfortunately the forests, owing to the adverse biotic factors are by and large under stocked and degraded resulting in the intense demand for food, fuel, fodder and small timber together with increased erosion of environment. To address these problems, a study was carried out to rehabilitate the degraded land through different agro forestry models in Northern Chhattisgarh region. The main agro forestry models developed in different sites were agrisilvicutural system, agrisilvi-pastoral-system, silvi-pastoral system and multistory models with multipurpose tree species. The species under trial were Bamboo sp., *Embelica officinalis*, *Dalbergia sissoo*, *Gmelina arborea*, *Pongamia pinnata*, *Albizia procera*, *Albizia lebbeck*, *Terminalia arjuna, Acacia catechu, Acacia nilotica, Azadirachta indica* and *Leucaena leucocephala,* at different degraded sites on farmers land, community land and government land at different spacing with different combinations. Mycorrhiza was used as biofertilizer treatment and control was also maintained for each treatment. The split plot design was selected because the fertility of land varied. Observations regarding height, collar diameter, VAM infection per cent, SVI and survival per cent were recorded. The physiochemical parameters of the soil and growth parameters of the species were recorded periodically and analyzed statistically. *Gmelina arborea* based agro-forestry model was found better in performance as compared to other developed models. Study reveals that degraded land could be restored and improved through development of appropriate agroforestry models, thus, enhancing the livelihood and environmental security.

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Introduction

Land degradation is a major threat to our food and environment security and therefore, regulation of degraded land for self-sufficiency in good food, fodder, and fuel, etc. along with environment security is the need of today and agroforestry can meet these criteria more effectively than many other land use patterns. The objective of such combinations is to increase, sustain and diversify the production of land thereby to help in reducing economic and environmental risks. Agroforestry has the potential to contribute directly to sustainable improvements in rural income and welfare, along with the reclamation of degraded agricultural lands, leading to the conservation of the tropical forests. Agroforestry system include multipurpose tree species have received wide attention today because of their potential to yield, fodder, fuel wood and small timber in addition to food. The livelihood of the rural population is interconnected with the availability of these products; therefore, there is a tremendous scope in motivating farmers to adopt Agroforestry in a region like Chhattisgarh in India. So this study prevents the scope of *Gmelina arborea* based agroforestry model for reclamation of desired land in Chhattisgarh. The development of *Gmelina arborea* agroforestry models on degraded agricultural lands can prove to be a paragon by virtue of its immense contribution towards the restoration of degraded lands through the improvement of soil fertility. The widespread introduction and promotion of such Agroforestry models can go a long way towards sustainable resource management, ecological and economic rehabilitation. The role of *Gmelina arborea* in biodiversity conservation and sustainable rural development is increasing by leaps and bounds. Due to its fast growth, easy propagation, soil binding property and short maturity period *Gmelina arborea* is being recognized as an ideal species for afforestation, soil conservation and social forestry programmes.

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Materials and methods

The experiment was carried at three sites i.e. government land, community land and farmers land maintaining four *Gmelina arborea* based agroforestry models i.e. Agrisiviculture, Agrisilvipasture, Silvipasture and Energy plantation (Table 1). For these experiments the inoculum of biofertilizer having mixed VAM was applied. 60 days old seedlings of *Gmelina arborea* were planted in pits having size of 45X 45 X 45 cm with 4 X 4m spacing. Biofertilizer was applied in nursery as well as in field. The mixed VAM fungi containing *Glomus mosseae*, *Acaulospora* sp. and *Gigaspora* sp. were used @ 30 g inoculum having 250 infective propagules. The development of VAM fungi in term of root colonization was measured by the method as recommended by Phillips and Hayman (1970). The agricultural crops, medicinal plants/spices and fodder crops were grown as per their schedule. Observations regarding growth parameters were recorded accordingly. Seedling Vigor Index (SVI) was calculated by following formula of Abdul-baki and Andeson (1973) as given below:

SVI = (Root length + shoot length) X Survival per cent.

For SVI random plants were uprooted from the polythene in nursery and digged up to 1m in field and measured. The observations regarding survival, per cent of infection, height, collar diameter, number of branches and biomass were recorded up to two year. The economics of each model and their different combinations was calculated. The same practice also repeated in the second year also. The economics of the crop grown under the models was work out. On the basis of expenditure and benefits in terms monetary, comparative study was made for future suggestions. Extraction of spores from the soil samples (25g) were extracted by wet sieving and decanting method (Gerdemann and Nicolson, 1963). Statistical analysis was also made. The phyto-sociological aspects of the highly degraded tract of Chhattisgarh were also studied to assess the impact of *Gmelina arborea* based agroforestry models with the short term agricultural crops on the restoration of ecology. The ecological/ vegetation survey was conducted by quadrat method on the three sites (government land, community land and farmers land) where the *Gmelina arborea* Agroforestry models were developed, and on untreated degraded agricultural lands. The Importance Value Index (IVI) for each of the species was determined the utilizing three characteristics, viz. relative frequency, relative density, and relative dominance according to the formula given by Curtis and Mc Intosh (1950).

Results and discussion

It is clear from the Table 2 that per cent of infection and number of spores per 100 g was found higher in VAM inoculated seedlings in first and second year. The disease per cent was also less in VAM inoculated seedlings in comparison to control. It clarifies that VAM helps in disease control.

Table 1. Major *Gmelina arborea* Based Agroforestry Models with Different Combinations.

Models	*Combinations*		*Type of land*
	Kharif *(June-Oct.)*	*Rabi* *(Nov.-May)*	
1. Agrisilvicuture	*Glycine max* (Soybean)	*Triticum aestivum* (Wheat)	Farmers land
	Glycine max (Soybean)	*Cicer aritiinum* (Gram)	
	Curcuma longa (Haldi)	*Mentha arvensis* (Mentha)	
	Zinziber offinale (Adrak)	*Mentha arvensis* (Mentha)	
	Corriandrum sativum (Dhania)	*Alium sativum* (Lahsun)	
	Glycine max (Soybean)	*Brassica campestris* (Sarson)	
2. Agrisilvi pasture	*Glycine max* (Soybean)	*Trifolium alexandrinum* (Berseem)	Farmers land
	Vigna mungo (Mung)	*Trifolium alexandrinum* (Berseem)	
	Corriandrum sativum (Dhania)	*Trifolium alexandrinum* (Berseem)	
	Vigna sinensis (Urad)	*Trifolium alexandrinum* (Berseem)	
3. Silvi pasture	*Sorghum bicolor* (M.P. chari)	*Trifolium alexandrinum* (Berseem)	Farmers land
	Pennisetum padicellatum (Deena nath grass)		
	Zea mays (Makka)		
	Pennisetum purpureum (Napier grass)		
4. Energy plantation	Embelica officinalis (Amla)	__	Govt.andCommunity land
	Pongamia pinnata (Karanj)	__	
	Albizia procera *(Siris)*	__	
	Albizia lebbeck (White siris)	__	
	Terminalia arjuna (Arjun)	__	
	Dalbergia sissoo(Sissoo)	__	
	Acacia catechu (Khair)	__	
	Acacia nilotica, (Babul)	__	
	Azadirachta indica (Neem)	__	
	Leucaena leucocephala(Subabul)	__	
	Bamboo Spp.	__	

The survival per cent in both the year i.e. first & second was higher in VAM treated seedlings in comparison to control. It supports that VAM fungi are known to enhance the drought tolerance capacity of the plants. The growth parameters like height collar diameter, dry and fresh weights were also found higher in VAM treated seedlings than the control. Verma and Jamaluddin (1994) reported that seedlings of *Acacia nilotica* inoculated with VAM fungi were capable of tolerating moisture stress conditions. VA Mycorrhiza are beneficial to their hosts by improving the uptake of water and minerals particularly phosphorus (Varma, 1995). Sieverding and Toro (1994) found that increased root length and improved K nutrition by VAM fungi can be very important on drought tolerance of tropical plants. Different groups of the microorganisms are associated with the root of *Albizia procera*, which help on the growth of plant growth through acquition of nutrients from the soil.

Table 2. Observations Regarding Growth Parameters of *Gmelina arborea* Seedlings.

	After one years		*After two year*	
	Treated with VAM	*Control*	*Treated with VAM*	*Control*
Number of spores/100g	220	15	416	110
Infection %	56.80	10.60	71.20	23.70
Number of branches	8	7	15	11
Height (shoot length) m	1.60	1.1	3.10	2.60
Root length	1.30	0.85	1.60	1.60
Survival Per cent	68.33	51.66	61.00	45.00
Collar diameter (Diameter) cm	1.80	1.25	3.40	3.10
Fresh wt. (Kg)	2.1	1.60	4.40	2.90
Dry wt. (Kg)	0.90	1.60	1.60	1.20
Disease %	2.00	10.00	1.00	4.00
SVI	198.15	100.73	286.7 1	89.00

Table 3. Importance Value Index (IVI) of ground flora identified on Gmelina arborea based Agroforestry Models.

Sl. No.	Species	Family	Plant type	IVI		
				Farmland	Community land	Govt. land
1	Acacia nilotica seedling	Mimosaceae	Tree	3.6	2.1	2.0
2	Acanthospermum hispidum	Asteraceae	Herb	1.7	1.5	1.5
3	Achyranthes aspera	Amranthaceae	Herb	2.8	3.0	-
4	Amaranthus viridis	Amranthaceae	Herb	3.4	1.9	-
5	Clatropis procera	Asclepiadaceae	Shrub	9.0	3.4	4.4
6	Cassia tora	Caesalpiniaceae	Shrub	24.5	30.0	18.2
7	Chloris barbata	Poaceae	Herb	11.6	4.4	5.2
8	Cymbopgon martini	Poaceae	Herb	42.1	20.2	12.0
9	Cyanodon dactylon	Poaceae	Herb	23.2	18.0	14.3
10	Desmodium triflorum	Fabaceae	Herb	30.5	-	21.6
11	Eleusine indica	Poaceae	Herb	36.0	22.6	-
12	Eragrostis ciliaris	Poaceae	Herb	10.6	8.2	6.9
13	Eragrostis pilosa	Poaceae	Herb	46.0	38.3	32.2
14	Eragrostis viscosa	Poaceae	Herb	12.6	10.2	6.2
15	Eulaliopsis binata	Poaceae	Herb	18.5	12.8	10.2
16	Euphorbia hirta	Eurphorbiaceae	Herb	6.5	3.8	2.4
17	Heteropogan contortus	Poaceae	Herb	-	3.4	16.1
18	Lantana camara	Verbenaceae	Herb	11.2	7.9	15.3
19	Phyllanthus urinaria	Eurphorbiaceae	Herb	6.5	4.5	3.9
20	Sida acuta	Malvaceae	Herb	3.3	1.8	-
21	Solanum nigrum	Solanaceae	Herb	-	2.0	1.8
22	Vernonia cinerea	Asteraceae	Herb	4.2	-	3.4
23	Ziziphus mauritiana seedling	Rhamnaceae	Tree	-	4.2	2.0

The majors once are VAM fungi, Rhizobium and Azotobactor. VAM provides phosphorus,while, Rhizobium and Azotobactor contribute to the nitrogen fixation in the rhizosphere of the plants (Tarrent, 1983). Verma *et al.* (1994) recorded maximum seedling volume of *Acacia nilotica* inoculated with *Glomus mosseae* and rhizobium in combination. Sharma *et al* (1990) observed that dual inoculation of *Acacia nilotica* with rhizobium and VAM exhibited better growth and dry biomass as compared to rhizobium and VAM treatment alone. Inoculation of plants with VAM fungi can stimulate nodulation and nitrogen fixation by legumes (Mosse, 1981). In degraded salt affected soils and nursery beds the density and population of VAM fungi are generally low; hence planting success is very poor.

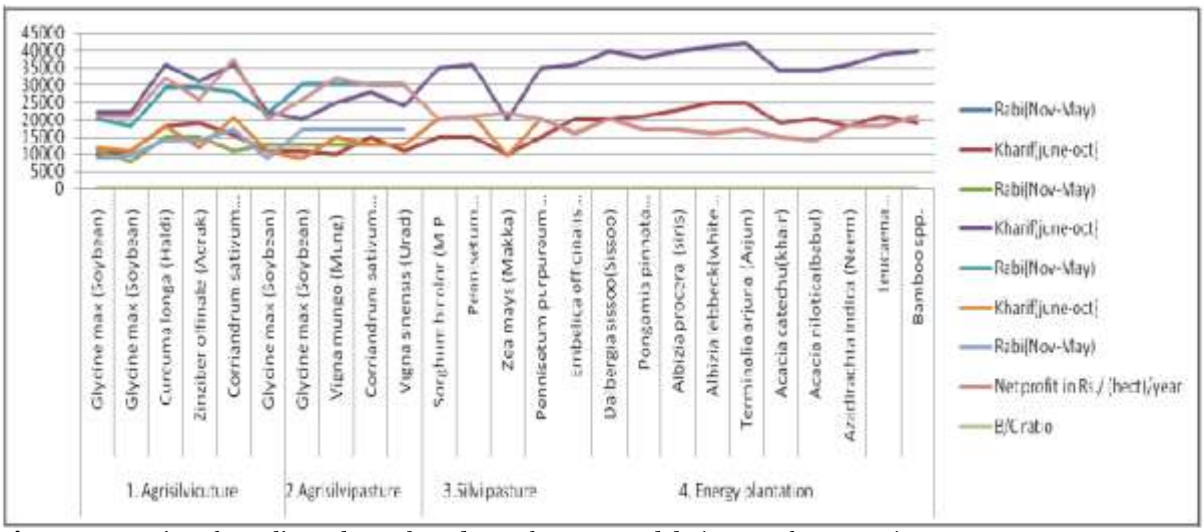

Fig. 1. Economics of Gmelina arborea based Agroforestry Models (Mean of Two year).

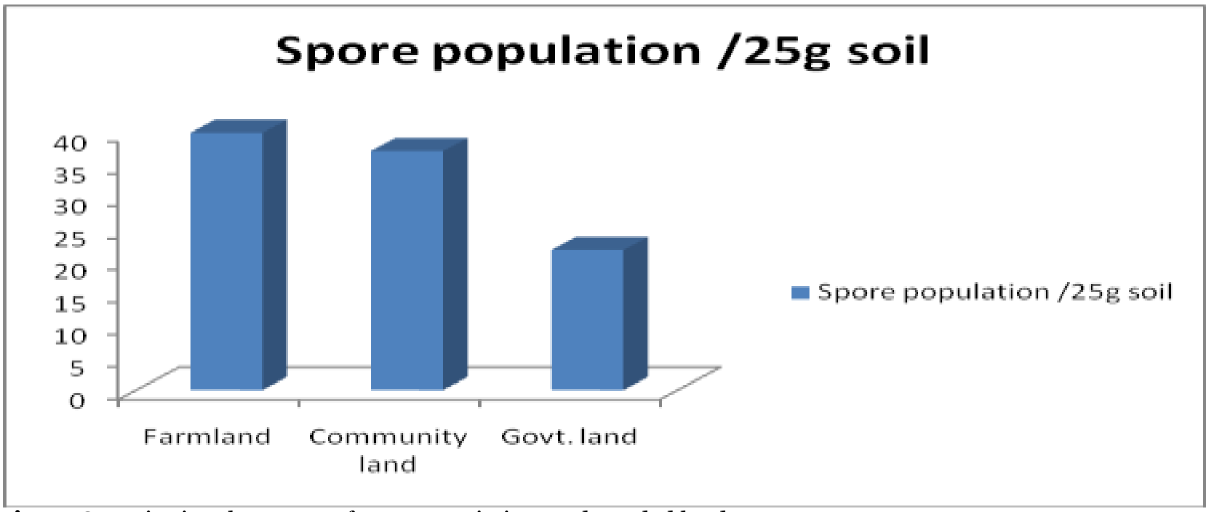

Fig. 2. Quantitative characters of VAM association on degraded lands.

Successful inoculation of suitable inoculum helps to establish the plant growth and reduce the need of fertilizers (Rose, 1971; Menge *et al.*; 1978). Reena and Bagyaraj (1990) demonstrated that the seedlings of *Acacia nilotica* when inoculated with 13 different VAM fungi had shown greater plant height, leaf number, girth, biomass and phosphorus content. VAM fungi are known to enhance the drought tolerance capacity of the plants. Height, collar diameter, VAM infection per cent, survival per cent and biomass were recorded. One-year result shows that biofertilizers increase the growth and survival percentage over control. During the study it was also noticed that seedlings treated with biofertilizers have better stress tolerance capacity in comparison to control. Height, collar diameter, VAM infection per cent, survival per cent and biomass were recorded. One year result shows that biofertilizers increase the growth and survival percentage over control. During the study it was also noticed that seedlings treated with biofertilizers have better stress tolerance capacity in comparison to control. Agarwal and Ojha (2004) reported that height, collar diameter, VAM infection per cent, survival per cent and biomass were found higher in 26 multipurpose tree species in comparison to control. They also noticed that seedlings treated with biofertilizers have better stress tolerance capacity. The Fig.1 presents cost and benefits analysis of the models under study. The profit was found in *Corriandrum sativum + Alium sativum* combination (Rs.37, 000/hact), followed by *Vigna mungo + Trifolium alexandrinum* (Rs.32, 000/hact), Curcuma longa + Mentha arvensis (Rs.32, 000/hact), respectively. The highest B/C ratio (1.46) was found in spices combimation i.e. Corriandrum sativum + Alium sativum among all combinations. The economic gain in medicinal and fodder combinations was also found remarkable among all studied models. The B/C ratio of energy plantation model was also found up to level of consideration and satisfaction.

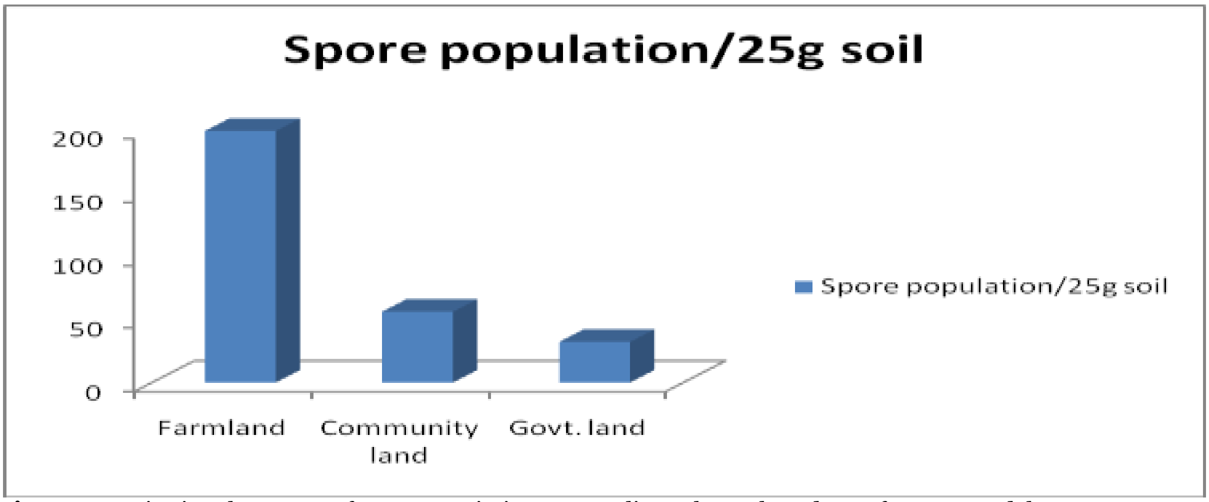

Fig. 3. Quantitative characters of VAM association on Gmelina arborea based Agroforestry Models.

Economics issues in agroforestry systems are very important and have received considerable attention lately (Arnold, 1983, Hoekstra, 1985). There are several complicated factors such as demand, supply, land use policies, market forces, etc., which are important in deciding the economics of agroforestry systems. Studies regarding investment and out turn would greatly assist the decision-makers in assessing the economic worthiness of the systems (Dwivedi, 1992). Dev Roy (1990) found that fodder production per unit area with fodder grasses and fodder trees is always higher than fodder production from grasses alone. Total benefits were much larger in silvipasture system in comparison to pure grass production system (Shankarnarayan *et al.*, 1987).

The ecological parameters worked out during vegetation survey in three different sites reveal that species richness is higher in farm land on comparison to community and government land. Maximum species similarity was found in all three sites. As evident from the result (Fig 3.), the rhizosphere soils of farmland were found to inhibit a more diverse population of VAM fungi. The maximum spore count (199/25 g) was observed in rhizosphere soils of farmland where as it was lowest in government land. Comparative assessment of occurrence of VAM fungi from three sites envisage that Farmland site harbor more VAM population in terms of richness and diversity than community and government lands. Table 3. depicts different ground flora at different sites. The farmland is characterized by 20 species within the *Eragrostis ciliaris, Cassia tora, Eragrostis pilosa* community. The community land is characterised by *Cyanodon dactylon ,Cymbopgon martini* which consist of 21 species. The government land is characterised by 19 species of *Heteropogan contortus, Lantana camara, Cassia tora. At* all the sites the number of species remains the same along with dominant species Cymbopgon martini. The farmland site is marked by more number of species and *Eleusine indica* at this site is co-dominant species. The community land is characterized by *Cassia tora*as co dominant species .The total number of species is less in government land and it is interesting to note that *Poaceae* family is the major contributor towards the composition at all the sites. However species varies from site to site. These ecological parameters clearly reveal that the degraded agricultural lands have been ecologically restored and are improving fast due to the development of *Gmelina arborea* based agroforestry models and the associated silvicultural and agricultural operations in continuity. Ecosystem development on drastically disturbed land starts with re-invasion of species from the surrounding plant communities and ultimately the development of self sustaining ecosystem is possible.

Conclusions

In fact the growers expect some kind of early return from his or her investment. Growing trees or fruit yielding plants required higher investment in comparison to agricultural crop. Due to low investment and short duration return growers prefer to adopt pure agriculture cropping system. Very few growers are able to invest money in growing trees or fruit yielding plants and wait for 3-4 or more years to return his or her money. So, present study provides an alternate and practical system of growing trees/ fruit yielding and agriculture crop simultaneously in the same field and at the same time with early and higher economic returns. Cultivation of multipurpose tree species in combination of agricultural crops and or fodder crops/ horticulture crops play an important in restoring productivity, ecosystem stability, biological diversity and midterm financial assistance to the growers. Utilization of VA mycorrhizae markedly increases the success of rehabilitation of disturbed and degraded lands. The VA Mycorrhiza not only enhances the agroforestry model but also enhance the phyto-sociological floristic of the degraded land. The cultivation of *Gmelina arborea* based agroforestry models gave rise to number of ground flora and also played significant role along with the added fertilizers, FYMs etc. Development of agroforestry models and the subsequent intercropping, maintenance and harvesting of crops/trees will open a new employment opportunities for the rural poor. This study dealt the scope of Gmelina arborea based agroforestry models through biotechnology being used in land rehabilitation programs. The study regarding soil productivity, carbon sequestration, detail micro flora population, and production of tree species at maturity is needed. However farmers of the Chhattisgarh region prefer this species to grow on their own fields due its fast growing habit, looking feature, falling leaves when agriculture crop ripens and demand of local market.

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