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Initial growth performance of Shola species under enrichment plantation in the Nilgiris, Tamil Nadu

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Abstract

Aim : Enrichment planting of native tree species is an important program to restore the biodiversity and ecological functioning of degraded vegetation and shola forest in particular. The success of enrichment planting depends on suitability of site specific shola species, which is limited for large scale afforestation and restoration programmes of sensitive ecosystems. With this background, an evaluation study was carried out to understand the performance of fifty two different afforested native species of shola at different sites in the Nilgiris district.

Methodology : The data on survival and growth characteristics are studied through enumeration technique from different altitude and aspect of the afforested Shola forest.

Results : The study revealed that the survival rate of different afforested species varied between 27 and 100 % with an average survival rate of 77.43%. The species *Syzygium cumini*, *Syzygium gardneri*, *Elaeagnus oblongus*, *Evodia lunu-ankenda*, *Ligustrum perrottettii* and *Michelia champaca* showed higher survival rate and better growth attributes than other planted species. *Elaeagnus oblongus*, *Evodia lunu-ankenda*, *Ligustrum perrottettii* and *Michelia champaca* performed better at higher elevation (above >1000 m). Among different aspect, South-Western aspect was suitable for planting number of species.

Interpretation : The differential growth performances of planted species were due to the differential silviculture requirement and adaptability mechanism of species to local site conditions. Hence, afforestation should be carried out in keeping the silviculture requirement of the species. The study revealed that site condition such as elevation, aspect and species silviculture characteristics are important factors influencing the performance of the Shola species.

Introduction

Forests play an important role in sustaining the environment. Shola forests are unique tropical wet evergreen montane forests that occur at higher elevations (between 1400 to 2400 m amsl) of the Western Ghats. These forests are high altitude gallery forests restricted to valleys, depressions and especially, along the folds of hills and water courses in southern India. The shola forests are of high ecological significance in maintaining the water flow of catchment rivers. The shola forests hosts higher endemism within one of the global biodiversity hotspots (Robin and Nandini, 2012). In recent years, a high pressure was exerted on these forests due to the expansion for agriculture, plantation, other developmental and land management activity resulted in the destruction of these forest lands (Sekar, 2008; Kumar *et al.*, 2014; Islam *et al.*, 2015; Sahoo *et al.*, 2015). It has been estimated that since 1850 half the shola forests in the Nilgiris have been destroyed and that the current area under sholas is about 4225 ha (Sukumar *et al.*, 1995; Rawat *et al.*, 2003). A latest survey in the Nilgiris have suggested that about 65% of the 180 shola pockets studied are facing a major threat from cattle grazing and wood cutting.

The study of hydrological implication of conversion of grasslands into Eucalyptus plantations has shown the reduction of about 16 and 27 % in water yield for first and second rotations of Eucalyptus plantation (Sikka *et al.*, 2003). On realizing the importance of the shola forest and long term vegetation study, the Tamil Nadu Forest Department and the district administration have taken many initiatives for conserving the existing shola vegetation and taken up enrichment planting in the degraded shola forest. Enrichment planting helps in fast recovery of such degraded forests over the natural regeneration, and improves species diversity and ecological condition (Erskine *et al.*, 2006; Rey Benayas *et al.*, 2009). But the success of enrichment plantations depends on the selection of species and its adaptations to the site conditions (Shankar Raman *et al.*, 2009; van Breugel *et al.*, 2011). Historically, re-generation of tree flora in shola fragments had been expressed as a matter of concern but a series of studies now indicate that shola species show adequate regeneration under natural conditions (Mohandass and Davidar, 2009). Initial attempts of artificially regenerating shoals in the degraded shola patches yielded little success due to the use of wildings planting material and lesser knowledge of the species-specific site requirement (Sekar, 2008). Subsequently to improve the ecological condition in the Nilgiris, forest department started enrichment planting with native shola species by nursery grown seedlings in the degraded sholas. However, availability of scientific studies and literature with regard to enrichment planting and artificial regeneration of sholas is meager. To achieve higher success and for the effective implementation of the enrichment plantation programme, a scientific evaluation of already afforested plantation is essential. With this background, the present study was carried out with an objective to evaluate the

performance and suitability of afforested shola plant species at different sites in the Nilgiris district.

Materials and Methods

Study area : The study was conducted in the Niligiris which lies at the junction of Eastern and Western Ghats and the study region falls under the hot moist sub-humid to humid climate of the agro-ecological sub-region 19.2. The Niligiris are situated in the southern part of the Tamil Nadu and the area distributed across 0.25 M ha, in a floristically rich mountain eco-system. This hill district is located between 10° 38' to 11° 49' N latitude and 75° 44' to 77° 87' E longitude with elevation ranging from 400 to 2636 m amsl. The area is drained by innumerable perennial streams draining into the river Moyar and Bhavani, which further join together on the plains to form a tributary of the river Cauvery (Mohandass and Davidar, 2009).

Selection of afforested sites : The study was carried during 2006 to 2008 in 5 year old shola species afforested plantations spread across the Niligiris district. In the present study, the performance of different shola species were investigated by measuring the survival rate and their growth characteristics and site suitability of species by a standard sampling technique. For the study, a representative 30 sites were selected among the total 77 afforested sites in the Niligiri forest division. From each afforested site detailed site characteristics was collected and analyzed to understand the site requirement for each species under different site conditions. To understand the general plant community's quick vegetation sampling method was adopted.

Characteristics of afforested sites : Necessary information of shola site characteristics was collected during the study period. The altitude of selected sites varied between 902 and 2323 m with an annual average rainfall between 1224 and 2739 mm. About 30% of the sample sites located less than 1000 m altitude and 50% of the sample sites with average annual rainfall of more than 1500 mm. The slope range of these sites varied from 5 to 33%.

Fig. 1 : Survival rate of afforested plant species under different forest range in the Nilgiris

Table 1 : Bio-physical parameters of dominant species at different altitude zones (Ht is plant height, RCD is root collar diameter and CD is canopy diameter)

Dominant species	<1000(m a.s.l.)			1000-1800(m a.s.l.)			>1800 (m a.s.l.)		
	Ht (cm)	RCD (mm)	CD (cm)	Ht (cm)	RCD (mm)	CD (cm)	Ht (cm)	RCD (mm)	CD (cm)
<i>Syzygium cuminii</i>	89	10	48	86	10	58	64.9	10	33
<i>Syzygium gardneri</i>	90	10	55	-	-	-	98	10	52
<i>Elaeagnus oblongus</i>	-	-	-	53	10	25	47	10	37
<i>Evodia lunu-ankenda</i>	-	-	-	68	10	56	92	14	49
<i>Ligustrum perrottetii</i>	-	-	-	69	9	24	51	9	19
<i>Michelia champaca</i>	-	-	-	169	30	94	202	50	103
<i>Syzygium montanum</i>	-	-	-	78	10	33	50	13	24

- Indicates species is absent in that elevation zone

Table 2 : Quantitative vegetation parameters of afforested shola species at different aspects

Aspect	Species	Relative density	Relative frequency	Relative dominance	IVI
NW	<i>Syzygium cuminii</i>	21	17	63	101
	<i>Elaeocarpus oblongus</i>	18	11	13	42
	<i>Psychotria congesta</i>	12	6	1	19
	<i>Evodia lunu-ankenda</i>	9	6	4	19
	<i>Syzygium gardneri</i>	9	6	12	27
	<i>Berberis tinctoria</i>	6	11	0	17
	<i>Litsea ligustrina</i>	6	11	1	18
	<i>Melia dubia</i>	6	6	1	13
NE	<i>Syzygium cuminii</i>	16	14	32	62
	<i>Ligustrum perrottetii</i>	14	5	5	24
	<i>Syzygium gardneri</i>	13	12	11	36
	<i>Michelia champaca</i>	7	5	31	43
	<i>Ilex denticulata</i>	6	2	1	9
	<i>Bixaorellana</i>	5	5	3	13
	<i>Syzygium arnottianum</i>	13	8	11	32
SE	<i>Syzygium cuminii</i>	12	11	35	58
	<i>Syzygium montanum</i>	12	11	7	30
	<i>Litsea wightiana</i>	7	5	4	16
	<i>Evodia lunu-ankenda</i>	6	5	3	14
	<i>Ligustrum perrottetii</i>	6	5	3	14
	<i>Pygeum gardineri</i>	6	3	2	11
	<i>Cedrella toona</i>	4	8	2	14
	<i>Syzygium cuminii</i>	15	7	31	53
SW	<i>Michelia champaca</i>	10	5	47	62
	<i>Ligustrum perrottetii</i>	8	5	3	16
	<i>Cedrella toona</i>	6	5	2	13
	<i>Syzygium arnottianum</i>	6	5	4	15
	<i>Syzygium montanum</i>	6	7	3	16
	<i>Daphniphyllum neilgherrense</i>	5	5	1	11

NW:North-West; NE:North-East; SE:South-East; SW:South-West

The soil depth varied from 8 cm to more than 45 cm (47% of the total sites). About 37% of the sampled sites with NE aspects followed by SE (26%), SW (23%) and NW (13%).

Growth parameters studied: Growth parameters of each species were collected by following a quadrant technique (10 m X 10 m). The details about the species planted at each site were also

collected during the field survey through interactions with the respective forest staff in that forest range. Species-wise growth parameters viz. survival rate, plant height, root collar diameter and canopy area were collected from the each quadrant. Relative density (RD), relative frequency (RF), relative dominance (RD) and importance value Index (IVI) were also worked out from the survey data (Mueller-Dombois and Ellenberg, 1974).

Table 3 : Suitable shola species recommended for future afforestation programme for different altitude and rainfall zones of Nilgiris

Parameter	Zone	Species
Elevation (m a.s.l.)	900 -1500	<i>Syzygium cuminii</i> , <i>Syzygium gardneri</i> , <i>Michelia champaca</i> , <i>Syzygium montanum</i> and <i>Michelia nilagirica</i>
	1500 -2100	<i>Syzygium cuminii</i> , <i>Syzygium montanum</i> , <i>Syzygium amottianum</i> and <i>Ligustrum perrottetii</i>
	>2100	<i>Syzygium cuminii</i> , <i>Syzygium amottianum</i> , <i>Ligustrum perrottetii</i> and <i>Eurya japonica</i>
Rainfall (mm)	1000 – 1800	<i>Syzygium cuminii</i> , <i>Syzygium montanum</i> , <i>Syzygium amottianum</i> , <i>Michelia champaca</i> , <i>Elaeocarpus oblongus</i> and <i>Litsea ligustrina</i>
	1000 – 2600	<i>Syzygium cuminii</i> , <i>Syzygium montanum</i> , <i>Syzygium amottianum</i> , <i>Michelia champaca</i> , <i>Elaeocarpus oblongus</i> and <i>Litsea ligustrina</i>
	>2600	<i>Syzygium cuminii</i> , <i>Cinnomomum zeylanicum</i> and <i>Syzygium gardneri</i>

Data analysis and interpretation: The parameter wise data were compiled in tabular form and statistical parameter wise mean, range, standard deviation and co-efficient of variation was calculated and interpreted. The grouping of data was carried out for altitude, range and zone wise for better understanding and interpretation of data to analyze the species performance at different afforested sites.

Results and Discussion

Among the 52 planted species, the survival rate varied between 27 and 100 % with standard deviation of 20 and CV of 27%, and the average survival rate of 77.43%. Out of 30 sample sites, about 23% of the sites have a survival rate of more than 90%, 40% of the sites showed survival rate between 75 and 90%. The average height of the saplings varied from 10 to 198 cm, and the root collar diameter varied from 9 to 62 mm while the canopy area cover varied from 284 to 8720 sq.cm. The growth performance of few dominant species at different altitude is tabulated and presented in Table 1. Among all the species, *Syzygium cuminii* performed well in the entire three altitude group, however better growth performance was noticed at lower altitude (<1000 m). On the other hand *Syzygium montanum* was not noticed in lower altitude. Whereas, species like *Elaeagnus oblongus*, *Evodia lunu-ankenda*, *Ligustrum perrottetii* and *Michelia champaca* performed very well above >1000 m elevation. Among all the planted species, maximum canopy diameter was observed in *Michelia champaca*. Growth parameters (height, root collar diameter and canopy cover area) wise, *Michelia spp.* performed better followed by *Syzygium spp.* Variability found in survival and growth performance in the study was due to differential in the silvicultural requirement and adaptability mechanism of species to different site conditions (Shankar Raman et al., 2009; Roman-Danobeytia et al., 2012). Similar results were reported by van Breugel et al. (2011) on the influence of site environment on the survival and growth parameters of 49 tropical plants reported from Panama forest. The forest range/shola survival percent of afforested species are presented in Fig. 1. Among the Nilgiri forest division, Governor shola, Ooty North and Kattabetta sites were registered as poor survival rate (27.3 to 54.6%) compared to other forest range/shola in the district. Poor performance of the seedlings was due to heavy biotic interference by the grazing domestic animals and degraded

site condition. However, the majority of the forest division/range recorded good to very good survival rate of afforested species in the Nilgiris district (72.7 to 96.2%). Frequency percent of different shola species were analyzed for the all afforested sites. The frequency percent of *Syzygium cuminii* (56.7%) was maximum followed by *Syzygium montanum* (30%) and *Syzygium gardneri* (26.7%). Under the frequency class of I, II and III, there were 48 (88%), 5 (10%) and 1 (2%) species, during the study period. Due to wider adaptability of *Syzygium spp.*, it was planted in almost all the sites as compared to other species.

Table 2 reveals that relative density, relative frequency, relative dominance and IVI values were highest for *Syzygium cuminii* and *Michelia champaca* as compared to other species. However, importance value index (IVI) of the dominant species varied from 9 to 101. Species like *Syzygium cuminii*, *Elaeocarpus oblongus* and *Psychotria congesta* recorded higher IVI under North-West aspect, where in *Syzygium cuminii*, *Ligustrum perrottetii* and *Syzygium gardneri* under North-East aspect, *Syzygium amottianum*, *Syzygium cuminii* and *Syzygium montanum* in South-East aspect, and *Syzygium cuminii*, *Michelia champaca* and *Ligustrum perrottetii* in South-West aspect. About 58% of the observed shola species were found at the sites located on the SW aspect, followed by sites located in NE (54%), SE aspect (46%) and the lowest was found on NW (25%)(data not shown). The shola sites facing South-Western aspect was suitable for planting number of species due to favorable site conditions available for the growth of the species. As the SW aspect shola receives more rainfall from south west monsoon which favour plants survival, there by indicating the influence of site environment on the survival and growth of the afforested plants (Shankar Raman et al., 2009; van Breugel et al., 2011). The other afforested study showed that enrichment plantations can facilitate forest succession in their understory through microclimate modification of site conditions by both physical and biologically (Park et al., 2010).

Sholas are extremely vulnerable to disturbance because the saplings do not regenerate in the open grasslands due to lack of tolerance to fire and frost (Jose et al., 1994). Initial efforts on regeneration of shola species with the planting of natural seedlings collected from the wild often met with low success rates

(Sekar, 2002). The preliminary vegetation survey data of sholas showed that species like *Michelia* spp., *Daphniphyllum* spp., *Syzygium* spp., *Rhododendron* spp., *Eurya* spp., *Celtis* spp., *Viburnum* spp., *Litsea* spp. and *Mappia* spp. were predominant on the higher hills and trees like *Turpinia* spp., *Syzygium* spp., *Litsea* spp., *Symplocos* spp., *Vaccinium* spp., *Ligustrum* spp., *Mappia* spp. and *Glochidion* spp. were common in lower hills. A list of suitable species for afforestation at different altitude and rainfall range was prepared and recommendations were based on the existing species abundance and its analysis, and also based on the performance of the already afforested species at varied sites in the Nilgiris (Table 3). Site specific species recommended for afforestation in shola forests will improve the species diversity and ecological conditions of the shola and also provides favorable environmental condition for further plant succession in the forest (Parrotta *et al.*, 1997).

From this study it can be concluded that afforestation of degraded shola forest sites is possible through enrichment plantation of nursery grown species of proposed species. The survival and growth variation among the species is mainly influenced by the site characters. Poor performance of some of the species can be due to lack of adaptability and resource availability, which clearly indicates instability of these species for artificial regeneration in degraded forest (Russo *et al.*, 2005). The study provides basic information about the suitability of species at different altitudes, rainfall, soil and aspects for afforestation of degraded shola forest areas in the Nilgiris. The present study reveals that site condition such as elevation, aspect and site disturbance factors influence the performance of the species afforested. The recommended species from the study reveals that establishment of nursery grown plant stocks can be encouraged for large scale afforestation of shola in the Nilgiris.

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