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Economic evaluation of multi purpose tree species in degraded lands of Karnataka

S.M. MUTANAL, H.Y. PATIL AND M.V. MOKASHI

ABSTRACT : A field experiment was conducted to know the economically viable trees on degraded lands at MARS, UAS, Dharwad under rainfed conditions. Nine trees *viz.*, *Eucalyptus tereticornis, Tectona grandis, Dalbergia sissoo, Anogeissus latifolia*, *Albizia lebbeck, Grevillea robusta*, H*ardwickia binnata*, *Acacia nilitica* and *Azadirachta indica* were planted at 2 x 2m with three replications in Randomized Block Design. Among the tree species, total biomass was higher in *Albizia lebbeck* followed by *Eucalyptus tereticornis* and *Grevillea robusta*. Soil physical properties like bulk density significantly decreased in *Dalbergia sissoo, Anogeissus latifolia*, *Albizia lebbeck* and *Hardwickia binnata.* Trees have reduced pH of soil compared to open conditions. The available nitrogen, phosphorus and potassium were higher in soil grown with tree canopy of *Albizia lebbeck*, *Hardwickia binnata* and *Tectona grandis,* respectively. The gross return, B : C ratio and IRR were higher in *Tectona grandis* (Rs. 31,647/ha/yr, 4.71 and 22 %, respectively) followed by *Eucalyptus tereticornis* (Rs. 22,547/ha/yr, 3.52 and 21 %, respectively) as compared to other tree species.

KEY WORDS : Degraded lands, Economical, Viability, Biomass, Soil physical properties

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INTRODUCTION

Increasing human population with soaring demands for material goods in the present scenario is causing unprecedented demand for forest resources. India too, is encountered with scarcity of forest resources as well as several concomitant environmental disasters which is the real challenge before the scientists.Growing stock of 4740 million m^3 with average volume of 74.42 m^3ha^{-1} is also far behind the world's average of 110 m^3ha^{-1}. Low per capita forest availability (0.07 ha) and widening gap between demand and supply of basic needs of rural inhabitants necessitates to devise strategies to overcome these problems.

There is acute shortage of fuel wood, fodder, timber and other tree-based products, plantation forestry has a tremendous scope in India. Tree planting will need considerable attention in view of the vital and permanent requirements met by trees. A multipurpose tree deliberately grown and managed for more than one output has a greater impact on a farmer's well being.

MEMBERS OF RESEARCH FORUM

Address of the Correspondence : **S.M. MUTANAL,** All India Co-ordinated Research Project on Agroforestry, University of Agricultural Sciences, DHARWAD (KARNATAKA) INDIA Email: mutanalsm@uasd.in

Address of the Coopted Authors : H.Y. PATIL AND M.V. MOKASHI, All India Co-ordinated Research Project on Agroforestry, University of Agricultural Sciences, DHARWAD (KARNATAKA) INDIA

Multipurpose trees should be capable of producing a wide range of products and have the capacity to contribute in its specific functions towards the sustainability of yields, an increase in output and/or reduction in inputs, and maintaining the ecological stability of the region (Hegde and Daniel, 1994).

Several problems are encountered in afforestation of highly degraded lands due to limitations of species suitability, soil depth, moisture and thermal stress, nutrient deficiency etc. The basic aim of planting tree species is to rehabilitate highly eroded areas, check soil and water losses and improve the degraded lands to provide fuel wood, fodder and timber to the poor famers (Singh *et al.*, 2009).

The term degraded lands evokes images of barren, desert plains with heavy winds or of severely eroded lands. These lands often associated with these lands are steep slopes, lack of fertility, salinity, soil acidity, eroded soils, stoniness, shalow soils, wetness or flooding. Soil with these constraints are often called problem soils and which can be managed (Dudal, 1980).

Multipurpose trees have positive influence on yields from these degraded lands. The trees can greatly reduce fossil fuel requirements for agricultural production and extend the use of fragile environments and marginal lands. Generally, multipurpose tree species can be used for meeting various social, environmental and industrial needs. Industries should provide support with inputs including credit, regular technical advice, harvesting and transport services. The farmer thus have a choice in selecting species depending upon the merits of the alternatives available to them (Hegde and Daniel, 1994).

The wider use of MPTS, especially nitrogen fixing tree species, would become an important factor in improving productivity and maintaining an enhanced nitrogen status in many tropical land use systems and also increase productivity and economic returns. Therefore, multipurpose tree species should be introduced in degraded lands to exploit their ability to provide the basic needs of people and protect the environment which also play main role for soil conservation and management.

MPTS have shown their worth in meeting the objectives of social forestry. The present study hence aims on the economic viability of the multipurpose tree species in the degraded lands.

EXPERIMENTAL METHODS

An experiment involving nine tree special *viz.*, *Eucalyptus tereticornis*, *Tectona grandis*, *Dalbergia sissoo*, *Anogeissus latifolia*, *Albizia lebbeck*, *Grevillea robusta*, *Hardwickia binnata*, *Acacia nilitica* and *Azadirachta indica* were planted on red gravelly soil at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad under rainfed conditions. The soil of the study area belong to degraded red soils with pH of 6.4 and N:P:K 172, 18.6 and 164.7 kg ha^{-1}, respectively. One year old nursery grown seedlings of these trees species were planted at a spacing of 2 x 2m. The experiment was laid out in Randomized Block Design with three replications. The general climate of the area is tropical and lies in northern transitional zone of Karnataka. The mean annual rainfall of the location is 783.6 mm which was received in 57.5 days (average of 43 years) rainy days. The mean annual maximum temperature raised from 37.8^{0}C to 27.^{0}C and annual minimum temperature varied from 14.5^{0}C to 21.6^{0}C. At the end of 20 years, sample trees were felled and biomass productivity in different part of tree species was assessed and presented. Based on the market rates of fuel and timber, and also the additional income contributed by each tree species was accounted for the total mean of the economic evaluation was made.

Soil samples were collected at 0-30 cm depth from 5 random locations at 1 m away from the main trunk for each species. The soil samples from each treatment bulked thoroughly mixed and a composite sample taken for analysis. Soils were analyzed for bulk density, particle density porosity, water holding capacity, pH, electrical conductivity (EC), available N, P and K.

Bulk density, particle density and porosity were determined by RD bottle method (Chopra and Kanwar, 1986). Water holding capacity was determined by the method using Keen Raczkowski box (Keen and Raczkowski, 1921) as described by Piper (1950). Soil pH and electrical conductivity were determined in a 1: 2.5 soil : water suspension. Organic carbon was estimated by Walkley and Black (1934) method. Available N was determined by alkaline $KMnO_4$ method of Subbiah and Asija (1956). Soil samples were analyzed for M. $NaHCO_3$ extractable P (Olsen *et al.*, 1954). Available K in soils was extracted by natural normal ammonium acetate (Jackson, 1973) and determined by the flame photometer.

EXPERIMENTAL RESULTS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under the following heads :

Biomass distribution :

Biomass productivity differed significantly among the different trees species (Table 2). The total biomass was significantly higher in *Albezzia lebbeck* followed by *Eucalyptus tereticornis* and *Grevillea robusta* as compared to other tree species. The biomass distribution in poles was maximum in *Eucalyptus tereticornis* followed by *Grevillea robusta.* Small branches, biomass was higher in *Albizia lebbeck* followed by *Dalbergia sissoo* as compared to other tree species. Similarly higher biomass in leave and twigs noticed in *Albizia lebbeck* followed by *Anogeissus latifolia*. This may be due to genetic variation in growth of trees species and their response to the site conditions. Similar variations in growth and productivity of trees species were reported by Mishra and Bhatt (2003) and Verma *et al.* (2014) conducted a study on root distribution pattern and biomass of seventeen year old trees of *Grewia optiva, Morus alba, Celtis australis, Bauhinia variegata* and *Robinia pseudoacacia* by using excavation method. He reported that, *R. pseudoacacia* has a maximum root biomass of 6.30kg and 68–87 per cent of root biomass occurred within top 0–30 cm soil depth. Vishwanatham *et al.* (1999) reported that *Bauhinia purpurea* and *Albezia lebbeck* produced the highest biomass when grown in the bouldery riverbed lands of Doon valley of northwest India.

Soil physical properties :

Bulk density of soil under all tree species was decreased as compared to initial status of soil. It was lowest in *Dalbergia sissoo, Anogeissus latifolia Albezia lebbeck* and *Hardwickia binata* as compared to the *Eucalyptus tereticornis*. The decrease in bulk density may be attributed to increased interaction of concentration of root, leaf litter and soil faunal activity. As in verse relationship was noticed between bulk density and soil organic carbon. Bulk density may affect the soil porosity and thereby affecting infiltration rate and water holding capacity of soil. Similar results were reported by Hosur and Dasog (1995). The effects being attributed to increased micropores of soil particles due to higher availability of organic carbon obtained from higher annual return of leaf litter. All the soil physical properties have been depends largely on carbon balance (Table 1).

Soil chemical properties :

Soil reaction pH ranged from 6.2 to 7.0. There was slight reduction in pH of soil under all tree species. The slight reduction was noticed in *Anogeissus latifolia Albezia lebbeck, Tectona grandis* and *Dalbergia sissoo* tree species as compared to other tree species. This decrease in pH may be due to litter fall and applied manures, which on decomposition is known produce weak acids in soil (Hosur and Dasog, 1995). Leaf litter addition to soil increased the EC over the initial value which is obviously due to decomposition of organic matter in the soil. The result collaborates the finding of Babu *et al.* (2007). Similarly, Drechsel *et al.* (1991) studied the effects of *Cassia siamea, Albizia lebbek, Acacia*

Table 1: Biomass distribution in different multipurpose tree species

Treatments	Timber/ pole (kg/tree)	Small branches (kg/tree)	Leaf and twigs (kg/tree)	Total biomass (kg/tree)	Total biomass (ton/ha)
Eucalyptus tereticornis	132.6	16.86	12.36	161.8	323.6
Tectona grandis	40.86	22.31	10.21	73.3	183.2
Dalbergia sissoo	88.4	32.20	15.26	135.8	285.1
Anogeissus latifolia	66.8	30.64	17.36	114.8	287.0
Albizia lebbeck	82.6	34.80	16.31	133.7	334.2
Grevillea robusta	88.7	18.20	11.62	118.5	296.2
Hardwickia binata	60.4	21.60	13.40	95.4	238.5
Acacia nilotica	45.8	28.60	10.40	84.8	202.4
Azadirachta indica	40.6	20.60	9.60	70.8	141.6
S.E. ±	2.25	1.41	0.74	3.23	14.23
C.D.(P=0.05)	6.68	4.19	2.19	9.57	42.00

auriculiformis and *Azadirachta indica* on soil fertility on five-year-old fallows on Ferric Acrisols in Central Togo. He reported that, litter quality and soil fertility under the four species were significantly different and topsoil pH increases significantly with increasing litter Ca levels.

Nitrogen :

The soil available nitrogen status was significantly higher under tree canopy of all trees compared to without tree species (open area). The available nitrogen status was in the order *Albezzia lebbeck*, *Dalbergia sissoo*, *Acacia nilotica*, *Tectona grandis* and *Hardwickia binata*.

The available Nitrogen was lowest under *Azadirachta indica* and *Eucalyptus tereticornis* possibly suggesting that less nitrogen storage in leaf litter. Many studies indicated that soil with trees have higher nitrogen status as compared with soil without any tree species (Sharma and Gupta, 1997 and Sharma, 2003). Aggarwal and Kumar (1990) and Sharma (2005) also reported that available nitrogen content was higher in *Prosopis cineraria* and *Acacia albida*. Semwal *et al.* (2003) reported that significantly higher N (2.2–2.6%) content of soil grown with *A. lebbek, A. nepalensis* and *D. sissoo*.

Phosphorus :

The available phosphorus content ranged from 17.3 to 23.4 kg /ha. The content of available phosphorus increased in soil with different tree species as compared to open site or without any tree species. The phosphorus content was slightly higher in soils covered with *Hardwickia binata / Albizia lebbeck* etc., compared to other trees. The trees with top root system have reached the plant material deeper layer and absorb nutrients and there by releasing on the surface layers. It has been observed in many tree species with different locations. Shankar *et al.* (2014) reported that among the

Table 2: Physical and chemical properties as affected by different tree species

Treatments	BD Mg M^{-3}	Porosity (%)	WHC (% V/V)	pH (1:2:5)	EC (ds/m)	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)
Eucalyptus tereticornis	1.36	36.6	5.32	7.0	0.16	190	18.2	240
Tectona gandis	1.36	43.6	6.36	6.4	0.15	230	20.6	280
Dalbergia sissoo	1.32	44.8	6.32	6.4	0.14	220	23.4	275
Anogeissus latifolia	1.30	45.6	6.34	6.5	0.15	235	22.2	275
Albizia lebbeck	1.33	45.4	6.48	6.4	0.17	245	22.8	278
Grevillea robusta	1.38	38.6	5.12	6.3	0.18	215	20.9	245
Hardwickia binata	1.33	39.6	5.84	6.4	0.15	235	21.9	255
Acacia nioitica	1.39	36.4	5.38	6.2	0.14	210	18.2	245
Azadirachta indica	1.38	39.4	5.12	6.3	0.14	180	17.3	215
Initial status of soil	1.42	35.6	4.32	6.8	0.14	162	15.8	184

Table 3: Economic evaluation of multipurpose tree species

Sr. No.	Treatments	Gross income (Rs. /ha /yr)	Cost of cultivation (Rs./ha /yr)	Net income (Rs. /ha /yr)	B : C Ratio	IRR (%)
1.	*Eucalyptus tereticornis*	24234	1688	22545	3.52	21
2.	*Tectona grandis*	33336	1688	31647	4.71	22
3.	*Dalbergia sissoo*	14152	1688	12463	2.04	17
4.	*Anogeissus latifolia*	15760	1688	14071	2.27	18
5.	*Albizia lebbeck*	16650	1688	14961	2.44	18
6.	*Grevillea robusta*	17450	1688	15761	2.56	19
7.	*Hardwickia binata*	13138	1688	11450	1.91	17
8.	*Acacia nilotica*	9982	1688	8293	1.48	15
9.	*Azadirachta indica*	12062	1688	10374	1.75	16

multipurpose tree system the phosphorus content under *Dalbergia sissoo* showed significantly higher over other land use system.

Potassium :

The available potassium content was higher in *Tectona grandis*, *Albizia lebbeck*, *Hardwickia binata* as compared to *Azadirachta indica* and *Grevillea robusta*. The increased content of available potassium may be due to absorption / uptake of potassium from lower layers and returning through the leaf litter on the surface soil layers. The similar results were reported in different tree spacing by Jha and Dimri (1991) and Prasad *et al.* (1991). The available potassium content under *Acacia nilotica* systems was high at three depths compared to the other systems (Shankar *et al.*, 2014). Among trees, *Anogeissus latifolia*, *Albezia lebbeck* and *Hardwickia binnata* have greater improvement of soil physical and chemical properties of soil.

Soil enrichment potential :

The nutrient cycling in the tree species depends upon site and physio-chemical properties of soil and root dynamics of trees. Data clearly indicated that soil in areas is low in organic carbon; pH was slightly acidic to neutral and low in available nitrogen, phosphorus and potassium. This may be attributed to lack of organic matter / litter on the surface soil, sites being devoid of tree cover and more prone to erosion. Similar findings have also been reported by Sharma (1989); Bhola (1995) and Nayak (1996).

Economic evaluation of tree species :

The suitability of particular tree farming mainly depends upon economic returns and viability on long term basis over a period of time. Gross returns were significantly higher in *Tectona grandis* (Rs. 31,647/ha/yr), *Eucalyptus tereticornis* (Rs. 22,547/ha/yr), *Grevillea robusta* (Rs. 15,761/ha/yr) as compared to other tree species. B : C ratio and IRR per cent were higher in *Tectona grandis* (4.71 and 22 %, respectively) and *Eucalyptus tereticornis* (3.52 and 21 %, respectively) and lowest in *Acacia nilotica* (1.48 and 15%, respectively) (Table 3). It could be attributed that tree growth and productivity of *Eucalyptus tereticornis* was better in degraded soil and *also Tectona grandis* due to its commercial exploitation has attained better viability as compared to other tree farming. Similar observations were reported by Sujatha *et al.* (2006); Chand *et al.* (1998) and Ghosh *et al.* (2007). Among tree species, in comparison with all the parameters, *Tectona grandis*, *Grevillea robusta*, *Anogeissus latifolia*, *Hardwickia binata* are the good tree species for inclusion in the agroforestry system. Degraded land can be improved through planting of trees *viz.*, *Albezia lebbeck*, *Eucalyptus tereticornis*, *Anogeissus latifolia*.

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