COMPARISON OF ACACIA AND EUCALYPTUS AGROFORESTRY SYSTEM FOR HILLS: TAMIL NADU, INDIA

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Abstract

Agroforestry provides social benefits by functioning as a protective system that ensures resource conservation, although some of these benefits are not directly measurable. Keeping in view facts this study was conducted at Research farm of Central Soil and Water Conservation Research and Training Institute, Research Centre (CSWCRTI,RC), Udhagamandalam, Nilgiris, Tamil Nadu, India for 21 years. In two experiments namely eucalyptus and acacia along with intercrops viz., grass legume mixture, scented geranium and potato, separately were

The net return was in the range of Rs. 1.95 to 3.15 lakhs per ha. from different treatments in eucalyptus based agroforestry system and it was highest in the case of potato with eucalyptus. The net returns ranged Rs. 0.51 to Rs. 0.92 lakh per ha. from different treatments with acacia based system and it was highest in the case of geranium with acacia followed by other treatments. This has indicated that eucalyptus based system was better than acacia based system. The inter cropping of potato, geranium, grass & legume mixture are economically viable options as per their ranking based on BCR, NPW and IRR economic criteria. Hence, study suggests that potato (first year only) and geranium in eucalyptus and acacia based agro forestry systems have performed better as compared to pure eucalyptus in the Nilgiris condition. Further, the livestock being a livelihood support enterprise in the hilly areas, grass & legume as an inter crop can be considered as another option to meet the demand of fodder for some years under agroforestry systems. However, both the system were found to be feasible option from the production as well as natural resources conservation point of view.

Key Words: Agroforestry system, cost benefit analysis, eucalyptus, acacia, Nilgiris, intercrops

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Introduction

Agroforestry provides social benefits by functioning as a protective system that ensures resource conservation. Ecological, economic, and social benefits of agroforestry are well documented, showing agroforestry as a viable land use in different parts of the world, particularly in developing countries (Kang and Akinnifesi, 2000; Neupane and Thapa, 2000). The higher yield of intercrop was due to existence of complementary interaction in eucalyptus-beans system was observed in Karnataka, India. Though, eucalyptus was reported to have negative effects on the yields of intercrops when it was grown for wood production. The competition to intercrops from eucalyptus may start from early stages when the tree is grown at higher density (1666 trees ha^{-1}) in short rotations for pulpwood (harvest cycle 4 or 5 years) and the intensity of competition could be much greater in later stages. Techniques such as canopy pruning, pollarding, thinning, root pruning by trenching and moving the first intercrop row farther from the tree-row were suggested for reducing the competition and to improve yields of intercrops in agroforesty. Despite great efforts, current adoption of agroforestry at the farm household level is much less than desired. Though, many success stories can be found but overall adoption of agroforestry by farm household is low (Neupane, 2000). One of the main reasons for slow adoption of agroforestry is that little attention has been given to the marketing problems of agro-forestry products, which deter farmers from large - scale adoption of agro-forestry practices. Previous research and promotion programs were targeted mainly on biophysical conditions such as biophysical suitability, species suitability, soil quality, biological productivity, and their technical solutions (Franzel, *et al*., 2001; Franzel, and Scherr, 2002; Neupane *et al*., 2002). In India plantations of exotic tree species like *populous debtoides, Acacia spp., Eucalyptus spp*., *Laucaena leucocephala* and *Prosopis juliflora* etc. was promoted to meet the increasing industrial and fuel wood demands (Bajaj, 1997). Eucalyptus was preferred to other exotic trees because of short term visible gains for straight pole, fast growth rate, higher productivity per unit area and least post- plantation management. However, economic gains of these trees has yet to be ascertained for wood and for ecological functions such as water usage, undersurface ground cover and allelopathic effects (Mathur and Sonin 1983, Bahuguna et.al. 1990, Jalota et. al. 2000 and Sajha et.al. 2001; Singh and Singh 2003).

The exotic acacia and eucalyptus were introduced in Nilgiris Hills in 1858 where E, globules was planted along with E Robusta. Acacia wood is excellent for fuel; charcoal and bark contain richest tanning material useful in tanneries. The Eucalyptus is useful for gum, fuel, timber, fibrous raw material for the paper, pulp and board industry. If these exotic trees are planted by the farmers, they have to wait for seven to ten years to realize any benefits (Samraj et al. 1984). The climate of the Nilgiris is temperate to sub-tropical, receiving good tropical sunshine days. The elevation of the study area is 2217 m above mean sea level. Its latitude and longitudinal dimensions are 10º38’ to 11º49’N and 75º44’ to 70º87’E, respectively. The average annual rainfall is 1180 mm distributed over 95 rainy days recorded during South -West and North-East monsoons (Sikka et al., 2000). The soils of the tract are latisol with high nitrogen and organic matter content with peat soils occurring in scattered patches in depressions of Nilgirs. Therefore, grass & legume mixture, scented geranium and potato could also be cultivated for some years along with

plantations in agroforestry systems. Thus, this is high time to evaluate the performance of two agroforestry systems in terms economic viability and sustainability. An attempt was made in this paper to compare the economics of both the systems to recommend the proper land use for small and marginal farmers of hilly areas.

MATERIAL AND METHODS

Profitability is an overriding factor in farmers' land-use decisions, which are, in time, largely determined by output, price and marketing facilities. Marketing agroforestry outputs is different from other agricultural commodities because of their diverse nature. Some products such as timber are often subject to government rules and regulations, which influence market conduct, performance and even structure. Imperfect and inefficient marketing systems reduce farmers' profit margin, thereby influencing their land use decisions. Therefore this is high time to compare and evaluate the both agroforestry systems in terms of economic profitability. Thus, two different experiments with acacia and eucalyptus along with intercrop namely, grass & legume mixture; scented geranium and potato during 1980 to 2001 were conducted. The layout of the experiment was carried out on plots of 16 m X 8 m on 16 per cent slope with the following four treatments for eucalyptus and acacia based agroforestry systems, respectively.

Experimental Details

Treatments	**Name of species**	
	Eucalyptus globulus	***Acacia mearnsii***
T1	Eucalyptus-Forestry Plantation (Control)	Acacia- Forestry Plantation (Control)
T2	Eucalyptus+ Grass+ legume Mixture (Silvi-pastoral)	Acacia+ Grass+legume Mixture (Silvi pastoral)
T3	Eucalyptus +Geranium (Agroforestry)	Acacia+ Geranium (Agroforestry)
T4	Eucalyptus +Potato (Agroforestry)	Acacia+ Potato (Agroforestry)

The seedlings of *Eucalyptus globulus* and *Acacia mearnsii* were planted during 1980 at an espacement of 2m X 2m. The espacement for grass *(Pennisetum clandestinum)* and legume (*Trifolium repens)* and grass mixture was 25cm X 25cm, for scented geranium (*Pelargonium graveolens)* 1m X 1m and 50cm X 25 cm in the case of potato (*Kufri Jyoti*). During 1987, the alternate rows of Eucalyptus and Acacia trees were felled and uprooted at the age of seven years to get a wider espacement of 4m X 2m for raising these inter crops again.

Inter crops with eucalyptus

Inter crops with acacia

The second felling was done in 1991 and third felling during 2001. The grasses & legumes were cut from 1981 to 1984 from Eucalyptus based and 1981 to 1986 from Acacia based systems and again in 1988 and 1989, respectively. Scented geranium was harvested from 1980 to 1983 and during 1989. Potato crop was harvested from 1980 to 1983 and again during 1988 to 1989 as per technical feasibility from both the experiments. During 1990 to 2001 eucalyptus and acacia were allowed to grow and finally harvested in 2001.

These inter crops could be raised successfully in the initial years and thereafter, due to close canopy of trees and root competition, these inter crops could not be taken later. When alternate rows of trees were felled during 1987, it was possible to rise the inter crops again i.e. grass–legume mixture, scented geranium and potato in all the treatments. Financially profitable but economically unprofitable land use would lead to inefficient use of scarce natural resources and impose a net drain on the society, resulting in poverty and resources degradation (Pagiola, 2001). Thus, to carry out the economic analysis, three more treatments (as scenarios) such as Eucalyptus with potato first year only (T_5), Eucalyptus with potato first year and second year only (T_6) and finally Eucalyptus with potato First year (1980) and first year after felling of Eucalyptus (1988), (T_7) were hypothesized. Similarly in the case of acacia also these treatments were hypothesized. The economic evaluation was carried out for agroforestry systems for all the seven treatments for the period of 21 years. The Net Present Worth (NPW), Benefit Cost Ratio (BCR), Internal Rate of Return (IRR) and Pay Back Period; PBP (Agarwal etal. 1995), at different discount rates were calculated for different treatments for both the systems as given below.

1. PVB $= \delta_t (\sum B_t)$
   PVC $= \delta_t (\sum C_t)$

   NPW $= \delta_t (\sum B_t - \sum C_t)$

2. BCR $= \dfrac{\delta_t (\sum B_t)}{\delta_t (\sum C_t)}$

3. IRR is the discount rate which makes PVB= PVC

Where,

PVB = Present value of benefits,

PVC = present value of Cost,

δ_t = discount rate,

B_t = benefits from the eucalyptus plantation,

C_t =cost involved in the eucalyptus plantation,

T = Time period

RESULTS AND DISCUSSION

The streams of cost incurred and benefits derived from each treatment were worked out. Cost included total variable cost where all the inputs actually used in the production process right from land preparation up to marketing were considered and valued at the prevailing market prices. In case of Eucalyptus, transportation and marketing cost ranged between 25 to 28 percent of the gross benefits in first felling and 10 to 15 percent in the second and third felling. In case of potato, cost of transportation and marketing was to be 25 percent of gross benefits. In the case of acacia the imputation of prices were calculated with same procedure as in the case of Eucalyptus. For valuation of other direct out put i.e. Grass & legume and scented geranium, actual price prevailed in the market during the sale of produce. Similarly valuation of potato, Eucalyptus and Acacia output, prevailing market prices were used (Table 1). Costs and benefits for each component of every treatment were calculated separately, and added up to obtain gross cost and gross benefits to carry out further analysis.

Table 1: Soil conditions of experimental plots

Years	PH(Soil/Water (1:2:5)	Bulk Density (gm/cc)	Nutrients available		
			Organic carbon	P(ppm)	K(ppm)
1980	4.27 **(4.71)**	1.16 **(1.10)**	3.37 **(5.73)**	7.39 **(15.63)**	68.22 **(94.27)**
1989	4.37 **(4.30)**	1.08 **(1.00)**	4.28 **(4.69)**	15.67 **(22.28)**	18.82 **(42.41)**
1992	4.47 **(4.40)**	1.10 **(1.05)**	4.24 **(5.46)**	13.83 **(26.30)**	19.33 **(24.97)**
2001	4.48 **(4.38)**	1.09 **(1.08)**	4.25 **(5.45)**	13.89 **(27.00)**	19.46 **(24.85)**

Figures in parenthesis indicate the available nutrients in eucalyptus and acacia based system

Estimation of yield of agroforestry systems- The eucalyptus yield with different intercrops is presented in table 2. The biomass yield was recorded in terms of wood, branches and leaves for eucalyptus. It was observed that eucalyptus wood yield (206.8 tons per ha.) was highest with potato, inter crop during 1987 as well as in second and third rotation (269.5 and 404.3 t/ha.) in same treatment. Similarly twigs yield was higher with treatment (T4) i.e. Potato with eucalyptus. The branches yield also was found to be higher in T4. However, wood, branches and leaves yield was higher in pure eucalyptus (T1) as compared to other treatments. The highest biomass production of eucalyptus with potato intercrop was due to the fact that the nutrients applied to the potato crop, the residual nutrients might have been utilized by eucalyptus plant and this has resulted in higher biomass production. Rotation wise biomass production of eucalyptus based agroforestry system has indicated that during Ist rotation (1980-1987) yield varied from 163.4 to 206.8 tones /ha. However, yield during IInd rotation (1981-1991) wood yield of eucalyptus was highest with potato (269.5 t/ha.) and lowest with grass and legumes mixture, In acacia based system wood yield was more with geranium (114.43 t/ha) followed by T4 (79.72 t/ha.), T2 (72.48 t/ha). During IIIrd harvesting no intercrops were taken and eucalyptus as well as acacia highest biomass production was recorded Table 2. The yield of potato in the case of Eucalyptus Agroforestry system was 16.3 tones/ha whiles it was about 24 tones/ha in the case of Acacia during first year of cultivation. The higher yield of potato in the case of Acacia based system may be due to slow growth of Acacia and more space was available for growth and development of potato crop. The potato cultivation in both the cases was tried during 1980 to 1982 and subsequently in 1988 to 1989 after first felling. The reducing trend in the yield of potato was observed in both cases as compared to first felling. The decreasing trends in the yield of inter crops due to the fact that more canopy development of plantations and less space remained for intercrops in subsequent years. The

yield of grass was observed to be higher in the case of Acacia as compared to Eucalyptus plantation as an intercrop. The possible reason could be more canopy coverage by the Eucalyptus plantation. Geranium yield also was found to be more in the case of Acacia plantations. Further, higher yields of intercrops were recorded for almost all the treatments in acacia based system which may be due to the fact that acacia is a nitrogen fixing species and might have enriched the soil fertility.

Table 2: Yield of agroforestry systems (t/ha.)

Year	Eucalyptus and Acacia based agroforestry systems (Treatments)														
	T1			T2				T3				T4			
	W	B	L	W	B	L	Grass & Legume	W	B	L	Gera-nium	W	B	L	Potato
1980							0				0.24 (0.36)				16.3 (23.99)
1981							7.65 (20.92)				3.18 (4.7)				6.19 (8.5)
1982							3.26 (2.85)				0.14 (1.03)				0.64 (2.3)
1983							0.68 (4.92)				0.12 (0.2)				
1984							0.1 (2.28)								
1985							(0) (0.89)								
1986							(0) (0.18)								
1987	186.0 (42.7)	11.9 (7.15)	13.0 (9.38)	173.3 (51.39)	11.7 (8.6)	12.3 (11.29)		163.4 (54.1)	12.5 (9.05)	11.3 (11.88)		206.8 (65.34)	15.2 (10.94)	14.3 (14.35)	
1988							2.48 (1.64)								14.0 (7.2)
1989							4.02 (2.23)				0.7 (0.8)				11.3 (8.01)
1991	204 (59.12)	16.1 (8.25)	19.9 (27.67)	199.7 (72.48)	14.7 (10.11)	18.5 (33.92)		241.5 (114.43)	17.65 (15.98)	24.7 (53.6)		269.5 (79.72)	18.6 (11.12)	22.7 (37.31)	
2001	315 (78.5)	24.2 (18.6)	29.9 (38.4)	300.5 (108.3)	22.1 22.5)	27.8 (42.4)	6.5 (1.5)	362.3 (145.2)	26.5 (25.6)	37.1 (56.8)		404.3 (107.3)	27.9 (23.8)	34.1 (42.6)	

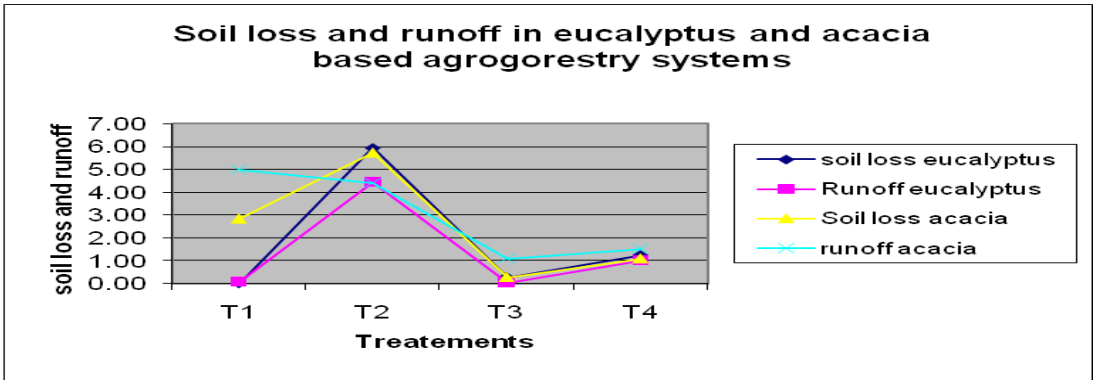
W= Wood, B=Branches, L= leaves,

Figures in parentheses indicate the yield of Agroforestry system with Acacia and normal figures are yield of Eucalyptus

Change in soil conditions of eucalyptus and acacia based agro forestry systems: The change in soil conditions under eucalyptus and acacia based agro forestry systems were observed that there was not much change in soil PH in both the systems. However, eucalyptus based agro forestry system has shown an increasing trend in PH (4.27 to 4.48) from 1980 to 2001. The organic carbon changed in the range of 3.37 to 5.45 in both the systems. The available phosphorus (P) was found to be increased in both the systems (1980-2001). However, available potash (K) was decreased over the periods.

Soil loss and run off in eucalyptus and acacia based agroforestry systems:

The soil lose and runoff is shown in fig. as below. It was observed that initially the soil loss and run off was more. At the later stage when canopy was developed the soil loss and run off decrease and reached to the permissible limit. This was the positive impact of the agroforestry systems.



Assessment of economic viability

Economic viability of each system was evaluated through NPW, BCR , PBP and IRR as economic measures used for evaluation. The discount rates applied to the benefits and cost streams is 10 percent for both the agroforestry systems. With the perusal of the table 3, it was observed that BCR varies from 1.06 to 4.25 at 10 percent discount rate for eucalyptus based system. While as in the case of acacia BCR varies from 1.43 to 2.71 at ten percent discount rate. The ranking of eucalyptus based agroforestry system for all treatments in order of NPW was T5>T4>T7>T3>T6>2T>T1 showing T5 superior which is potato first year only as hypothesized treatment. However, potato with eucalyptus was better (T4) while in the case of acacia, order of ranking was T3>T5>T6>T7>T2>T1>T4 indicating T3 is superior. The ranking of all treatments based on BCR criteria in eucalyptus based system was T3>T5>T2>T1>T7>T6>T4 showing T3 is better. In acacia based system it was T3>T5>T2>T1>T6>T7>T4 and found to be T3 is better. The ranking of these treatment based on IRR in eucalyptus based agroforestry system was T5=T7>T6>T3>T2>T1>T4 and in the case of acacia it was T5>T7>T6>T3>T2>T1>T4 indicating T5 treatment is better. Though the ranking based on different economic criteria i.e. NPW, BCR, IRR do not reflect the same trend. In most of the cases T5 (potato first year only) treatment is found to be better as compared to other treatments. Further, IRR is the best economic measure to evaluate the project and it has suggested that potato first year (T5) and potato

first year and first year of felling (T7) are best treatments as compared to others in both the systems. The analysis clearly indicates that farmers input and efforts in the agroforestry system could be effectively saved if potato had been cultivated first year only in both the agro forestry systems. The scented geranium in both the system may be another option. Hence, both the agroforestry systems were found to be economically viable as per the different economic criteria. Further it was observed that entire cost of cultivation can be recovered with in one year in the case of potato cultivation for first year only in both the agro forestry systems. The payback period receives one year owing to the fact that potato cultivation as an intercrop is highly profitable in first year it self. Thus inter cropping of potato, geranium and grass & legume mixture in both the agroforestry systems are economically viable propositions as per economic criteria in the Nilgiris. The findings are in augment with the studies of Agarwal et.al. 1995 and S. Chand et.al. 2002.

Table 3: BCR, NPW, PBP and IRR of the agroforestry systems (1980-2001)

Treatments	Discount rate 10%			IRR
	BCR	NPW	Payback Period (PBP)	%
T1	3.41 **(1.87)**	59771 **(11569)**	8 **(12)**	54 **(25.5)**
T2	3.70 **(1.93)**	72152 **(18774)**	8 **(8)**	55 **(32.5)**
T3	4.25 **(2.71)**	86369 **(33318)**	8 **(8)**	59 **(38.0)**
T4	2.12 **(1.06)**	91396 **(5031)**	1	50 **(15.6)**
T5	4.06 (2.18)	110224 (32068)	1	>90
T6	2.62 (1.66)	79038 (26235)	1	70 (63)
T7	2.94 (1.43)	89925 (21957)	1	>90 (70)

Figures in parentheses indicate the BCR, NPW, IRR and Pay Back Period (PBP) of Acacia agroforestry system

Conclusions

This study suggests that potato and geranium as inter crop in eucalyptus and acacia based agroforestry systems are economical propositions for Nilgiris. Further, the livestock being a livelihood support enterprise in the hilly areas, grass and legume mixture under both the systems also can be considered as an option to solve the the fodder problem for some years on sloping lands of Nilgiris. Findings have clearly indicated that agroforestry system is better option for marginal and small farmers to run their livelihood in hilly areas. Further, they need not to wait for long time maturity of plantation crops, inter crops can give some marginal income in the initial years 1980- 82, 1988-89 respectively potato. It was observed that there is a great potential to increase smallholders income, as well as to slow down the present degradation process and enhance the quality of natural resource base by removing constraints on agroforestry system adoption.

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