Performance of Sapota-Teak based agroforestry system in hill zone of Karnataka

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ABSTRACT : A long-term agroforestry experiment consisting of arable crops (Paddy, maize, sunhemp). Silvicultural trees *viz.*, Eucalyptus *tereticomis*, Casuarina-equisetifolia. *Albizia molucana*, *Tectona grandis, Dalbergia sissoo*, horticultural tree (sapota) and pasture crop (guinea grass) was initiated on black clayey soils at Prabhunagar (Dharwad) during 1976. Sapota (*Achras sapota*) was planted at 10 m apart and three tree species were planted in between 2 Sapota plants. Guinea grass (*Panicum maximum*) slips were planted on either side of sapota and tree species in a small strip of 1 m width. At the end of 17 years (felling all short rotation trees and only adjoining long rotation trees), economic analysis indicated that, benefit cost ratio and internal rate of returns were highest in agroforestry system with *T. grandis* (1.67:1 and 23.2%, respectively) and were lowest in sapota+C. *equisetifolia* (0.99:1 and 12%, respectively). The economic analysis at the end of 28 years (felling trees) indicated that benefit cost ratio was higher in sapota+*T. grandis*+field crops (3.23:1) followed by sapota+*Lagerstroemia lanceolata*+field crops (2.71:1) and sole sapota (2.36:1). This teak based agroforestry model is economically viable agroforestry system.

Key Words: Silvicultural tree, monoculture, long-term agroforestry, Benefit Cost Ratio, Internal Rate of Returns.

1. INTRODUCTION

Agroforestry has established itself as one of the most promising land management systems, helping in the expeditious enhancement of productivity per unit area on sustainable basis. This technology has dual role in supporting the socio-economic status of the farmers on one hand and mitigating adverse climatic effects of deforestation to greater extent by increasing the green cover index on the other. Monoculture of fruit trees being risk prone, suitable crop combinations in the interspaces of mango orchard generate additional income and improving productivity per unit area/volume as a result of efficient utilization of natural resources and improve ecological conditions. However, not much has been done on this important aspects except few inter-cropping studies in mango (Rajput *et al.* 1989; Chanda, 1989).

Sapota is an important tropical fruit grown in hill and transitional zones of Karnataka under rainfed and protective irrigation conditions. Wider spacing provided to this fruit crop provides an opportunity to raise intercrop in the first 15-20 years. Combination of tree and field crops can improve the microclimate and protect the environment (Hegde, 1995) Agroforestry is considered to be a sustainable land use system particularly in tropical world (Nair, 1989). With this objective research efforts have been made during 1976 at Agricultural Research Station Prabhunagar UAS Dharwad. An analysis of the performance of sapota in agri-silvi-horti-pastoral system was made during 1999 and 2004.

2. METE RIALS AND METHODS

An experiment was initiated during 1976 on black clayey soils of Agricultural Research Station, Prabhunagar, Dharwad. The experiment involved arable crops. (maize, paddy, fodder maize, sunhemp) horticultural crop sapota (*Achrus sapota*) and Silvicultural crops *viz.*, *Eucalyptus tereticornis, Albizia molucana, Casuarina equisetifolia, Tectona grandis* and *Dalberia sissoo*. Sapota was planted at a spacing of 10x10 m. In between two Sapota plants, tree species were planted across the slope leaving a space of 3m from sapota to first tree and subsequent 2 trees were planted at 2 m distance. Thus leaving a space of 3 m between the last tree and sapota. Guinea grass was planted in a strip of 1 m along sapota and tree species. In between two rows of sapota and tree species, field crops were grown for 15 years (maize for four years, paddy for five years, fodder maize for three years, sunhemp four for years) and subsequently cultivation of field crops was not possible due to canopy closure by tree crops and sapota together.

The soils of the experimental area was having pH of 6.7 and available nitrogen, phosphorous, potassium were 2.78, 18.6, 260 kg/ha, respectively. The annual rainfall of 1069.3 mm is received in 74 rainy days. The mean monthly maximum temperature ranges from 27.1 and 34.9 ^{o}C and mean monthly minimum temperature ranges from 15.7 from 21.7^{o}C. The recommended package of practices were followed for maize, paddy, fodder maize (South African tall) and sunhemp. Silvicultural operations *viz.*, pruning and

soil working were done every year at early stages for tree species. Branch pruning the trees and climber control were done at later stages. For sapota soil working and recommended doze of fertilizer application were done every year before the on set of monsoon. Necessary observations on growth of sapota trees and field crops were made at regular intervals. The trees (*C. equisetifolia, A. molucana* and *E. tereticornis*) were felled in short rotation and teak and sissoo (long rotation timber species) trees on either side of sapota were felled after 17 years of study. The coppice growth was allowed in *E. tereticornis*, while *C. equisetifolia* was replanted and *A. molucana* was replaced by *Lagerstroemia lanceolata.*

The economic analysis of the system was made based on the market rates of inputs and outputs. The economic viability was assessed at the end of 17 years and also at the end of 28 years of the agroforestry system.

3. RESULTS AND DISCUSSION

3.1 Analysis of the system after seventeen years

Field crop yield : In interspace of sapota + trees, maize, paddy, fodder maize (South African tall) and sunhemp were grown for four, five, three and three years, respectively. Maize yields did not differ significantly in first four years due to slower initial growth of tree species and consequently less competition to agricultural crops.

Grain yield of paddy was high in the initial three years and gradually reduced with the age of trees. Yields were significantly lower in paddy with sapota + *E. tereticornis* and paddy with sapota + *A. molucana*, while higher yields were obtained in sapota + *T. grandis* and sapota + *D. sissoo*. After 11 years, the yields of fodder maize crop reduced by 61, 53 and 27 per cent in sapota + *E. tereticornis*, sapota + *A. molucana* and sapota + *T. grandis*, respectively as compared to sole sapota (Table. 1).

After 13 years, sapota and tree species occupied 5.8 m inter space and the space available for agricultural crop was reduced to 4.2 m. This was further reduced depending upon the growth of sapota and tree species with the age. During this period sunhemp was grown for in situ incorporation.

Growth and fruit yield of Sapota plants : Height and spread of sapota were higher with *C.equisetifolia* trees followed by with *T.grandis* and was lowest in *E.tereticornis*. This is due to fast growth of *E.tereticornis*, which posed sever competition to sapota for nutrient, moisture and light. (Table 3).

Sapota fruit yield was higher when grown with only field crops ix without tree species (24.77 q/halyr) followed by Field Crop + Sapota+ *A.molucamz* (18.39 q / h a / y r) a n d Field Crop+sapota+*D.sissoo* (15.46 q/ha/yr). Lowest fruit yield was recorded in sapota+ Field Crop + *E.tereticornis* (12.89q/halyr) and sapota + Field Crop+*T. grandis* (5.55 q/ha/yr) (Table. 2). Higher reduction in sapota yield was with *T. grandis* (77%) and *E.tereticornis* (47%) as compared to the *D.sissoo* (35%), *C.equisetifolia* (35%) and *A.molucana* (27%). This is due to their growth habits (wider crown

Analysis of the system after 17 years

Table 1. Yield of field crops in Sapota - Teak based agroforestry system

Agroforestry Systems m	Maize (q/ha)				Paddy (q/ha)					FM	FM	FM	SH
	76-77	77-78	78-79	79-80	80-81	81-82	82-83	83-84	84-85	85-86	86-87	87-88	88-89	89-90
S+G (no trees)+FC	8.8	9.0	9.4	10.0	14.6	13.4	13.0	13.4	9.4	*	81.3	16.8	19.1	1.20
S+G+ E. tereticornis+FC	8.8	9.0	9.4	10.0	14.6	13.4	13.0	7.6	4.6	*	33.3	8.8	2.7	0.7
S+G+ A. molucana+FC	8.8	9.0	9.4	10.0	14.6	13.4	13.0	6.5	12.5	*	29.2	7.4	10.6	0.7
S+G+ C.equisetifolia+FC	8.8	9.0	9.4	10.0	14.6	13.4	13.0	10.9	12.6	*	45.6	3.2	10.8	0.5
S+G+ T. grandis+FC	8.8	9.0	9.4	10.0	14.6	13.4	13.0	10.9	10.1	*	47.1	15.9	14.0	1.0
S+G (no trees)+FC	8.8	9.0	9.4	10.0	14.6	13.4	13.0	13.2	10.1	*	52.9	6.4	17.0	0.5
	91-92 & 92-93 sunhemp was grown and incorporated													

FM - Fodder maize; * Not sown; SH- Sunhemp; S - Sapota; G - Grass, FC - Field crops

Table 2. Sapota fruit yield (q/ha) Sapota-Teak based agroforestry system

Agroforestry Systems	85-86	86-87	87-88	88-89	89-90	90-91	91-92	92-93	93-94	Av fruit yield (q/ha/yr)
S+G (no trees)+FC	2:32	2.41	7.86	13.05	20.55	24.00	26.63	37.60	7.83	
S+G+*E.tereticornis*+FC	5.62	1.56	5.12	10.33	15.63	1.50	12.70	16.70	4.69	12-Zg18.39
S+G+ *A. molucana* +FC	10.26	0.24	7.00	4.29	19.52	1.90	22.00	30.60	6.91	
S+G+ *C. equisetifolia* +FC	14.66	2.64	10.21	5.12	21.80	7.60	23.84	22.91	2.96	15.86
S+G+ *T. grandis*+FC	7.14	11.53	13.30	5.24	7.15	3.45	2.10	6.25	0.28	5.55
S+G (no trees)+FC	13.73	12.27	10.60	6.13	20.75	6.85	18.80	17.72	3.57	15.46

Table 3: Height and spread of Sapota in Sapota-Teak based agroforestry system

Agroforestry Systems	Height			Crown diameter (m)		
	76-77	84-85	93-94	76-77	84-85	93-94
S+G (no trees)+FC	0.32	2.30	4.0	0.36	2.26	5.20
S+G+*E.tereticornis*+FC	0.45	2.86	3.0	0.32	3.28	4.80
S+G+*A.molucana*+FC	0.28	2.86	3.10	0.28	3.43	3.95
S+G+ *C.eauisetifolia*+FC	0.39	2.94	3.20	0.46	3.15	4.60
S+G+ *T. grandis*+FC	0.20	2.30	4.10	0.32	2.44	4.20
S+G (no trees)+FC	0.20	2.35	4.4	0.28	2.65	4.80

spread, of teak and fast growth of eucalyptus). During early stages, *D.sissoo* and *C.equisetifolia* had positive influence on fruit yield of sapota but as tree growth advanced, it resulted in lower fruit yield.

Both *C.equisetifolia* and *D.sissoo* were having positive influence on fruit yield of sapota due to their sparse canopy and low moisture requirement during initial years of establishment and thereby the growth of sapota was better with these species. Similar observations were observed in pepper also (Mathail, 1983).

Growth of trees species : Height was higher in *E.tereticornis* followed by *A.molucana* and was lowest in *D.sissoo* and *T.grandis*. DBH was higher in *A.molucana* followed by *E.tereticornis* and *C.equisetifolia*. The lowest DBH was observed in *D.sissoo* and *T.grandis* (Table 4).

Among the tree species *E. tereticornis* recorded the highest timber volume (0.912 m^3/tree) followed by *A.molucana* (0. 55 m^3) whereas lowest timber volume were noticed in *D.sissoo* and *T.grandis*. This is due to slow growth of trees (sissoo and teak) resulting in lesser volume.

Income from different components : Income from sapota, field crops and trees was worked out on the basis of yield and market value (Table 5). Sapota with field crops alone i.e, without tree species had higher average income (Rs. 6028/ha/yr) followed by Field Crop+*A.molucana* + sapota (Rs. 4607/ha/yr) and field Crop +*C.equisetifolia*+sapota (Rs.3450/ ha/yr). This is mainly due to lower fruit yield of sapota observed under the tree cover.

Income from field crops was higher when grown with only sapota (Rs. 1600/ha/yr) followed by Field Crop + Sapota + *T.grandis* (Rs.1459/ha/yr) and was least with *E. tereticornis* (Rs.1136/ha/yr). Among the tree species teak recorded higher average income (Rs. 8701/ha/yr) with felling of 2/3 population as compared to felling of all trees in eucalyptus (Rs. 3833/ha/yr). This is mainly due to differential value of timber and differences in firewood quantity in tree species. Though teak produced less volume than eucalyptus, its economic value in market is much higher.

Table 4. Height, DBH and volume of tree species in Sapota - Teak based agroforestry system

Agroforestry Systems	Height			Crown diameter (m)			Volume (M^3/tree)
	76-77	84-85	93-94	76-77	84-85	93-94	93-94
S+G (no trees)+FC	-						
S+G+*E. tereticomis*+FC	0.60	13.55	20.4	0.15	15.74	26.57	0.912
S+G+*A. molucana*+FC	0.66	7.45	14.4	0.12	13.66	38.82	0.552
S+G+ *C. equisetifolia*+FC	0.50	8.81	11.7	0.32	10.54	20.00	0.262
S+G+ *T. grandis*+FC	0.40	4.88	9.4	0.21	6.56	14.79	0.142
S+G+ *D. sissoo*+FC	0.42	8.27	7.7	0.15	9.90	15.21	0.118

Table 5. Income from different components of the system as affected by different tree species in Sapota -Teak based agroforestry system (17 years)

	INCOME			
Agroforestry Systems	Field crops (Rs/ha)	Sapota (Rs/ha)	Tree species (Rs/ha)	Total income (Rs/ha)
S+G (no trees)+FC	27200	102476	-	129696
S+G+ *E. tereticornis*+FC	19312	53074	67883	140269
S+G+ *A. molucana* +FC	20638	78319	33317	132274
S+G+ *C. equisetifolia*+FC	19329	58786	15554	93669
S+G+ *T. grandis*+FC	24803	16558	147924	189285
S+G+ *D.sissoo*+FC	20655	58157	56613	135425

FC - Field Crops, S-Sapota, G-Grass

Total income : Total average income from agri-silvi-horti system was higher in field crop+sapota+*T.grandis* (Rs. 11,134/ha/yr) followed by Field Crop + Sapota + *D.sissoo*. The agroforestry system involving teak as the component and with field crop and sapota could generate higher income owing to high price to the teak timber. Higher income from sapota with sissoo was mainly due to higher fruit yield, which accounted for higher total income. Average total income was higher by 46 per cent in field crop+Sapota+*T.grandis* as compared. to sole sapota+field crop. (Table. 5)

This clearly indicates that in tropical hill zone, sapota+teak is more viable system based on total income and compatibility with field crops. Madiwalar *et. al* (1996) have reported higher total income with field crop + *Tectona grandis* + papaya (another tropical fruit crop) on red gravelly soils in Dharwad and also higher net returns were realized with integration of tree with agricultural crops at Bijapur (Korwar 1992). Raising agricultural crop became difficult due to spread of crown of tree species and that of sapota. During 1993-94 (after 17 years) all *C.eguisetifolia, E.teretirocnis. A.molucana* were felled and in case of *Tectona grandis* and *D. sissoo*, trees on either side of sapota only were removed to encourage the growth of sapota and the central remaining tree.

Income from perennial components : Income from sapota trees was worked out on the basis of quantum of yield and prevailing market price. Sapota grown with only field crop recorded higher total income (Rs. 1,02,476/ha) followed by sapota + field crop + *A. molucana* (Rs. 78.319/ha) and *C.equisetifolia* (Rs. 58,786/ha). This is due to lesser competitive effect of *A.molucana* on sapota. The lowest income was observed in sapota + field crop + *E. tereticornis* (Rs. 53,074) and field crop + sapota + *T. grandis* (Rs. 16,558/ha). With regard to income from tree species teak has recorded higher income (Rs.1,47,924/ha) though only 2/3 population is felled as compared to complete felling of *E.tereticornis* (Rs. 67, 883/ha) *A. mulucana* (Rs. 33,317/ha) and *C.equisetifolia* (Rs.15,554/ha). This is due to differential timber value for teak rather than the volume, which is higherwith eucalyptus and other species except *D.sissoo*.

Economic analysis at the end of 17 years : The economic analysis of different agroforestry systems was worked out at the end of 17 years of experimentation (Table 6). Average net returns was higher in sapota+grass+*T.grandis*+ FC (Rs. 5593/ha/yr) and was followed by *E. tereticornis* (Rs. 2743/ha/yr) as compared to sapota + *C. equisetifolia* + field crops (Rs. 1127/ha/yr). Benefit Cost Ratio and Internal Rate of Return were lowest

in agroforestry system involving *C.equisetifolia* and *A. molucana* indicating these species are not better than the treatment without tree components. The benefit cost ratio was highest in agroforestry systems with *T. grandis* (1.67:1) followed by with *D. sissoo* (1.22:1) and lowest was noticed in sapota + *C. equisetifolia* (0.99:1). Hence, the system involving Field Crop + sapota and *T.grandis/ D.sissoo* are economically more viable as compared to other tree species studied.

3.2 Analysis of the system after 28 years

After felling the trees, as mentioned above coppice growth was allowed in eucalyptus. *Casuarina equisetifolia* was replanted as it does not coppice. *Lagerstroemia lanceolata* was planted in place of *A. molucana* as it had spreading crown. In teak and *D. sissoo*, middle tree was retained by pruning side branches for timber purpose.

Growth of trees : *T.grandis* recorded significantly maximum height (20.75 m) dbh (30.90 cm) and crown spread (42.17 m^2/pl) as compared to *D.sissoo* (13.16m, 25.21 cm and 21.60 m^2/pl, respectively). Among the replanted trees, the growth of *E.tereticornis* was better as compared to *L. lanceolata* and *C.equsietifolia*. Coppice growth of eucalyptus was higher as compared to fresh planted *L.lanceolata* and *C.equisetifolia* (Table 7 & 8).

Growth of sapota : After felling of trees, the growth of sapota increased in the system consisting of trees *viz., C.equisetifolia, A molucana* and *E.tereticornis* as compared to with *T.grandis* and *D.sissoo* as shaded sapota was exposed to bright sun light.

At the end of 28 years of experimentation, height and spread was significantly higher in sapota with *C.equasetifolia*, by *Lagerstroemia lanceolata*, followed by with *E.tereticornis* (Table 9 & 10). The trend was similar in all the years. On the contrary sapota fruit yield increased in sapota + *C.equietfifolia* and sapota + *L.lanceolata*. In a similar situation, Jayachandran and Nair (1998) reported that rhizome yield of ginger reduced under shade than in open field. The increased reduction in fruit yield of sapota was noticed with *T.grandis* and *D.sissoo* as compared to sapota+*L.lanceolata*. This is due to severe competitive effect of retained trees (*T.grandis* and *D.sissoo*). Sapota fruit yield was significantly higher with *L.lanceolata*, *C. equisetifolia* and sapota alone (Table 11).

Economic Evaluation : The value estimation of standing trees (*T.grandis* & *D.sissoo*) was worked out based on local market value prevailing. Finally the economic evaluation of the system was worked out at the end of 28 years of experimentation.

The analysis revealed that the returns (discounted interest at 12%) were higher in sapota + *T.grandis* + field crop followed by sapota + *L.lanceolata* + field crops as compared to sapota+field crops. Benefit cost ratio was higher in sapota + *T.grandis* + field crops (3.23) followed by sapota + *L.lanceolata* + field crop (2.71) and sapota + field crops (2.36:1). Hence, based on the Benefit Cost ratio (BCR), Internal Rate of Returns (IRR) and net returns it can be inferred that the teak-sapota based agroforestry model is economically viable and is suitable for hilly areas and irrigated lands (Table 12).

Table 6. Economic evaluation of Sapota -Teak based agroforestry system (17 years)

Agroforestry Systems	Av. Cost (Rs/ha/yr)	Av. Gross Returns (Rs/ha/yr)	Av. Net Returns (Rslhalyr)	Discounted @ 12% interest			BCR	IRR (%)
				Av.Cost (Rs/ha/yr)	Av. Gross Returns (Rs/ha/yr)	Av. Net Returns (Rs/ha/yr)		
S+G (no trees)+FC	2703.4	5286.9	2583.5	913.3	1211.3	297.9	1.32	21.5
S+G+E.tereficomis+17C	2758.2	5522.6	2764.3	962.2	1128.4	166.2	1.17	16.0
S+G+A.molucana+FC	2758.2	5180.0	.2421.7	962.2	1092.6	130.3	1.13	15.2
S+G+C.euisetifolia+FC	2758.2	3886.1	1127.8	962.2	961.5'	-0.7	0.99	12.0
S+G+ T. randis+FC	2758.2	8351.3	5593.1	962.3	1611.5	649.2	1.67	23.2
S+G+D.sissoo+FC	2758.2	5378.9	2620.6	962.3	1170.9	208.7	1.22	17.2

FC-Field crop, S-Sapota, G-Grass

Analysis of the system after 28 years.

Table 7. Height of tree species (m) in Sapota - Teak based agroforestry system during different years

Agroforestry system	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05
S+G (No trees)+FC	-	-	-	-	-	-	-	-	-	--	-	-
S+G+*E.tereticomis* +FC	20.4	*	10.2	13.47	14.09	14.93	16.42	18.27	20.3	20.0	20.40	20.85
S+G+ *L.lanceolata*+FC	14.4	*	1.2	1.46	1.61	3.61	6.52	7.02	7.3	7.6	7.87	7.89
S+G+C.*equisetifolia* +FC	11.7	*	2.1	2.3	2.41	3.5	4.35	5.00	5.9	6.2	7.10	7.02
S+G+*T. grandis*+FC	9.4	10.6	14.7	16.35	16.62	16.83	17.42	17.00	17.9	18.1	19.22	20.75
S+G+*D.sissop*+FC	7.7	9.6	10.6	11.68	12.18	12.63	12.85	12.90	12.8	12.9	12.89	13.16

Short rotation tree species *viz., Eucalyptus tereticornis, Albizia molucana* and *Casuarina equisetifolia* were felled and replanted. In long rotation tree species viz., *Tectona grandis* and *Dalbergia sissoo*, middle one is retained.

Table 8. DBH of tree species (cm) in Sapota -Teak based agroforestry system during different years

Agroforestry system	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05
S+G (No.trees)+FC	-	-	-	-	-	-	-	-	-	-	-	-
S+G+*E.fereticomis*+ FC	26.6	38.2	38.0	18.0	18.0	20.0	20.0	21.0	23.1	23.50	23.90	24.60
S+G+ *L.lanceolata*+FC	38.8	13.3	13.0	3.0	29.0	7.0	7.0	8.0	8.36	12.36	13.16	13.36
S+G+C *equisetifolra* +FC	20.0	4.0	4.0	3.0	3.0	8.0	8.0	9.0	8.82	9.40	10.00	10.16
S+G+*T. grandis*+FC	14.8	75.2	75.0	26.0	27.0	28.0	28.0	28.0	29.4	30.20	30.38	30.90
S+G+*D.sissoo*+FC	15.2	53.0	53.0	20.0	20.0	22.0	22.0	24.0	24.1	24.80	24.75	25.21

Table 9. Height of sapota (m) in Sapota -Teak based agroforestry system during different years

Agroforestry system	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04	04-05
S+G (No trees)+FC	-	-	4.56	5.29	5.41	5.48	5.98	6.12	6.37	6.40	6.67	6.87
S+G+*E.tereticornis*+FC	-	-	4.78	4.79	4.86	4.82	5.26	6.43	6.67	6.56	6.89	7.19
S+G+ *L.lanceolata*+FC	-	-	4.83	4.93	4.52	5.18	6.47	6.51	6.73	6.86	6.90	6.95
S+G+C *equisetifolra* +FC	-	-	4.80	4.89	4.90	5.34	5.77	5.95	6.13	6.57	6.67	6.88
S+G+*T. grandis*+FC	-	-	4.04	4.'65	5.00	5.00	5.29	5.34	5.43	5.51	5.83	5.89
S+G+*D.sissoo*+FC	-	-	4.55	4.45	4.59	4.65	5.27	557	5.77	5.78	5.95	5.96

Table 10. Spread of sapota m in Sapota - Teak based agroforestry system during different years

Aroforestrysystem	93-94	94-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	02-03	03-04*	04-05'
S+G (No trees)+FC	-	-	6.51	6.73	7.12	7.31	7.88	8.22	8.18	8.09	58.57	43.00
S+G+*E.tereticornis*+FC	-	-	6.45	7.26	7.61	7.79	5.87	6.35	7.74	7.72	59.90	49.16
S+G+-*L.lanceolata*+FC	-	-	7.93	8.09	7.89	8.35	7.99	8.24	8.55	8.52	68.26	70.40
S+G+C.*equisefifolia*+FC	-	-	6.88	6.80	6.89	7.83	8.28	8.24	8.53	7.93	67.45	59.90
S+G+*T.granais*+FC	-	-	5.71	5.35	5.47	5.59	5.23	5.77	6.03	5.97	51.25	41.00
S+G+*D.sissoo*+FC	-	-	6.15	5.61	6.02	6.28	5.46	5.28	6.47	6.08	46.45	44.10

*Crown area (m^2/pl)

Table11.Fruit yield of sapota/ha inSapota-Teak based agroforestry system during different years

Agroforestry system	93-94	194-95	95-96	96-97	97-98	98-99	99-00	00-01	01-02	102-03	03-04	04-05
S+G (No trees)+FC	7.83	76.40	128.64	136.73	70.6	86.4	98.9	107.1	117.5	53.51	14.05	21.36
S+G+*E.terelicornis*+ FC	4.69	82.26	106.34	141.23	740	91.8	115.7	134.2	122.6	59.4	16.30	26.42
S+G+-*L.lanceolata*+FC	6.91	102.6	152.50	183.15	99.50	129.4	146.8	169.6	161.4	85.2	17.20	31.41
S+G+C.*equisetifolia* +FC	2.96	78.00	70.91	97.53	83.50	102.6	126.1	139.0	139.8	54.4	14.97	24.89
S+G+*T.grandis*+FC	0.28	17.10	15.40	40.11	42..10	53.6	50.4	63.1	63.7	19.2	2.65	7.43
S+G+*D.sissoo*+FC	3.57	29.54	31.05	51.10	5010	61.8	61.1	80.5	82.9	43.3	7.44	19.52

Table12.Economic evaluation of Sapota - Teak based agroforestry system (28 years)

Agroforestry Systems				Discounted @ 12% interest				
	Av. Cost (Rs/ha/yr)	Av. Gross Returns (Rs/ha/yr)	Av. Net Returns (Rs/ha/yr)	Av. .Cost (Rs/ha/yr)	Av. Gross Returns (Rs/ha/yr)	Av. Net Returns (Rs/ha/yr)	BCR (%}	IRR
S+G(No trees)+FC	6710.7	23436.6	16725.8	1148.3	2713.2	1564.8	2.36	30
S+G+*E. tereticomis* +F C	6768.8	25971.6	19202.8	1194.1	2772.7	1578.6	2.32	26
S+G+-*L.lanceolata*+FC	6768.8	31502.8	24734.0	1194.1	3239.0	2044.9	2.71	28
S+G+C.*equisetifolia*+FC	6768.8	23302.5	16533.7	1194.1	2481.6	1287.5	2.08	25
S+G+*T.grandis*+FC	6768.8	45746.1	38977.3	1194.1	3859.0	2164.9	3.23	30
S+G+*D.sissoo*+ FC	6768.8	31647.9	24879.1	1194.1	2594.1	14000	2.17	25

S- Sapota; G- Grass; BCR- Benefit Cost Ratio. IRR- Internal Rate of Returns

Similar observations were recorded by Bhava, *et al.* (1988) while studying the response of intercropping on the economics of mango under south Gujarat conditions. The sapota teak based agroforestry being a multicomponent system will generate employment through out the year and enhance the returns as compared to monocropping of sapota.

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