ANNUAL RESULTS/REPORT
NOVEMBER 1991 TO NOVEMBER 1992

1. Introduction

The All India Coordinated Research Project on Agroforestry was started at the Livestock Research Station, Thiruvazhamkunnu during December, 1983. The area enjoys a warm humid tropical climate with average annual rainfall of 2518 mm. The mean maximum and minimum temperature are 31.37° C and 23.9° C respectively. The soil is formed mainly from granitic and gneissic parent materials.

2. Details of academic and supporting staff.

Sl. No.	Scientists	Sanct-ioned	In position	Vacant	Name and Design.
I.	Scientific				
1.	Associate Professor	1	addl. charge	1	Dr. B. Mohan Kumar Associate Professor
2.	Assistant Professor (Agronomy/Horticulture Soil Conservation/Agrl. Engineering)	3	1	2	Smt. S. Parvathy Asst. Professor (Ag. Engineering) w.e.f. 14.10.92
3.	Jr. Asst. Professor (Agronomy/Horticulture /Agrl.Engineering/Plant Pathology)	4	0	4	Dr. K.V.Suresh Babu Jr. Asst. Prof. (Hort.) upto 31.10.1992
II.	Technical				
1.	Farm Assistant	2	2	0	Mr. Thomas, C. Mr. C.P. Nandakumar
2.	Lab. Assistant Gr.III	2	2	0	Mr. P. Bharathan Mr. A.N. Raghu
III.	Supporting				
1.	Assistant Gr. II	1	1	0	Mr. P.V. Chamunni
2.	Driver (LDV)	1	1	0	Mr. T. Moidu
3.	Peon	1	1	0	Mr. K. Narayanan

3. Research Projects:

Project i) Diagnostic survey and appraisal of existing farming systems and Agfoforestry practices.

Project ii> Collection and evaluation of promising species/cultivars of fuel, fodder and small timber species.

Project iii> Studies on management practices of Agroforestry systems.

a) Spatial arrangement and harvesting schedule silvo-pastoral system.

b) Compatibility of different components in silvi-pastoral system.

c) Utility of some fast growing trees as pepper standards : Part 1- raised from cuttings

d) Utility of some fast growing trees as pepper standards : Part 2- raised from seedlings

Project iv> Provenance trial on Jack (Artocarpus heterophyllus)

Project v> Operational research project on Agroforestry

4. RESEARCH RESULTS

Project i> Diagnostic survey and appraisal of existing farming systems and Agroforestry practices.

a. TREE DIVERSITY, SIMILARITY AND STRUCTURE OF THE HOME GARDENS IN KERALA.

Despite the 'rubber and coconut boom' the state experienced during the recent past, homestead agroforestry forms a dominant land use system in many parts of the tropics especially in the peninsular Indian state of Kerala (Nair and Sreedharan, 1986; Jose, 1992), Although no precise estimates on the land area under home gardens pertaining to Kerala are available, most of the 4180900 operational holdings in the state (average size: 0.43 ha; KAU, 1989) can be categorized as homesteads.

Considering the importance of homestead agroforesty, a survey was conducted in 17 selected thaluks of Kerala with the objective of characterizing the extent of similarities and diversities in the floristic composition of the homegardens of Kerala and also estimating the availabilties of commercial timber and fuel wood from the homesteads.

Method

The field work involved contacting individual farmers belonging to small (holding size below 0.4 ha), medium (0.4 to 2 ha holdings) and large (>2.0 ha of holding size) in the 17 selected thaluks and was accomplished during 1991 and 1992. A total of 253 farmers were actually contacted with a minimum of five in each of the thaluk-wise holding category (97, 117 and 39 respectively in small, medium and high classes). Contact farmers were selected through a stratified random process in which samples consisting of at least one member from each of the holding-size category was randomly selected from every panchayat falling under the selected thaluks. Details were gathered through a personal discussion with the farmers concerend and also enumerating all the trees (scattered trees on farm lands, border trees and the monocultural plantations such as coconut, rubber etc.) on the homesteads (>15 cm girth at breast height) by measuring their height and girth using a clinometer and tape respectively. However, for the monocultural plantations only mean height, mean girth and density were recorded. Standing volume of trees on area-basis were worked following Nair's yield table. Simpson's diversity index (Simpson, 1949), and Sorenson's similarity index were also worked out.

Species diversity

There was a tremendous degree of variability as far as the

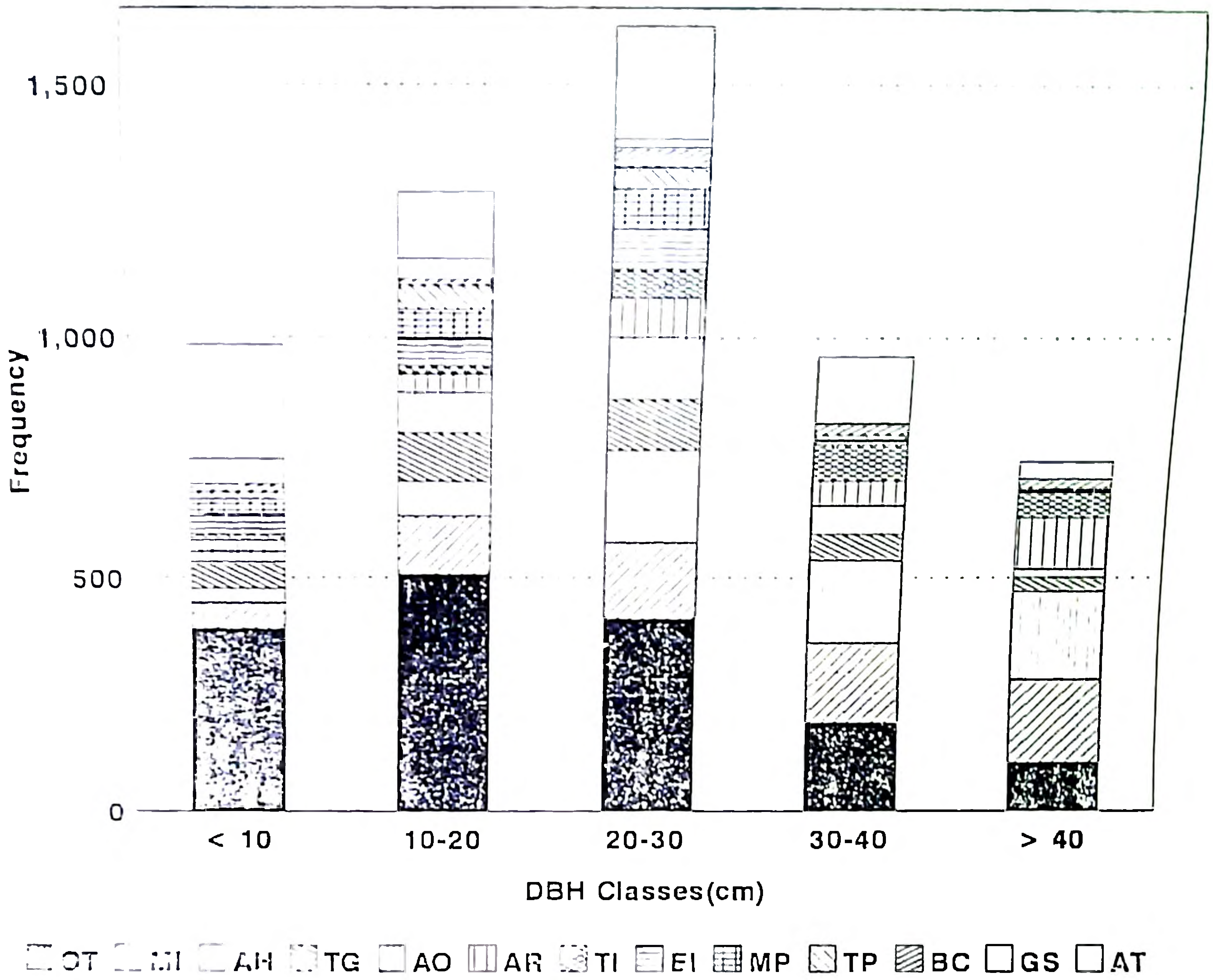


Fig. 1. Diameter frequency distribution of important tree species in the homegardens of 17 selected thaluks in Kerala (MI - Mangifera indica, AH - Artocarpus heterophyllus, TG - Tectona grandis, AO - Anacardium occidentale, AR - Artocarpus hirsutus, TI - Tamarindus indicus, EI - Erythrina indica, MP - Macaranga peltata, TP - Thespesia populnea, BC - Bombax ceiba, GS - Gliricidia sepium, AT - Ailanthus triphysa, OT - Others)

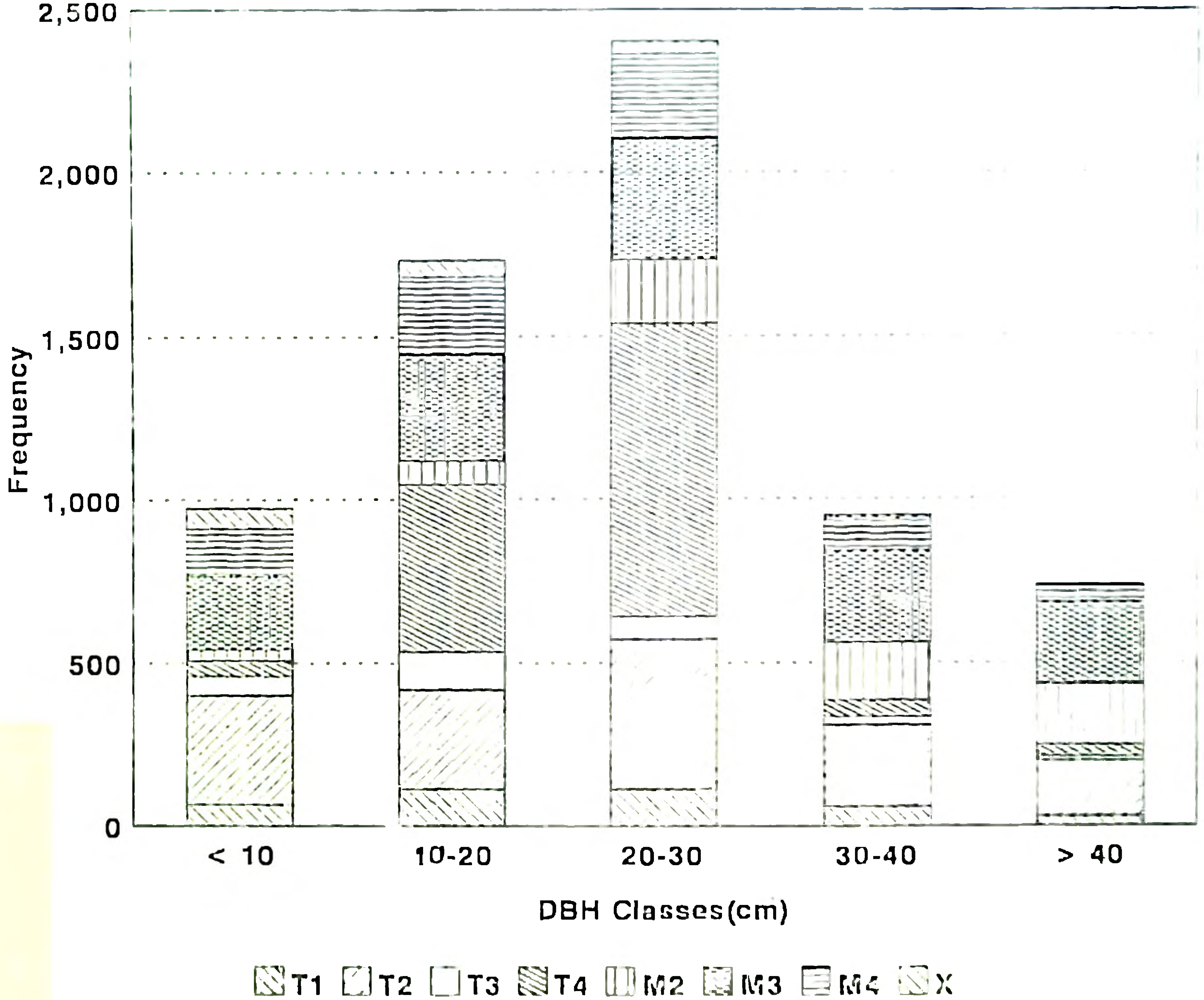


Fig. 2 Diameter frequency distribution of utlization classes of important tree species in the homegardens of 17 selected thaluks in Kerala (T - Primarily timber yielding species, M - Multiple use species, PL - Palms, X - uses other than those listed; 1,2,3,4 - classification based on durability; 1 - perishable, 2- moderately perishable, 3 durable, 4 - very durable).

species diversity and number of trees encounted in the homesteads of the selected localities were concerned. In total 124 species were identified. The number of species found in the home gardens ranged from 16 in the coastal area of Parur to as much as 57 in Cochin thaluk again in the coastal region of the state. Coconut and arecanut by and large were the most dominant components of the home gardens in the entire state. Their respective total frequencies of the sampled area were 16955 and 13845. Other dominant species included Mangifera indica, Artocarpus heterophyllus, A. hirsutus, Anacardium occidentale, Tectona grandis, Tamarindus indicus, Erythrina indica, Macaranga peltata, Thespesia populnea, Bombax ceiba, Gliricidia sepium and Ailanthus triphysa. The respective diameter frequency distribution of these trees are presented in Fig 1.& 2.

Simpson's diversity index (see: Table 1) for the homesteads ranged from 0.39 (Kollam) to 0.74 (Kottayam) suggesting that floristic diversity was moderate compared to a value over 0.90 for the species-rich ever-green forests of the Western Ghats. A Simpsons' floristic diversity of 0.74 implies that of the 100 pairs of trees selected at random, 74 pairs will be constituted by different species. Shannon-Wiener diversity index also indicated a similar trend. Species diversity in the home gardens of Kerala is of the highest order (Jose, 1992; Babu et al 1992). Homegardens create a forest-like multi-storey canopy structure. Perhaps the forest like structure is derived from either the lack of a discernible planting pattern, or alternately, is the result of deliberate planning to mimic the forest (Singh, 1987).

Table 1 . Diversity indexes for the tree species encountered in the homesteads of 17 thaluks in Kerala state.

TALUK	AREA (M^2)	NO. OF SPECIES (S)	NO. OF INDIVIDUALS (N)	N/S	SIMPSON'S INDEX (D)	SHANNON-WIENER INFORMATION FUNCTION		
						H'	H_{MAX}	$E=H'/H_{MAX}$
CHIR	19.38	33	2612	79.15	0.539	1.5525	5.0448	0.3077
ERNA	30.48	34	2379	69.97	0.631	2.0449	5.0878	0.4019
HOSD	43.00	56	3669	65.52	0.581	1.7753	5.8078	0.3057
KART	49.20	26	1619	62.27	0.393	1.4487	4.7008	0.3082
KOCH	31.25	57	3466	60.81	0.592	1.9822	5.8333	0.3398
KOLL	19.34	23	1192	51.83	0.379	1.4766	4.5239	0.3264
KOTH	19.48	19	2261	119.00	0.459	1.3038	4.2482	0.3069
KOTT	13.50	38	1164	30.63	0.742	3.0736	5.2483	0.5856
KUNN	26.67	34	2587	76.09	0.608	2.2692	5.0878	0.4460
MUVA	24.65	50	3033	60.66	0.575	1.9443	5.6443	0.3445
NEDU	19.72	36	773	21.47	0.680	2.7509	5.1703	0.5321
NEYY	22.58	16	1773	110.81	0.398	1.4693	4.0003	0.3673
PARU	27.47	32	2802	87.56	0.556	1.5945	5.0004	0.3189
PATH	31.55	18	1368	76.00	0.499	1.8465	4.1702	0.4428
PERI	27.47	58	5460	94.14	0.423	1.5274	5.8584	0.2607
THAL	20.13	18	811	45.06	0.721	2.7380	4.1702	0.6566
VAIK	12.68	36	1554	43.17	0.442	1.6357	5.1703	0.3164

PATH-Pathanapuram, KOTH-Kothamangalam, HOSD-Hosdurg, ERNA-Ernad, KUNN-Kunnathunad, PERI-Perinthalmanna, KOTT-Kottarakkara, MUVA-Muvattupuzha, PARU-Parur, KART-Karthikappally, NEYY-Neyyattinkkara, CHIR-Chirayinkil, KOLL-Kollam, THAL-Thalappily, VAIK-Vaikam,

Table 2 Sorensens Similarity Index (percentages) for 17 thaluks in Kerala State

	PATH	KOTH	HOSD	ERNA	KUNN	PERI	KOTT	MUVA	PARU	NEYY	CHIR	KOLL	THAL	VAIK	KART	NEDU
PATH	0.00															
KOTH	66.67															
HOSD	45.71	33.80														
ERNA	37.50	36.73	48.84													
KUNN	58.33	53.06	51.16	43.75												
PERI	44.44	41.10	54.55	56.82	54.55											
KOTT	61.54	45.28	57.78	50.00	55.88	52.17										
MUVA	40.63	36.92	50.98	47.50	70.00	57.69	59.52									
PARU	52.17	42.55	45.24	38.71	61.29	41.86	57.58	48.72								
NEYY	60.00	51.61	29.41	34.78	47.83	31.43	44.00	38.71	54.55							
CHIR	51.06	54.17	42.35	44.44	57.14	50.57	53.73	45.57	55.74	44.44						
KOLL	81.08	68.42	42.67	37.74	64.15	46.75	59.65	46.38	62.75	62.86	61.54					
THAL	56.25	66.67	28.57	33.33	50.00	38.89	38.46	34.38	47.83	40.00	51.06	54.05				
VAIK	64.00	47.06	45.45	39.39	60.61	48.89	65.71	51.22	59.38	50.00	49.23	65.45	40.00			
KART	50.00	43.90	41.03	46.43	46.43	45.00	56.67	44.44	51.85	42.11	54.55	57.78	40.00	48.28		
NEDU	52.00	54.90	56.82	45.45	57.58	53.33	60.00	48.78	56.25	54.17	64.62	65.45	40.00	52.94	55.17	
KOCH	36.62	30.56	42.20	36.78	45.98	50.45	46.15	44.66	54.12	31.88	48.84	44.74	36.62	58.43	45.57	47.1[illegible]

PATH-Pathanapuram, KOTH-Kothamangalam, HOSD-Hosdurg, ERNA-Ernad, KUNN-Kunnathunad, PERI-Perinthalmanna, KOTT-Kottarakkara, MUVA-Muvattupuzha, PARU-Parur, NEYY-Neyyattinkkara, CHIR-Chirayinkil, KOLL-Kollam, THAL-Thalappily, VAIK-Vaikam, KART-Karthikappally, NEDU-Nedumangad, KOCH-Kochi

Moreover, species diversity, size, shape and plant density also vary from place to place, influenced by cultural, ecological and socio-economic factors (Rico-Gray et al 1990).

Sorensens similarity indexes (Table 2) indicated a moderately high degree of simiarity for the different tree species enountered in the homesteads of Kerala. A comparison of two nearby thaluks Thalassery and Hosdurg surprisingly yielded the lowest similarity index. As Kerala falls under a single broad eco-climatic zone (humid tropics) it is not surprising that many of the home garden species have a cosmopolitan distribution pattern. The rgression between species number and holding size, however, yielded a very low r^2, implying that holding size probably is not a powerful determinant of species diversity.

Timber and firewood production in the homesteads.

Palms yielded the highest commercial timber and fuel wood volumes (Tables 3 and 4). Average commercial timber yield from homesteads ranged form 6.6 to 50.8 m^3 ha^{-1} and fuel wood volume was of the order of 23 to 86 m^3 ha^{-1} indicating that a substantial proportion of the society's timber demands are met with from the homesteads. In this connection, a study conducted at the Kerala Forest Research Institute at Peechi also has indicated that of the supply of wood from different sources in Kerala, homesteads accounted for 74.4 to 83.6 per cent. Estates (cardamom, rubber, tea, coffee) contributed 9.3 to 11.8 per cent of the total supply and imports 2.4%. Supply of wood from forests including plantations and illicit felling accounted for only 4.7 to 11.4 per cent (Krishnankutty, 1990).

Table 3.Commercial Volume of Growing stock of Trees in Homesteads of selected Thaluks in Kerala State (volume in m^3/ha overbark)

Taluk	T1	T2	T3	T4	M2	M3	M4	PL	X	TOTAL
THAL	1.5814	0.0541	0.0399	0.3674	1.7930	11.0331	5.6308	6.7150	0.0000	27.2145
PATH	0.0091	0.3025	0.0000	0.0255	1.4651	0.9619	0.4502	6.3033	0.0000	9.5176
CHIR	0.0955	0.3837	0.0811	0.0145	0.7864	0.2085	0.0000	10.7528	0.0993	12.4217
ERNA	0.6188	1.5522	0.0660	0.3703	2.1734	1.2788	0.1226	5.6923	0.0000	11.8743
HOSD	0.0588	0.1408	0.1939	0.1391	0.4702	0.7440	0.2952	15.3066	0.2490	17.5976
KART	2.0508	3.2229	0.3435	0.5436	3.9899	7.4884	0.2629	2.5537	0.0000	20.4556
KOCH	0.0000	1.5598	0.1877	0.4778	0.7662	1.5590	0.3680	19.5019	0.3165	24.7370
KOLL	0.0000	0.4281	0.4290	0.1041	0.7968	1.2523	0.1189	33.7771	0.0000	36.9064
KOTH	0.0155	0.9977	0.0000	0.0000	2.6557	0.8380	0.1523	26.0405	0.0000	30.6997
KOTT	0.6644	6.7922	1.0326	4.9800	10.0707	11.3024	6.3643	8.9000	0.7146	50.8213
KUNN	1.2483	10.5647	0.5561	0.2404	5.2130	7.9580	0.5627	13.8217	0.1272	40.2921
MUVA	0.4194	5.0714	0.2018	0.4166	1.6746	2.4516	0.4333	21.0824	0.0676	31.8187
NEDU	0.0000	0.2766	0.0000	0.2213	1.0441	0.5677	0.2672	4.2000	0.0000	6.5768
NEYY	0.0000	4.8872	0.4482	0.3733	2.7064	3.1646	0.3777	12.0350	0.0000	23.9924
PARU	0.0105	1.2345	0.1423	0.0502	2.5249	1.4979	0.4082	19.0754	0.0000	24.9439
PERI	0.2185	1.2523	0.2163	0.1541	0.0796	0.4849	0.0508	30.2715	0.0085	32.7365
VAIK	0.0000	1.2626	0.0000	0.0862	1.6678	0.5148	0.2630	18.9562	0.0000	22.7506

PATH-Pathanapuram, KOTH-Kothamangalam, HOSD-Hosdurg, ERNA-Ernad, KUNN-Kunnathunad, PERI-Perinthalmanna, KOTT-Kottarakkara. MUVA-Muvattupuzha, PARU-Parur, NEYY-Neyyattinkkara, CHIR-Chirayinkil, KOLL-Kollam, THAL-Thalappily, VAIK-Vaikam, KART-Karthikappally, NEDU-Nedumangad, KOCH-Kochi

Wood Utilization Classes:
T- Primarily timber yielding species M-Multiple use species PL-Palms X-Uses other those listed above.(1,2,3,4-Classification based on natural durability : 1-Very durable, 2-Durable, 3-Moderately durable, 4-Perishable)

Table 4. Fuelwood Volume of Growing stock of Trees in Homesteads of selected Thaluks in Kerala State
(volume in m^3/ha overbark)

Taluk	T1	T2	T3	T4	M2	M3	M4	PL	X	TOTAL
NEDU	0.1917	1.2189	0.1081	0.5586	2.2950	2.0987	0.7563	15.6962	0.0873	23.0107
PERI	1.1339	3.6182	0.4701	0.8104	0.1401	1.6051	0.4903	18.9171	0.1322	27.3174
HOSD	0.2546	0.3216	0.6486	0.3025	0.6898	1.5341	0.8693	24.2034	0.4063	29.2302
PATH	0.3256	0.7700	0.0869	0.0372	2.5398	1.9412	1.8203	21.8146	0.0000	29.3356
ERNA	2.1532	2.7309	0.4456	0.4273	2.6662	2.3156	0.7635	24.5653	0.0175	36.0850
KOCH	0.0024	3.2663	0.9787	1.0318	1.0261	2.8278	0.8846	26.9783	0.8913	37.8872
KART	3.0224	5.3412	0.8445	0.7254	8.6947	14.2724	0.3149	8.1408	0.0000	41.3561
THAL	2.0485	0.1167	0.0583	0.9064	2.9308	15.3338	7.5915	14.1186	0.0000	43.1045
MUVA	0.9259	8.5439	0.2882	0.7284	2.4290	4.6938	1.0703	26.0762	0.2363	44.9920
PARU	0.0825	2.1693	0.5043	0.1486	3.9762	2.3924	1.0011	38.6968	0.0398	49.0109
NEYY	0.0000	6.1369	1.9812	0.4125	3.3111	4.4187	0.7941	38.5860	0.0000	55.6404
CHIR	0.3777	1.4675	0.1807	0.0881	1.3897	0.9730	0.2273	55.2116	0.3677	60.2831
KOTT	1.1475	9.8420	1.4469	6.5049	11.9124	16.3124	13.1162	29.3000	0.8784	70.4606
KOLL	0.0872	1.4298	0.4846	0.4526	1.5797	2.5301	0.9279	60.0000	0.0552	67.5472
KOTH	0.2596	1.1269	0.0000	0.0291	3.5388	1.5404	0.6289	61.0026	0.0000	68.1263
VAIK	0.0106	3.6446	0.0440	0.1900	2.9228	1.8423	0.8807	64.1194	0.0019	73.6563
KUNN	2.1677	15.4448	0.5948	0.3991	7.8163	13.9235	2.1468	42.7634	0.6659	85.9224

PATH Pathanapuram, KOTH-Kothamangalam, HOSD-Hosdurg, ERNA-Ernad, KUNN-Kunnathunad, PERI-Perinthalmanna, KOTT-Kottarakkara, MUVA-Muvattupuzha, PARU-Parur, NEYY-Neyyattinkkara, CHIR-Chirayinkil, KOLL-Kollam, THAL-Thalappily, VAIK-Vaikam, KART-Karthikappally, NEDU-Nedumangad, KOCH-Kochi

Wood Utilization Classes:
T- Primarily timber yielding species, M-Multiple use species, PL-Palms, X-Uses other those listed above.(1,2,3,4-Classification based on natural durability : 1-Very durable, 2-Durable, 3-Moderately Durable, 4 Perishable)

b. SHADE TREES OF CARDAMOM PLANTATIONS - A PHYTOSOCIOLOGICAL ANALYSIS

Cardamom (Elettaria cardamomum (L.) Maton) is an important spice crop of our country. Kerala accounts for about 70 per cent of the total annual production (3450 metric tonnes) and about 60 per cent of the 93947 ha of cardamom lands in India (Kunju, 1991). Hitherto, India had a near monopoly in cardamom production. However, of late, Guatemala, which has extensive untapped natural forests and where labour is cheap, has emerged as a major competitor, and indications are that they may soon capture some of the important segments of the traditional markets dominated by India.

Cardamom plantations ("cardamom hill reserves" in forestry parlance) were established in the Western Ghats after clearing the moist tropical forests, the natural home of cardamom. Consequently a great deal of disturbance was caused to the ecosystem (Cherian, 1977). Regulation of shade is probably the most crucial operation in cardamom cultivation. This involves selective removal of trees to facilitate light penetration (about 40-60 per cent) to the understorey. Cardamom thrives well only under optimal light conditions, too much or too little shade inhibits its growth. Shade acts as a moisture and temperature regulator, thus creating the microclimatic conditions favourable for the growth and development of cardamom (Abraham et al, 1979; FAO, 1984). Long term viability of cardamom plantations depends mainly on the maintenance of ideal light and moisture conditions (FAO, 1984). Shade management of cardamom plantations, therefore, constitutes an important, but vastly neglected area. There is also a great diversity of tree species that are used as shade trees in cardamom plantations. Species diversity varies from place to place. But there is very little documented information on this aspect (see: Tejwani, 1987).

Hence an attempt was made to analyze the structural and floristic aspects of shade trees in cardamom plantations. Another objective of the study was to document the major shade trees of cardamom estates.

Fifty random 10 m x 10 m quadrats were established in the cardamom plantations at Pampadumpara in Kumili forest range (between 9° 25' and 9° 57' N latitude, 76° 20' and 76° 21' 45" E longitude; Kerala state). The terrain is very rugged and the soils are inceptisols of varying depths. The climate is characteristically hot and humid with a mean annual precipitation of 2800 mm. The maximum mean daily temperature during the hottest month of March is about 35° C and mean daily minimum during the coldest month of January is about 16°C. All trees (≥10 cm GBH) in the 0.5 ha were enumerated by measuring the height and girth at breast height (GBH) using a Suunto optical reading clinometer and a tape, respectively. The social status of individual trees were also evaluated by grouping the trees into crown classes such as dominants (trees which form the upper most leaf canopy and have their leading shoots free), codominants (the slightly shorter dominants), intermediates (trees which do not form part of the upper most canopy but the leading shoots of which are not definitely overtopped by the neighbouring trees) and suppressed (trees with their leading shoots overtopped by their neighbors).

The following parameters (see: Curtis and McIntosh, 1950; Simpson, 1949) were also worked out: Frequency (number of individuals of the 'i'th species), Relative Frequency (Number of quadrats of occurrence x 100/number of occurrences of all species), Density (number of individuals of the species 'i' per hectare), Relative Density (Number of individuals of a species x 100/number of individuals of all species), Basal Area ($GBH^2/4$'PI'), Relative Basal Area (Basal area for the species x 100/ Basal area for all species), Importance Value Index (Relative Density + Relative Frequency + Relative Basal Area) and Simpson's Floristic Diversity Index ($D = 1-[\sum_{i=1}^{s} (n_i/N)^2]$ where, D = Simpson's Index; S = total number of species, n_i= number of individuals of ith species, N = total number of individuals in the plot).

Floristic composition and diversity

A total of 40 tree species were encountered in the 0.5 ha sampling area at Pampadumpara (Table 5). *Vernonia arborea* had a maximum observed density of 146 trees per hectare (28 per cent of the individuals), closely followed by *Artocarpus heterophyllus* with 21 per cent of the individuals (112 trees per hectare). Other predominant species (having a density of more than 10 trees per hectare) included : *Actinodaphne malabarica*, *Persea macrantha*, *Cinnamomum malabatrum*, *Cedrela toona*, *Prunus ceylanica*, *Erythrina lithosperma*, *Bischofia javanica*, *Chionanthes malabarica*. *Macaranga peltata* and *Mallotus albus*. A large number of species (20), however, were represented only once or twice in the sampling area. This included as many as six exotics (see:

Table 5. Phytosociological parameters (Frequency, Relative Frequency, Density, Relative Density, Basal Area, Relative Basal Area and Importance Value Index (IVI)) of different shade trees in the cardamom plantations of Pampadumpara.

Species	Frequency	Rel. Frequency	Density (no ha^{-1})	Rel. Den.	Basal Area ($m^2 ha^{-1}$)	Rel. Basal Area	IVI
Vernonia arborea Ham.	73.0	20.99	146	27.97	11.35	45.64	94.60
Artocarpus heterophyllus Lamk.	56.0	16.02	112	21.46	2.19	8.80	46.28
Actinodaphne malabarica Balak	13.0	6.08	26	4.98	0.62	2.49	13.55
Persea macrantha (Nees) Kosterm.	13.0	6.63	26	4.98	1.06	4.27	15.88
Cinnamomum malabatrum (Burm.f)Bl.	10.0	4.42	20	3.83	0.14	0.57	8.83
Cedrela toona Roxb.	8.0	3.31	16	3.07	0.74	2.98	9.36
Erythrina lithosperma Bl. ex Miq.	7.0	3.86	14	2.68	1.01	4.05	10.61
Prunus ceylanica (Wt) Miq.	7.0	2.76	14	2.68	0.48	1.93	7.38
Bischofia javanica Bl.	6.0	2.21	12	2.30	0.06	0.25	4.76
Chionanthes malabarica (Wall ex G.Don) Bedd.	6.0	3.31	12	2.30	0.15	0.60	6.22
Macaranga peltata (Roxb.) M.-A.	5.0	1.66	10	1.92	0.24	1.00	4.57
Mallotus albus auct. non M.-A.	5.0	2.76	10	1.92	0.51	2.05	6.73
Acrocarpus fraxinifolius Wt.&Arn.	4.0	2.21	8	1.53	0.06	0.25	3.99
Alseodaphne semecarpifolia Nees.	4.0	1.66	8	1.53	0.32	1.29	4.48
Clerodendrum viscosum Vent.	4.0	1.10	8	1.53	0.06	0.25	2.88
*Grevillea robusta A. Cunn.	4.0	2.21	8	1.53	0.07	0.30	4.04
*Maesopsis eminii Engl.	3.0	1.66	6	1.15	0.17	0.70	3.50
Euodia roxburghiana Benth.	3.0	1.66	6	1.15	0.48	1.92	4.73
*Swietenia macrophylla King	3.0	1.66	6	1.15	0.01	0.05	2.86
Cinnamomum keralense Kosterm.	2.0	1.10	4	0.77	0.09	0.34	2.22
Myristica beddomei King	2.0	1.10	4	0.77	1.98	7.98	9.85
*Paraserianthes falcataria (L.) Nielsen	2.0	1.10	4	0.77	0.14	0.57	2.44
Vateria indica L.	2.0	1.10	4	0.77	0.16	0.63	2.50
Syzygium cumini (L) Skeels	2.0	0.55	4	0.77	0.86	3.44	4.76
Tectona grandis L.f.	2.0	0.55	4	0.77	0.20	0.83	2.15
*Acacia auriculiformis A. Cunn ex Benth.	1.0	0.55	2	0.38	0.01	0.04	0.97
Clausena heptaphylla W.&A.	1.0	0.55	2	0.38	0.002	0.01	0.94
Dalbergia latifolia Roxb.	1.0	0.55	2	0.38	0.06	0.23	1.16
Ficus tsjahela Burm.f.	1.0	0.55	2	0.38	0.12	0.48	1.42
Gmelina arborea Roxb.	1.0	0.55	2	0.38	0.67	2.69	3.63
Grewia tiliifolia Vahl.	1.0	0.55	2	0.38	0.24	0.98	1.92
Holigarna arnottiana Hk. f.	1.0	0.55	2	0.38	0.01	0.05	0.98
Lagerstroemia microcarpa Wt.	1.0	0.55	2	0.38	0.09	0.36	1.30
Mallotus philippensis (Lamk) M.-A.	1.0	0.55	2	0.38	0.13	0.54	1.48
Mangifera indica L.	1.0	0.55	2	0.38	0.02	0.08	1.02
Mesua ferrea auct. non L.	1.0	0.55	2	0.38	0.11	0.43	1.37
Olea dioica Roxb.	1.0	0.55	2	0.38	0.05	0.19	1.12
Pterocarpus marsupium Roxb.	1.0	0.55	2	0.38	0.08	0.32	1.25
*Spathodea companulata Beaux.	1.0	0.55	2	0.38	0.002	0.01	0.94
Sterculia guttata Roxb.	1.0	0.55	2	0.38	0.10	0.41	1.35
Total	261		522		24.84		

*exotics

Table 5) alongwith a number of deciduous tree species (e.g. Tectona grandis, Gmelina arborea, Grewia tiliifolia, Lagerstromea microcarpa, Pterocarpus marsupium, etc.).

The basal area of the stand was 24.04 m^2 ha^{-1}, about 46 per cent of which was made up of a single species viz. V. arborea, a medium sized tree of the family asteraceae (Table 5). It yields a pale brown, smooth, durable, straight grained and moderately hard wood suitable for wooden boxes, match boxes and house building, but splits easily and is most commonly used as fuel (CSIR, 1976). It has an IVI of 94.6 (Table 5). Four more of the 40 species had importance value indexes greater than 10. They are: A. heterophyllus, P. macrantha, A. malabarica and E. lithosperma. This clearly indicates the dominance of a small number of species in the stand. Asteraceae, Lauraceae, Moraceae and Fabaceae in the decreasing order had the largest four family importance value indexes.

The density dependent Simpson's floristic diversity index (D) was 0.86, implying that 14 out of the 100 pairs taken at random are composed of the same species. This however, is considered to be some what low for a wet evergreen forest ecosystem (where D is usually more than 0.90).

Dominance of a smaller number of species in the stand and the relatively low floristic diversity can be attributed to the continued anthropogenic pressure coupled with the creation of large sized openings, characteristic of cardamom plantations in the Western Ghats, which probably brought about shifts in the regeneration pattern of trees. Most of the seedlings and young trees of sciophytic species cannot survive in the drastically modified environment and they gradually die. The growth of heliophilic and light tolerant species (e.g. V. arborea, A. heterophyllus. P. macrantha, C. malabatrum, L. microcarpa, M. indica, M. peltata, L. indica, M. philippensis etc.), both ever green and deciduous is, however, favoured.

The species that occupy the site after the disturbance (thinning, clearing etc.) are generally characterized by a rapid growth rate, produce tender wood and are normally absent in the homeostatic phases except for a few adult individuals scattered in the formation (Pascal, 1988). Their seeds are probably present on the forest floor even before the opening, but they normally do not grow under a dense forest cover. Their germination is initiated by the microclimatic modifications caused by the opening. Early colonizers also reinvade the site through the stochastic event called 'seed rain' (see: Whitmore, 1983) and they decide further shifts in dominance, provided continued disturbances are not occurring. However, recruitment of additional species probably may be inhibited by the continued manipulation/disturbance for cardamom cultivation and hence the sequential recruitment or replacement of species which one might expect in a normal secondary successional situation might not operate in the cardamom hill reserves.

Vegetation structure

Stand physiognomy of the cardamom plantations was distinctly different from that of natural forests. The wet evergreen forests are usually characterized by a multi-tiered stand structure.

However, the tree cover in most of the cardamom areas comprise mostly of a monolayer of intermediate trees (see: Fig 3). Fig 4 also highlights the fact that height classes in the range of 10-20 m are predominant. Other height classes are ill-represented probably because the lower strata trees and shrubs were systematically eliminated in the process of cardamom cultivation. The emergent trees have disappeared from the site due to continued exploitation. Due to the 'domino effect' gaps created by the death of the top canopy trees seldom get covered. Weeding and/or other cultural practices preclude understorey tree regeneration in cardamom plantations. The cumulative effect would be decline in cardamom productivity in the long run due to the alteration in the physical environment. It also may bring about ecological degradation of the site.

The diameter frequency distribution (Fig. 5) tend to follow an inverse 'J' shaped distribution, characteristic of the uneven aged stand structure, except for the <10 cm diameter at breast height (DBH) class. Lower frequency in the <10 cm DBH class is a direct consequence of the stand manipulation for growing cardamom. Implicit in the lower frequency of this size class is the regeneration problems/stand manipulation to check the under-growth of trees. Systematic exploitation at frequent intervals to remove trees, regulate canopy etc., thus modifies the stand structure by introducing a simplification in the distribution of ages of the individuals.

Project ii) Collection and evaluation of promising species/cultivars of fuel, fodder and small timber species.

Fig. 3. Frequency distribution showing the social status of shade trees in a 0.5 ha of cardamom plantation

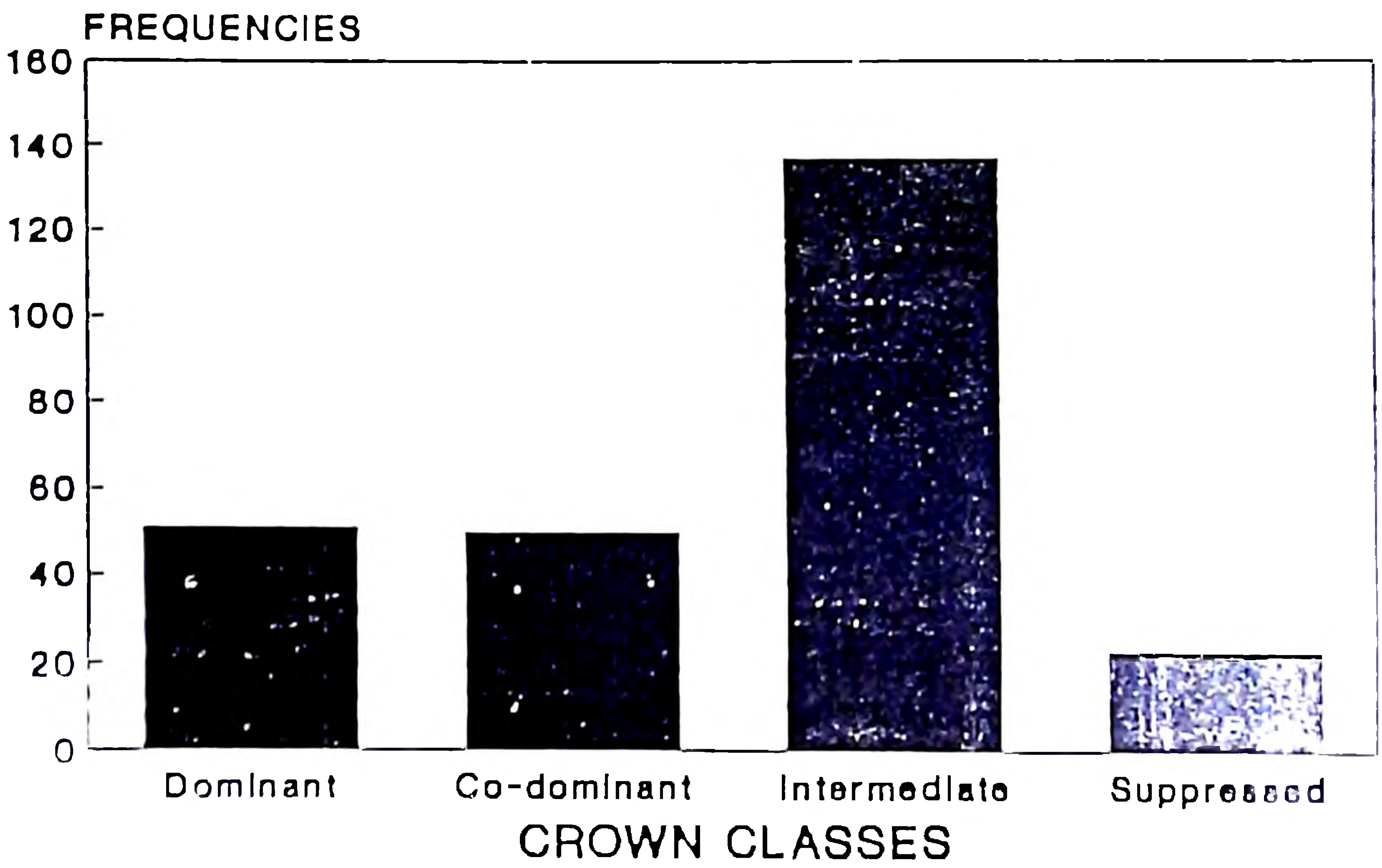
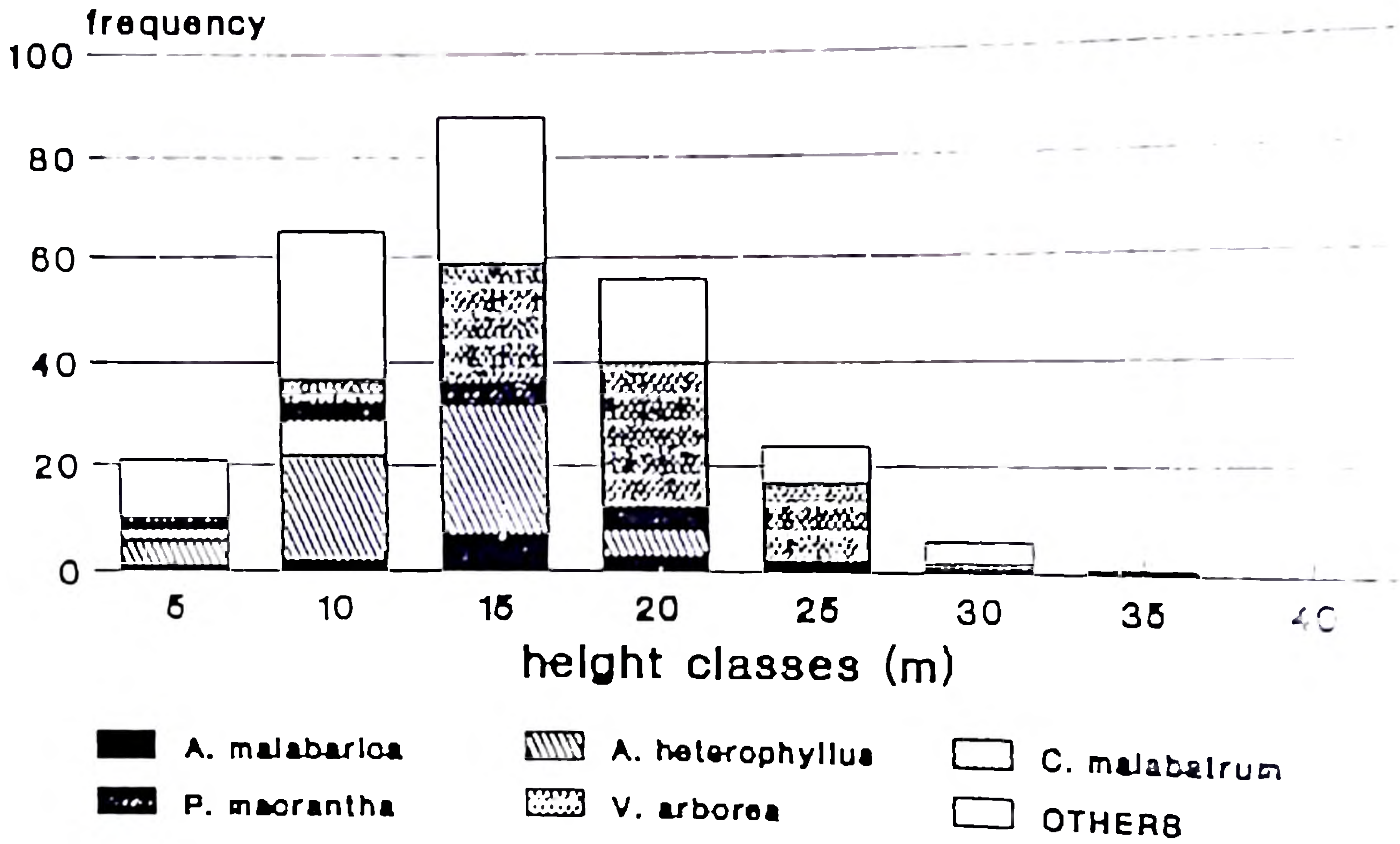
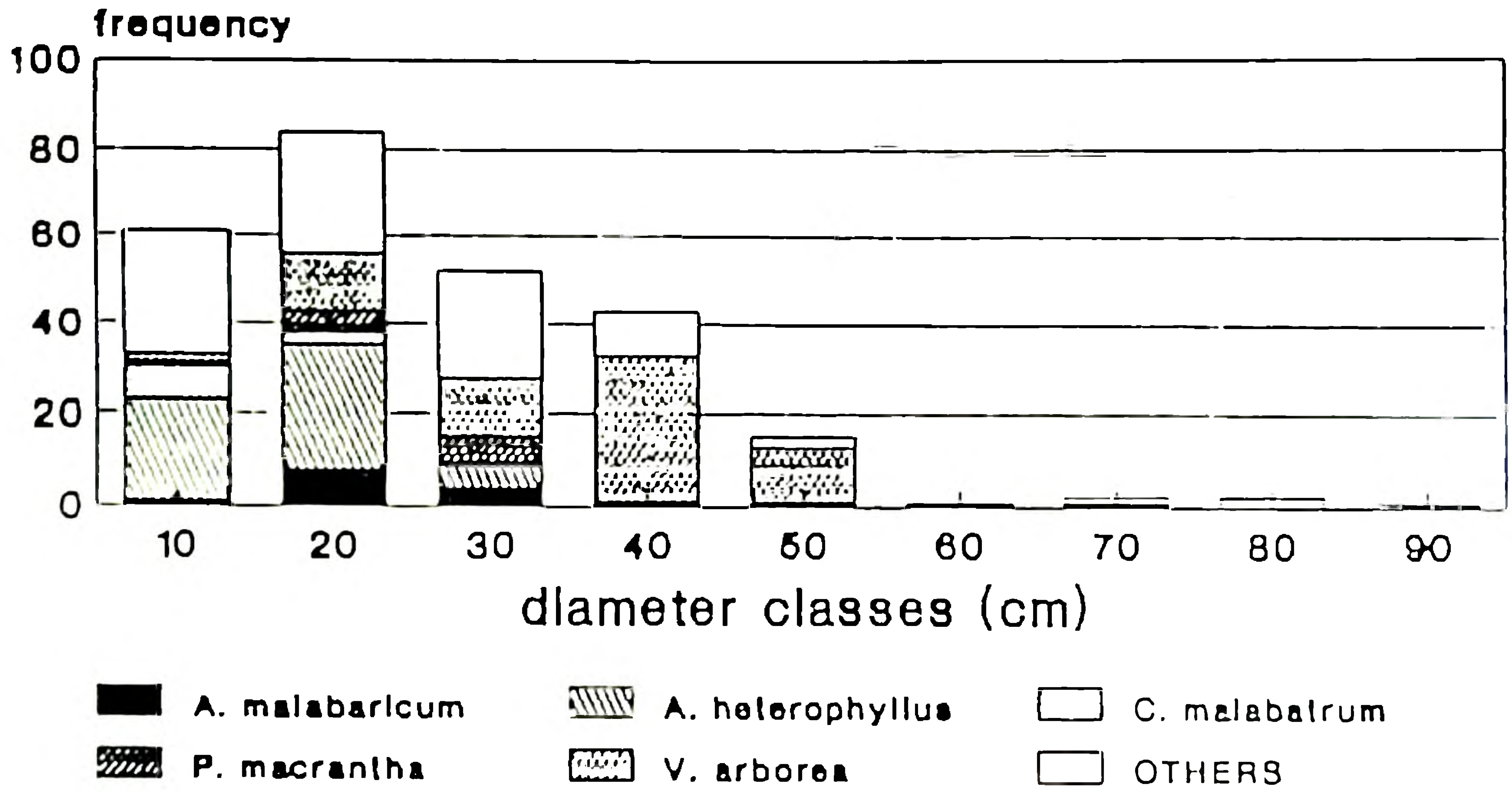


Fig. 4. Height distribution of shade trees in a 0.5 ha of cardamom plantation



only those species having more than 10 individuals in 0.5ha are represented

Fig. 5. Diameter distribution of shade trees in a 0.5 ha of cardamom plantation



Only those trees having more than 10 individuals in 0.5 ha are represented

Ten fast growing multi-purpose tree species were compared in a randomized block experiment to identify suitable multi-purpose tree species, since 1985. The results indicate that Acacia auriculiformis recorded the highest tree height (16.18 m in March 1992). However, highest radial growth was recorded by (51.26 cm collar girth in March 1991) Paraserianthes falcataria. The mean annual volume increment followed the order: Acacia auriculiformis> Paraserianthes falcataria> Casuarina equisetifolia> Artocarpus heterophyllus> Emblica officinalis> Ailanthus triphysa> Artocarpus hirsuta> Leucaena leucocephala> Pterocarpus marsupium.

In another related study the litter dynamics in Acacia auriculiformis stands was characterized. Acacia auriculiformis A. Cunn. ex. Benth., is the single most important exotic tree species that has been extensively planted under the Social Forestry programmes of Kerala State. A native of Australian continent, acacia is characterized by fast growth, high biomass production, ever green habit, high calorific value (20450 KJ kg^{-1}; NAS,1980) and ability to withstand adverse edaphic and climatic conditions. The social forestry component incidentally was added to the forestry programmes of the state during the early eighties primarily to augment the fuel and timber availability to the rural masses, especially after the landsat data on depleting closed canopy forest cover became public.

However, indiscriminate planting of this species under the garb of afforestation, has invited adverse criticism from the environmental activists, who consider the persistent litter and the consequent reduced decay rates, low nutrient turn over, and possible allelopathic effects as potent disadvantages of this exotic species.

Cycling of organic matter through litter fall and its subsequent decay are important mechanisms of soil restitution, both under natural forests and in man made plantations. Furthermore, considerable amount of nutrients are also returned to the soil through the litter-route and made available for reabsorption (see: Kumar and Deepu, 1992). However, only anecdotal information exist in the literature concerning the litter dynamics of acacia. In view of this an attempt was made to characterize the dynamics of litter fall and litter decay in an even aged stand of acacia.

The study on quantification of litter fall was conducted in a six year-old Acacia auriculiformis plantation established by the Social Forestry Wing of the Kerala State Forest Department at Pullazhi (10° 30' N latitude and 76° 20' E longitude and 15 m above mean sea level), near Thrissur over an area of about four hectares (the Pu site). The study on litter decay was conducted at Vellanikkara (the Ve site; 10° 32' N latitude, 76° 16' E longitude and 22.5 m above mean sea level).

At the Pu site, containerized Acacia auriculiformis seedlings were planted during 1984 at a spacing of 2mx 2m. The trees were having an average height of about 14 m and an average breast height diameter of about 9.5 cm at the time of the present study (six years of age). At the Ve site also the trees were of approximately of the same size and age, but was planted in an irregular fashion.

For litter collection 20 specially designed circular litter traps each having an area of $Ø.24m^2$ and 15 liter capacity (see: Hughes et al, 1987), made of four 21Ø cm long (2-3 mm in thickness) galvanized iron wires, were installed at the Pu site in January 199Ø, in a random manner (at a uniform height of Ø.75 cm above the ground level). Each trap essentially consisted of a hoop with 55 cm diameter made by overlapping and firmly tying the ends of one of the iron wires and a tripod (made using the remaining three galvanized wires). The hoop was tied horizontally on to the tripod and a plastic grain bag was also attached to the inside of the wire hoop with its tapering end downwards.

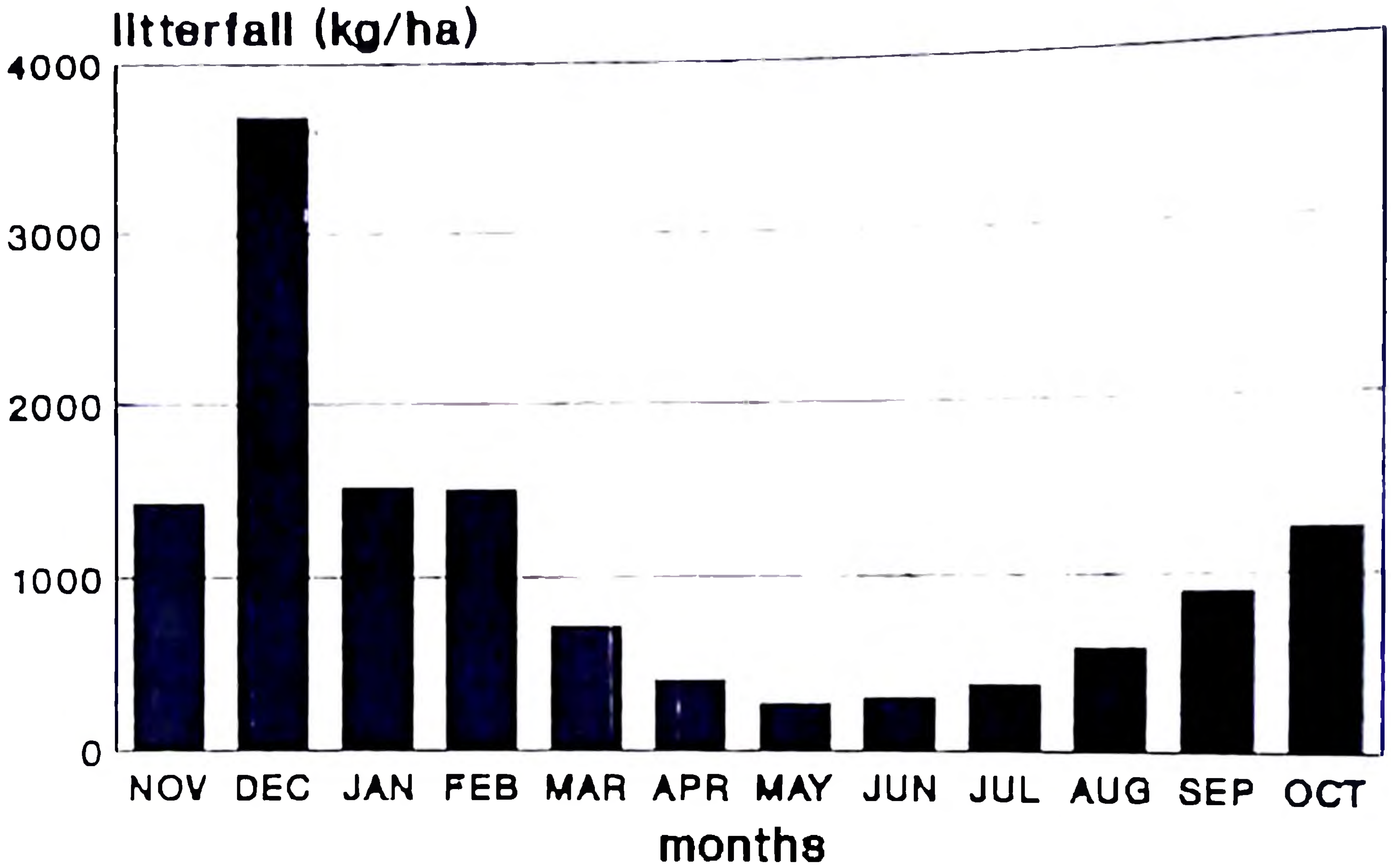
Litter was collected from each trap at monthly intervals during the period from February 199Ø to October 1991. The samples were oven dried ($7Ø^{\circ}$ C for 48 h), weighed and the mean litter fall on unit area was computed for each month. The litter samples were also periodically analyzed for nitrogen, phosphorus and potassium contents following the procedures of Jackson (1967).

The standard litter bag technique was adopted for characterizing litter decomposition dynamics. Twenty g samples of freshly fallen leaves of acacia, collected from Vellanikkara during January 199Ø and dried under shade for about 48 h, were transferred to nylon mesh bags (4 mm). Litter moisture contents were also simultaneously determined on six replicate samples and the dry weights of the samples in the litter bags were calculated. A total of eighty such litter bags (16 months x 5 replications) were placed in the litter layer of the acacia plantation at the Ve site during January 199Ø and anchored to painted stakes to facilitate easy detection. Litter bags were retrieved at monthly intervals and the oven dry weights of the contents determined after removing the extraneous materials under running cold water. The model for constant potential weight loss (Olson, 1963) was fitted to the data on mass disappearance.

Litterfall

The average annual litter fall was estimated to be 12.99 t ha^{-1} with a mean monthly value of 1.08 t ha^{-1} (range: 0.27 to 3.69 t ha^{-1}). Seasonal variations in the litter production rates was also very pronounced ($p=0.01$; F ratio for months: 610; Fig. 6). In general, it followed a monomodal distribution pattern with a distinct peak in December (28.5 % of the total detritus production). The period from September to February accounted for bulk of the annual litter production (79.8%). Most of the indigenous tree species of this region also had a peak detritus production rate during the period from December to April (see: Kumar and deepu, 1992). However, summer months (March, April, May) were lean periods as far as acacia litterfall was concerned. Litter production remained markedly low during this period and continued to be so until the end of the south-west monsoon (June to August). The December collection, moreover, was characterized by a high proportion of pods and twigs, which may be attributed to the high velocity winds prevailing during this period. However, attempts made to correlate litter fall to climatological parameters particularly with mean monthly rain fall and pan evaporation rates suggested no strong relationships (r values were 0.27 and 0.18 respectively), implying a strong genetic

Fig. 6 Seasonal variations in acacia litterfall



control of the phenological parameters such as litter fall in acacia.

Litter decay

Regarding litter decomposition dynamics, the biomass remaining in the litter bags exhibited an inverse 'J' shaped exponential pattern of decline (see: Fig. 7; decay rate coefficient for 16 months, k = Ø.28). Up to about 9Ø per cent of the litter contents disappeared in about six months time. Nevertheless, residual biomass were present in the bags up to the end of the study period (sixteen months). Although in comparison to the native species (see: Kumar and Deepu, 1992), acacia litter residues exhibited a relatively longer longevity, but it cannot be construed as wholly persistent or recalcitrant. Nevertheless, they may remain on the soil surface for a relatively longer period of time as evidenced by the lack of total disappearance of litter even after 16 months.

Litter decomposition is by and large a function of the soil moisture availability, atmospheric temperature and above all, the biochemical quality (lignin:nitrogen ratio) of the litter. Although the biochemical quality of acacia litter is considered to be inferior (low nitrogen contents and possibly high lignin contents) under the warm humid tropical climate they may decompose reasonably well.

Nitrogen and phosphorus contents of the composite litter samples were highest in December, which can probably be attributed to the abundance of pods/seeds in the litter, which are usually potent nutrient sinks. As regards to potassium,

Fig. 7 Biomass remaining in the litter bags at various time intervals

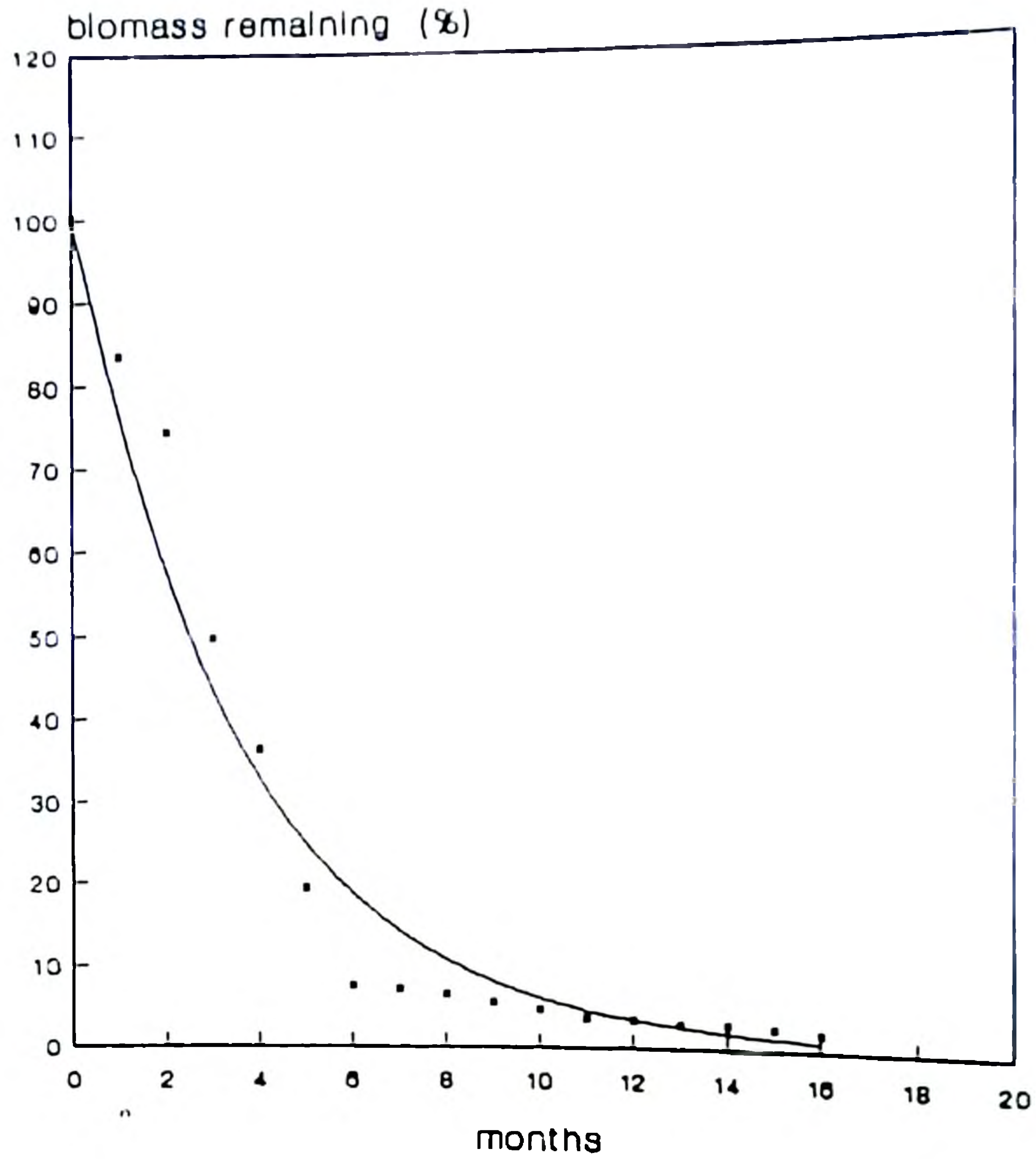


Table 6. Monthly variations in the nutrient concentrations of <u>Acacia auriculiformis</u> litter collected during the period from November 1990 to October 1991.

Month	nutrients (% dry weight)		
	N	P	K
November	1.20 (0.01)	0.010 (0.001)	0.19 (0.005)
December	1.67 (0.01)	0.031 (0.002)	0.30 (0.005)
January	1.33 (0.01)	0.016 (0.001)	0.27 (0.004)
February	1.12 (0.03)	0.006 (0.001)	0.20 (0.004)
March	1.19 (0.02)	0.007 (0.001)	0.22 (0.00)
April	1.25 (0.03)	0.012 (0.001)	0.23 (0.004)
May	1.33 (0.01)	0.017 (0.001)	0.22 (0.004)
June	1.45 (0.02)	0.013 (0.002)	0.24 (0.005)
July	1.37 (0.01)	0.013 (0.002)	0.25 (0.005)
August	1.24 (0.01)	0.017 (0.001)	0.23 (0.004)
September	1.19 (0.01)	0.009 (0.002)	0.36 (0.005)
October	1.25 (0.01)	0.011 (0.002)	0.21 (0.009)

Values in parenthesis indicate standard error of mean.

September registered the peak value (Table 6). September incidentally represents a period of profuse flowering in acacia and naturally the litter also contained substantial amounts of floral parts, which are generally rich in potassium contents (see: Crawford, 1976).

Relatively lower contents of nitrogen and phosphorus were obtained during the dry period. This may be attributed to an efficient re-translocation mechanism operating to re-capture the nutrients from the senescing plant parts. Probably re-translocation is more efficient during the summer season, when the reduced soil moisture availability restricts nutrient uptake. Nutrient release through litter decomposition is also generally low during this period. So when soil nutrient availability is low, the retranslocation mechanisms are probably more efficient.

Project iii) Studies on management practices of Agroforestry systems.

a) Spatial arrangement and harvesting schedule in silvo-pastoral systems

An experiment was laid out during June 1989 with <u>Leucaena leucocephala</u> and guinea grass. The objective here was to standardize the planting geometry of leucaena and the harvesting schedule of both components. The experimental variables consisted of factorial combinations of four spatial arrangement and four harvesting schedules with three replications. There were regeneration problems as far as leucaena was concerned and hence gap filling was carried out during 1990. The fodder yield is being continuously recorded.

b) Compatibility of different components in silvi-pastoral system.

Factorial combinations of four multi-purpose trees (Leucaena leucocephala (Lam.) de Wit., Casuarina equisetifolia L., Acacia auriculiformis A Cunn. ex Benth. and Ailanthus malabarica DC) and four fodder species (Hybrid napier- Pennisetum purpureum Schm., Guinea grass- Panicum maximum Jacq., Congo signal-Brachiaria ruziziensis Griseb. and Teosinte-Euchlaena mexicana Schrad.) were evaluated in silvo-pastoral system. The main objective of this experiment is to find out the most suitable combinations of tree and fodder species for silvo-pastoral systems and to evaluate the growth and productivity of various fodder crops.

^{32}P solution was injected into the soil at different depths (25 cm, 50cm) and at different lateral distances (15 cm and 50 cm) at the rate of 0.05 mCi per plant to elucidate the nature of root interaction among the different tree and grass components described earlier and the radioactivity recovered in foliage samples collected at 15 and 30 days interval from the treated and neighboring plants were analyzed after wet digestion in a liquid scintillation system. Only data pertaining to the 15 days after treatment are presented here.

A comparison of the leaf ^{32}P concentrations of the grass and tree combinations (Table 7) suggest that grasses in general had a higher ^{32}P activity compared to trees and grass monocultures exhibited a significantly higher radio-activity than grass-tree combinations implying that there may be competition for below ground site resources such as water and nutrients between the

Table 7. Mean recovery of ^{32}P in the leaves ($\log_e$ cpm g^{-1}) of different forage grasses and multi-purpose trees as influenced by lateral distances and depth intervals at 15 days after application.

Tree-grass combinations	Tree	Grass
Acacia-congo signal	5.35	7.60
Acacia-guinea grass	5.18	7.66
Acacia-hybrid napier	5.22	8.34
Acacia-teosinte	5.09	6.24
Casuarina-congo signal	3.84	7.87
Casuarina-guinea grass	4.56	7.63
Casuarina-hybrid napier	4.48	9.82
Casuarina-teosinte	3.93	5.86
Leaucaena-congo signal	6.01	6.25
Leaucaena-guinea grass	5.34	7.55
Leaucaena-hybrid napier	5.36	8.37
Leaucaena-teosinte	5.90	6.20
Ailanthus-congo signal	4.82	7.66
Ailanthus-guinea grass	3.70	7.73
Ailanthus-hybrid napier	4.26	8.06
Ailanthus-teosinte	4.60	6.74
Monocultures		
Acacia	5.51	-
Leucaena	4.98	-
Casuarina	2.95	-
Ailanthus	4.48	-
Congo signal	-	9.37
Guinea grass	-	9.19
Hybrid napier	-	9.08
Teosinte	-	8.33
SEm	0.238	0.302
CD(0.05)	0.661	0.836
Lateral distances (cm)		
15	5.33	8.79
50	5.28	8.78
Depth intervals (cm)		
25	4.52	7.05
50	3.98	6.49
SEm	0.107	0.135
CD(0.05)	0.296	0.374
Interaction CD	-	1.672
CV	17.3%	13.44%

Table 8. Tree height, girth at breast height (GBH) and forage yield under different tree-grass combinations during the fifth of experimentation.

	Height (m)	GBH (cm)	Fodder Yield (t/ha)
Acacia auriculiformis			
Congo signal	9.857	27.167	11.089
Guinea grass	9.000	21.467	16.222
Hybrid napier	1.000	30.500	24.556
Teosinte	10.033	24.600	22.222
Casuarina equisetifolia			
Congo signal	8.367	17.733	15.942
Guinea grass	6.100	17.133	20.111
Hybrid napier	7.667	14.767	44.627
Teosinte	8.100	15.767	23.878
Leucaena leucocephala			
Congo signal	7.867	19.100	7.067
Guinea grass	8.933	20.600	13.833
Hybrid napier	7.167	14.733	20.139
Teosinte	8.767	21.767	11.333
Ailanthus triphysa			
Congo signal	3.933	15.000	16.106
Guinea grass	3.533	13.500	37.328
Hybrid napier	3.733	16.233	41.044
Teosinte	4.150	18.900	24.389
Grass monocultures			
Congo signal	-	-	30.778
Guinea grass	-	-	57.889
Hybrid napier	-	-	81.500
Teosinte	-	-	28.556
COMPARISON OF TREE MEANS			
SE	0.304	1.384	1.388
CD (0.05)	0.705	3.218	3.227
COMPARISON OF FODDER MEANS			
SE	0.304	1.384	1.241
CD (0.05)	NS	NS	2.887
COMPARISON OF INTERACTION EFFECTS			
SE	1.413	2.767	2.775
CD (0.05)	0.608	NS	6.455
CV	14.24%	24.82%	17.52%

compnents of the silvi-pastoral system. Among the various combinations of grasses and trees, hybrid napier consistently registered high values of ^{32}P in the leaves, probably suggesting that this forage species can endure competition with trees to a great extent. Among the trees also there were significant variations as far as radio-activity was concerned. Casuarina and ailanthus registered significantly low ^{32}P activity suggesting that the competitive influences of these trees are probably of a lesser magnitude.

The results of the field trial also revealed that growth and yield of fodder species were significantly influenced by the tree components only after canopy formation. All fodder species grown in association with C. equisetifolia and A. malabarica recorded comparatively higher forage yields even after canopy formation. Acacia recorded the highest tree height and girth at breast height (Table 8).

C) Utility of some fast growing trees as pepper standards : Part 1- raised from cuttings

An RBD experiment with three replications having three species of erythrina (E. indica Lam., E. stricta Roxb. and E. lithosperma Bl. ex Miq.) were compared with four other multipurpose tree species (Garuga pinnata Roxb., Gliricidia sepium (Jacq.) Walp., Moringa oleifera Lam. and Thespesia populnea (L) Soland ex Correa) in cultural systems involving black pepper (Piper nigrum L.) at Thruvazhamkunnu since 1988.

Pepper trained on E. indica recorded the highest dry pepper yield (589 kg ha^{-1} in 1991) followed by G. sepium, while E. stricta registered the maximum radial growth of trees. Mean tree height, however, followed the order G. sepium > G. pinnata > E. lithosperma > E. stricta > E. indica > M. oleifera > T. populnea. The differences in terms of pepper yield were, however, statistically not significant both in 1990 and 1991. Besides, being the first year of flowering, pepper yields were generally low during 1990. Vine height during the initial three years also was not significantly influenced by the supports on which they were trained.

Regarding height of support trees, G. sepium consistently registered the highest average height (7.94 m in December 1991), closely followed by G. pinnata in 1991 (7.75 m), E. lithosperma in 1990 and E. stricta in 1989. Height differences among the trees were statistically significant at all stages of observations ($p=0.01$; CD(0.05) = 0.61, 1.01 and 1.21 respectively for December 1989, 1990 and 1991).

Radial growth differences were also significant during 1990 and 1991 ($p=0.01$; CD(0.05)=1.96 and 2.25 respectively) E. stricta registered the maximum diameter at breast height both during 1990 (10.35 cm) and 1991 (12.08 cm), followed by G. pinnata and M. oleifera respectively. The data on branching pattern did not exhibit any clear trends, probably on account of the repeated annual lopping of the trees to facilitate light penetration to the associated pepper crop.

On the whole, E. indica, G. pinnata and G. sepium were found to be promising trees for training pepper vines. Support trees for pepper should have ideally the following characteristics:

canopy and tolerance to pests and diseases. In addition, they should also shed their foliage during the rainy season and retain the same during summer, having desirable bark characteristics (rough and non-exfoliating), deep rooted and hence not competing with the pepper vines and also yielding commercially valuable timber or other products such fruits, foliage, green manure etc. While it is difficult to have a species that combine all these desirable attributes, E. indica and G. sepium exhibit moderately fast growth and also possess potential for nitrogen fixation, being members of the family fabaceae, can be considered as promising supports for pepper.

The results also suggest that the timber production function cannot be easily combined with the tree's role as a support, although ideally such a situation might undoubtedly be the best. For instance, it is difficult to grow good quality timber yielding species such as T. populnea as supports for pepper vines under the eco-climatic conditions of the present experiment, primarily because of the fact that height growth in this species did not commensurate with the vine growth rates, although it has the potential to yield fodder, green manure and good quality timber. T. populnea, however, may have a niche in the shallow water table situations and coastal areas. Besides, E. stricta, E. lithosperma and M. oleifera also turned out to be less promising supports for pepper on account of their prolonged leafless periods.

d) Utility of some fast growing trees as pepper standards : Part 2- raised from seedlings

In this experiment seven tree species (Grevillea robusta, Acacia auriculiformis, Ceiba pentandra, Artocarpus heterophyllus, Ailanthus triphysa, Macaranga peltata and Casuarina equisetifolia) were compared. Seedlings were planted during June 1988 and the pepper vines were trained on after one year. Preliminary observations indicated Casuarina equisetifolia recorded maximum height followed by Acacia and Ceiba.

5. New research projects taken up during the period

Project iv) Provenance trial on Jack (Artocarpus heterophyllus

About 100 jack provenances, planted at the Agricultural Research Station Mannuthy during 1980 are being evaluated. Accessions AH 2, 27, 28, 29, 32, 35, 51, 56, 61, 82, 84, 88, 98, 101, and 103 were found to be promising. All these had heights greater than 10.5 m as on April, 1992.

Project v) Operational research project on Agroforestry

It is proposed to start the Agroforestry ORP during the next year.

6. Important visitors : nil

7. Civil works in the station : nil

8. Infrastructural development : nil

9. Publications by academic staff:

Mohan Kumar, B. and Jose K. Deepu 1992. Litter production and decomposition dynamics in moist deciduous forests of the Western Ghats in Peninsular India. Forest Ecology and Management, 50:181-201.

Thomas Mathew, Mohan Kumar, B., Suresh Babu, K.V. and Umamaheswaran, K. 1992. Comparative performance of some multi-purpose trees and forage species in Silvo-pastoral systems in the humid regions of southern India. Agroforestry Systems, 17:205-218.

Mohan Kumar, B., Thomas Mathew, Suresh Babu, K.V. Umamaheswaran, K. and Chinnamani, S. 1992. Comparative performance of three erythrina species with four other multi-purpose trees as supports for pepper vines. Paper submitted to the International erythrina conference to be held at CATIE, Turrialba during Ocotber, 1992.

Mohan Kumar, B. and Thomas Mathew. 1992. Shade trees of cardomom plantations - a phytosociological analysis. Sent to Indian Spices.

Anoop, EV, Mohan Kumar, B. and Abraham, CT. 1992. Teak growth in response to weed control treatments. J. Trop. Forest Sci. (in review).

Mohan Kumar, B., Suresh Babu, K.V. Sasidharan, N.K. and Thomas mathew. 1992. Agroforestry practices of central Kerala in a Socio-economic milieu. Paper presented in the National Symposium on Socio-economic Research in Forestry held at the Kerala Forest Research Institute, Peechi, May 1992.

Mohan Kumar, B. Vijayakumar, NK and Abraham CC. 1992. Protecting crops and livestock from high velocity winds. Hindu dated July 8, 1992.

Mohan Kumar, B., N.K.Vijayakumar and C.C.Abraham 1992. Windbreaks for protection of crops. Yojana, June 15, 25-26.

Mohan Kumar, B., Sudhakara, K. and Prasoon Kumar, 1992. Influence of growth medium, mineral nutrients and auxin on growth of Sweitenia macrophylla King and Dalbergia latifolia Roxb. seedlings. Journal of Tree sciences, 11(1):

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Kumar, B. M. and Jose K. Deepu 1992. Litter production and decomposition dynamics in moist deciduous forests of the Western Ghats in Peninsular India. Forest Ecology and Management, 50.181-201.

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