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Contents

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Nutrient management for enhancing productivity of forest plantations

Man-made forests are raised in a large scale throughout the world to meet the growing demand for timber, paper and pulp, and fuel wood. Success of plantations mainly depend upon, among several other factors, the availability of nutrients. The application of nutrients has been considered much less important in forestry compared to agriculture as the slow growth and long rotation of forest crops result in little nutrient loss. Moreover, long term application of nutrients was considered uneconomic. However, the ever increasing demand from plantations in recent years has made nutrient application imperative. Certain short rotation plantation species demand easily available nutrients which makes fertilizer application more economic. In order to make plantation forestry attain the desired goals as regards their quality and yield, nutrient application has become a necessity.

Nutrient deficiency can occur due to many reasons like infertility of soil, inadequate rate of nutrient cycling, poor microbial associations, weed competition, leaching caused by high rainfall, drought, lime induced chlorosis, effect of different pH levels, etc.

The nutrient deficit caused by the foregoing factors are indicated by stunted growth or poor vigour of individual plants, pale or thin crowns, short leaders and irregular diameter distribution. The change in foliage colour is also an indication of nutrient deficiency. Most of these factors would make the plants unhealthy and susceptible to diseases resulting in declined yield. Fertiliser trial, foliar and soil analyses and pot trials can give a more conclusive diagnosis of nutrient deficiency.

Fertilisers are used in such situations to correct a specific deficiency of a particular nutrient in order to establish a crop on an impoverished or infertile site and to enhance its growth. Undoubtedly, fertilizer application at planting time is the most important practice and the main concern. However, fertilizer application during post establishment phase, pole stage and pre-felling phase also result in maximum sustainable growth. Fertilizer application can be done by several means among which hand application is the best. Hand application is slow but ensures proper placement of fertilizer in any area and in any kind of terrain. The quantity to be applied depends on the requirement of each species and the fertility status of the soil. The high cost of fertilizers, especially mineral fertilizers, sometimes prevent their procurement in large quantities and application. In such situations, we may have to adopt certain nutrient conservation practices. They are usually cheap in capital cost but their application is time consuming and labour intensive and involves careful husbanding of the soil. This would result in gradual improvement of soil fertility and will lead to dramatic growth responses. Some of the common nutrient conservation practices are -

i. **Species selection:** If the growth of a particular tree species is very much dependent on the addition of a specific fertilizer, the option is to plant a less demanding species.

ii. **Site preparation practices:** During clearing operations before planting, ground cover should be maintained to protect soil surface from erosion and leaching.

iii. **Nutrient cycling:** A large portion of plant nutrients are held in the foliage of the trees. As far as possible the litter left behind during forestry operations should be retained in plantations for the return of the stored nutrients.

iv. **Mulching:** Mulching improves soil moisture conditions and organic matter status.

v. **Animal dung:** Placing animal dung in the soil enhances its fertility by retaining more nutrients.

vi. **Using plants as soil improvers:** Members of leguminosae have the capacity to fix atmospheric nitrogen through *Rhizobium* present in the root

nodules. Growing legumes enhances N status of the soil.

Application of a high dose and an unsuitable fertiliser will be detrimental to plant growth. Thus the slogan for the next century will be to increase the productivity by means of modified silvicultural operations and improved soil nutrient management techniques to meet the ever-increasing demand for timber, paper and pulp.

M. Balagopalan and S. Jayasankar
Division of Soil Science

KFRI sets up a solar light trap at Nilambur for monitoring insect populations

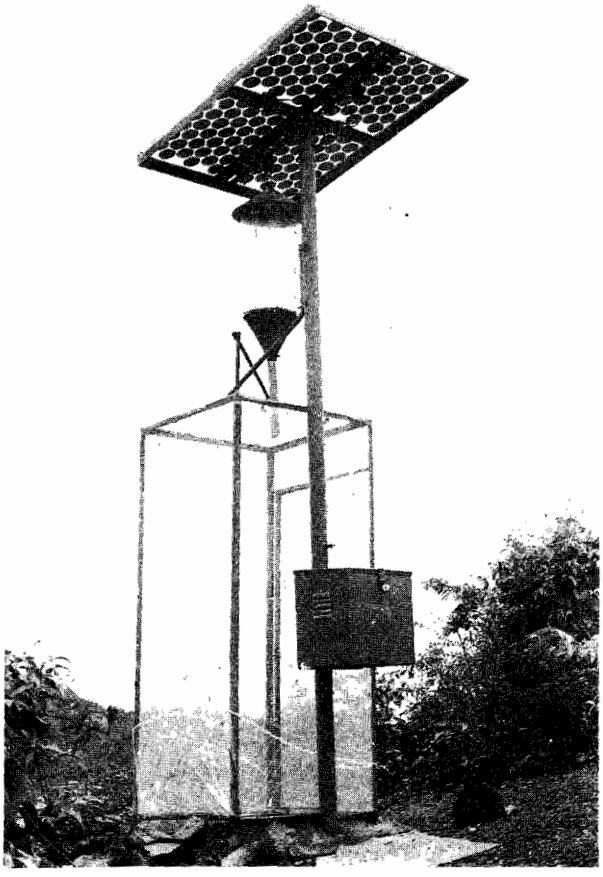
The Entomology Division of KFRI has set up a Solar Light Trap at Nilambur with technical and material help from ANERT (Agency for Non-conventional Energy and Rural Technology). The trap was installed on 19 May 1993 at Ambalakunnu within the Kariem-Muriem Teak Plantation, about 20 km from Nilambur town, where the electricity line does not reach.

The trap consists of a 20W blacklight fluorescent tube emitting light of wavelength 300 nM to 400 nM which attracts night flying insects. The blacklight is not harmful to human beings. The insects attracted by light strike against perspex baffles while flying around the tube, and drop into a funnel fixed at the bottom of the tube (Figure). Through the funnel the insects are led into a screened cage fixed on the ground. The required insects are collected daily from this walk-in cage, for studies.

The blacklight tube is powered by a battery which is charged using a Solar Photo-Voltaic System (SPV). The light is switched on automatically at dusk, controlled through the SPV system. A timer facilitates automatic on-off for pre-set periods.

The trap, developed indigenously by scientists at KFRI and ANERT, has several advantages over conventional light traps - facility to operate in remote areas without electricity, operation for specific time periods, use of a blacklight tube for greater attraction of insects, and facility for collection of live insects.

The trap set up within the teak plantation at Nilambur is being used mainly to monitor the outbreak development of the teak defoliator, *Hyblaea puera* in order to time the application of biocontrol measures. It can also be used for several other purposes, including monitoring of insect biodiversity in remote areas.



Division of Entomology

Landslides in forests of southern Western Ghats

During November 1992, Kulathupuzha Valley and Shendurney Valley, south of the Achankoil gap in the Southern Western Ghats, experienced one of the worst landslides (Fig. 1) in the history of Kerala. Why landslides of this magnitude occur in areas like this which are clothed by thick forests, will remain a question unanswered; but the fury and terror caused by it is still alive in the memory of the people who witnessed and survived the disaster. It was learnt that heavy rainfall and storm occurred in these areas prior to the landslide. The magnitude of the landslides was such that it took months to realign the road for transportation of reed for Hindustan Newsprint Corporation from Kulathupuzha Valley.

An attempt was made to survey some of the locations where landslides occurred, travelling through accessible coupe roads. During the survey, a total of 36 landslides were recorded in a stretch of about eight kilometers along the old coupe road, from Kallar to Pandimottai, which fall inside the Shendurney Wildlife Sanctuary. Surprisingly, at a place called Sangli, the Sangli river was found taking a deviation from the usual course (from the south-west direction to north-east direction). The amount of timber washed downstream in the Sangli river - a tributary of Kulathupuzha river - is ample proof to show how disastrous the landslide was! (Fig. 2). It

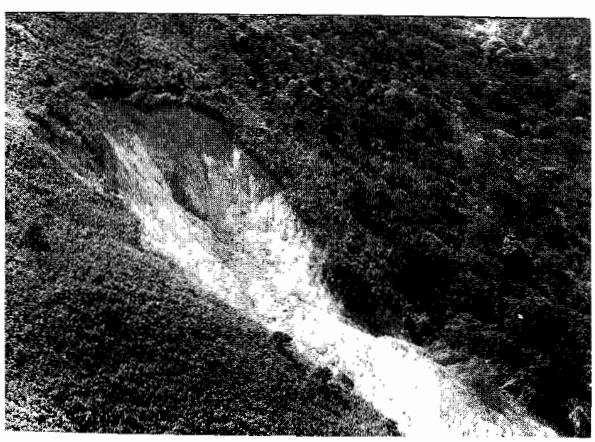


Fig. 1.Landslide in Shendurney Valley

Fig.2.Timber washed downstream in the Sangli river

was observed that even elephants could not negotiate some of the landslide hit areas which lie along the elephant tracks.

Several hypotheses have been put forth by various schools for the occurrence of landslides in this part of the Western Ghats but the exact reasons are still unknown. The magnitude of the disaster can be quantified by conducting a study using aerial photographs taken before the disaster and then conducting a ground survey as available at present. The Shendurney and Kulathupuzha Valleys drain into the Kallada reservoir which is situated within the Shendurney Wildlife Sanctuary. Water in the reservoir remained muddy even after a lapse of six months. This is unlike the situation found in other reservoirs in Kerala where the water becomes clear within a few days after the rains are ceased. Landslides occurring in the catchment areas of reservoirs are known to affect the capacity of the reservoirs also. The landslides occurred in Kulathupuzha and Shendurney valleys have converted large extent of the forest areas into mere barren land. It would be worthwhile if the succession of plant communities in these barren areas are studied by continuous monitoring.

K.K. Ramachandran
Division of Wildlife Biology

Weather data for Peechi (1992)

Table 1 shows the monthly averages of the weather parameters recorded at the KFRI weather station at Peechi during 1992. The cumulative monthly rainfall is given in Fig. 1. The annual rainfall since 1988 is given in Fig. 2.

Highlights

Day with highest maximum temperature : 13th April (42°C)
Day with least minimum temperature : 8th January (16°C)
Day with highest maximum r.h. : 27th June (100%)
Day with least minimum r.h. : 2nd March (29%)

Total rainfall for the year : 2956 mm
Day with maximum rainfall : 16th November (89 mm)
Month with maximum rainy days : July (20 days)
Total number of rainy days : 77 days

Day with maximum sunshine : 16th April (10.8 hours)
Month with maximum sunshine : April (8.8 hours)

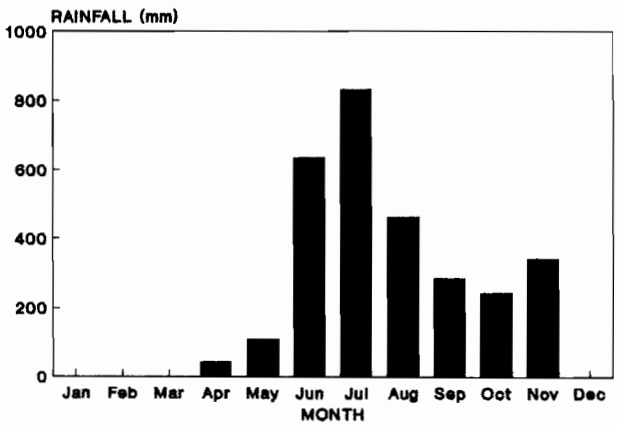


Fig.1. Cumulative monthly rainfall for the year 1992

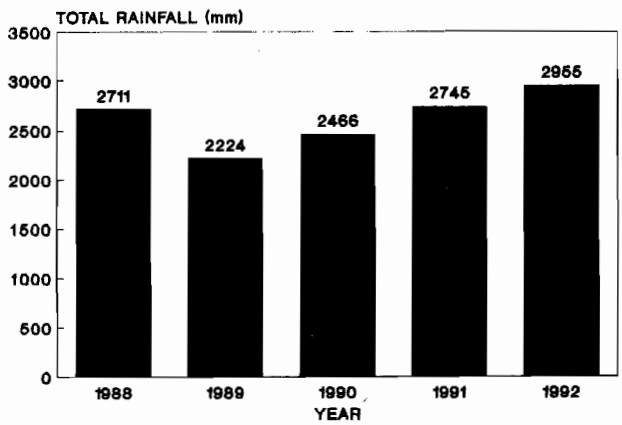


Fig.2. Annual rainfall since 1988

Table 1. Weather data for 1992 at Peechi (Latitude 10°32'N, Longitude 76°20'E, Altitude 100 m)

Month	Mean temp (°C)		Mean r.h. (%)		Rainfall (mm)	Daily mean wind velocity (km/hr)	Daily mean bright sunshine (h)
	Max	Min	Max	Min			
January	35.0	19.3	83	46	0 (0)	8.6	7.9
February	37.7	20.9	94	48	0 (0)	4.9	6.5
March	39.7	21.9	96	45	0 (0)	4.0	8.4
April	39.7	23.5	93	52	43.4 (2)	3.8	8.8
May	36.2	23.3	95	59	108.8 (4)	2.8	5.4
June	31.5	22.3	89	74	634.8 (15)	8.7	1.4
July	30.2	21.3	92	78	831.2 (20)	NR	0.7
August	30.4	21.7	90	77	463.6 (12)	NR	2.2
September	32.1	21.4	89	69	286.5 (9)	NR	3.6
October	32.5	21.8	89	67	244.3 (7)	NR	4.4
November	32.3	21.6	89	66	341.6 (8)	NR	4.6
December	32.5	20.6	82	54	1.4 (0)	NR	7.5

Note: r.h.: Relative humidity; The figures in parentheses indicate the number of rainy days when rainfall was >10 mm; NR: Not recorded.

Jose Kallarackal and C.K. Somen
Division of Plant Physiology

Volume table for *Acacia auriculiformis*

A provisional volume table for *Acacia auriculiformis* was reported by Jayaraman and Rajan (Jayaraman, K. and Rajan, A.R. 1991. Yield from *Acacia auriculiformis* plantations in Kerala. *KFRI Research Report 81*. Kerala Forest Research Institute). Since the publication of this report, the volume table was revised based on additional data. The revised volume table is reproduced here with finer prediction intervals.

Tree volume table for *Acacia auriculiformis*

Gbh (cm)	Volume (m^3)	Gbh (cm)	Volume (m^3)	Gbh (cm)	Volume (m^3)	Gbh (cm)	Volume (m^3)	Gbh (cm)	Volume (m^3)	Gbh (cm)	Volume (m^3)
10	0.00186	34	0.07079	58	0.24193	82	0.47783	105	0.73459	128	1.00242
11	0.00258	35	0.07609	59	0.25073	83	0.48856	106	0.74610	129	1.01411
12	0.00345	36	0.08158	60	0.25966	84	0.49932	107	0.75763	130	1.02579
13	0.00448	37	0.08724	61	0.26867	85	0.51012	108	0.76917	131	1.03751
14	0.00568	38	0.09309	62	0.27778	86	0.52101	109	0.78077	132	1.04919
15	0.00706	39	0.09910	63	0.28702	87	0.53191	110	0.79234	133	1.06086
16	0.00863	40	0.10528	64	0.29633	88	0.54286	111	0.80393	134	1.07257
17	0.01038	41	0.11164	65	0.30573	89	0.55388	112	0.81557	135	1.08423
18	0.01234	42	0.11814	66	0.31522	90	0.56491	113	0.82718	136	1.09589
19	0.01448	43	0.12481	67	0.32484	91	0.57598	114	0.83881	137	1.10754
20	0.01683	44	0.13165	68	0.33451	92	0.58713	115	0.85048	138	1.11922
21	0.01938	45	0.13863	69	0.34426	93	0.59828	116	0.86213	139	1.13086
22	0.02213	46	0.14575	70	0.35413	94	0.60946	117	0.87378	140	1.14248
23	0.02509	47	0.15305	71	0.36404	95	0.62068	118	0.88548	141	1.15414
24	0.02824	48	0.16047	72	0.37404	96	0.63197	119	0.89715	142	1.16575
25	0.03161	49	0.16802	73	0.38414	97	0.64325	120	0.90882	143	1.17735
26	0.03517	50	0.17572	74	0.39428	98	0.65456	121	0.92050	144	1.18897
27	0.03893	51	0.18357	75	0.40449	99	0.66594	122	0.93222	145	1.20055
28	0.04291	52	0.19153	76	0.41480	100	0.67731	123	0.94390	146	1.21211
29	0.04707	53	0.19962	77	0.42515	101	0.68871	124	0.95559	147	1.22370
30	0.05142	54	0.20786	78	0.43556	102	0.70016	125	0.96731	148	1.23524
31	0.05599	55	0.21620	79	0.44603	103	0.71161	126	0.97900	149	1.24677
32	0.06073	56	0.22465	80	0.45659	104	0.72307	127	0.99069	150	1.25828
33	0.06566	57	0.23325	81	0.46718						

Note: Volume refers to the solid volume with bark of wood greater than 10 cm girth over bark.

K. Jayaraman
Division of Statistics

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Muraleedharan, P.K., Rugmini, P. and Anitha, V. 1993. **Farm size and productivity relationship in modern agriculture: A case study of the kole lands in Thrissur**. Proc. Fifth Kerala Science Congress, Kottayam, January 1993, pp. 156-157.

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Nair, K.S.S. and Mathew, G. 1992. **Biology, infestation characteristics and impact of the bagworm *Pteroma plagiophleps* Hamp. in forest plantations of *Paraserianthes falcataria***. Entomon, 17: 1-13.

Sankaran, K.V. 1993. **Decomposition of leaf litter of albizia (*Paraserianthes falcataria*), eucalypt (*Eucalyptus tereticornis*) and teak (*Tectona grandis*) in Kerala, India.** Forest Ecology and Management, 56: 225-242.

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Saxena, K.G., Tiwari, A.K., Porwal, M.C. and Menon, A.R.R. 1992. **Vegetation maps, mapping needs and scope of digital processing of landsat thematic mapper data in tropical region of South-West India.** Indian Journal of Remote Sensing, 13: 2017-2037.

Research Reports

Jayaraman, K., Muraleedharan, P.K. and Gnanaharan, R. 1992. **Evaluation of social forestry plantations raised under the World Bank Scheme in Kerala.** KFRI Research Report No.85. Final Report of Research Project 139/'91. Divisions of Statistics, Economics and Wood Science.

Abstract: The plantations raised by the Social Forestry Wing of the Kerala Forest Department from 1985 to 1990 in Kerala under the World Bank Scheme were assessed for survival through a stratified two-stage sampling plan. About 27% of the existing plantations were covered with proportional allocation of the sampling units among the strata. Survival rates were found to vary with type of plantation and year of planting. Survival shifted from 80% in younger years to around 60% in later years.

Productivity of four important species included in the planting programme was assessed through mean tree method. The species were *Acacia auriculiformis, Casuarina equisetifolia, Eucalyptus grandis* and *Grevillea robusta*. All the above species except *Grevillea robusta* exhibited high potential productivity to the order of 12 to 20 t ha^{-1} yr^{-1} of woody biomass in 5.5 to 7.5 years. The biomass of all the components of the tree put together averaged out to 101 t ha^{-1} for *Acacia auriculiformis* and 56 t ha^{-1} for *Casuarina equisetifolia* in terms of dry weight at 6.5 years of age. Strip and small block plantations in general fared better than large block plantations with respect to the total biomass.

The overall moisture content of trees of *Acacia auriculiformis* varied from 103% at 3.5 years to 96% at 6.5 years. Phyllodes showed maximum moisture content followed by bark, branches and bole. Trees of *Casuarina equisetifolia* showed an overall moisture content of 94% at 3.5 years which decreased to 82% at 6.5 years. Needles showed highest moisture content followed by bark, branches and bole. In the case of *Eucalyptus grandis* moisture content of trees decreased from 163% at 5.5 years to 106% at 7.5 years as observed through mean tree method. Bark carried the highest moisture level for trees at 5.5 years, 6.5 years and 7.5 years taken for the study. Leaves also contained higher levels of moisture when compared to bole and branches. *Grevillea robusta* showed an overall moisture content of 92% for trees at 3.5 years and 98% for trees at 4.5 years through mean tree method. Bark had higher levels of moisture when compared to leaves, branches and bole for this species.

Plantations have been raised over an area of 20,408 ha till 1990-91 under the World Bank Scheme in Kerala. Major portion of this area falls under 'large block' category. As many as 70 species are found planted in these plantations more important of which are the species mentioned above. There has been a shift in the choice of species planted over the years. The emphasis was on fast growing exotics in the initial years but more of indigenous species have been planted in recent years.

Rotation age which changes with the objects of management vary with the species. A 7-year rotation was proposed for *Acacia auriculiformis* based on a previous study by the Institute. The present study has indicated the need for thinning for *Casuarina equisetifolia* at the end of 4 years in good quality sites.

Harvesting age could be extended to 7th or 8th year for the same species in poor quality sites. Average site index for plantations of *Acacia auriculiformis* and *Casuarina equisetifolia* raised under the World Bank Scheme have been worked out which along with the other parameters like rotation age and stocking level at harvest is useful for working out the annual outturn from the plantations. Provisional volume table and variable density yield table prepared for *Casuarina equisetifolia* are additional outputs of the present study.

Jose Kallarackal and Somen, C.K. 1992. **Water use of selected indigenous and exotic trees.** KFRI Research Report No.86. Final Report of Project KFRI 128/'90. Division of Plant Physiology.

Abstract: Several exotic species have been used for afforestation in Kerala as a part of the Social Forestry Programme, mainly funded by the World Bank. Among them, the most widely planted species is *Acacia auriculiformis* which has met with great success in survival and yield. However, the tree has been the subject of discussion and criticism from some members of the public who have alleged several environmental problems associated with its large scale introduction. Among them, its excessive consumption of water is the most serious one. This report is an attempt to study the water use of *A. auriculiformis* by evapotranspiration. To determine how far the evapotranspiration is comparable to other trees, two other species, namely *Anacardium occidentale* (cashew) and *Tectona grandis* (teak) have been also studied.

To determine the water use of the three species we have selected three pure plantations belonging to the above species in Palghat and Trichur Districts of Kerala. Intensive monitoring of rainfall interception, soil moisture, leaf water potentials, microclimate above the canopy and leaf area index were done in all the three plantations round the year on selected sampling dates. Stomatal resistance and net photosynthesis were also measured simultaneously. The major factor which contributes to water loss from a dry canopy is the stomatal resistance (opening and closing of stomata). This, in turn is controlled by the environmental variables and soil water availability. We have established predictive correlations between stomatal resistance and the environmental variables, especially vapour pressure deficit. The analysis of these relations have helped us to know the comparative degree of stomatal response to environmental variables in the three species studied. This indicates that cashew shows less response to vapour pressure deficit when compared to acacia. It has not been possible to understand the exact correlations in teak. However, teak prevents a lot of water loss during dry periods by shedding its leaves.

The water use efficiency of the trees have been also compared. Cashew and acacia are certainly more efficient in their water use when compared to that of teak. At the same time, a cashew tree can consume more than 400 l of water a day during peak summer.

Several observations related to rainfall interception, microclimate, water potentials, etc. are presented in this report. A chapter on conclusions and recommendations is also included towards the end.

Muralidharan, E.M. 1993. **Propagation of medicinal plants, rattans and bamboos by tissue culture.** KFRI Research Report No.87. Final Report of Project No.129/'90. Division of Genetics.

Abstract: Five species of bamboos, three each of rattans and medicinal plants were selected for micropropagation. Preliminary research findings are reported here.

Rapid multiplication of *B. arundinacea* from seedlings was obtained on a medium containing BAP. *In vitro* flowering was observed in a few cultures which could be maintained over two subcultures. Sprouting and elongation of axillary buds was observed in mature culm nodal explants of all the bamboo species cultured.

Immature excised embryos of *Calamus pseudotenuis*

cultured on auxin containing medium became enlarged and nodular. Shoot tip explants in all the three rattan species did not multiply under any of the conditions tested. Sprouting of axillary buds was obtained in cultured pseudobulbils of *Malaxis rheedii* and rhizomes of *Kaempferia galanga*. Cotyledons from immature seeds of *Wrightia tinctoria* gave rise to a callus on a medium containing 2, 4-D.

Jose Kallarackal, 1993. **Studies on water use, photosynthesis and growth of eucalypts**. KFRI Research Report No.88. Final Report of Project No.KFRI 127/'89. Division of Plant Physiology.

Abstract: Eucalypts have been introduced into Kerala as a commercial plantation. *Eucalyptus grandis*, a species suitable for the high ranges and *E. tereticornis* (formerly called as *E. hybrid*), a species for the plains, contribute to the major part of about 30,000 ha in the plantation sector of the Forest Department. This report presents the results of a detailed investigation on the alleged excessive water consumption by the two eucalypt species planted in Kerala.

Three eucalypt plantations were chosen for intensive monitoring. One of them, *E. tereticornis* plantation at Varavoor is located in an area with relatively high evaporative demand, approximately 3000 mm annual rainfall and 1800 trees ha^{-1}. The second plantation of *E. tereticornis* is situated at Palode, where the rainfall is 2500 mm per annum, but more uniformly distributed. The plantation has a density of 1050 trees ha^{-1}. The third plantation, *E. grandis* is at Muthanga, where the annual rainfall is 1300 mm. The plantation exists at 750 m above sea level and contain 1600 trees ha^{-1}.

Using a scaffold tower in the plantations, microclimate parameters like temperature, relative humidity, wind speed, total solar radiation and net radiation were measured 2 m above the canopy level. The temperature at the ground level was also measured. Along with the above microclimate parameters, hourly measurements of the stomatal conductance were made. The data collected thus were applied in the Penman-Monteith equation to get the hourly water loss due to transpiration. The canopy leaf area index was also measured for the above computations. The daily transpiration rates are extrapolated to monthly values.

The transpiration loss of water at the three plantations for the 9 months were as follows: Varavoor 1563 mm, Palode 853 and Muthanga 1181 mm. The per tree consumption of water ranged between 18 and 44 litres day^{-1} in *E. tereticornis*. In *E. grandis* the per tree consumption was between 13 and 40 litres day^{-1}. In all the three locations, the water potentials were maintained at relatively higher levels even during the non rainy months. This means that the plants were not under water stress during any part of the year. The stomatal control of transpiration in response to increasing atmospheric vapour pressure deficit, when examined, shows that in *E. tereticornis* apparently the control was not existing at the available soil water content. In *E. grandis*, relatively good control existed with nearly complete closure at values above 4.0 kPa irrespective of the soil water availability.

The relatively high water potentials and the stomatal conductance values throughout the year give indications for abstraction of water from deeper layers of the soil. Since the water tables in these localities occur anywhere within 15 m depth, the eucalypt roots extracting water from the phreatic aquifer cannot be ruled out.

The maximum net photosynthetic rate in both the species was around 20 mol $m^{-2}s^{-1}$. In *E. tereticornis*, the water use efficiency was similar during both pre and post monsoon period. In *E. grandis* the water use efficiency was less during the post monsoon period compared to the pre monsoon period. In general, the water use efficiency was better for *E. tereticornis*.

Mammen, C. 1993. **History of Forest Management in Kerala**. KFRI Research Report No.89. Final Report of Project Econ.05/'84. Division of Economics.

Abstract: The attempt has been to discern the main trends rather than present the chronology of events. Three broad phases in forest management has been identified. They are presented as (i) the rise of forestry, (ii) the period of turbulence and change, and (iii) the ascent of conservation.

The major achievements during the period of the rise of forestry are the reservation of forests, the perfecting of teak planting techniques and initiation of systematic management on the basis of carefully prepared working plans.

During the period of turbulence and change, efforts at mechanisation of logging and opening up of forests for food crop cultivation affected the continuity of operation according to the working plans. The post Independence Forest Policy (1952) favoured subsidised supply of forest raw materials to industries. Large scale industrial plantations were also raised. Added to these, forest clearance for irrigation and power projects and peasant migration into forests led to phenomenal loss of forests and destroyed the compactness of the reserved forests. Legislation for government take over of private forests was enacted during this time and a State Forest Research Institute to support forestry was set up.

The Wildlife (Protection) Act 1972 and the Forest Conservation Act 1980 are major events in the ascent of conservation. Restriction on clearfelling and stopping of selection felling has arrested the earlier trend of forest degradation. The recommendation of the High Power Expert Committee on Forest Policy in 1986 in Kerala and the conservation oriented New Forest Policy (1988) of the Government of India reflect a sensitivity to global concerns and is a strong indication of change from past trends.

Mammen, C., Krishnankutty, C.N. and *Rajan, A.R.* 1993. **Socio-economic study of farm forestry - A study of four villages in Kerala.** KFRI Research Report No.90. Final Report of Project Econ.02/'82. Divisions of Economics and Statistics.

Abstract: This study is an attempt to examine the variation in tree cropping in home gardens in four villages in Kerala. A socio-economic and land use survey was carried out in 247 households where cropping pattern and tree growth details were recorded. A cropping intensity index appropriate for comparing mixed cropping agriculture was developed and separate intensities were worked out for seasonal and annual crops, perennial crops, tree crops and miscellaneous crops.

Using the size class of land holdings as a proxy for economic status, comparison between households in each village and comparison between villages was done. No difference was observed in the cropping intensity of tree crops between size classes of land holding in all villages. However, density of trees (in number) showed much variation.

With the increase in the intensity of perennial crops, intensity of tree crops decline. When the combined intensity of perennial and tree crops was considered, the highest intensity was found in the smallest size classes of holdings in three out of four villages. Considering the intensity of all crops together, it was found that smaller holdings have relatively higher cropping intensities.

Among trees in home gardens the category of multiple use trees accounted for 50 to 70 percent in different villages. The mean number of trees per hectare was found to be significantly different between villages and between size classes of holdings. In all villages, decrease in tree diversity was noticed with decrease in size of holding.

Socio-economic factors have contributed to the intensification of cultivation in home gardens. Multipurpose trees or trees with high value are preferred for new planting.

Sankaran, K.V., Balasundaran, M., Thomas, P. Thomas and Sujatha, M.P. 1993. **Litter dynamics, microbial associations and soil studies in *Acacia***

auriculiformis **plantations in Kerala.** KFRI Research Report No.91. Final Report of Project No.KFRI 126/'89. Divisions of Pathology and Soil Science.

Abstract: Litterfall in 3- to 6-year-old acacia plantations was quantified using litter traps. Annual litter production in the plantations ranged between 9.3 and 12.0 t ha^{-1}. The leaf litter constituted 62 to 69% of the total fall; twigs, pods, inflorescence stalks, seeds, flowers and bark made up the rest of the collection. Annual litter yield in acacia plantations was higher than those reported for other major forest plantation species in Kerala and elsewhere.

Decay rate of acacia leaf litter was determined using the mesh bag technique. The dry weight loss of litter (laid on the surface of soil - LSS) was 64.4% at Chettikulam (C), 65.6% at Kothermanakkadu (K) and 86% at Kannamkuzhy (Ka), after a period of 12 months. The corresponding values for litter partially buried in the soil (LPB) were 94.5% at site C and 92.6% (after a period of six months) at site Ka. In general, the rate of decomposition of acacia leaf litter was lower than the decay rate of leaf litters of major plantation species reported from Kerala. The faster decomposition of LPB indicated that periodic raking of soils in acacia plantations would accelerate litter degradation.

A survey was conducted in 26 plantations of acacia to assess the status of mycorrhizal associations. It revealed that acacia forms VA mycorrhizal association in Kerala soils. The extent of colonization by VAM fungi was very high (varied between 90 and 100%) in majority of the plantations. The VAM colonization was correlated with silt content, clay content, porosity and bulk density of soil; it was not correlated with the soil nutrient status. *Glomus* spp. were found to be the dominant VAM fungi in acacia plantations.

Five VAM fungi were screened under glass house conditions for their efficacy in promoting the growth of acacia seedlings. Seedlings inoculated with *Glomus fasciculatum* had maximum increase in height, shoot and root dry mass, total P content and mycorrhizal colonization. Based on the present study, use of *G. fasciculatum* as an inoculant VAM fungus for acacia is found to be promising.

For assessing the status of root nodulation of acacia in Kerala, soil samples were collected from 26 plantations, using soil core sampler. The average number of nodules per 100 cm^3 of soil, based on sixty samples, was calculated for each plantation. The study indicated that nodule number varied depending upon the soil. Generally, degraded, less fertile soils showed more number of nodules. There was a significant inverse relationship between soil organic carbon and nodule number. Nursery experiments, inoculating acacia seeds with *Rhizobium* cultures isolated from the 26 plantations revealed significant difference between the isolates in their efficiency for nodule formation. There was significant positive correlation between number of nodules and seedling biomass.

The soil characters of acacia plantations were compared with those of adjacent fallow land to ascertain the effect of acacia growth on the soil properties. Soil analysis revealed that there was no significant difference between acacia plantations and adjacent fallow land in physical and chemical properties of soil as well as soil nutrient contents except in the case of pH which was significantly lower in acacia plantations (pH 4.7).

Nair, K.K.N., Muktesh Kumar, M.S., Sankaran, K.V., Florence, E.J.M., Vijayakumaran Nair, P., Jayson, E.A., George Mathew, Balagopalan, M. and Menon, A.R.R. 1993. **Baseline studies for the proposed Nature Study Centre at Kalady in the Malayattoor Forest Division.** KFRI Research Report. Final Report of Project No.KFRI 137/'91.

Abstract: The report provides first hand scientific information on (i) Angiosperm flora, (2) Macrofungal flora, (3) Wildlife, (4) Insect fauna, (5) Soil characteristics, and (6) Vegetation analysis of natural and man

made forests (1,500 ha area) that come under the purview of the proposed Natural Study Centre at Kalady. It also provides a checklist of plant diseases in the area and an idea on the land use pattern.

Other Publications:

BIC-India Bulletin

BIC-India Bulletin Vol.3, No.1 (January 1993) and No.2 (June 1993). Bamboo Information Centre, Kerala Forest Research Institute, Peechi, India. The bulletin is available free of cost on request.

Books

Rattan Management and Utilization: Proceedings of the Rattan (Cane) Seminar, India, 29-31 January 1992, Trichur. (Eds.) S. Chand Basha and K.M. Bhat. Price: Rs.300/-; Foreign - US $ 25/-.

New research projects

KFRI 174/'93

Ecological and environmental assessment of forest cover of Kerala with special reference to soil/vegetation and wildlife.
Investigators: S. Chand Basha (Director), S. Sankar (Soil Science) and P.S. Easa (Wildlife Biology).
Objectives: (1) To evaluate the present status of different forest ecosystems with special reference to environmental degradation in the Western Ghats of Kerala with emphasis on vegetation, soil and wildlife, (2) Assess the conservation/restoration potential of the forests, and (3) To prepare a database on the forest including thematic maps.

Sponsored by the Department of Science, Technology and Environment, Kerala.

KFRI 175/'93

Tracing the epicentres of teak defoliator outbreaks in Kerala.
Investigators: K.S.S. Nair, V.V. Sudheendrakumar, R.V. Varma and K. Mohanadas (Entomology), Santhosh K. John (Nilambur Sub Centre), P. Vijayakumaran Nair (Wildlife Biology) and P. Padmanabhan (Entomology).
Objectives: (1) To validate the hypothesis that teak defoliator outbreaks originate in small epicentres during the early growth season, and (2) To map the spatial distribution of outbreaks in a temporal sequence in Konni and Nilambur teak plantations.

KFRI 176/'93

Evaluation of parasites for biological control of the teak defoliator.
Investigators: V.V. Sudheendrakumar, K. Mohanadas, R.V. Varma and K.S.S. Nair.
Objectives: (1) To evaluate the efficacy of selected parasites of *Hyblaea puera*, (2) To standardise technology for mass production of selected parasites, and (3) To test the efficacy of parasites for dissemination of nuclear polyhedrosis virus of *H. puera*.

Sponsored by Kerala Forest Department.

KFRI 177/'93

Establishment of permanent plots to demonstrate the effect of protecting teak plantations from the teak defoliator.
Investigators: R.V. Varma, K.S.S. Nair, K. Mohanadas and Santhosh K. John.
Objectives: (1) To demonstrate the difference in growth of teak due to insect defoliation between a protected and unprotected group of teak trees, and (2) To demonstrate the need to adopt control measures against teak defoliator and to include it as part of intensive management practices.

Sponsored by Kerala Forest Department.

KFRI 178/'93

Standardisation of indirect evidences of wild animals for field identification and preparation of a field guide.
Investigators: E.A. Jayson and P.S. Easa (Wildlife Biology)
Objectives: (1) To characterise and standardise the indirect evidences of wild animals for easy field identification, and (2) To prepare a field guide for identification of wild animals based on indirect evidences.
Sponsored by Kerala Forest Department.

KFRI 179/'93

Studies on the flora of Periyar Tiger Reserve.
Investigator: N. Sasidharan (Botany)
Objectives: (1) To study the flora of the Periyar Tiger Reserve, (2) To identify the rare and threatened endemic plants in the flora and their distribution, and (3) To prepare a reference herbarium collection.
Supported by the Kerala Forest Department.

KFRI 180/'93

Wildlife census of Kerala 1993.
Investigator: P.S. Easa
Objectives: To estimate the population of major wildlife species in the forests of Kerala using various techniques.
Supported by Kerala Forest Department.

KFRI 181/'93

Teak plantations in Nilambur: An economic review.
Investigator: Mammen Chundamannil (Economics)
Objectives: (1) To compile the available information on teak plantations in Nilambur Division classified according to different site qualities, (2) To calculate the optimum economic rotation for each site quality of teak plantations, (3) To prepare a harvesting and replanting schedule based on the guidelines of the High Level Expert Committee and the principles of sustained yield and even flow of output, and (4) To make suggestions regarding investments and intensity of management and to identify constraints, if any, in achieving higher productivity.
Supported by Kerala Forest Department.

KFRI 182/'93

Effect of faster growth on timber quality of teak.
Project Leader: S. Chand Basha
Investigators: K.M. Bhat (Wood Science) and E.P. Indira (Genetics).
Objectives: (1) To determine the effect of faster growth due to different factors like site, spacement/ thinning, irrigation, fertilization and genetic selection on timber quality, and (2) To estimate the heritability of selected wood quality parameters like specific gravity, microfibrillar angle, juvenile wood proportions, etc.
Supported by Kerala Forest Department.

KFRI 183/'93

Studies on crop damage by wild animals in Kerala and evaluation of control measures.
Investigator: E.A. Jayson
Objectives: (1) To survey and quantify the crop damage by wild animals on agriculture crops in Kerala, and (2) To evaluate the efficiency of electric fences in stopping wild animals from entering into the crop fields.
Supported by Kerala Forest Department.

KFRI 184/'93

Studies on epiphytic flora in the tropical forest ecosystem of Western Ghats with special reference to Nilgiri Biosphere.

Project Co-ordinator: S. Chand Basha
Investigator: Muktesh Kumar (Botany)
Objectives: (1) Collection and enumeration of epiphytic flora and study of the species abundance, occurrence and distribution, (2) Study the interaction of the epiphyte-host relationship, (3) Epiphytosis: Incidence and occurrence, (4) Establishment of a green house and *ex-situ* conservation of the rare and endangered species, (5) Allocation of herbarium and preserved materials for future study, and (6) Publication of a flora exclusively of the epiphytic plants of the Western Ghats.

Supported by Kerala Forest Department.

KFRI 185/'93

An investigative survey of stream fishes, their habitat distribution and behaviour ecology in the NBR area of Kerala.
Investigators: S. Chand Basha and P.S. Easa
Objectives: (1) To prepare an authentic and detailed checklist of the fish fauna in the Nilgiri Biosphere Reserve of the Kerala region, (2) To understand the standing crop and abundance of fishes and the related limnological conditions of the aquatic ecosystem, (3) To study the specific habitats of rare and endemic varieties of fishes and other communities, feeding and breeding behaviour, (4) To evaluate the traditional fishing methods, if any, crafts and gears and their possible suggestions for environmental friendly modifications, (5) To study the socio-economic and cultural potential of the tribal communities residing near the streams and rivers, and (6) To formulate possible strategies and techniques for the development of recreation oriented fisheries like museums and aquarias for tourism development and environmental friendly piscicultural operations for the welfare of the tribal and forest dependent communities.

KFRI 186/'93

Studies on the growth and prevention of sapstain fungi in rubber wood and its effect on strength properties.
Investigator: E.J.M. Florence (Pathology)
Objectives: (1) To field test different chemicals against sapstain fungi, and (2) To evaluate the strength properties of rubber wood affected by sapstain fungus *Botryodiplodia theobromae*.
Supported by the State Committee on Science, Technology and Environment, Government of Kerala.

KFRI 187/'93

Studies on the growth and architecture of tree species of home garden agroforestry systems of Kerala.
Investigator: U.M. Chandrasekhara (Agroforestry-cum-Publicity)
Objectives: (1) To survey all major tree species growing in home gardens of the central midland zones of Thrissur, Kerala, and (2) To study the growth and architecture of individual species, each with further categorization into seedlings, saplings and mature ones, under different microclimatic conditions of home gardens.

Supported by State Committee on Science, Technology and Environment, Government of Kerala.

KFRI 188/'93

Expert system for designing experiments in forestry.
Investigators: P. Rugmini and K. Jayaraman (Statistics)
Objectives: To develop an expert system helpful in designing experiments in forestry.

Supported by the Institute.

KFRI 189/'93

Economics of forest plantations in Kerala.
Investigator: Mammen Chundamannil
Objectives: (1) To study the structure of costs and the

stream of outputs from teak, eucalypts, bombax, ailanthus and albizia plantations, (2) To compare the Net Present Value (NPV) and Internal Rate of Return (IRR) of different plantations, (3) To do a sensitivity analysis using different assumptions regarding rotation, age, wood prices, cost structure, technological changes, site quality, distribution and stocking, and (4) To evaluate the plantation programme taking into consideration different criteria such as profitability, return to investments, output per ha per year, value of production in terms of industrial output and basic needs goods, linkages with other sectors, employment generation, ecological acceptability, etc.

KFRI 190/'93

Evaluation of newer termiticides including plant products for forest plantation establishment.
Investigators: R.V. Varma and K.S.S. Nair
Objectives: (1) To evaluate newer termiticides and formulations including products of plant origin to find out their efficiency, (2) To standardise suitable dosages for the effective insecticides, and (3) To study the persistence of selected products in comparison to standard organochlorine termiticides.

Supported by Kerala Forest Department.

Participation in seminars, symposia and workshops

Dr. K.K.N. Nair (Botany) attended a workshop on 'Environmental Problems in High Ranges of Kerala' organized by WWF at Thekkady on 1 Oct. 1992.

Dr. E.M. Muralidharan (Genetics) attended the Biotek India 1992 Conference held at Bangalore during 28-31 October 1992.

Dr. P.S. Easa (Wildlife Biology) attended a conference on Biodiversity at the Indian Institute of Science, Bangalore during 9-10 Novemeber 1992.

Dr. K.M. Bhat (Wood Science) participated in a National Conference on 'Standardisation and quality upgradation of lignocellulosic panel products' held in New Delhi during 28-29 December 1992 and presented a paper entitled 'Classification of canes (rattans) according to properties and end-uses'. Another paper, 'Application development of rubber wood, palm wood and bamboo' by *Dr. R. Gnanaharan* (Wood Science) was tabled.

Smt. P. Rugmini (Statistics) and *Mr. E.A. Jayson* (Wildlife Biology) attended the Fifth Kerala Science Congress held at Kottayam during 28 - 30 January 1993. The following papers were presented. i) 'Variation in the productivity of teak plantations in Kerala' (*K. Jayaraman and P. Rugmini*). *ii*) Diversity of species abundance distribution of birds in the adjoining forests of Silent Valley National Park (*E.A. Jayson*).

Dr. S. Chand Basha (Director), *Dr. R.V. Varma* (Entomology), *Dr. K.K.N. Nair* (Botany) and *Dr. K.K. Ramachandran* (Wildlife Biology) participated in the Indo-British Workshop on biodiversity held at Bangalore from 4-6 February 1993.

Guest Lecture

Dr. R. Gnanaharan gave invited lecturers to the students of a Certificate Course at the Indian Plywood Industries Research and Training Institute, Bangalore, on 11 November 1992.

Dr. K. Swarupanandan (Ecology) delivered a special lecture on 'Acid rain, green house effect and ozone depletion' at the Government Victoria College, Palghat, on 6 January 1993. He also gave a lecture on 'Vegetation types of Kerala with reference to succession and diversity' at the Trainers Training Course on Biological Diversity, held at TBGRI, on 17 February 1993.

Dr. K.K. Ramachandran, Dr. P.S. Easa and *Mr. E.A. Jayson*

(Wildlife Biology) gave invited talks on the following topics at the Trainers Training course held at TBGRI, Palode on 17 February, 1993. i) Role of protected areas in biodiversity conservation (*P.S. Easa*) ii) Animal diversity in Kerala (*K.K. Ramachandran)* iii) Avifauna of Kerala (*E.A. Jayson*).

Dr. P.S. Easa delivered a lecture on 'Wildlife conservation' at Marthoma College, Tiruvalla on 15 January 1993.

Dr. E.M. Muralidharan gave a lecture on 'Somatic embryogenesis and artificial seeds' at the Centre for Biotechnology, University of Cochin, on 26 February 1993.

Visits

Shri K. Sankara Pillai (Librarian-in-Charge), Project Leader, Bamboo Information Centre, India, visited Bamboo Information Centre, Beijing, China, during 20-30 September 1992 under the exchange programme of personnel between the two Information Centres.

Training Programme

Dr. K.V. Bhat (Wood Science) visited the University College of North Wales, Bangor, U.K., to attend a 12-week training programme (starting from 20 January 1993) in modern sawmilling and saw doctoring techniques under the ODA Project.

Forthcoming events

22-26 November 1993

Water Issues in Forests Today, Canberra, Australia.

Contact: International Symposium on Forest Hydrology, C/o. ACTS, GPO Box 2200, Canberra ACT 2601, Australia.

23-26 November 1993

Impact of Diseases and Insect Pests in Tropical Forests, Peechi, India.

Contact: Dr. K.S.S. Nair, Kerala Forest Research Institute, Peechi - 680 653, Thrissur District, Kerala, India.

29 November - 1 December 1993

ASEAN Seminar on Management and Conservation of Biodiversity. Kuala Lumpur, Malaysia.

Contact: Director, ASEAN Institute of Forest Management, Suit 903, IGB Plaza, 6, Jalan Kampar, 50400 Kuala Lumpur, Malaysia.

6-10 December 1993

International Congress on Modelling and Simulation 1993 - Modelling Change in Environmental and Socio-economic Systems, Perth, Australia.

Contact: International Congress Secretariat, Prof. M. McAleer, Dept., of Economics, Univ. of Western Australia, Nedlands, WA 6009, Australia.

6-11 December 1993

Sustainable Development of Degraded Lands through Agroforestry in Asia and the Pacific, New Delhi, India.

Contact: Panjab Singh, Director, Indian Grassland and Fodder Research Institute, Jhansi - 284 003, India.

7-9 March 1994

Recent Advances in Dipterocarp Research for Sustainable Forest Management, Chiang Mai, Thailand.

Contact: Director, ASEAN Forest Tree Seed Centre Project, Muak-Lek, Saraburi, Thailand 18180.

28-31 March 1994

4th International Conference on Plant Protection in the Tropics, Kuala Lumpur, Malaysia.

Contact: The Honorary Secretary, 4th MAPPS ICPPT, C/o. Department of Plant Protection, Faculty of Agriculture, 43400 UPM Serdang, Selangor, Malaysia.

17-23 April 1994

3rd Asian Conference on Mycorrhizae: Biology and Taxonomy, Yogyakarta, Indonesia.
Contact: Director, SEAMEO BIOTROP, P.O. Box 17, Bogor, Indonesia.

24-30 April 1994

Minimum Data Requirements for Sustainable Forest Management, Stellenbosch, South Africa.
Contact: Prof. B. Bredenkamp, Faculty of Forestry, University of Stellenbosch, Private Bag X 5018, 7599 Stellenbosch, South Africa.

April 1994

Forest Nursery Operations in Tropical Countries, Rotorua, New Zealand.
Contact: M.I. Menzies, NZ Forest Research Institute, Private Bag 3020, Rotorua, New Zealand.

25-28 April 1994

Behaviour, Population Dynamics and Control of Forest Insects, Blacksburg, USA.
Contact: Dr. Thomas L. Payne, Dept. of Entomology, Virginia Polytechnic Institute and State University, 216 Price Hall, Blacksburg, USA.

Campus news

Ph.D. awarded

Shri V.K. Rahmathulla, Research Fellow attached to the Entomology Division (1987-1989), has been awarded Ph.D. Degree by the University of Calicut for his Thesis entitled 'Studies on geometrid fauna of Kerala. This study was carried out under the guidance of Dr. George Mathew (Entomology).

S.K. Seth Memorial Prize

Dr. S. Chand Basha (Director) won the S.K. Seth Memorial Prize for the year 1992 for his article entitled 'Mangroves of Kerala - a fast disappearing asset' published in the March 1992 issue of 'Indian Forester'.

KFRI Publications

Author/Editor	Title	Price	
		India (Rs.)	Foreign (US$)
K.S.S. Nair et al.	Ecodevelopment of Western Ghats	200.00	18.00
K.K.N. Nair et al.	Tropical Forest Ecosystem Conservation and Development in South and South-East Asia.	200.00	18.00
I.V.R.Rao et al.	Bamboos : Current research	140.00	15.00
N. Sasidharan	Forest Trees of Kerala	15.00	5.00
C.Renuka	Rattans of the Western Ghats	100.00	8.00
K.M. Bhat	Structure and Properties of South Indian Rattans	75.00	5.00
S. Chand Basha & K.M. Bhat	Rattan Management and Utilisation	300.00	25.00
K.V. Sankaran et al.	Litter Dynamics, Microbial Associations and Soil Studies in *Acacia auriculiformis* Plantations in Kerala	75.00	8.00

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