AGRONOMIC RESOURCE INVENTORY OF A HOMESTEAD IN THE SOUTHERN ZONE OF KERALA

BY

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THESIS

SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENT FOR THE DEGREE

MASTER OF SCIENCE IN AGRICULTURE

FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

1993

Dedicated to

my beloved Grand Parents

DECLARATION

I hereby declare that this thesis entitled "Agronomic resource inventory of a homestead in the southern zone of Kerala" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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28.10.1993

CERTIFICATE

Certified that this thesis, entitled "Agronomic resource inventory of a homestead in the southern zone of Kerala" is a record of research work done independently by Sri. Happy Mathew, K. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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ACKNOWLEDGEMENT

The author wishes to express his profound feelings of gratitude and indebtedness to:

Dr. M. Achuthan Nair, *Associate Professor of Agronomy, College of Agriculture, Vellayani and Chairman of the Advisory Committee from whom I got the first suggestion to undertake this problem of investigation. Invaluable were the guidance rendered, sustained interest shown and the constructive criticism throughout the course of this investigation and preparation of the thesis;*

Sri. P. Chandrasekharan, *Professor and Head of the Department of Agronomy, College of Agriculture, Vellayani for taking time to critically scrutinise the manuscript and rendering suggestions;*

Dr. N. Mohanakumaran, *Associate Director, NARP (S.R.), College of Agriculture, Vellayani for his helpful suggestions and encouragement rendered to him at every phase of the conduct of the investigation and final preparation of the thesis;*

Sri. E.R. Narayanan Nair, *Professor of Agricultural Economics, College of Agriculture, Vellayani for his friendly approach, constant encouragement, and ungrudging help;*

Dr. P.K. Ashokan, *Associate Professor, College of Forestry, Vellanikkara for his timely help, encouragement and valuable suggestions during the preparation of this thesis;*

the teachers and non teaching staff of the Department of Agronomy, College of Agriculture, Vellayani for their whole hearted co-operation and assistance extended throughout the course of this investigation;

Miss. Shalini Pillai, P., Miss. Sajitha Rani, Smt. Sree Durga, N., Sri. Pratapan, K., Smt. Sheela, K.R., Sri. George Joseph, Sri. Sujo Sebastian, Sri. Thomas George, Sri. Sreekumar, S., Sri. Anil, B.K., Miss. Sheela R., Sri. Moosa, P.P., Sri. Jimmy Jose, Sri. Raj Nandan, Sri. Nizamudeen, A., Sri. Anil Kuruvila and all other post-graduate and graduate students who helped him at one stage or another during the course of this labourious and difficult investigation and preparation of the thesis;

Sri. Sreekumar and Sri. Sanjeev for designing and neatly drawing the graphs and figures.

his uncle Dr. P.A. Varghese for sending him some of the equipments required for the investigation from United States;

Sri. Nagappan and his family for generously permitting him to carry out the investigation in their homestead and for the innumerable help rendered to him throughout the course of this investigation;

the Kerala Agricultural University for providing him the facilities required for the investigation;

the Indian Council of Agricultural Research, New Delhi for awarding Junior Research Fellowship for carrying out the Post-Graduate programme;

Miss. Sudha, V.S. and M/s. Repromen for neatly executing the typing of the thesis;

his beloved father, mother, brothers and sister for their inspiration and constant encouragement throughout the course of this investigation;

his wife Smt. Suja, her parents, brother and sister for their innumerable help and encouragement during the final stages of the preparation of this thesis;

and above all to God Almighty whose blessings helped him a lot to continue and successfully complete this small piece of work.

HAPPY MATHEW, K.

Vellayani,
28.10.1993.

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LIST OF ABBREVIATIONS

@	at the rate of
Ca	calcium
cm	centimetre
C.V.	coefficient of variance
et al.	and others
Fig.	figure
FYM	farm yard manure
g	gram
g . cm-3	gram per cubic centimetre
ha	hectare
hp	horse-power
Hrs.	hours
i.e.	that is
K	potassium
KAU	Kerala Agricultural University
kg	kilogram
$kg.ha^{-1}$	kilogram per hectare
$kg.ha^{-1}.yr^{-1}$	kilogram per hectare per year
l	litre
m	metre
m^2	square metre
Mg	magnesium
mm	milli-metre
N	nitrogen

No.	number
Nos.	numbers
P	phosphorus
ppm	parts per million
RH	relative humidity
Rs.	rupees
t	tonnes
$t.ha^{-1}$	tonnes per hectare
$t.yr^{-1}$	tonnes per year
viz.	namely
^{o}C	degree celsius
%	per cent

INTRODUCTION

INTRODUCTION

Agroforestry is a recent concept. It involves mixed husbandry of multipurpose trees with agricultural crops. Today agroforestry is considered as an agricultural system, particularly of small farmers' in the tropics. There are various traditional agroforestry systems which are accepted by many as superior land use systems.

Homestead system or homegarden is one among the agroforestry systems. This is unique to the state of Kerala, particularly in the southern zone, where the average size of holdings is comparatively small.

Homestead is an operational farm unit in which crops (dominated by tree crops), livestock, poultry and/or fish production is carried out mainly for satisfying the farmers' needs. More than 80 per cent of the produce generated in a homestead is consumed within the home itself, the remaining 20 per cent providing subsidiary income to the house owner. The farmers utilize the area available around the houses for different enterprises. They choose trees, annual crops and crop combinations based on their home requirements, without any scientific basis.

The complex role of the tree, and the biological interaction between trees and other components within the homesteads have not yet been scientifically studied. Hence design and development of homestead agroforestry models are very essential.

One of the important advantages of agroforestry is that the trees act as nutrient pumps. Transfer of nutrients from plant parts to soil takes place in varying degrees in tree-plant-soil system. The extent of nutrients that leach out from the plant parts also differ. However, we know little about the variation in nutrient content and the quantity of nutrients added by plant cycling. The relationship between nutrient cycling and productivity in homegardens has not been worked out so far.

It is known that the nature and activity of microflora and fauna in a given soil environment depend upon the crops grown and the management practices followed. The nature of microorganisms associated with perennials such as tree crops is likely to be almost constant; but the introduction of other crops into the system could change this equilibrium. Information on the nature and population of microflora in homesteads is lacking and hence should receive priority.

Trees in agroforestry systems change the microclimate. But scientific information on the impact of trees and intensive cropping on the microclimate of homesteads is lacking. Such studies have not been attempted so far.

Soil and solar energy are the two basic resources of practical crop production. The homesteads of Kerala are mainly coconut based, with a multitude of other crops. The under utilization of solar radiation is a major cause for their low productivity. An understanding of the influence of light intensity and light penetration through different tree species is essential to effectively undertake intercropping in the homegardens, for maximum production and profit. Because of the lack of scientific information, recommendations could not be made so far to improve the productivity of the homesteads, where the farmers undertake subsistance farming. Under these circumstance an investigation was undertaken in a selected homestead with the following objectives:

1) To make an inventory of the biological components in the selected homestead.

2) To study the structure and function of the various biological components of the system.

3) To study the nutrient cycling, changes in soil (physical, chemical and biological) properties ,

4) To study the changes in microclimate as influenced by the perennial trees , and

5) To study the economics of the homestead.

REVIEW OF LITERATURE

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Research on agroforestry was started only recently with the increasing awareness and interest in agroforestry especially in the tropics. Work has been carried out to study the potential role of trees in agroforestry in general and homesteads in particular. Even though a number of research reports are available on nutrient dynamics in forest ecosystem, the role of trees and the biological interaction between trees and other components in the homesteads have not been systematically studied. Reports on the changes in physical, chemical and biological properties of homestead soil, study on microclimate, light penetration, influence of trees on these systems and economics of homestead systems are very few. A review of research on the relevant aspects related to agroforestry homegardens is given below.

2.1 Homestead agroforestry systems, Definition and Structure

Pal et al. (1985) attempted to redefine certain terms in cropping system research to make them more rational and widely acceptable. But they missed to redefine the term homestead farming in their endeavour. Many workers have defined homesteads based on their structure and function.

Ninez (1984) defined homestead production system as a sub system which aims at the production of household consumption items either not obtainable, not readily available or not affordable through field agriculture. Nair and Sreedharan (1986) defined homestead as an operational farm unit in which a number of crops (including tree crops) are grown with live stock, poultry and/or fish production mainly for the purpose of satisfying the farmers' basic needs.

Stoler (1975) referred to the term mixed garden or house garden for the homestead agriculture. Homestead agroforestry practices have been described by Liyange et al. (1985) from Sri Lanka, Nair and Sreedharan (1986) from India and Khaleque (1987) from Bangladesh. Hanman (1986) referred homestead to the home and its adjoining land owned and occupied by the dwelling unit of the household including the immediate area surrounding the dweller's unit and the space used for cultivation of trees and vegetables. Soemarwoto (1987) reported a typical homestead with a multitude of crops presented in a multitier canopy configuration.

Stoler (1975) reported that with growing pressure on the land and decreasing area of crop land per head, the population of land under homegarden has been increasing upto 75% of the cultivated land. He also reported that with the decline in size of holdings, the income was increasingly sought from off farm employment. This caused reduction in the cultivation of annual crops and increased the cultivation of trees and perennials which needed only less labour. Nair (1984) found that homegardens are known for their stable yields, very varied products, continuous or repeated harvests during the year and their inputs. He also reported that inclusion of woody species in the farm land reduced various undesirable processes of soil degradation and productivity decline.

Nair and Krishnankutty (1984) concluded that Kerala had a high density of population resulting in small size farm holdings. The size of holdings ranged commonly from 0.02 ha to 1.00 ha. Jacob and Alles (1987) reported that Kandyan gardens in Sri Lanka represented a home garden system practised in small homestead holdings, of an average size of 1.00 ha in the mid-country regions. William and Khaleque (1987) reported that homestead forests are an existing system in Bangladesh. The size of the homesteads in Bangladesh range between 0.020 - 1.44 ha, the average being only 0.097 ha.

Nair and Sreedharan (1986) reported coconut as the most dominant and important tree crop in the Kerala homesteads. The other perennial crops in the homestead were arecanut, black pepper, cocoa, cashew and various tree species. The most important multipurpose trees in homegardens of Kerala were identified by them as teak, jack, casuarina, portia, silver oak, pala and ilavu. Abdul Salam et al. (1992) reported that kumbi, vatta, venga, ayoni, ilavu, teak,perumaram, portia, erythrina elanji and mahogoni as the major tree communities grown in homegarden agroforestry system in Kerala.

Jacob and Alles (1987) observed that in Kandyan gardens of Sri Lanka, the most important tree crops in the system were arecanut, jack and coconut. The largest number of crops grown on a farm was 18 and the lowest four Eighty per cent of the farms grew 8-15 crops.

The structure and function of homegardens were described by Anderson (1954), Kimber (1973) and Fernandes et al. (1984).

Fernandes and Nair (1986) felt that the structural complexity, species diversity, multiple output nature and tremendous variability in the home gardens (as homestead sometimes referred to) make them extremely difficult to work with according to the currently available research procedures. The research works to define the homestead and to describe its structure and function has not been attempted systematically so far, especially in the case of homegardens in Kerala. So this is to be attempted on a priority basis.

2.2 Nutrient cycling

One of the main principles of soil management in agroforestry is to make the best use of its resource - conserving and resource - sharing potentials. The main advantage of trees in a homestead is the addition of nutrients by organic cycling, that take place to varying degrees in all land use systems become particularly relevant in the homestead agroforestry context because of the likely effects of trees on such processes. Closed nutrient cycling known to operate in mixed evergreen natural forests are not strictly operative in homestead agroforestry systems (Nair, 1984).

According to Switzer and Nelson (1972), three principal mineral flow pathways affect the nutrition of terrestrial communities. They are geochemical, biogeochemical and biochemical cycling. The geochemical cycle links external environment to the ecosystem i.e. nutrient cycling between environment and the plant communities. The major processes involved in these cycling process are atmospheric inputs and inputs from soil parent material.

The biogeochemical cycle is the circulation of nutrient capital between soil, standing crop and litter subsystem. It involves the atmosphere, soil and plant. The major biogeochemical cycling processes are nutrient uptake by plants and its return by litterfall, stemflow and throughfall (Switzer and Nelson, 1972).

The biochemical cycle includes the nutrient redistribution in the living biomass that act to conserve elements within the standing crop. This includes the redistribution and retranslocation of nutrient elements within the plant system itself, mainly during the period of deficiency, leaf ageing and final leaf senescence (Switzer and Nelson, 1972).

The three cycling processes are coupled in overall community nutrition; but the relative significance of one or the other of these major pathways differs from element to element (Charley and Richards, 1983). A conceptual model involving all these cycling processes are given in Fig. 1.

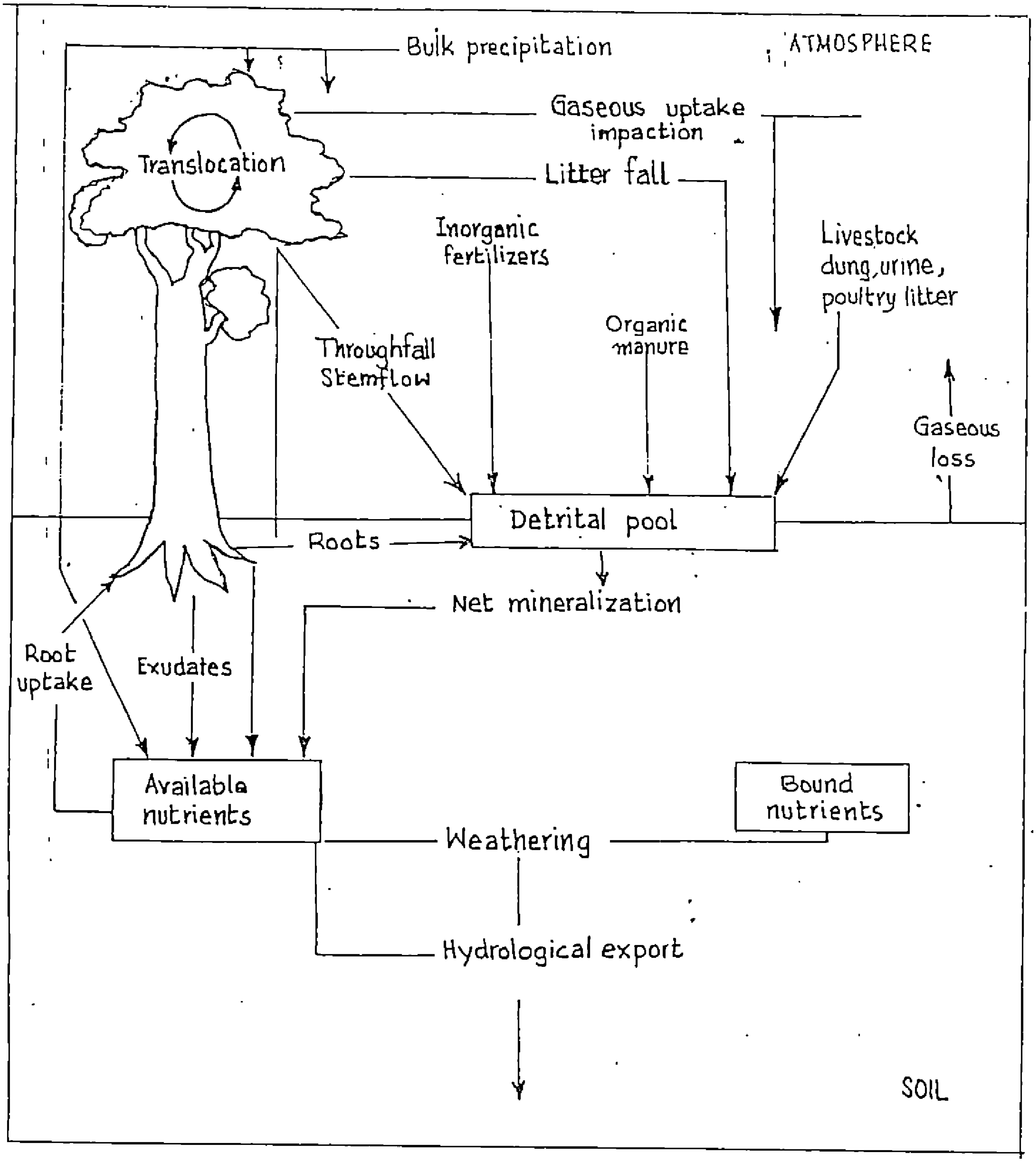

Fig 1. GENERALIZED PICTURE OF NUTRIENT CYCLING PATHWAYS IN HOMESTEAD SYSTEMS

There were many reports on the nutrient dynamics in forest ecosystem. However, little attention had been given to the study of nutrient cycling processes in homesteads so far. A review of available literature on the nutrient cycling in crop-tree ecosystem related to the present investigation is reviewed hereunder.

One of the important advantage of agroforestry is that the trees act as nutrient pumps. Transfer of nutrients from plant parts to soil takes place in varying degrees with tree-plant-soil system (Mitchell et al., 1975; Bormann et al., 1977).

The relationship between nutrient cycling and productivity has been worked out by Ovington et al. (1962) and Rodin and Bazilevich (1967). Specific studies have also compared elemental cycling, elemental distribution, productivity etc. (Heilman and Gessel, 1963; Fagerstorm and Lohm, 1977; Madwick et al., 1970).

Nutrient cycling is an important aspect that has to be considered while deciding the management practices for any agroforestry system. In most tree species significant quantities of nutrients are accumulated and cycled through litterfall, stemflow and throughfall (Will, 1959).

2.2.1 Litterfall

Switzer and Nelson (1972) reported that the nutrients taken up by trees are returned eventually to the soil. The principal agencies involved are stemflow, throughfall, litterfall, shedding of roots and exudation from roots.

Das and Ramakrishnan (1985) reported that the litter on the forest floor acts as an input-output system for nutrients. Das and Ramakrishnan (1985), Pande and Sharma (1986) and Harmon et al. (1990) studied the litter dynamics in temperate and/or homogenous forests. However, we know little about the variation in the quantity of litter, its nutrient content and quantity of nutrient added by trees in homestead systems.

Vinha and Pereira (1983) reported that the phenology of litter production varied from species to species.

George (1982) reported that Eucalyptus hybrid contributed 6207 $kg.ha^{-1}$ litter per year. Nair and Shrivastava (1985) compared the litterfall in plantations and natural stands and found that maximum litter measured was higher in the plantations than in the natural stands. Chaubey et al. (1988) reported that litter production was greater (1.5 - 2.0 tonnes) in the teak plantations than natural forests. Litter production from protected site and unprotected site also varied. Nirmal Ram et al. (1986) observed that the annual production was 4885.7 $kg.ha^{-1}$ from the protected site and 3648.9 $kg.ha^{-1}$ from the unprotected sites. Shajikumar and Ashokan (1992) estimated the quantity of litter produced by *Eucalyptus tereticornis*, *Glyricidia sepium*, *Leucaena leucocephala* and *Ailanthus tryphysa* as 4059, 1751, 3323 and 1593 $kg.ha^{-1}.yr^{-1}$ respectively.

Westman (1978) studied the nutrient dynamics of litter in a sub-tropical Eucalyptus forest and reported that litterfall was greater during summer.

Shajikumar and Ashokan (1992) had revealed that *Eucalyptus tereticornis* produced maximum litter in August - September.

The average litterfall and nutrient return for temperate deciduous and coniferous forests were estimated by Cole and Rapp (1980). They estimated 5400 and 4380 $kg.ha^{-1}\ yr^{-1}$ of litter in temperate deciduous and coniferous forests respectively.

Charley and Richards (1983) found that Eucalyptus forests under warm temperate conditions demonstrated variation in litter from year to year.

Miller *et al.* (1976) estimated a total litterfall of 15.69 tonnes to 23.82 tonnes in differently fertilized plots in corsicano pine (*Pinus nigra* var. *maritina*) of 36 years age.

Pushp and Surendra (1987) concluded after studying the dynamics of nutrients and leaf mass in Central Himalayan forest trees and shrubs, that the climate, growth form and different ecophysiology of species interact in a complex fashion to influence the pattern of leaf phenology and nutrient retranslocation. He further reported that pine growing in low fertile soil had a greater nutrient retranslocation capacity with greater litterfall.

In natural forests and man made protected plantations, cycling of nutrients is an important aspect as considerable amounts of nutrients are returned to the soil through leaffall and made available for reabsorption.

Miller et al. (1976) concluded that litterfall accounted for nearly all the nitrogen and phosphorus released by the trees. Charley and Richards (1983) reported that leaves accounted for 50-70 per cent of total litterfall and they also accounted for most of the inputs of Ca, Mg, S, N, P and K that reached the floor in organic debris.

Species is an important factor in cycling of nutrients. Tappeiner and Alm (1975) reported that there was interspecific differences in leaf nutrient content within the plant communities.

Khanna and Nair (1977) reported the nutrient output in a 30 year old pure coconut plantation. They reported the output from leaves as 33.1, 3.8 and 13.4 $kg.ha^{-1}\ yr^{-1}$ of N, P and K respectively and 0.4, 0.1 and 0.3 $kg.ha^{-1}\ yr^{-1}$, N, P and K respectively from the spathe and rachis.

Kadeba and Aduayi (1985) estimated the nutrient return in a stand of Pinus caribea as 15.9, 0.6, 17.3, 18.2 and 6.3 kg. ha^{-1}. yr^{-1} of N, P, K, Ca and Mg respectively. Chaubey et al. (1988) compared the nutrient content of teak plantations and natural forests. They found a greater content of N, P, K and Ca in plantation than in forest litter.

Shajikumar and Ashokan (1992) have revelead that out of the four species investigated, the N,P and K content in the litter was more in Glyricidia sepium and Leucaena leucocephala. The quantity of N added to the soil by Euclyptus tereticornis, Glyricidia sepium, Leucaena leucocephala and Ailanthus triphysa were 65, 58, 103 and 25 kg.ha^{-1} respectively. The P cycled through litter was 4.8, 1.9, 5.3 and 1.8 kg. ha^{-1}. respectively.

Season is another factor which determines the nutrient return. According to the review of Bray and Gorham (1964) moist tropical forests shed litter at a fairly steady rate through out the year, whereas the deposition in arid-zone ecosystem is unpredictable because of the large random element in the timing and magnitude of precipitation events. Rodin and Bazilevich (1967) showed that N clearly dominated the mineral content of litterfall in Tundra and deciduous forests of the temperate zone, on the other hand calcium was predominant in broad leaved forests of temperate zone and in subtropical rain forest communities. They further reported that mineral return in annual litterfall may exceed 2000 kg. ha^{-1} in tropical rain forests, 100-200 kg. ha^{-1} in coniferous forests and 250-500 kg. ha^{-1} in temperate deciduous forests.

Rodin and Bazilevich (1967) reported that about 50-70 kg. ha^{-1} of N is added by litterfall in coniferous forests and 250-325 kg. ha^{-1} of N in tropical and subtropical forests.

Cole and Rapp (1980) estimated the nutrient return for temperate deciduous and coniferous forests. The nutrient return accounted to 61, 42, 68, 11 and 4 kg. ha^{-1}. yr^{-1} of N, K, Ca, Mg and P for temperate deciduous forests and 37, 26, 37, 6 and 4 kg. ha^{-1}. yr^{-1} of N, K, Ca, Mg and P respectively for temperate coniferous forests.

Singh (1984) studied the variation in the nutrient content in leaf litter in a year. They found that the P content remained stable while the content of K and Mg showed small variations during the year, but there was little overall change.

Site characteristics is another factor which determine the nutrient return. Thomas and Grigal (1976) and Chapin et al. (1980) found that species of infertile site showed greater proportional retranslocation of N, P and K than do the species adapted to fertile site. Radwan et al. (1984) reported that weight of leaf litter was not significantly related to site index, stand, age or basal area.

Procter et al. (1985) reported that the nutrient status of the site was characterised by the total content in litterfall than by the concentration in litterfall. Pushp and Surendra (1987) reported that pine growing in low fertile soils had greater nutrient retranslocation capability with greater litterfall.

There were reports on certain other factors which affected the annual nutrient return by litterfall. Bray and Gorham (1964) reported on the year to year variation in annual nutrient return in litter. They found that the results vary widely from year to year. Sharma and Pande (1989) found that nutrient concentrations were related to tissue longevity and species life forms.

Switzer and Nelson (1972) found that after 20 years of biomass and nutrient accumulation, the plant ecosystem drew very little of its annual nutrient requirements from soil reserve. Instead, it obtained most of its needs from the established external litter decay. Cole and Rapp (1980) found that, out of the total nutrient return by litterfall, stemflow and crown wash, 83 per cent, 41 per cent, 71 per cent , 60 per cent and 85 per cent of N, K, Ca, Mg and P were by litterfall alone.

2.2.2 Throughfall and Stemflow

The composition of throughfall and stemflow had been studied in a number of ecosystems, especially in western hemisphere regions and Australia. Most of these reports were for temperate hard woods and conifers. Very little attention has been paid to study the nutrient cycling properties of the tropical tree species.

Helvey and Patric (1965) reported that rain striking plant surfaces either drops to the soil as throughfall or is channelled to the ground as stemflow. In most situations 85 per cent or more of input is by throughfall and sometimes less than 10 per cent is by stemflow. Switzer and Nelson (1972) reported that the nutrient taken up by trees are eventually returned to the soil. The principal agencies involved are stemflow, throughfall, litterfall, shedding of roots and exudation from roots.

Miller *et al*. (1976) reported that throughfall accounted for about two-third of the gross rainfall whereas stemflow represented only from 1.7 to 3.4 per cent.

The concentration of elements in stemflow were higher than those in throughfall by a factor averaging 1.2 for nitrogen, 3.1 for phosphorus and 3.4 for potassium. Harry *et al*. (1978) reported that stemflow accounted for only about two per cent of the total water received beneath the canopy. Jordan (1978) reported that the contribution of nutrients by stemflow may be higher in tropical forests, between 17.5 and 22 per cent. George (1979) observed that throughfall water will contain less elements when compared to stemflow. Baker and Attiwill (1987) found that the concentration of all elements were greatest in stemflow, than in throughfall and least in rainfall.

Turkey (1970) indicated that one of the principal factors affecting leaf leaching was the duration of rains.

Harry *et al*. (1978) reported that leaching of phosphorus, potassium and calcium from the trees were usually greater on the more productive sites than on poorer ones. He also found that stemflow was positively correlated with tree diameter. Charley and Richards (1983) reviewed that the annual nutrient load in throughfall varied greatly with forest trees. The quantities vary with conifers and broad leaved species, with less addition in case of conifers. They found that the throughfall nutrients in tropical forests were greater.

Scheir (1987) studied about the chemistry of throughfall in red maple and found that the concentration of Ca, K, Mg and Fe were lowest in May and it increased to a peak in July and then decreased.

Nye (1961) estimated the K, Ca, Mg and P content in throughfall in rain forests of Ghana as 202, 16, 7 and 3.3 $kg.ha^{-1}$ yr^{-1} respectively. Bernhard -Reversat (1975) reported an annual elemental input of 177, 64 and 9.1 $kg.ha^{-1}$ of K, total N and P respectively in rainforests of Ivory Coast. Golley *et al.* (1975) reported an annual return of 50 kg. ha^{-1} of K in rainforests of Panama. Manokaran (1980) reported that the annual addition of nutrients to the soil through stemflow and throughfall in a low-land tropical rain forests as 6.7, 24.6, 3.9, 1.4 and 19.2 kg.ha^{-1}. yr^{-1} of total N, K, Ca, Mg and Na respectively.

Khanna and Nair (1977) reported that 151 kg. ha^{-1}. yr^{-1} potassium was added by coconut washout in Kerala.

Westman (1978) estimated an annual addition of 9, 2.8 and 0.25 kg ha^{-1} of K, total N and P respectively in pine forests of U.S.A. He also reported an annual nutrient return of 9, 14, 7, 35, 85 and 17 kg.ha^{-1}. yr^{-1} of K, Ca, Mg, total N, Cl and S respectively by throughfall. Turvey (1979) estimated the addition of Na, K, Ca and Mg in a Eucalyptus plantation in Australia by throughfall as 17, 36, 6 and 5 kg. ha^{-1}. yr^{-1} respectively.

Rainfall also contributed to the nutrient cycling process. Babukutty (1966) estimated 7.8 kg. ha^{-1} of nitrogen addition by monsoon rains. Vijayalakshmi and Pandalai (1962) estimated an addition of 2.3 and 4.8 kg.

$ha^{-1} \cdot yr^{-1}$ of nitrogen and phosphorus through rains. Miller et al. (1979) found that for phosphorus there was no significant inputs in aerosols; but for potassium, calcium and magnesium, this was an important source.

2.3 Soil physico chemical properties

The homestead farming system is very complex due to the involvement of the number of components including multipurpose tree species and animals. Due to the constant addition of the organic matter to the soil by litter fall (Brinson et al., 1980) the chances of changes in soil physico chemical properties is great.

The research reports on the major factors which has got influence on major soil physico chemical properties are reviewed here.

2.3.1 Physical properties

Jose and Koshy (1972) observed that the morphological features of the soil had been altered by silvicultural operations. Nelliat and Shamabhat (1979) reported that mixed farming caused substantial improvement in the physical and biological characteristics of the soil.

Pathak (1954) and Salter *et al*. (1965) observed that addition of organic matter through FYM or other sources increased the water holding capacity of the soil. Biswas and Khosla (1971) and Singh *et al*. (1976) found that addition of FYM increased the available water capacity of soil. Rajput and Sastry (1988) observed that there was significant increase in water retention of soils by addition of FYM.

Morachan (1978) reported significant decrease in bulk density with increase of carbon content of soil. Mazurak *et al*. (1975) reported substantial reduction in bulk density with application of FYM and other manures due to more number of large aggregates in this situation. Improvement is bulk density by FYM addition was reported by Nambiar and Ghosh (1984). Rajput and Sastry (1987) noticed that there was significant changes in aggregation status and bulk density with addition of FYM.

There were many reports on the beneficial effects of trees in soil and water conservation. A report from China (Xiaoliang, 1977) indicates that under tropical monsoon climate, the establishment of forests on eroded slopes reduced annual soil erosion from about 15000 to 3000 $m^3 \cdot km^{-2}$ over a period of 10 years.

Tejwani (1979) reported from India that improvements in soil physical properties occured by afforestation. Afforestation also reduced water run off and soil erosion.

Humbel (1975) reported that in an undisturbed forest ecosystem, water movement under saturated conditions take place in soils through macropores that dominated the pore space, resulting in reduced surface run off even in regions of intense rains. Pereira (1979) demonstrated the favourable influence of trees on the hydrological characteristics and water balance of the area.

2.3.2 Chemical properties

The major recognized avenue for addition of organic matter and hence, of nutrients to the soil from the trees standing on it is through litterfall, (Brinson *et al.*, 1980). There are several studies on this aspect from tropical forests. (Kira, 1989; Cornforth, 1970 ; Edwards, 1977). The bulk of the organic matter and nutrients that are so added to the soil are located in topsoil (Folster *et al.*, 1976)

The gradual accumulation of mineral nutrients by perennial, slow growing trees, and the incorporation of these into an enlarged plant - litter soil nutrient cycle was the mechanism responsible for soil enrichment (Nair, 1984).

According to Morachan (1978) organic carbon significantly decreased the bulk density of the soil.

Significant increase in organic carbon content, nitrogen and cation exchange capacity were noticed by Rajput and Sastry (1987) with addition of FYM.

2.4 Micro-organisms

Due to the complex nature of homestead systems (Fernandes and Nair, 1986), not much studies had been attempted on the rhizosphere micro-organisms in the system. A few reports related to the present investigation are reviewed hereunder.

Clark (1949) reported that the nature and activity of microflora and fauna in a given soil environment depend upon the crops grown and the management practices followed.

Nair (1973) observed that short term changes in soil environment produced by season and to a small extent by crop species brought about temporary quantitative changes in micro-organisms, but these changes persisted only for the length of time over which the new factors were operative.

Gaur and Mathur (1966) reported on the beneficial effect of humus on the growth of azotobacter. Bhardwraj and Gaur (1970) found that the azotobacter population increased or decreased with organic carbon in the soil. Mishustin and Shilnikova (1971) observed that the addition of phosphatic fertilizers improved the bacterial growth and its proliferation. Potty (1977) reported that the number of fungi and actinomycetes were higher in rhizosphere of coconut palms, when the interspaces of palms were intercropped with fodder crops. Gaur and Mukherjee (1980) found that mulching increased the population of fungi, actinomycetes and bacteria. They found that azotobacter population was stimulated by about one and a half fold to four folds and actinomycetes and fungi populations by to three folds with mulching.

Nair and Rao (1977) reported from a study in root regions of coconut palms, that intensive cropping of coconut plantations enhanced microbial activity in the rhizosphere of coconut. Nair and Balakrishnan (1977) concluded that crop combination acts as a buffer against drastic changes of ecoclimate and this was found to have considerable effect on the various biological processes occuring on the environment and on the multiplication of plant parasites.

Nair and Rao (1977) concluded that the increase in number of micro-organisms in intensively cropped coconut cacao mixed plantations was due to the formation of soil organic matter by leaf fall from cacao.

2.5 Microclimate

The microclimate in a homestead system vary widely when compared with a pure crop system or an uncropped land. Very few studies were conducted regarding this aspect in homesteads. Information relevant to the present investigation is given below.

2.5.1 Soil temperature

Nair and Balakrishnan (1977) concluded that a crop cover on the ground helped to reduce temperature at soil surface during summer months. He also concluded that crop combination acted as a buffer against drastic changes in ecoclimate. Nair (1983 and 1984) observed that the homestead system caused less exposure of the bare soil and hence reduced soil temperatures.

2.5.2 Relative humidity

Relative humidity is an important factor which influences crop yields, indirectly, by changes in the rates of evapotranspiration and by incidence of pests and diseases.

Nair and Balakrishnan (1977) reported that shading reduced air temperature in the crop combination and the higher relative humidity values caused considerable reduction in the rates of evaporation in the ecoclimate of crop combination. They found that relative humidity in all cropping systems with coconuts had a higher value than open area. They further observed that the evaporation in the ecoclimate of crop combination was only about 30 per cent of that from open area. One of the main reasons for this was the higher values of relative humidity in crop combinations.

Nair (1979) reported that the leaf canopies of the components in a homestead are arranged in such a way that they occupy different vertical layers with the tallest component having foliage tolerant to strong light and shorter components having foliage requiring or tolerating shade and high humidity.

2.6 Light intensity

Solar energy is the ultimate source of energy for all plants. So the study of the light penetration by the tree canopies and their shading effect assumes importance in any cropping system. There are a few reports on the effect of trees on the light penetration characteristics, which are reviewed below.

Gardner (1965) reported that solar radiation is the primary force for evapotranspiration.

Nelliat et al. (1974) studied the apparent coverage of ground by coconut palms of different age groups. They observed that when the palm is about 8-10 years of age, the percentage of light transmitted was only about 20 per cent and then the transmission increased progressively and the canopy coverage of the ground decreased. Nair and Balakrishnan (1976) measured the intensity of light falling at the plantation floors of coconut during different seasons of the year at different distances from the palms of about 25 years of age. They found that at a distance of 3.5 m from the base of palms, the interception of solar radiation by coconut leaves was only 44 per cent of radiation. Nair and Balakrishnan (1976) reported that the percentage interception of available light by coconut palms was maximum during the early mornings (upto about 10.00 Hrs.). Therefore the peak availability of light for other intercrops was during 10.00 Hrs. to 16.00 Hrs. Nair (1979) observed that the leaf canopies of components in a typical homestead are arranged in such a way that they occupy different vertical layers with the tallest component having foliage tolerant to strong light and high evaporative demand and shorter components having foliage requiring or tolerating shade and high humidity. Nair (1983 and 1984) reported that the homestead system in Kerala caused less exposure to the bare soil.

Nair and Sreedharan (1986) reported that during the initial stages of coconut growth all sun loving crops were grown in lower tier and from bearing stage (8 years) to about 25 years of coconut, when the shade was rather dense, shade loving crops like yams, turmeric, ginger and so on were grown. Afterwards the incoming solar radiation in the garden increased and the homestead can be filled with a number of annual and perennial crops.

2.7 Economic analysis

Economic analysis is important to assertain whether the system is sustainable or not. The best way of economically analysing a homestead agroforestry system is by way of cost:benefit analysis and calculation of net return (Hoekstra, 1985). A review of research was undertaken to the related aspects of the present investigation.

Whenever input/output data are available, computation may be made to evaluate the proposed or existing system. The computational methods available for such evaluation are subdivided into optimization and non-optimization ones. While the first type enables the analyst to find the optimum solution, the second type enables the analyst to determine which of the alternative solution is the better one, not necessarily the optimum one. (Hoekstra, 1985).

The optimization methods are based on the technique of linear programming, which had been described by Beneke and Winterboer (1978), Heady and Candler (1958). Hoekstra (1985) observed that because of the rather large amount of data required over a long period, these optimization methods are not very popular for analysis of agroforestry systems. Hence he suggested the non-optimization method, better known as cost:benefit analysis as a better method for analysing agroforestry systems. In this system the inputs and outputs are taken into consideration for analysis.

Leaf litter from trees and shrubs may be used to add soil nutrients and organic matter to the soil. So far there were no recorded instances of leaf litter being sold commercially. Market prices may be derived, however, on the basis of nutrient content and prices of commercially available fertilizers (organic and in-organic). Hence leaf litter should be valued through the agricultural production system. This approach have been reported by Balasubramanian (1983); Hoekstra (1983); Ngambekii and Wilson (1984) and Vergara (1982).

Homestead systems present simultaneous mixing in both time and space of some combination of perennial and annual plants and/or animal production (ICRAF, 1983). The basic premise of an agroforestry system is that total net benefit is greater where joint rather than singular production exists. Several authors have studied the use of joint production economics in analysing agroforestry systems (Etherington and

Matthews, 1983; Harou, 1983; Hoekstra, 1985; and Raintree, 1982).

Nair (1976) calculated the net income from a multistorey crop combination of coconut + black pepper + cocoa + Pine apple in existing coconut garden of about 25 years of age in Kerala under irrigated management as Rs. 15430/- per annum. Nelliat and Krishnaji (1976) reported a net return of Rs. 15661/- from a multistorey cropping system with black pepper, cacao and pine apple in one hectare of coconut under rainfed condition in Kerala. He also estimated a net return of Rs. 11631/- in a mixed cropping of one hectare of rainfed area with 50 per cent area under coconut and the rest for tuber crops viz. cassava, elephant foot yam, sweet potato and greater yam.

Nelliat and Shamabhat (1979) reported that adoption of mixed farming practices in root (wilt) affected areas of coconut had helped to enhance the productivity of the coconut palms as well as of the land.

A study conducted by Kerala Gandhi Smarak Nidhi (1985) in the homesteads of Kerala, incorporating mixed farming concept, reported a total net income of

Rs. 9200/- per year from a plot of 0.12 ha with 23 coconut palms, 12 cloves, 56 bananan, 49 pineapple, 30 pepper vines and fodder grass. The rest of the area was set apart for cassava and vegetables with Leucaena being planted all around. A cow also formed a part of the above scheme. Abdul Salam et al. (1992) (b) while developing a model for homesteads for coastal uplands of south Kerala for an area of 0.2 ha for a four (2+2) member family, estimated a net income of Rs. 17513/- by fully utilising the land and resources and ensured a benefit of Rs. 1.84 per rupee invested. Adbul Salam et al. (1991) developed a model for multipurpose farming systems in South Kerala, for an area of 0.4 ha. They predicted a net return of Rs. 17273/- from among 23 activities fully utilising the space. They worked out a benefit:cost ratio of 1.8.

It can be seen from the review of research that the majority of the works on the nutrient cycling aspects had been done on the forest ecosystem with very little work on the homestead system. Reports on the changes in physical, chemical and biological properties of homestead soil, study on the microclimate, light penetration and overall economics of the homestead system are very few. Even some of the work done were only for any one of these factors. A comprehensive study on all these aspects and overall economics of the homesteads are totally lacking. Hence this investigation was carried out.

MATERIALS AND METHODS

MATERIALS AND METHODS

Investigations were undertaken on the agronomic resources inventory of a homestead of 0.2 ha size in Thiruvananthapuram district of the southern zone of Kerala, for a period of one year from June 1991 to May 1992. The study consisted of, among other things, the nutrient cycling by different tree species, the influence and role of the various tree species on the physical, chemical and biological properties of the soil, their influence on the microclimate in the homestead garden and overall economics, with a view to maximising productivity and increasing the income. The results were compared with an open system (control). The materials used and the methods adopted are described hereunder.

3.1 Location of study

The study was conducted in a homestead in Vellayani, near the College of Agriculture, situated in the southern zone of Kerala. The location details of the homestead are given below.

Place	:	Vellayani
District	:	Thiruvananthapuram
State	:	Kerala

Country	:	India
Latitude	:	8.5^{o} N.
Longitude	:	76.9^{o} E.
Elevation	:	29 metre above the MSL.
Area of the homestead	:	2057.5 m^2

3.2 Structure and Function of the homestead

3.2.1 Species composition and density

A detailed plan of the homestead showing the position of different components such as crops (including multipurpose tree crops), permanent structures like house, well, poultry shed, cattle shed and goat house was prepared, which is presented as Fig. 2. The various crops, the area occupied by the crops and the population of poultry and livestock were also recorded (Table 1 (a) and 1 (b)).

3.3 Nutrient cycling

The following considerations guided the study of nutrient cycling in the homestead.

1. The total nutrient addition (by the different nutrient cycling processes) by the different trees varies with the species, the canopy size and diameter of the tree trunk.

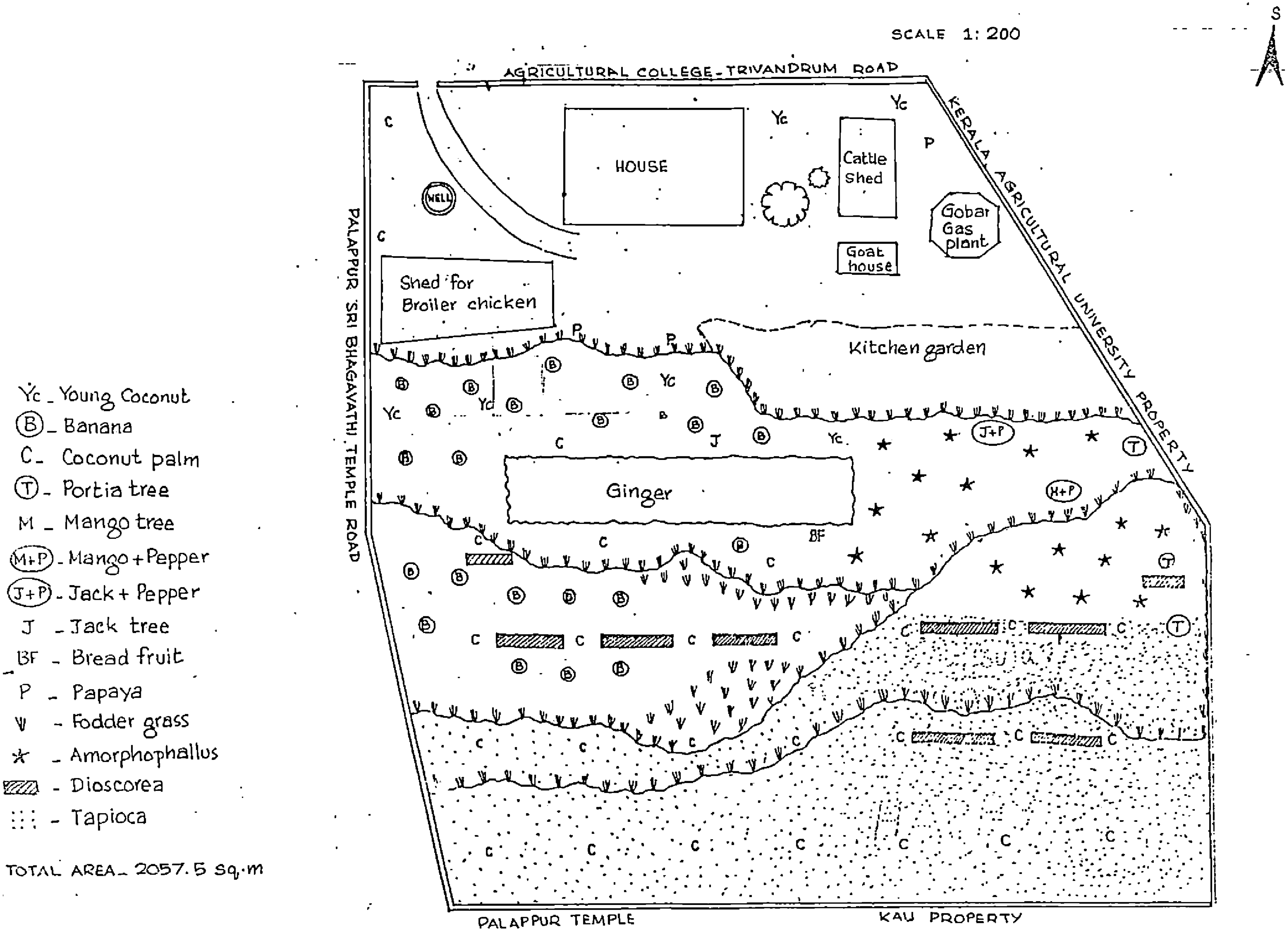

Fig. 2. LAYOUT PLAN OF THE HOMESTEAD.

Table 1(a). Inventory of crop species/trees in the homestead (Area - 2057.5 m^2)

Crop	Scientific name	Population/ Area	Growth form	Economic produce	Main Harvesting season
Coconut (Adult)	Cocos nucifera	27	Tree	Fruit	45 days interval
Coconut (Young)	Cocos nucifera	8	Tree	-	-
Mango	Mangifera indica	2	Tree	Fruit	February - March
Jack	Artocarpus hetrophyllus	2	Tree	Fruit	January - March
Portia	Thespesia populenea	3	Tree	Timber	
Breadfruit	Artocarpus altilis	1	Tree	Fruit	April - May
Banana (Nendran and Palayankodan)	Musa spp.	26	Perennial herb	Fruit	March - May
Pepper	Piper nigrum	2	Perennial woody climber	Berries	February
Papaya	Carica papaya	3	Tree	Fruit	Throughout the year
Cassava	Manihot esculenta	620	Tree	Tuber	May
Ginger	Zingiber officinale	40 m^2	Perennial herb	Rhizome	January
Fodder grass (Guinea grass)	Panicum maximum	20,000 hills	Grass	Foliage	Bimonthly intervals
Elephant foot yam	Amorphophallus campanulatus	18	Herb	Tuber	December - January
Dioscorea	Dioscorea esculenta	44	Herbaceous climber	Tuber	December - January
Vegetables		80 m^2	Annuals and perennials	Leaf, Fruit	Throughout the year

Table 1(b). Inventory of livestock and poultry in the homestead

Enterprises	Value	Economic products
Cow + Calf	2 Units	Milk, milk products dung and urine
Goat + Kids	1 Unit	Milk, dung and urine
Poultry	20 Nos.	Egg, poultry litter
Broiler chicken	600 Nos.	Chicken, poultry litter

2. The nutrient addition in the homestead varies with the intensity, duration and interval of rainfall.

3. The estimates of nutrient addition were made for the homestead under study.

4. One homestead with an area of about $2500 m^2$ (0.2 ha) was studied.

3.3.1 Litterfall

3.3.1.1 Method of litter collection

Litter collection from mango, jack and portia trees were made with suitable litter traps devised locally and set under the trees (Plate I). Bamboo baskets of size 0.5 m diameter and a depth of 0.4 m were used. These baskets were set below the trees in between three wooden poles at a height of about 0.5 m from the ground. The poles were used to keep the bamboo basket out of contact with the soil and to prevent the possible entry of soil into the baskets during splashing of rainwater. The poles also prevented termite attack of bamboo baskets. The canopy area of the trees were found and demarcated on the ground. This area was then divided into three concentric circles with the tree trunk at the centre. These circles were later subdivided into 28 semicircles

(Fig. 3). Six traps were set into these semicircles at random. The position of the traps were interchanged at quarterly intervals by selecting a set of fresh random numbers. The change in position would account for the spatial variation encountered beneath the canopy. The damaged baskets were removed and replaced with fresh ones.

In the case of coconut, the leaf fall from the trees was collected.

3.3.1.2 Chemical analysis of litter

The litter samples from the tree species were collected and dried at 70°C in a hot air oven. The samples collected from each tree were separated. Samples collected from one tree species each month were pooled and samples analysed for nitrogen, potassium, phosphorus, calcium and magnesium, and their content expressed in percentage. The methods adopted for nutrient analysis are given below.

Nitrogen	-	Microkjeldahl's method (Jackson, 1967)
Phosphorus	-	Vanadomolybdate phosphoric yellow method (Jackson, 1967)
Potassium	-	Atomic absorption Spectro photometry (Issac and Kerber, 1971)

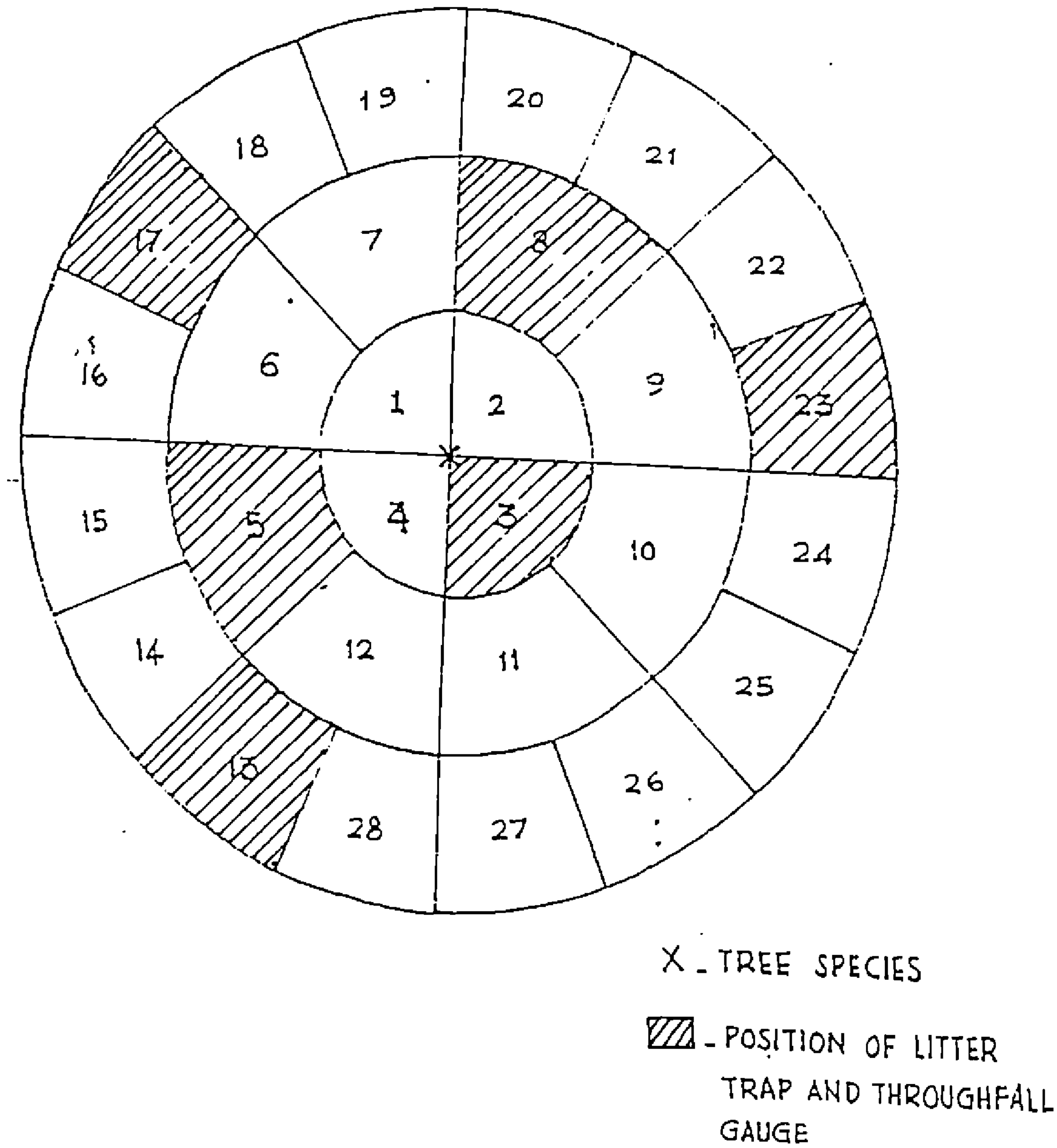

Fig. 3. SCHEMATIC REPRESENTATION OF POSITIONING OF LITTER TRAPS AND THROUGHFALL GAUGES

3.3.1.3 Quantification of litter and nutrient addition

The quantity of litter collected at monthly intervals per unit area under the tree canopy was found out. The quantification was done separately for each tree species viz. jack, mango and portia by using the following formula.

Annual litter fall ($kg.yr^{-1}$)

$$\frac{\text{Average annual litter collection in the litter trap (kg)}}{\text{Area of the litter trap } (m^2)} \times \text{Canopy area } (m^2)$$

The litterfall was made on canopy area basis as the trees were isolated and wide apart in the homestead.

In case of coconut, the total number of leaves fallen were counted and their weight found out, and expressed in $kg.yr^{-1}$.

From the total quantity of litter addition and the nutrient content of the litter, the nutrient addition by litterfall to the whole system was estimated and expressed in $kg.yr^{-1}$.

3.3.2 Throughfall

3.3.2.1 Method of collection

Throughfall was collected using special gauges designed for the purpose (Plate II). It consisted of six 0.2 metre diameter polythene funnels connected to collecting bottles, placed on the ground under each tree species. The litter that fell inside the gauges were trapped by plugs of sterilized cotton wool, that were replaced at periodical intervals. Random locations were alloted to the gauges. The procedure followed for setting the gauges was the same as that for setting the litter traps (Fig. 3).

To account for spatial variation encountered beneath the tree conopy, the location of the traps under each tree was changed at monthly interval. A similar gauge was set up in an open area along with a standard raingauge of 6 inches diameter (Plate III). The water collected in these guages were collected at periodic interval depending on the volume of water collected in the gauges, during rains.

3.3.2.2 Chemical analysis of throughfall

The samples of throughfall collected at periodic

Plate I Method of setting up of litter traps under the tree species

Plate II Method of setting up of throughfall gauges under the tree species

Plate I

Plate II

interval were stored at 2°C awaiting analysis. The nutrients N,P and K were analysed at monthly interval after pooling the samples collected each month from each tree (Miller et al., 1976). Similar samples were collected from open area and analysis was done.

3.3.2.3 Nutrient addition by throughfall

It was assumed that all the water coming by way of rainfall over the tree canopy is chanelled to the ground as throughfall and stemflow. The total quantity of water by rainfall was calculated from the volume of water collected in the open gauge, raingauge and the gauge area. The total quantity of throughfall was calculated from the canopy area, stemflow volume and the total quantity of rainwater received over the area.

$$\text{Total volume of water received by rainfall over the canopy area (l)} = \frac{\text{Volume of water received for unit rain (l)}}{\text{Area of the gauge } (m^2)} \times \text{Total rainfall} \times \text{Canopy area } (m^2)$$

$$\text{Volume of water by throughfall in a tree (l)} = \text{Total volume of water received by rainfall (l/tree)} - \text{Volume of water collected by stemflow from the same tree (l)}$$

From the value of volume of throughfall and its nutrient content, the total nutrient addition by each

Plate III Raingauge set up in the selected homestead to record the rainfall data

Plate IV Method of fixing stemflow gauge on the tree species

Plate III

Plate IV

tar was washed a number of times with distilled water to ensure that the coal tar used for fixing the gauges was free of any nutrients under study.

3.3.3.3 Nutrient addition by stemflow

The volume of water received by stemflow from each tree species was measured at periodic intervals, depending upon the intensity and duration of rainfall. The total quantity of water received by stemflow was thus computed. From the nutrient content in the stemflow, the total nutrient addition by each tree species at monthly intervals to the homestead by stemflow was calculated. The estimates were converted for the whole system and expressed in $kg.yr^{-1}$.

3.3.4 Nutrient addition by livestock dung, urine, poultry litter and inorganic fertilizers

The quantities of dung, and urine excreted by the respective animals were collected every day and quantified. The total quantity of manures added to the homestead were estimated. The total quantity of poultry litter was also estimated. The quantity of inorganic fertilizers applied for the various crops in the homestead and their nutrient value was also taken into consideration while calculating the total nutrient addition.

3.4 Soil physico-chemical properties

Soil samples were collected from the homestead at two depths ie 0-15 cm and 15-30 cm at quarterly intervals. A number of samples were collected from different parts of the field and composited before the samples were taken for analysis. The following physical and chemical properties of the soil samples were estimated. The data on the analysis of soil before starting the investigation is furnished in Appendix - I. The methods adopted for the study of the physical and chemical properties are given below.

3.4.1 Physical properties

a)	Mechanical analysis (%)	-	International Pipette Method (Piper, 1966)
b)	Particle density ($g.cc^{-1}$)	-	Core method
c)	Bulk density ($g.cc^{-1}$)	-	Core method
d)	Maximum water holding capacity (%)	-	Keen-Raczkowski box method
e)	Moisture content (%)	-	Oven dry method

3.4.2 Chemical properties

a)	Available nitrogen (%)	-	Alkaline permanganate method (Subbiah and Asija, 1956)
b)	Available phosphorus (%)	-	Calorimetric method (Klett Summerson Photo-electric Calori meter) (Jackson, 1973)

c)	Available Potassium (%)	-	Atomic absorption Spectrophotometry (Issac and Kerber, 1971)
d)	Organic Carbon (%)	-	Walkley and Black Rapid Titration method (Jackson, 1973)
e)	Soil pH	-	pH meter method

3.5 Soil micro-organisms

Soil samples were collected from the rhizosphere of the different trees in the homestead at monthly intervals. A number of samples were collected from different places in the field. The depth of sampling was 0-15 cm. All the samples were composited and analysed for microbial population, within one day of collection of the samples. The total number of bacteria, fungi and actinomycetes per gram of soil was estimated by the dilution plate technique (Timonin, 1940). Bacteria and actinomycetes were estimated at 10^{-3} and fungus at 10^{-6} dilution. Soil samples collected from the control fields were also analysed for micro-organisms.

Kauster medium was used for growing bacteria and actinomycetes and Martin's Rose Bengal agar for growing fungi.

The bacterial, fungal and actinomycetes colonies developed, after 2,5 and 7 days respectively. The readings were recorded as colony forming units (cfu)

3.6 Microclimate

A field observatory was set up in the homestead to observe the soil temperature, light intensity, relative humidity and rainfall data. These data were compared with the data collected from the meteorological observatory situated about 500 m from the homestead under study. The meteorological parameters such as temperature, rainfall, relative humidity, and sunshine hours recorded during the period of study, obtained from the meteorological observatory are given in Appendix - II and Fig. 4.

3.6.1 Soil temperature

Soil thermometers were installed in the homestead at a depth of 15 cm during the month of June 1991. Observations were made on the soil temperature at 7.25 A.M. and 2.25 P.M till 31st of May 1992. Observations were recorded at weekly intervals and the monthly mean calculated. Similar observations were made on the open field also, and the variations compared.

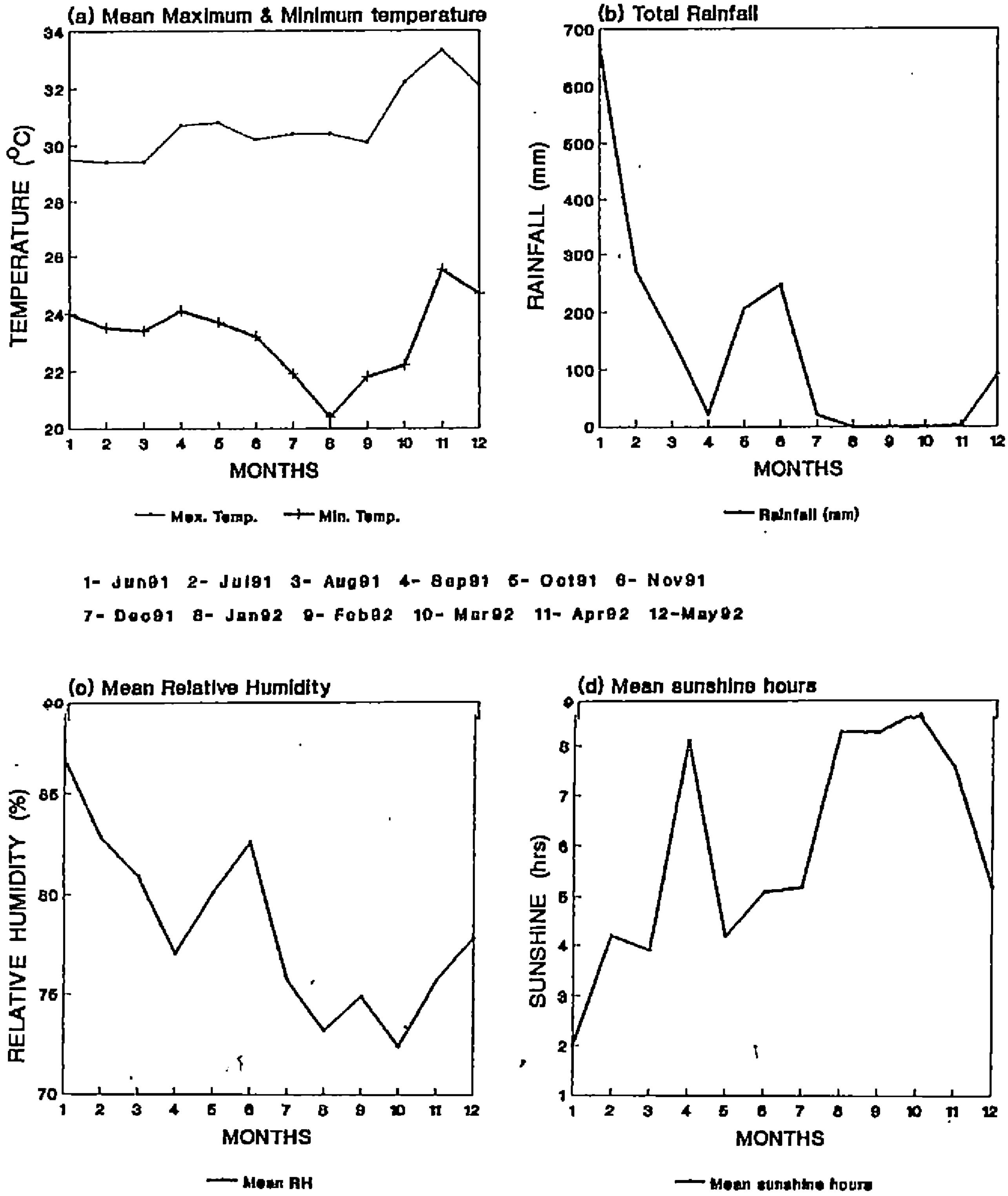

Fig. 4 Weather conditions during the period of study
[From June 1991 to May 1992]

3.6.2 Relative humidity

The relative humidity in the homestead and in the open field was found out at a height of 1.5 m from the ground, using a sling psychrometer. The relative humidity below the perennial trees in the homestead viz. coconut, jack and mango was observed and compared with that in the open field. The frequency and interval of data collection were similar to those for soil temperature data.

3.7 Light intensity

The shading effect of the tree species (coconut, jack and mango) in the homestead and their light interception during different times of a day were studied at monthly intervals. The light intensity was determined under these trees in the ground level at a distance of 2 m from the tree base using a lux meter. The data were collected at 10.00, 12.00, 14.00 and 16.00 hours. The light intensity in the open area was also found out at the same time and interval. From the data, the percentge interception of solar radiation, the light penetration characteristics and the shading effect of the tree crops were calculated.

3.8 Economic analysis

The economics of the whole system was worked out. All the enterprises/activities in the homestead agroforestry system were spatially defined and their total costs, gross return and net return were found out. From the space utilized by the crops, the cropping intensity was worked out. From the total costs incurred in the system and the gross returns, the benefit:cost ratio was calculated. The method adopted for evaluating the homestead system was the non-optimization method also known as cost-benefit analysis (Hoekstra, 1985).

RESULTS

RESULTS

Investigations were carried out in a homestead in the southern zone of Kerala from June 1991 to May 1992 to make an inventory of the agronomic resources and to quantify the nutrient addition by different components in the homestead including the tree species. The different avenues of nutrient cycling processes such as litterfall, throughfall and stemflow were studied. The soil physical, chemical and microbiological changes were investigated. The changes in microclimatic condition of the homestead system as influenced by the different components was also assessed and observations recorded. Economics of the system was analysed to estimate the net return and benefit:cost ratio. The results obtained by the investigations are given hereunder.

4.1 Structure and function of the homestead

4.1.1 **The homestead**

The homestead under study lies in Thiruvananthapuram district in the southern zone of Kerala. The total rainfall received in the homestead during the period of study was 1683.7 mm. The number of rainy days was 99. The maximum rainfall was received during the month of June. There was no rainfall during the months of January, February and March. The homegarden comprised of an area of 2057.5 m^2. A detailed plan of the homestead showing the locations of different crops in the homestead (including tree crops), and the permanent structures like house, well, cattle shed, poultry shed, and goat house is given in Fig. 2. The house, road and other permanent features together comprised an area of 410 m^2 The rest of the area was set apart for cultivation.

The topography of the land is undulating. The land is divided into five contours based on the slope of the land and contour bunds were laid which was undertaken under the supervision of the Department of Soil Survey, Government of Kerala. The soil is classified as red loam (Table 17). The initial soil analysis revealed that the soil is medium in available nitrogen, very high in available phosphorus and low in available potassium. The soil was having near neutral reaction (Table 18).

The only irrigation facility available in the homestead is a well. The water from the well is not at all sufficient even for irrigating vegetables, especially in summer months. The 0.5 hp pumpset established was mainly meant for home purposes.

4.1.2 Farm family

The homestead was inherited by the farmer from his ancestors. The household consisted of four members, the owner of the home Sri. Nagappan aged 45 years, his wife Lalitha aged 32 years and their two sons. The elder son Deepak is studying in the VIIIth standard and the younger one IVth. standard. Both are studying in a school about 11 km from their house. The main occupation of the farmer and his wife is agriculture. In addition to the agricultural activities the house owner also finds time to undertake some cottage industries.

4.1.3 Crops and cropping pattern

The detailed plan of the homestead (Fig. 2) clearly indicates the locations of different crops including the tree species. An inventory of the crops including the multipurpose trees grown in the homestead is furnished in Table 1(a). The cropping system is coconut based homestead farming.

There were 27 adult coconut palms in the homestead. All the palms were of West Coast Tall variety planted about 32 years back. There were also eight young non bearing komadan palms of four years old. The adult coconut palms gave an average yield of 48 nuts per tree, during the year under study. The price of coconuts varied between Rs. 3 and 4 per nut during different periods of the year. Good management practices were followed for the coconut palms. Inorganic fertilizers were applied in addition to large quantities of organic manures.

The other tree components occupied in the homestead are two mango trees, two jack trees, three portia trees, three papaya and one breadfruit tree. The mango trees were local Kilichundan variety and pepper is trailed on one of them. Among the two jack trees, one is Muttom Varika and the other a local variety. The local variety tree is used as a standard for pepper. The Muttom Varika yielded about 10 jack fruits while the local variety produced about 30. The three portia trees were planted on the boundary. The papaya produced on an average, about 30 fruits per plant per year. The breadfruit tree yielded 30 kg of fruits during the year of study. The bread fruits were sold at a price of Rs. 3 per kg. The two pepper vines yielded 1.6 kg of dried pepper. It was sold at a price of Rs. 25 per kg.

In the interspaces of these perennial tree crops, a large variety of annual crops were grown. Majority of the area was set apart for tuber crops, namely cassava and yams. Banana, ginger and fodder grass were also grown in the interspaces. An area of 80 m^2 was set apart for kitchen garden.

Sree Sahya variety of cassava was grown in an area of 620 m^2. The setts for planting was locally purchased. The cassava gave an yield of 1750 kg of fresh tuber. The price of the tuber was Re. 1 per kg. Among the 44 dioscorea plants, 20 were of high yielding Sreelatha variety, the seed material of which was obtained from CTCRI, Sreekaryam. The others were of local variety. Eighteen plants of elephant foot yam were also planted by him. The seed material of this local variety was obtained from his previous year's crop. The tubers were sold after the home consumption and after reserving for seed materials. The dioscorea was priced @ Rs. 6 per kg and elephant foot yam Rs. 4 per kg. Guinea grass was planted mainly along the contour bunds. An area of 40 m^2 was set apart for cultivation of ginger. The other major crop in the homestead was banana. Both Palayankodan and Nendran varieties were cultivated. The planting materials were obtained from the previous years' crop. There were 14 Nendran and 12 Palayankodan bananas. The farmer obtained 12 Nendran and 10 Palayankodan bunches. Half of the fruits were sold and the price varied between Rs. 30 and 40 per bunch. Eventhough there was shade and a higher humidity in the homestead, mainly due to the presence of a large number of mutipurpose tree crops and a high intesity (1.55) of cropping, there was not much incidence of pests and diseases in the above mentioned crops during the period of study.

A kitchen garden was maintained by the farmer in an area of 80 m^2. A variety of vegetable crops such as bhindi, brinjal, chilli, amaranthus, drumstick, ashgourd etc. were cultivated. The seeds of all these vegetables were obtained from the Instructional Farm, Vellayani. The kitchen garden was not sufficient to meet the entire household requirements of vegetables. There was severe incidence of pests and diseases during the crop season for vegetables. The control methods adopted were as per the package of practices recommendations of the Kerala

Agricultural University. The vegetables were grown utilising the available rainfall.

The farmer followed an approach of organic farming. The entire quantity of organic manure obtained from livestock and poultry, which amounted to 10.1 tonnes(Table 15) was applied in the homestead itself. Relatively small quantities of inorganic fertilizers i.e.to the tune of 110 kg NPK mixture was applied during the period of study (Table 16). The litterfall from the trees was also incorporated into the homestead soil itself (Table 28).

4.1.4 Livestock and poultry

The inventory of the livestock and poultry in the homestead is given in Table 1(b). The farm family had two cows and two calves. One cow was of Jersey breed, aged 5 years and the other a local breed aged 7 years. The Jersey cow yielded on an average 8 litres of milk per day. The milk is sold at a price of Rs. 5.50 per litre. Two litres of milk was used for his home consumption and the surplus sold. He also maintained a goat, a local breed, with its two kids. The goat yielded on an average 0.7 litre of milk per day. This milk was fully utilized for home consumption.

These animals were fed with green fodder, paddy straw, concentrates, dried tapioca leaves and at times with banana leaves and pseudostem. About two tonnes of paddy straw and 1.8 tonnes cattle feed were consumed during the period of study.

There were 20 poultry birds reared in the backyard system. They laid about 1000 eggs per year. The eggs were fully utilized for house consumption. The farmer also owned a broiler chicken farm. Hundred chicks each were brought in every 2 months. The chicks of 3 days old was supplied by A.V.M. Hatcheries, Tamilnadu, arranged through a private agency in Thiruvananthapuram. Chicks of 6 weeks age attains a weight of 1 to 1.5 kg and were sold at a price of Rs. 40 per kg of dressed chicken.

4.1.5 Fertilizers and Manures

The farmer gave more emphasis on the addition of organic manures rather than the inorganic fertilizers. He applied 70 kg of 10:5:20 NPK mixture to 35 coconut palms and 40 kg 10:10:10 NPK mixture to other crops during the year of study. The entire quantity of FYM produced by the animals in the homestead was applied to the crops. Total quantity of organic manure applied was to the tune of about 10.1 tonnes.The emphasis on organic cycling of nutrients is also evident from the fact that the organic matter obtained by litterfall was fully incorporated in the homestead system itself.

4.1.6 Capital and Marketing

Income for livelihood of the farmer was mainly obtained by the sale of surplus agricultural products. This included coconuts, pepper, cassava, yams, banana, milk and broiler chicken. The income from each of these enterprises is given in Table 24.

Credit for agricultural purposes was obtained by the farmer from the District Co-operative Bank, Thiruvananthapuram. The short term loan of Rs. 10000/- at an interest rate of 12 per cent per annum was availed for managing the poultry unit.

The major commodities involved for marketing were coconut, banana, cassava, yams, milk and broiler chicken. The surplus of agricultural commodities after household consumption were sold. The income obtained from each of these enterprises is furnished in Table 24. A major portion of transactions took place in the homestead itself. Coconut was sold in Balaramapuram market of Thiruvananthapuram district, which is only 7 km from the homestead. It is a daily market. The surplus milk after consumption was sold to the Milk Marketing Society very near to the homestead. The milk was collected both in the morning and in the evening and the payment was made on a monthly basis. The broiler chicken was supplied to the quarters and the hostels in the College of Agriculture, Vellayani.

4.2 Nutrient cycling

4.2.1 Litterfall

4.2.1.1 Mango

The monthly variation in litter addition to the homestead by the mango trees is presented in Table 2. The data revealed that there was variation in the quantity of litter fall during different months of the year. It was noted that the maximum litter addition was during the month of June (9.43 kg), which accounted for 10.68 % of the total input by litterfall. The minimum amount of litter was recorded during the month of August, with a litterfall of 6.57 kg. The total annual litter addition was estimated to be 88.26 kg.

Data on the monthly variation in nutrient content of litter and total nutrient addition by litterfall are also furnished in Table 2. The data showed that the

Table 2. Litterfall, nutrient content and nutrient addition by mango trees* at monthly interval

Month	Litterfall (kg)	Nutrient content in the litter (%)			Total nutrient addition (kg)		
		N	P	K	N	P	K
June 1991	9.43	1.1963	0.210	0.435	0.1128	0.0198	0.0410
July 1991	8.25	1.1485	0.215	0.440	0.0948	0.0177	0.0363
August 1991	6.57	1.0527	0.225	0.420	0.0692	0.0148	0.0276
September 1991	7.07	1.1006	0.230	0.480	0.0778	0.0163	0.0339
October 1991	7.18	1.0527	0.225	0.470	0.0756	0.0162	0.0337
November 1991	8.30	1.1485	0.225	0.465	0.0953	0.0187	0.03861
December 1991	6.91	0.9570	0.210	0.480	0.0661	0.0145	0.0332
January 1992	6.96	0.8735	0.220	0.425	0.0608	0.0153	0.0296
February 1992	6.59	0.8735	0.230	0.410	0.0576	0.0152	0.0270
March 1992	7.02	1.1006	0.230	0.485	0.0773	0.0161	0.0340
April 1992	6.91	1.1485	0.210	0.495	0.0794	0.0145	0.0342
May 1992	7.07	1.1485	0.225	0.465	0.0812	0.0159	0.0329
Total	88.26				0.9479	0.1950	0.4020

* Canopy area - 105 m^2
No. of trees - 2
Age of trees - 12 years

nutrient content in the litter varied during different months of the year. Among the major nutrients, the content of N was the largest followed by K and P. The total nutrient addition was also found to vary with season of the year. It was found that the maximum nutrient addition was during the month of June. As a whole the mango trees in the homestead annually added 0.91, 0.2 and 0.4 kg. of N, P and K respectively.

4.2.1.2 Jack

The variation in litter addition to the homestead by jack trees at monthly interval is given in Table 3. It is evident from the data that a total of 137.11 kg of litter was annually added by litterfall by the two jack trees, of 14 years old with canopy coverage of 122 m^2. The maximum litterfall was noticed during the month of November and the minimum during May.

The nutrient status of litter and the contribution of nutrients by litterfall to the homestead by the jack trees are also presented in Table 3. The data showed that among the major nutrients, N was the predominant fraction in the litter while the concentration of P was found to be the lowest. The annual nutrient addition by litterfall from jack amounted to 1.42, 0.39 and 0.62 kg of N, P and K respectively.

Table 3. Litterfall, nutrient content and nutrient addition by jack trees* at monthly interval

Month		Litterfall (kg)	Nutrient content in the litter (%) N	P	K	Total nutrient addition (kg) N	P	K
June	1991	8.71	1.1006	0.280	0.4720	0.0959	0.0244	0.0411
July	1991	11.26	1.0527	0.270	0.4520	0.1185	0.0304	0.0509
August	1991	10.89	1.2920	0.290	0.4600	0.1407	0.0316	0.0501
September	1991	9.15	1.1006	0.295	0.4800	0.1007	0.0270	0.0439
October	1991	12.01	1.1006	0.280	0.4720	0.1322	0.0336	0.0567
November	1991	14.44	0.9570	0.285	0.3950	0.1382	0.0412	0.0570
December	1991	13.32	0.9092	0.290	0.3850	0.1211	0.0386	0.0513
January	1992	12.39	0.9092	0.280	0.4210	0.1126	0.3437	0.0522
February	1992	11.64	0.8613	0.290	0.4410	0.1003	0.0338	0.0513
March	1992	13.76	1.0527	0.290	0.4210	0.1449	0.0399	0.0579
April	1992	10.89	1.1006	0.280	0.5305	0.1199	0.0305	0.0578
May	1992	8.65	1.1006	0.280	0.5305	0.0952	0.0242	0.0459
Total		137.11				1.4202	0.3895	0.6161

* Canopy area - 122 m^2
No. of trees - 2
Age of trees - 14 years

4.2.1.3 Portia

Data on the addition of litter by portia trees to the homestead and its monthly variation are furnished in Table 4. The results revealed that the annual litter addition by the three portia trees of 7 years age and with a canopy area of 174 m^2 to the homestead was to the tune of 205.42 kg. The maximum litterfall was noticed during the month of February and the minimum during August.

The nutrient content of litter and the total nutrient addition by litterfall to the homestead by portia trees are also presented in Table 4. It can be further noticed that, K was the major nutrient fraction present in the litter followed by N and P. The annual nutrient input by litterfall was estimated to 3.13, 2.15 and 0.75 kg of K, N and P respectively.

4.2.1.4 **Coconut**

Data on the litter addition to the homestead by the coconut palm is given in Table 5. It is evident from the data that there was variation in the rate of leaf fall between different harvesting seasons. There were 27 coconut palms in the homestead with an average age of 32 years. Their canopy coverage was estimated

Table 4. Litterfall, nutrient content and nutrient addition by portia trees* at monthly interval

Month		Litterfall (kg)	Nutrient content in the litter (%) N	P	K	Total nutrient addition (kg) N	P	K
June	1991	14.20	1.2441	0.3400	1.4800	0.1767	0.0483	0.2102
July	1991	18.11	1.2441	0.3550	1.4600	0.2253	0.0643	0.2644
August	1991	13.49	1.0527	0.3650	1.5000	0.1420	0.0492	0.2024
September	1991	16.06	1.0527	0.3600	1.5200	0.1691	0.0578	0.2441
October	1991	15.54	1.0049	0.3500	1.4700	0.1562	0.0544	0.2284
November	1991	15.60	1.0049	0.3600	1.5800	0.1570	0.0562	0.2468
December	1991	18.02	1.0049	0.3800	1.5200	0.1811	0.0685	0.2739
January	1992	18.74	0.9570	0.3750	1.5800	0.1793	0.0708	0.2961
February	1992	19.80	0.9570	0.3850	1.5600	0.1895	0.0762	0.3089
March	1992	19.62	1.0049	0.3700	1.4800	0.1972	0.0726	0.2904
April	1992	19.53	1.0527	0.3650	1.5400	0.2056	0.0713	0.3008
May	1992	16.69	1.0527	0.3450	1.5500	0.1757	0.0576	0.2587
Total		205.42				2.1547	0.7472	3.1251

* Canopy area - 174 m^2
No. of trees - 3
Age of trees - 7 years

Table 5. Leaffall, nutrient content and nutrient addition by coconut palms* at harvesting interval

Month		Leaffall (kg)	Nutrient content in the litter (%) N	P	K	Total nutrient addition (kg) N	P	K
July	1991	64.48	0.7178	0.1200	0.4100	0.4628	0.0774	0.2644
September	1991	62.00	0.6699	0.1150	0.4200	0.4153	0.0713	0.2604
October	1991	99.20	0.7178	0.1250	0.4210	0.7121	0.1240	0.4176
December	1991	69.44	0.7656	0.1200	0.4310	0.5316	0.0833	0.2993
January	1992	74.40	0.6699	0.1200	0.3920	0.4984	0.0893	0.2916
March	1992	64.48	0.7178	0.1250	0.4010	0.4628	0.0806	0.2586
April	1992	54.56	0.8135	0.1250	0.3810	0.4438	0.0682	0.2079
May	1992	62.00	0.7178	0.1200	0.3600	0.4450	0.0744	0.2232
Total		550.56				3.9718	0.6685	2.2230

* Canopy area - 972 m^2
No. of trees - 27
Age of trees - 25 years

to 972 m^2. It is seen from the data that the leaf fall was maximum during the harvesting period in October. The total litter addition by leaf fall amounted to 505.56 $kg.yr^{-1}$.

The nutrient content of leaf litter and the nutrient return by leaf fall in coconut are also furnished in Table 5. The data revealed that among the three major nutrients, nitrogen was the major nutrient constituent in the litter followed by potassium and phosphorus. The total nutrient return by coconut leaf fall accounted for 3.97, 0.67 and 2.22 kg of N, P an K respectively.

4.2.2 Throughfall

4.2.2.1 Mango

The nutrient content in throughfall and the variation in nutrient addition by throughfall, by the two mango trees are presented in Table 6. The data clearly showed that there was considerable variation in the nutrient concentration during the different rainy periods of the year. It was found that the nitrogen concentration in throughfall varied from 0.85 ppm in September to 2.1 ppm during the month of April. The

Table 6. Nutrient content and nutrient addition by throughfall in mango trees* at monthly interval

Month		No. of rainy days	Total rainfall (mm)	Nutrient content (ppm)			Total nutrient addition (10^{-3} kg)		
				N	P	K	N	P	K
June	1991	24	669.3	0.88	0.095	1.46	64.5855	6.6791	108.2834
July	1991	14	272.0	0.70	0.084	1.38	21.0084	2.5211	41.4939
August	1991	14	154.5	0.70	0.082	1.34	11.9343	1.3850	22.9730
September	1991	1	22.4	0.85	0.091	1.19	2.0979	0.2258	2.9557
October	1991	17	205.8	0.75	0.084	0.96	19.2759	2.0748	21.8043
November	1991	12	247.1	0.80	0.084	0.85	21.7865	2.2880	23.0790
December	1991	2	20.2	1.40	0.090	0.96	3.1164	0.2015	2.1420
January	1992	0	-	-	-	0.00	0.0000	0.0000	0.0000
February	1992	0	-	-	-	0.00	0.0000	0.0000	0.0000
March	1992	0	-	-	-	0.00	0.0000	0.0000	0.0000
April	1992	3	1.5	2.10	0.109	2.60	0.3455	0.0179	0.4232
May	1992	12	90.9	1.90	0.103	2.44	19.0439	1.0324	24.5207
Total		99	1683.7				163.1943	16.4256	247.6752

* Canopy area - 105 m^2
No. of trees - 2
Age of trees - 12 years
Average diameter of tree trunk - 0.255 m

concentrations of P and K were also maximum during the month of April. The P concentrations varied from 0.082 ppm to 0.109 ppm while that of K was found to vary from 0.85 to 2.6 ppm. It was also clear that the largest nutrient constituent in throughfall was potassium and the lowest phosphorus. The total nutrient addition was found to be more during the month of June for all the major nutrients studied. There was no nutrient input by throughfall during the summer months of January, February and March, as there was no rainfall during that period. Invariably it is clear from the data that the total rainfall was a vital factor which determined the annual nutrient load in throughfall. Annually throughfall addition was in the order of 0.16, 0.016 and 0.25 kg of N, P and K respectively in the homestead.

4.2.2.2 Jack

Data on the nutrient content and annual nutrient input to the homestead system by Jack trees are furnished in Table 7. It can be found from the data that there was wide variation in the nutrient concentrations in throughfall between different periods of rain. The nitrogen content varied between 0.65 ppm during the month of August and 2.3 ppm during the month

Table 7. Nutrient content and nutrient addition by throughfall in jack trees* at monthly interval

Month		No. of rainy days	Total rainfall (mm)	Nutrient content (ppm)			Total nutrient addition (10^{-3} kg)		
				N	P	K	N	P	K
June	1991	24	669.3	0.76	0.0218	1.26	65.2334	1.8715	107.7260
July	1991	14	272.0	0.67	0.0152	0.86	23.3800	0.5295	29.8363
August	1991	14	154.5	0.65	0.0130	0.91	12.8844	0.2527	17.9389
September	1991	1	22.4	0.85	0.0170	1.10	2.4406	0.0488	3.1586
October	1991	17	205.8	0.80	0.0160	1.00	21.106	0.4221	26.3837
November	1991	12	247.1	0.70	0.0150	0.90	23.7583	0.0475	28.5102
December	1991	2	20.2	1.60	0.0310	2.60	4.1431	0.0803	6.7320
January	1992	0	-	-	-	-	0.0000	0.0000	0.0000
February	1992	0	-	-	-	-	0.0000	0.0000	0.0000
March	1992	0	-	-	-	-	0.0000	0.0000	0.0000
April	1992	3	1.5	2.30	0.0360	2.90	0.4408	0.0069	0.5655
May	1992	12	90.9	1.80	0.0280	2.10	20.3972	0.3262	23.8937
Total		99	1683.7				173.7838	3.5905	244.7449

* Canopy area - 122 m^2
No. of trees - 2
Age of trees - 14 years
Average diameter of tree trunk - 0.279 m

of April. The potassium content was maximum during May and it varied from 0.86 to 2.9 ppm. The phosphorus concentration varied between 0.013 ppm and 0.036 ppm. The annual nutrient return was the largest during the month of June for all the nutrients studied. It can be seen from the data that the two jack trees in the homestead returned 0.17, 0.004 and 0.24 kg yr^{-1} of N, P and K respectively by throughfall. Invariably total rainfall played a vital role in determining the annual nutrient return.

4.2.2.3 Portia

The contribution of nutrients by throughfall to the homestead by the three portia trees is given in Table 8. It is evident from the data that the nutrient concentrations in the throughfall varied during different periods of the year. The nitrogen content showed a variation from 0.7 ppm to 1.4 ppm, while the phosphorus concentrations ranged between 0.072 and 0.12 ppm. Potassium was the major constituent in throughfall among the nutrient analysed and the maximum concentration was 2.9 ppm observed during the month of April. It is clear from the data that the total nutrient return increased with the increase in the total rainfall. Hence a maximum addition for all the

Table 8. Nutrient content and nutrient addition by throughfall in portia trees* at monthly interval

Month		No. of rainy days	Total rainfall (mm)	Nutrient content (ppm)			Total Nutrient addition (10^{-3} kg)		
				N	P	K	N	P	K
June	1991	24	669.3	0.70	0.082	1.98	85.6150	9.9371	241.7434
July	1991	14	272.0	0.70	0.072	1.43	34.8139	3.5809	71.2478
August	1991	14	154.5	0.65	0.072	1.39	18.3674	2.0341	39.4893
September	1991	1	22.4	0.85	0.091	1.29	3.4783	0.3706	5.3070
October	1991	17	205.8	0.80	0.086	1.06	30.0655	3.2190	39.8947
November	1991	12	247.1	0.90	0.105	0.96	40.6081	4.7380	43.3834
December	1991	2	20.2	0.85	0.110	1.10	3.5061	0.4072	4.0838
January	1992	0	-	-	-	-	0.0000	0.0000	0.0000
February	1992	0	-	-	-	-	0.0000	0.0000	0.0000
March	1992	0	-	-	-	-	0.0000	0.0000	0.0000
April	1992	3	1.5	1.40	0.091	2.90	0.3953	0.0247	0.7917
May	1992	12	90.9	1.40	0.120	2.74	22.4286	2.0010	45.5532
Total		99	1683.7				239.2782	26.3126	491.4943

* Canopy area - 174 m^2
No. of trees - 3
Age of trees - 7 years

nutrients was observed during the month of June. There was more nutrient addition during the month of June. The total nutrient return by throughfall was estimated as 0.24, 0.026 and 0.49 $kg.yr^{-1}$ of N, P and K respectively.

4.2.2.4 Coconut

Monthly variation in nutrient content and nutrient return by throughfall to the homestead system by the coconut palms are presented in Table 9. The data revealed the differences in nutrient concentration in throughfall during different months of the year. The nitrogen concentrations was found to vary between 0.7 ppm and 1.05 ppm. The phosphorus content in throughfall varied from 0.050 to 0.071 ppm while that for potassium was between 0.94 ppm and 1.42 ppm. It is evident from the data that total rainfall always played a key role in determining the total nutrient input by throughfall. The total nutrient addition was thus maximum during the month of June. The data indicated an annual nutrient return of 1.48, 0.11 and 2.19 kg of N, P an K respectively, to the homestead by throughfall alone.

Table 9. Nutrient content and nutrient addition by throughfall in coconut palms at monthly interval

Month		No. of rainy days	Total rainfall (mm)	Nutrient content (ppm)			Total nutrient addition (10^{-3}kg)		
				N	P	K	N	P	K
June	1991	24	669.3	0.95	0.071	1.42	649.0627	48.5028	968.1314
July	1991	14	272.0	0.90	0.066	1.41	250.0664	18.1958	391.9007
August	1991	14	154.5	0.80	0.061	1.37	126.2434	9.6228	216.1922
September	1991	1	22.4	0.85	0.061	1.31	19.4108	1.3802	29.9084
October	1991	17	205.8	0.70	0.050	0.96	146.7914	10.4782	201.3206
November	1991	12	247.1	0.70	0.066	1.03	176.2528	16.4948	258.0757
December	1991	2	20.2	0.75	0.067	0.94	15.4839	1.3725	19.4108
January	1992	0	-	-	-	-	0.0000	0.0000	0.0000
February	1992	0	-	-	-	-	0.0000	0.0000	0.0000
March	1992	0	-	-	-	-	0.0000	0.0000	0.0000
April	1992	3	1.5	1.05	0.071	1.13	1.6096	0.1079	1.7204
May	1992	12	90.9	1.00	0.071	1.16	92.8649	6.5902	107.7268
Total		99	1683.7				1477.7859	112.7452	2194.3870

* Canopy area - 972 m^2
No. of trees - 27
Average age of palms - 32 years

4.2.3 Stemflow

4.2.3.1 Mango

The contribution of nutrients by stemflow in the homestead by mango trees at monthly intervals is given in Table 10. The data revealed that the nutrient concentrations in stemflow varied with the season of the year. The nitrogen concentrations recorded a maximum value of 2 ppm during the month of May, while the phosphorus and potassium concentration were maximum during the month of April, with a value of 0.183 and 2.74 ppm respectively. It is evident from the data that the total nutrient addition depended mainly on the total rainfall and the nutrient content in the stemflow. The maximum nutrient addition was recorded during the month of June. The annual nutrient input by stemflow to the homestead by mango trees was estimated to be 0.721, 0.169 and 1.061 g of N, P and K respectively.

4.2.3.2 Jack

The monthly variation in the nutrient content, the volume of water collected by stemflow and its annual nutrient return by jack trees are presented in Table 11. The nutrient concentrations in stemflow varied

Table 10. Nutrient content and nutrient addition by stemflow in mango trees* at monthly interval

Month		No. of rainy days	Total rainfall (mm)	Stemflow volume per plant (l)	Nutrient content (ppm)			Total nutrient addition (10^{-3} kg)		
					N	P	K	N	P	K
June	1991	24	669.3	124.80	1.40	0.109	1.71	0.3444	0.0272	0.4287
July	1991	14	272.0	38.26	0.88	0.103	1.66	0.0669	0.0079	0.1273
August	1991	14	154.5	21.23	0.84	0.084	1.56	0.0357	0.0036	0.0663
September	1991	1	22.4	5.71	0.88	0.088	1.50	0.0099	0.0010	0.0172
October	1991	17	205.8	52.43	0.52	0.084	1.43	0.0550	0.0088	0.1502
November	1991	12	247.1	60.41	0.93	0.091	1.30	0.1118	0.1095	0.1579
December	1991	2	20.2	4.90	1.60	0.109	1.06	0.0152	0.0011	0.0104
January	1992	0	-	-	-	-	-	0.0000	0.0000	0.0000
February	1992	0	-	-	-	-	-	0.0000	0.0000	0.0000
March	1992	0	-	-	-	-	-	0.0000	0.0000	0.0000
April	1992	3	1.5	0.98	1.90	0.183	2.74	0.0036	0.0036	0.0052
May	1992	12	90.9	18.35	2.00	0.178	2.67	0.0734	0.0065	0.0979
Total		99	1683.7					0.7209	0.1692	1.0611

* Canopy area - 105 m^2
No. of trees - 2
Age of trees - 12 years

Table 11. Nutrient content and nutrient addition by stemflow in jack trees.at monthly interval

Month		No. of rainy days	Total rainfall (mm)	Stemflow volume per plant (l)	Nutrient Content (ppm) N	P	K	Total nutrient addition (10^{-3} kg) N	P	K
June	1991	24	669.3	132.90	1.60	0.024	1.73	0.4253	0.0064	0.4598
July	1991	14	272.0	41.23	1.20	0.021	1.37	0.0989	0.0017	0.1129
August	1991	14	154.5	21.42	0.80	0.019	1.13	0.0343	0.0008	0.0484
September	1991	1	22.4	6.22	0.90	0.019	1.55	0.0112	0.0002	0.0193
October	1991	17	205.8	53.22	0.90	0.018	1.55	0.0959	0.0019	0.1653
November	1991	12	247.1	64.23	0.80	0.017	2.41	0.1028	0.0022	0.3096
December	1991	2	20.2	5.32	1.60	0.031	3.46	0.0170	0.0033	0.0368
January	1992	0	-	-	-	-	-	0.0000	0.0000	0.0000
February	1992	0	-	-	-	-	-	0.0000	0.0000	0.0000
March	1992	0	-	-	-	-	-	0.0000	0.0000	0.0000
April	1992	3	1.5	1.13	3.30	0.032	3.52	0.0075	0.0001	0.0079
May	1992	12	90.9	21.23	2.90	0.030	2.90	0.1231	0.0013	0.1231
Total		99	1683.7	347.00				0.9160	0.0179	1.2831

* Canopy area - 122 m^2
No. of trees - 2
Age of trees - 14 year

during different months of the year. The maximum nitrogen concentration recorded was 3.3 ppm and the maximum concentration of P and K recorded was 0.032 and 3.52 ppm respectively. The concentrations of all the nutrients in stemflow were the largest during the month of April. The total nutrient addition by way of stemflow to the homestead by the two jack trees was 0.916, 0.018 and 1.283 $g. yr^{-1}$ of N, P and K respectively.

4.2.3.3 Portia

The nutrient concentration and total contribution of nutrients by stemflow to the homestead system by three portia trees are furnished in Table 12. The data showed that the stemflow volume was dependent upon the total rainfall. The concentrations of N, P and K were maximum during the month of April. It was also found that, among the nutrients studied, potassium was the most important component, followed by nitrogen and phosphorus. The potassium concentrations varied from 1.36 to 3.61 ppm, while the concentration of nitrogen varied from 0.88 to 1.75 ppm. The phosphorus concentrations varied between 0.081 to 0.14 ppm. The total nutrient addition was maximum for all the nutrients during the month of June. The respective N,

Table 12. Nutrient content and nutrient addition by stemflow in portia trees * at monthly interval

Month		No. of rainy days	Total rainfall (mm)	Stemflow volume per plant (l)	Nutrient content (ppm)			Total nutrient addition 10^{-3} kg)		
					N	P	K	N	P	K
June	1991	24	669.3	132.90	1.6	0.0240	1.73	0.4253	0.0064	0.4598
July	1991	14	272.0	41.23	1.28	0.021	1.37	0.0989	0.0017	0.1129
August	1991	14	154.5	21.42	0.84	0.019	1.13	0.0343	0.0008	0.0484
September	1991	1	22.4	6.22	0.98	0.019	1.55	0.0112	0.0002	0.0193
October	1991	17	205.8	53.22	0.9	0.018	1.55	0.0959	0.0019	0.1653
November	1991	12	247.1	64.23	0.8	0.017	2.41	0.1028	0.0022	0.3096
December	1991	2	20.2	5.32	1.6	0.031	3.46	0.0170	0.0033	0.0368
January	1992	0	-	-	-	-	-	0.0000	0.0000	0.0000
February	1992	0	-	-	-	-	-	0.0000	0.0000	0.0000
March	1992	0	-	-	-	-	-	0.0000	0.0000	0.0000
April	1992	3	1.5	1.13	3.3	0.032	3.52	0.0075	0.0001	0.0079
May	1992	12	90.9	90.23	2.90	0.030	2.90	0.1231	0.0013	0.1231
Total		99	1683.7	347.00				0.916	0.0179	1.2831

* Canopy area - 122 m^2
No. of trees - 2
Age of trees - 7 years

P and K additions by portia trees through stemflow to the homestead were 1.15, 0.097 and 2.018 $g.yr^{-1}$.

4.2.3.4 Coconut

The nutrient contribution from coconut palms by stemflow is given in Table 13. The data indicated that there was considerable variation in the concentrations of N, P and K during the different months of the year. It was also evident that the volume of stemflow varied with the total rainfall. The maximum volume of stemflow was during the month of June when the rainfall was maximum. The nutrient concentrations recorded the highest values during the month of April. The nitrogen concentration in coconut stemflow varied from 0.70 to 2.9 ppm, the phosphorus concentrations from 0.061 to 0.11 ppm and potassium concentrations from 1.61 to 2.46 ppm. The values of total nutrient addition by stemflow in coconut was estimated to 8.69, 0.55 and 12.92 $g\ yr^{-1}$ of N, P and K respectively. The total nutrient addition was maximum during the month of June.

4.2.4 Rainfall

The nutrient content and contribution of nutrients by rainfall to the homestead system are presented in

Table 13. Nutrient content and nutrient addition by stemflow in coconut palms * at monthly interval

Month		No. of rainy days	Total rainfall (mm)	Stemflow volume per plant (l)	Nutrient content (ppm)			Total nutrient addition (10^{-3} kg)		
					N	P	K	N	P	K
June	1991	24	669.3	92.38	1.60	0.091	1.92	3.9908	0.2270	4.7890
July	1991	14	272.0	26.58	1.55	0.083	1.86	1.1124	0.0596	1.3348
August	1991	14	154.5	16.18	1.25	0.073	1.81	0.5461	0.0319	0.7907
September	1991	1	22.4	5.12	1.15	0.071	1.61	0.1590	0.0098	0.2226
October	1991	17	205.8	50.42	0.80	0.061	1.61	1.0886	0.0830	2.1909
November	1991	12	247.1	61.10	0.70	0.071	1.81	1.1548	0.1171	2.9860
December	1991	2	20.2	1.32	0.85	0.076	1.76	0.0303	0.0027	0.0627
January	1992	0	-	-	-	-	-	0.0000	0.0000	0.0000
February	1992	0	-	-	-	-	-	0.0000	0.0000	0.0000
March	1992	0	-	-	-	-	-	-	-	-
April	1992	3	1.5	0.120	2.9	0.110	2.46	0.0094	0.0004	0.0080
May	1992	12	90.5	8.23	2.7	0.100	2.39	0.5999	0.0222	0.5311
Total		99	1683.7	261.43				8.6913	0.5537	12.9158

* Canopy area - 972 m^2
No. of trees - 27
Average age of trees - 32 years

Table 14. The data revealed that the nutrient concentrations of N and K varied during different periods of the year.

There was no appreciable P in the rain water during the period of the study. The values for nitrogen content in rainwater varied from 0.10 to 0.29 ppm while the K concentrations varied between 0.31 ppm and 0.475 ppm. The total nutrient addition to the homestead was calculated after excluding the tree canopy areas. The annual nutrient return in an area of 684.5 m^2 was 282.51, 0 and 509.21 g of N, P and K respectively.

4.2.5 Livestock and Poultry

The data on the total manurial addition to the homestead by livestock and poultry is furnished in Table 15. The data revealed that two units of cow and its calves, excreted 8395 kg of cowdung annually. The urine excretion was to the tune of 5475 litres. The goat and its kids were found to excrete about 219 kg of wet dung and 365 litres of urine per year. The data indicated that the 620 poultry birds in the homestead annually added 1500 kg of poultry litter to the homestead.

Table 14. Nutrient content and nutrient addition by rainfall in the homestead* at monthly interval

Month		No.of rainy days	Total rainfall (mm)	Nutrient content (ppm)			Nutrient addition (10^{-3} kg)		
				N	P	K	N	P	K
June	1991	24	669.3	0.29	0	0.470	139.850	0	226.652
July	1991	14	272.0	0.29	0	0.475	56.8340	0	94.0708
August	1991	14	154.5	0.28	0	0.440	31.1721	0	48.4215
September	1991	1	22.4	0.16	0	0.320	2.5806	0	5.1680
October	1991	17	205.8	0.11	0	0.310	15.5724	0	45.9710
November	1991	12	247.1	0.10	0	0.310	17.8038	0	55.1912
December	1991	2	20.2	0.14	0	0.305	2.0398	0	4.4389
January	1992	0	0.0	-	-	-	0.0000	0	0.0000
February	1992	0	0.0	-	-	-	0.0000	0	0.0000
March	1992	0	0.0	-	-	-	0.0000	0	0.0000
April	1992	3	1.5	0.26	0	0.445	0.2806	0	0.4809
May	1992	12	90.9	0.25	0	0.440	16.3732	0	28.8175
Total		99	1683.7				282.5065	0	509.2118

* Homestead area excluding tree canopy area = 684.5 m^2

4.2.6 Inorganic fertilizers

The nutrient addition by the various inorganic fertilizers to the homestead is given in Table 16. The data showed that the farmer added 70 kg of coconut mixture and 40 kg 10:10:10 NPK mixture to the homestead during the year of study. The total nutrient addition by these fertilizers came to 11.0, 7.5 and 18.0 kg of N, P and K respectively.

4.3 Soil physico-chemical properties

4.3.1 Physical properties

Data on the variation in physical properties of the homestead soils and its comparison with that in the control are furnished in Table 17. The data showed that there was an intercorrelation between the moisture content measured on fresh weight basis and that on dry weight basis. The percentage moisture content showed a higher value in the case of the control soils in both top and bottom layers, as compared with the moisture content in the homestead. The soil samples showed the same trend during all the months except during June, when the soils in the homestead showed a higher value, that too only for the bottom 15-30 cm soil layer.

Table 15. Quantity and nutrient addition by livestock and poultry

Animal	Unit	Manure	Annual addition (kg^{-1})	Average nutrient content (%)			Nutrient addition (kg)		
				N	P	K	N	P	K
Cow + Calf	2	Wet dung	8395	0.15	0.10	0.05	12.593	8.395	4.198
Cow + Calf	2	Urine	5475	0.20	0.01	0.20	10.950	0.548	10.950
Goat + Kids	1	Wet dung	219	0.65	0.50	0.03	1.423	1.095	0.657
Goat + Kids	1	Urine	365	1.70	0.02	0.25	6.250	0.073	0.913
Poultry	620 Nos.	Poultry litter	1500	1.20	0.60	0.30	18.000	9.000	4.500
Total							49.171	19.111	21.218

Table 16. Nutrient addition by inorganic fertilizer application in the homestead

Fertilizer	Quantity (kg)	Total nutrients added (kg)		
		N	P	K
Coconut mixture (10:5:20)	70	7.0	3.5	14.0
NPK Mixture (10:10:10)	40	4.0	4.0	4.0
Total	110	11.0	7.5	18.0

Table 17. Comparison of physical properties of the homestead soil with that of the control, collected at quarterly interval

Month			Depth of sampling (cm)	% Moisture Fresh weight Basis	% Moisture Dry Weight Basis	Bulk density ($g \cdot cm^{-3}$)	Particle density ($g \cdot cm^{-3}$)	Maximum water holding capacity (%)
June	1991	Homestead Soil	0-15	9.71	10.76	1.19	2.83	50.28
			15-30	12.44	14.21	1.27	2.67	44.10
		Control	0-15	11.00	12.37	1.31	2.35	36.93
			15-30	11.06	12.43	1.24	2.55	31.53
September	1991	Homestead Soil	0-15	11.00	12.37	1.21	2.46	42.75
			15-30	11.00	12.37	1.35	2.45	38.00
		Control	0-15	11.27	12.69	1.27	2.45	35.82
			15-30	12.38	14.12	1.30	2.55	32.10
December	1991	Homestead Soil	0-15	8.16	11.35	1.01	2.35	45.57
			15-30	7.40	10.09	1.23	2.80	42.89
		Control	0-15	8.88	9.34	1.25	2.40	33.43
			15-30	8.75	9.59	1.30	2.50	30.01
March	1992	Homestead Soil	0-15	5.79	6.15	1.24	2.55	36.93
			15-30	7.91	8.58	1.36	2.62	31.51
		Control	0-15	6.40	7.03	1.27	2.35	32.18
			15-30	8.40	11.49	1.31	2.45	30.10
June	1992	Homestead Soil	0-15	10.13	11.28	1.27	2.65	45.18
			15-30	11.27	12.69	1.30	2.41	41.75
		Control	0-15	12.38	14.12	1.36	2.46	33.82
			15-30	11.00	12.37	1.27	2.45	31.23

Mechanical analysis

Homestead soil

(0-15 cm):
% Clay - 22.10
% Sand - 30.10
% Silt - 43.50

(15-30 cm)
% Clay - 20.20
% Sand - 31.30
% Silt - 45.40

Soil Type: Red loam soil

Control

(0-15 cm)
% Clay - 18.10
% Sand - 34.10
% Silt - 43.60

(15-30 cm)
% Clay - 18.20
% Sand - 35.30
% Silt - 41.60

Soil type: Red loam soil

The data on bulk density revealed that the homestead soil was found to have a lesser value for bulk density in the top 0-15 cm soil layers. A reverse trend was generally noticed in the bottom soil layers. The particle density generally showed a higher value in homestead soils irrespective of the depth of sampling.

It is evident from the data that the maximum water holding capacity was always higher in the homestead soil in both the top 0-15 cm and bottom 15-30 cm soil layers. The maximum values were observed for the samples.analysed during the month of June, 1991.

The mechanical analysis data did not show much variation between the homestead and control soils.

4.3.2 Chemical properties

Comparison of chemical properties of homesteads soil with that of control (estimated at quarterly interval) are presented in Table 18. The data revealed that the nutrient status in the case of available nitrogen, available phosphorus and available potassium were higher in the homestead soil as compared to that in the control. The available N content varied from

Table 18. Comparison of chemical properties of the homestead soil with that of the control, collected at quarterly interval

Month			Depth of sampling (cm)	Nutient status (kg.ha^{-1}) Available Nitrogen	Available Phosphorus	Available Potassium	Organic Carbon (%)	Organic matter (%)	pH
June	1991	Homestead soil	0-15	260.22	210.00	87.00	0.7125	1.2258	5.8
			15-30	158.10	190.00	54.00	0.4950	0.8514	5.8
		Control	0-15	125.44	39.00	52.00	0.4050	0.6966	5.7
			15-30	88.16	21.00	14.00	0.3450	0.5934	5.7
September	1991	Homestead Soil	0-15	219.52	242.00	111.12	1.0575	1.8189	5.6
			15-30	188.16	178.00	100.76	0.8025	1.3803	5.7
		Control	0-15	115.38	36.00	48.00	0.4725	0.8127	5.6
			15-30	87.28	18.00	19.00	0.3975	0.6837	5.7
December	1991	Homestead Soil	0-15	172.48	334.00	51.62	0.8400	1.4448	5.6
			15-30	150.88	240.00	47.86	0.7875	1.3545	5.8
		Control	0-15	102.13	34.00	46.00	0.4800	0.81256	5.8
			15-30	87.12	21.00	20.00	0.4050	0.6966	5.7
March	1992	Homestead Soil	0-15	250.88	206.00	87.00	0.4800	0.8256	5.5
			15-30	235.20	132.00	54.00	0.4050	0.6966	5.6
		Control	0-15	112.14	30.00	40.00	0.4725	0.8127	5.7
			15-30	89.24	20.00	19.00	0.3675	0.6321	5.7
June	1992	Homestead Soil	0-15	200.60	190.00	86.00	0.9000	1.5480	5.7
			15-30	180.70	170.00	84.00	0.5100	0.8772	5.6
		Control	0-15	109.76	30.00	39.00	0.3970	0.6837	5-7
			15-30	80.12	21.00	21.00	0.3450	0.5934	5-6

172.48 to 260.22 $kg.ha^{-1}$, in the case of the homestead soil at a depth of 0 to 15 cm soil layer while that in 15-30 cm bottom soil layer varied between 150.88 and 235.20 $kg.ha^{-1}$. But, in the case of control, it varied from 102.13 to 125.44 $kg.ha^{-1}$ in bottom soil layers. In the case of available P, the maximum value of 334.00 $kg.ha^{-1}$ was recorded in the month of June 1992. These variations were noticed for the samples collected from 0-15 cm deep soil layers. The variation for the bottom 15-30 soil layer was between 132 and 240 $kg.ha^{-1}$. The control showed a very low value for the estimates on available P. The available K varied from 51.62 to 111.12 $kg.ha^{-1}$ while it was only betwen 39 and 52 kg. ha^{-1} for the control at 0 to 15 cm depth.

The data on Table 18 further revealed that the percentage of organic matter was always greater in the top soil layers. The organic matter content varied from 0.8256 to 1.8198 per cent in the top layers of homestead soil. But, in the control, the percentage variation was between 0.6837 and 0.8127. It can be seen from the data that the pH of the soils does not show much variation during different seasons of the year or with differences in depth of sampling.

4.4 Soil micro-organisms

The number and nature of micro-organisms in the homestead soil and that in the control are given in Table 19. The results indicated that there was intense microbial activity in the homestead when compared with that in the control. The fungal population was found to vary from 32×10^6 to 71×10^6 in the homestead soil and from 4×10^6 to 8×10^6 in the control. The maximum population for fungi was noticed during the month of September 1991, while the population observed was minimum during the month of June 1991, in the case of both the homestead and the control soils. The populations of bacteria and actinomycetes were also found to show the same pattern as that in fungi. The bacterial population in the homestead soils varied betweem 112×10^3 and 242×10^3, while the population in the control varied from 20×10^3 to 50×10^3. The data showed that the actinomycetes population varied from 49×10^3 to 110×10^3 and 5×10^3 to 10×10^3 for the homestead and the control soils respectively. It is evident from the data that the homestead soil showed an increased microbial population for all the micro-organisms.

Table 19. Monthly variation in the number and nature of micro-organisms in the homestead soil in comparison with that of the control

Months		Population per gram of soil											
		Fungi x 10^6				Bacteria x 10^3				Actinomycetes x 10^3			
		Homestead soil		Control		Homestead soil		Control		Homestead soil		Control	
		Mean	C.V	Mean	C.V	Mean	C.V	Mean	C.V	Mean	C.V	Mean	C.V
June	1991	32	4.42	4	0.00	112	7.18	20	4.08	49	2.89	5	16.33
July	1991	47	3.00	6	13.61	143	8.97	24	9.00	74	7.72	6	13.61
August	1991	62	4.23	7	11.66	210	3.04	30	5.44	96	4.74	10	16.33
September	1991	71	3.45	10	16.34	242	2.94	50	4.32	110	5.20	9	9.07
October	1991	65	5.48	8	13.61	221	1.92	40	5.40	98	6.61	10	14.14
November	1991	52	5.44	6	11.66	168	7.34	28	5.83	80	6.69	7	11.66
December	1991	47	1.74	7	11.66	156	3.66	26	6.28	70	9.26	8	10.20
January	1992	40	4.08	5	16.34	132	4.67	30	5.44	62	9.50	7	11.66
February	1992	36	2.27	4	0.00	136	9.53	31	6.97	55	3.93	5	16.33
March	1992	48	1.70	6	13.61	169	6.71	29	8.44	76	7.44	7	11.66
April	1992	51	4.24	6	13.61	172	9.27	25	3.27	78	1.81	8	10.21
May	1992	55	6.47	7	11.66	188	6.40	33	8.92	78	5.54	7	11.66

4.5 Microclimate

4.5.1 Soil temperature

Data on the monthly mean variation in soil temperature in the homestead in comparison with that in the control is presented in Table 20. The data revealed that the soil temperature measured in the homestead and in the control showed a maximum variation of 2.6°C, observed during the month of May 1992. The monthly mean soil temperatures varied between 27.0 and 29.9°C for the homestead soils, while the variation was from 28.2 to 33.7°C for the control. It was clear from the data that homestead soils always recorded a lower soil temperature than the control, irrespective of the time or month of observation.

4.5.2 Relative humidity

The variation in relative humidity under different agroforestry tree species in comparison with that in the open condition is furnished in Table 21. The data showed that the relative humidity values were generally greater under the tree species in the homestead than in the control. This was noticed during all the periods of humidity measurement. The maximum variations were

Table 20. Comparison of monthly mean soil temperature in the homestead with that of the control

Month		Soil temperature in the homestead Time			Soil temperature in the control Time		
		7.25 AM	2.25 PM	Mean	7.25 AM	2.25 PM	Mean
June	1991	23.8	30.1	27.0	25.2	31.2	28.2
July	1991	24.9	29.8	27.4	25.8	32.4	29.1
August	1991	25.7	30.1	27.9	25.9	33.4	29.7
September	1991	25.2	33.4	29.3	27.8	37.3	32.10
October	1991	25.8	31.0	28.4	26.5	34.1	30.00
November	1991	24.6	31.3	28.0	25.2	34.8	30.00
December	1991	25.5	32.1	28.8	26.6	35.9	31.3
January	1991	27.2	32.6	29.9	27.5	39.8	33.7
February	1991	27.3	32.5	29.9	27.5	39.8	33.7
March	1991	25.2	33.4	29.3	26.4	41.0	33.7
April	1991	26.7	32.4	29.6	26.9	38.7	32.8
May	1991	26.1	31.9	29.0	26.2	39.4	32.8
Mean		25.9	31.7	28.8	26.5	36.26	31.4

Depth of measurement : 15 cm

Table 21. Comparison of Relative Humidity under different tree crops in the homestead with that of the control

Month	Crop	R.H (%) 7.25 AM	R.H (%) 2.25 PM	Mean R.H (%)
June 1991	Under Coconut	93.9	82.5	88.2
	Under Jack	94.2	85.3	89.8
	Under Mango	94.0	83.4	88.7
	Control	93.8	79.6	86.7
July 1991	Under Coconut	89.4	79.5	84.5
	Under Jack	89.6	82.1	85.9
	Under Mango	89.8	80.8	85.3
	Control	89.4	76.2	82.8
August 1991	Under Coconut	89.0	74.1	81.6
	Under Jack	89.0	79.1	84.0
	Under Mango	89.0	78.2	83.6
	Control	88.4	73.3	80.9
September 1991	Under Coconut	88.1	68.2	78.2
	Under Jack	88.2	74.5	81.4
	Under Mango	88.1	72.4	80.3
	Control	87.2	66.8	77.0
October 1991	Under Coconut	90.1	76.8	83.5
	Under Jack	90.2	80.1	85.2
	Under Mango	90.0	79.4	84.7
	Control	89.7	70.4	80.1
November 1991	Under Coconut	93.0	75.4	84.2
	Under Jack	93.1	81.1	87.1
	Under Mango	93.0	79.2	86.1
	Control	92.0	71.3	82.6
December 1991	Under Coconut	91.0	68.3	79.7
	Under Jack	92.0	73.2	82.6
	Under Mango	91.3	70.0	80.7
	Control	90.6	60.8	75.7
January 1992	Under Coconut	90.7	62.3	76.5
	Under Jack	90.8	66.8	78.8
	Under Mango	90.8	65.2	78.0
	Control	90.9	55.5	73.2
February 1992	Under Coconut	92.1	62.3	77.2
	Under Jack	91.9	65.1	78.5
	Under Mango	91.8	64.2	78.0
	Control	91.1	58.7	74.9
March 1992	Under Coconut	88.1	63.2	75.7
	Under Jack	88.2	67.3	77.8
	Under Mango	88.0	66.0	77.0
	Control	86.6	58.2	72.4
April 1992	Under Coconut	86.3	67.0	76.7
	Under Jack	86.4	69.2	77.8
	Under Mango	86.3	68.1	77.2
	Control	86.3	65.0	75.7
May 1992	Under Coconut	88.0	69.2	78.6
	Under Jack	88.2	73.2	80.7
	Under Mango	88.2	70.1	79.2
	Control	88.0	67.5	77.8

Height of measurement: 1.5 m from the ground level observed in the afternoon than in the morning. It was seen from the data that the mean relative humidity values were the highest for the measurement under jack trees followed by mango trees and coconut palms. The variation was more pronounced for the humidity measured in the afternoon hours, while it was less during the morning hours.

4.5.3 Light Intensity

The monthly variation in light intensity at the floor of the different tree crops in the homestead during different periods of the day are furnished in Table 22. It is evident from the data that the light intensities at the floor of all the tree crops studied were always less than that in the control. The variation was much pronounced for jack trees, followed by mango trees and coconut palms. The maximum light intensity received during the period of study was 1,22,000 lux recorded during March 1992, in the control. The minimum value recorded in the control was in September 1991, i.e.31800 lux. The percentage variation in light infiltration by the different tree canopies during different times of the day is presented in Table 23. The data revealed that the percentage of light infiltration was maximum under coconut palms,

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Table 22. Monthly variation in light intensity in lux at the floor of different tree crops in the homestead during different times of the day

Month		Crop	Time (Hrs.) 10.00	12.00	14.00	16.00	Mean
June	1991	Coconut	12,800	18,600	17,700	10,300	14,850
		Jack	3,800	5,900	6,200	3,100	4,750
		Mango	6,400	8,900	9,000	4,800	7,325
		Control	49,900	70,000	68,000	45,500	57,350
July	1991	Coconut	13,500	16,500	16,800	11,400	14,550
		Jack	4,000	6,500	6,700	3,700	5,225
		Mango	7,000	8,800	8,800	6,500	7,775
		Contro	52,600	68,000	69,000	43,300	58,225
August	1991	Coconut	14,800	19,500	18,900	12,800	16,500
		Jack	5,200	7,800	7,900	5,000	6,475
		Mango	7,200	9,900	9,700	7,300	8,525
		Control	57,000	80,800	78,900	49,800	66,625
September	1991	Coconut	16,700	21,000	22,200	13,600	18,375
		Jack	6,200	8,400	8,100	4,700	6,850
		Mango	8,200	9,100	9,300	6,900	8,375
		Control	68,900	11,0000	10,8000	44,000	82,725
October	1991	Coconut	11,700	14,300	13,400	8,600	12,000
		Jack	4,100	5,600	4,400	3,100	4,300
		Mango	5,200	6,900	7,100	4,100	5,825
		Control	47,300	54,200	53,600	31,800	46,725
November	1991	Coconut	10,600	13,400	13,600	9,600	11,800
		Jack	2,900	3,100	3,200	2,800	3,000
		Mango	4,800	6,200	6,300	5,100	5,600
		Control	42,000	58,000	57,000	33,800	47,700
December	1991	Coconut	15,200	20,100	20,200	13,400	17,225
		Jack	6,100	8,800	8,100	4,800	6,950
		Mango	8,100	9,300	9,300	7,100	8,450
		Control	60,800	10,80,00	111,000	52,000	80,450
January	1992	Coconut	14,300	19,600	20,300	10,100	16,075
		Jack	5,700	7,800	7,600	3,200	6,075
		Mango	7,300	9,600	9,200	4,700	7,700
		Control	58,400	98,600	99,300	43,600	74,975
February	1992	Coconut	13,800	18,700	17,600	11,000	15,275
		Jack	5,200	6,900	6,700	3,400	5,550
		Mango	6,900	8,900	8,700	4,300	7,200
		Control	60,300	71,300	59,700	44,600	61,475
March	1992	Coconut	19,600	31,000	29,000	15,600	23,800
		Jack	6,800	8,200	8,100	4,200	6,825
		Mango	8,600	15,700	14,900	7,800	11,750
		Control	83,000	122,000	121,000	63,000	97,250
April	1992	Coconut	18,300	29,600	27,800	12,700	22,100
		Jack	68,000	9,100	9,200	3,900	7,250
		Mango	9,200	14,900	13,800	5,900	10,950
		Control	74,000	118,000	101,000	47,300	85,075
May	1992	Coconut	16,700	23,800	24,100	13,200	19,450
		Jack	5,900	11,000	11,300	4,100	8,075
		Mango	7,900	12,300	13,800	6,700	10,175
		Control	66,200	88,700	89,200	51,100	73,800

Distance of measurement: 2 m from the base of the trees

Table 23. Percentage light infiltration by the different tree canopies during different times of the day

Month		Crop	Time (Hrs.)				Mean
			10.00	12.00	14.00	16.00	
June	1991	Coconut	25.65	26.57	26.03	24.82	25.77
		Jack	7.62	8.43	9.12	7.47	8.16
		Mango	12.83	12.71	13.24	11.57	12.59
July	1991	Coconut	25.67	24.26	24.35	26.33	25.15
		Jack	7.60	9.56	9.71	8.55	8.86
		Mango	13.31	12.94	12.75	15.01	13.50
August	1991	Coconut	25.96	24.13	23.95	25.70	24.94
		Jack	9.12	9.65	10.01	10.04	9.71
		Mango	12.63	12.25	12.99	14.66	13.13
September	1991	Coconut	24.24	19.09	20.56	30.91	23.70
		Jack	8.99	7.64	7.50	10.68	8.70
		Mango	11.90	8.27	8.61	15.68	11.12
October	1991	Coconut	24.74	26.38	25.00	27.04	25.79
		Jack	8.67	10.33	8.21	9.75	9.24
		Mango	10.99	12.73	13.25	12.89	12.47
November	1991	Coconut	25.24	23.10	23.86	28.40	25.15
		Jack	6.90	5.34	5.61	8.28	6.53
		Mango	11.43	10.69	11.05	15.09	12.07
December	1991	Coconut	25.00	18.61	18.20	25.77	21.90
		Jack	10.03	8.15	7.30	9.23	8.68
		Mango	13.32	8.61	8.38	13.65	10.99
January	1992	Coconut	24.49	19.88	20.44	23.17	22.00
		Jack	9.76	7.91	7.65	7.34	8.17
		Mango	12.50	9.74	9.26	10.78	10.57
February	1992	Coconut	22.89	26.23	29.48	24.66	25.82
		Jack	8.62	9.68	11.22	7.62	9.29
		Mango	11.44	12.48	14.57	9.64	12.03
March	1992	Coconut	23.61	25.41	23.97	24.76	24.44
		Jack	8.19	6.72	6.69	6.67	7.07
		Mango	10.36	12.87	12.31	12.38	11.98
April	1992	Coconut	24.73	25.08	27.52	26.85	26.05
		Jack	9.19	7.71	9.11	8.25	8.57
		Mango	12.43	12.63	13.66	12.47	12.87
May	1992	Coconut	25.23	26.83	27.02	25.83	26.23
		Jack	8.91	12.40	12.67	8.02	10.50
		Mango	11.93	13.87	15.47	13.11	13.60

Open value taken as 100%

during all months of the year irrespective of the time of measurement. The data indicated that the percentage infiltration by jack tree canopies was the lowest. On an average, the percentage light infiltration varied from 21.90 to 26.05, 6.53 to 10.50 and 10.57 to 13.6 for coconut, jack and mango respectively. The light infiltration followed the same pattern during different periods of the day.

4.6 Economic analysis

The economic analysis of the homestead system with all its farming activities is presented in Table 24. It was evident from the data that a total of 2976 m^2 was utilised by the different crops, roads and permanent structures. The total area available for cropping in the homestead was only 1647.5m^2 excluding the area for roads and permanent structures. The gross cropped area was estimated to 2566 m^2. Hence the cropping intensity was calculated to 1.56. The data revealed that the labour and other expenses on different enterprises in the homestead was Rupees 18819.5 and 18219.0 respectively. The total costs were thus estimated to be Rs. 37038.50. The data also showed that the gross return by farming activities was to the tune of Rs. 60528.60 and the net return was calculated

Table 24. Economic analysis (benefit:cost analysis)

Sl. No.	Enterprises	Population/ Area	Space used (m^2)	Labour Costs	Other expenses (Rs.)	Total expend- -iture (Rs.)	Gross return (Rs.)	Net return (Rs.)	Benefit: cost ratio
1.	Adult coconut palms	27	972	1182.00	613.00	1795.00	4092.60	2297.60	2.28
2.	Young coconut palms	8	224	250.00	140.00	390.00	Nil	-390.00	-
3.	Banana-Nendran	14	56	250.00	62.00	312.00	420.00	108.00	1.35
4.	Palayankodan	12	54	250.00	51.00	301.00	410.00	109.00	1.36
5.	Tapioca	620	620	800.00	60.00	860.00	2225.00	1365.00	1.59
6.	Elephant foot yam	18	18	200.00	36.00	236.00	315.00	79.00	1.33
7.	Dioscorea	44	44	250.00	44.00	294.00	420.00	126.00	1.43
8.	Fodder grass	20000 hills	24	100.00	0.00	100.00	160.00	60.00	1.60
9.	Ginger	40 m^2	40	100.00	15.00	115.00	140.00	25.00	1.22
10.	Kitchen garden	1 Unit of 80 m^2	80	500.00	250.00	750.00	600.00	-150.00	0.80
11.	Mango tree	1	69						
12.	Mango + Pepper	1	36						
13.	Jack tree	1	61	75.00	21.00	96.00	202.00	106.00	2.10
14.	Jack + Pepper	1	61						
15.	Bread fruit	1	21	12.50	12.00	24.50	94.00	69.50	3.84
16.	Papaya	3	12						
17.	Portia tree	3	174	-	-	-	-	-	-
18.	Cow + Calf	2	30	9100.00	8300.00	17400.00	24800.00	7400.00	1.43
19.	Goat + Kids	1	10	2250.00	465.00	2715.00	3300.00	585.00	1.22
20.	Poultry birds	20	10	100.00	300.00	400.00	850.00	450.00	2.13
21.	Broiler chicks	600	100	3400.00	7850.00	11250.00	22500.00	11250.00	2.00
22.	House and other permanant structures	-	260	-	-	-	-	-	-
	Total		2976	18819.50	18219.00	37038.50	60528.60	23490.10	1.63

to be Rs. 23490.10. The benefit:cost ratio came to 1.63. The data clearly showed that labour costs accounted for the greatest share of costs on cropping activities.

Among the individual enterprises the poultry unit provided the maximum net return while the benefit:cost ratio was found higher for coconut cultivation.

The benefit by the different nutrient cycling processes like litterfall, stemflow throughfall and rainfall is given in Table 25. The data revealed that the various nutrient cycling processes accounted for nutrient addition costing Rs. 179.89. The litterfall was the major nutrient cycling component among the different processes of nutrient return benefiting Rs. 128.58.

The abstract of the economic analysis of the whole homestead system is presented in Table 26. It is evident from the data that the different enterprises in the homestead resulted in a net return of Rs. 23490.10 at a cost of Rs. 38238.50. The savings by family labour come to Rs. 5625/-,which was added to the profit. Thus the data revealed that the homestead under study provided a net benefit of Rs. 28094.99 taking into

Table 25. Economic analysis of the nutrient cycling processes

Source	Total input to the system (Benefit)(Rs.)	Total output from the system (Cost) (Rs.)	Net benefit (Rs.)
Leaf litter	128.58	0.00	128.58
Throughfall stemflow and rainfall	51.31	0.00	51.31
Total	179.89	0.00	150.11

Table 26. Abstract of the economic analysis

Source	Cost (Rs.)	Return (Rs.)	Benefit (Rs.)
Crops, livestock and poultry	37038.50	60528.60	23490.10
Nutrient cycling processes	0.00	179.89	179.89
Interest on initial investment of Rs. 10000/- @ 12% per annum	1200.00		- 1200.00
Savings in terms of family labour	-	5625.00	5625.00
Total	38238.50	66333.49	28094.99

consideration all the enterprises, inputs by nutrient cycling processes, savings by providing family labour and the interest on initial investment of Rs. 10000. This amount of Rs. 10000 obtained as a short term agricultural loam from the District Co-operative Bank, Thiruvananthapuram at an interest of 12 % per annum.

DISCUSSION

DISCUSSION

Contrary to popular belief, a sizeable percentage of total production of most of the crops is obtained from small holdings. This assumes a significant proportion in terms of both the population they support and the area they cover. In the small holdings, the farmers usually integrate crop and animal production with perennial crops, primarily to meet their food requirement. Examples of some of the profitable production systems from different parts of the world have been described by Ruthenberg (1980). Integrated land use systems are a logical consequence in these small holdings because of the demographic characterisation of such areas. With this background, the results of the investigation entitled "agronomic resource inventory of a homestead in the southern zone of Kerala" are discussed hereunder.

5.1 Structure and function

The concept of homegardening is age old and this practice is being undertaken by the farmers in the tropics from time immemorial. They cultivate an array of crops including multipurpose tree crops for their home needs based on resources and input availability.

Very often the productivity of the home gardens show a declining trend because of unscientific and haphazard planting of crops and trees. Besides, the pest and disease incidence along with competition between crops resulted in productivity decline.

A prominent structural characteristic of the homegarden is the great diversity of species with many life forms varying from those on the ground, such as the tall trees of ten metres and more, like coconut palms and vines climbing on bamboo poles and trees. These create the forest like multistorey canopy structure of many home gardens.

5.1.1 The homestead

The homestead selected for the investigations is in Thiruvananthapuram district in the southern zone of Kerala. The detailed plan of the homestead, given in Fig. 2, showed the location of all the components in the homestead. It also showed that the homestead comprised an area of 2057.5 m^2 (0.2 ha). About 20 per cent of the area was utilized by the permanent structures like buildings and road. Rest of the area was cultivated with a multitude of crops.

The topography of the land is an undulating one. Contour bunds were laid depending on the slope, which ensured proper conservation of water and prevented soil erosion. The contour bunds were planted with fodder grass as biological agents against soil erosion problem. The soil of the homestead is red loamy one. The rainfall recorded was of the order of 1683.7 mm with fairly good distribution (Appendix - II). The red loamy soil and plentiful of rain are the two important characters of the southern zone (KAU Status Report 1984 and 1985), which are congenial for a good crop stand. Irrigation facilities in the homestead are lacking. The only source of water was a well. Water from the well was not sufficient even for the household needs especially in severe summer months. A pumpset with capacity of 0.5 hP installed served for pumping the water for domestic consumption. The scarcity of water is the main reason for his inability to cultivate vegetables in summer season. This invariably resulted in a reduction in his income.

5.1.2 Farm family

The household is a four (2+2)member family. The family comprised father, mother and their two sons. The main occupation of the farmer is agriculture. He is also engaged in some small scale industries. The two school going sons are studying in Thiruvananthapuram. The farmer and his wife are educated upto matriculation. They provided a labour input to the tune of 112.5 man labour days. The labour was provided for the maintenance of kitchen garden, livestock and poultry. Abdul Salam et al. (1992) estimated labour input of 182 man days by a four member agricultural family. The lower labour input by this family under study may be due to the fact that the farmer and his wife set apart more time in teaching their sons and attending their welfare. The farmer was also engaged in a small scale match making industry. Besides these, they have also employed a distant relative at a monthly salary of Rs. 500/-.

5.1.3 Crops and cropping pattern

The detailed plan showing the respective location of the different components in the homestead including tree crops and permanent structures is given in Fig. 2. An appraisal of Fig. 2 and Table 1(a) showed that the homestead consisted of a number of crops including multipurpose tree species, resulting in an intensive cropping with cropping intennsity of 1.56. The intensive cropping nature of the homesteads in Kerala have been reported by Abdul Salam et al. (1992) and Nair and Sreedharan (1986).

The major perennial tree crop in the homestead is coconut. This homestead can be considered as a coconut - based homestead system. Such systems have been described by Abdul Salam et al. (1991) and Nair and Sreedharan (1986).

The crops are planted in the homestead based on the space available and according to the convenience, rather than following a specific pattern of planting or spacing as done in monoculture. It is evident from Table 12 and Fig. 2 that there was an intensive cultivation in the homestead with a multitude of crops. Nair and Krishnankutty (1984) reported that a reduction in size of holding will lead to a high intensity cropping. This was true in the case of homestead cultivation in Kerala. Their findings hold good in the present study also.

The tree crops like coconut, jack, mango, portia and breadfruit occupied the top most layer of the canopy. Pepper was grown using jack and mango as standards. Banana was grown in the second layer.

Crops like dioscorea, cassava, elephant foot yam and vegetables occupied the third layer. The ground layer was occupied by fodder grass and ginger. This is found in conformity with the report of Fernandes and Nair (1986). They gave a schematic representation of the structure of different homegardens from various geographical regions and reported that the canopies of most of the home gardens consisted of two to five layers. This pattern of arrangement of crop components ensured efficient utilization of space and a high degree of solar energy harvesting and this helped in increased production and profit. The structural arrangement, canopy configuration and component interaction of the homestead is also similar to other home gardens and this has ensured high degree of resource use efficiency both temporally and spatially (Abdul Salam et al., 1991).

Coconut is the major crop in the homestead. It is evident from Table 24 that among all the enterprises, the benefit:cost ratio was maximum for coconut. The main reason for the high return from coconut is due to the lesser labour requirement of the crop when compared with other components (Table 27) and the high price of the produce. The price of coconut varied from Rs. 3/- to 4/- per nut during the year of study. The average yield was of the order of 48 nuts per year. Nair (1979) and Nair and Sreedharan (1986) observed that the main reason for the pre-eminent position of coconut palms was the easiness to manage the crop and its less labour requirement. This coupled with the high benefit-cost ratio may be the reason why the farmer had resorted to plant eight more coconut palms in the homestead, four years ago, even when the prices of coconut was low and fluctuating. Another reason may be the fact that the "recoupment" or "pay back period" of coconut planting is estimated to be 16 years, which means that the amount required to bring up the plantation to bearing stage and the annual recurring cost of cultivation thereafter will be paid back fully within a period of 15 years from planting, and subsequently there will be steady realisation of income. However, a coconut holding can be considered as an investment which a family can build up by supplementing small amount of cash with much unpaid family labour.

The harvesting of nuts was carried out once in every 45 days. Harvesting incurs the major cost involved in coconut production especially in case of subsistance farming. The coconut climbers are paid Rs. 2/- per tree for harvesting. Another important operation in coconut farming is the intercultivation and taking of basins in September after the cessation of heavy rains. These operations also helped to conserve moisture from the last monsoon rains (Nair, 1979). Inorganic fertilizers were applied at the rate of two kg per palm (10:5:20 NPK mixture) along with intercultivation during May-June. Organic manures such as cowdung and poultry litter were also applied to the palms during the month of December. They were applied at the rate of 20 kg per palm. All these operations required 15 labourers.

The young palms were also managed well with intercultivation, weeding and manuring as in the case of adult palms. Cultural operations for young palms required five labour days. The total labour utilized for the 35 coconut palms was 20 men labourers, in addition to the labour involved in harvesting of nuts. Nelliat and Krishnaji (1976) estimated a labour requirement of 150 man days per year for one hectare of pure coconut plantation. The estimate will come to 30 man days if calculated for 35 palms. The lower labour requirement in the homestead may be because of the intensive cropping and intercultivation in the homestead, which demanded a lesser labour for managing individual crops.

Another tree component in the homestead is jack. There are two jack trees. Pepper is trailed on one of them which is a local variety and the other jack is Muttom Varikka. No intercultivation is specifically done for jack trees. The jack trees yielded well and a total of 40 fruits were obtained from them. Thirty fruits were sold at a price of Rs. 2/- per fruit and the rest was used for home consumption. The climbing and harvesting of the jack fruits were carried out by those who purchased the fruits and hence no expenditure was incurred by way of harvesting.

Two mango trees of local Kilichundan also formed part of the system. No intercultural operations were done for the mango trees. One pepper was trailed on one of these trees, effectively utilizing the space and solar energy. About 40 kg of unripe mango was obtained from these trees. This was sold at a price of Rs. 3/- per kg.

The fruit trees, jack and mango were used as live standards for pepper. The two pepper plants of variety Karimunda were provided good management practices. Karimunda was grown as it can tolerate shade well. It was also observed that the jack and mango trees, had a very good canopy and hence there was fairly good shade.

The intercultivation and weeding was done twice in the year. Only organic manures were applied to the plants at the rate of 20 kg per plant. Prophylatic spraying of Bordeaux mixture was carried out to prevent possible fungus attack. No pests or diseases were noticed during the year. The plants yielded 1.6 kg dried pepper. The produce was sold at a price of Rs. 25/- per kg, which was much lower than the previous years price of Rs. 40/- per kg.

Another tree component in the homestead was the breadfruit plant. This tree yielded 21 kg of produce. The fruits after maturity was harvested and sold at a price of Rs. 3/- per kg. Sale of the produce was also undertaken locally. The fruits were also used for the household consumption and the rest was sold locally. About 25 kg of organic manure was applied to the tree.

The three papaya plants regularly supplied the home with fruits, all of which were utilized for consumption. On an average a tree gave 30 fruits per year. No intercultural operations were given except for the application of organic manures at the rate of 10 kg per plant. The plants were of local variety and only about two years old. This coupled with the shading by other trees may be the reason for the lower per plant yield, in contrast to a higher yield of even 100 or more fruits per plant per year obtained in papaya orchards. All the fruits produced in the plants were not available for consumption as some of the fruits were consumed by squirrels and birds.

The portia trees were grown in the boundary of the field. It is mainly grown for timber. They also served as live fences.

It can be seen that a number of other crops were also grown in the interspaces of these perennial tree crops. The prevalence of intercropping in between tree crops is a common feature in the homesteads of Kerala. According to Nelliat and Krishnaji (1976), under rainfed conditions in coconut gardens, tuber crops and banana are best suited. The intercropping also reduced the risk in monocropping and increased the total net return. The minimisation of risk by intercropping in coconut gardens have also been reported by Nair (1984). The major objective of the farmer of this homestead to adopt mixed cropping is to increase the net return, thus reducing the risk in monocropping.

The major tuber crops grown was tapioca. The variety Sreesahya was cultivated by the farmer. He cultivated cassava in an area of 620m^2 and followed good management practices, adopting the package of practices recommendations of KAU. About 1.5 tons of cattle dung was applied to the field and mixed with soil during the time of land preparation. He also applied about 20 kg of inorganic fertilizers (10:10:10 NPK mixture). Regular weeding and intercultural operations were carried out. Eventhough rats were a serious problem, the menace was not so serious during the year of study. He used the local methods to control rats. It can be seen that the benefit - cost ratio for tapioca cultivation was 1.59 and cultivation resulted in a net return of Rs. 1365/- (Table 24). The tuber was sold fresh after keeping about 200 kg for future use as dried product. The transaction took place in the homestead itself and it was sold at a price of Rs. 1/- per kg. The stems were collected and sold at the rate of Rs. 0.50 per stem after keeping enough seed material for next season. The leaves and tender parts of the stem were dried and fed to cattle. Abdul Salam et al.(1992)(a) reported a net profit of Rs. 0.15 per unit of cassava cultivation from a survey in homesteads in southern Kerala. But the value for the homestead under study was Rs. 2.2 per unit of cassava, a very high value. This can be attributed to the high yield obtained, due to the cultivation of high yielding variety, good management practices etc.

Tuber crops like amorphophallus and dioscorea were also planted in the interspaces between the tree crops. Eighteen plants of amorphophallus yielded a net return of Rs. 79/-. The seed material was obtained from the previous season's crop. Dioscorea were trailed on the coconut palms. Twenty plants were of high yielding Sreelatha variety and the seed material of which was obtained from CTCRI, Sreekaryam. The other plants were of local variety. The Sreelatha variety yielded about 2 kg per plant while the local variety yielded about 3 kg per plant. The high yield in local variety may be due to planting of large sized tubers and their capacity to tolerate shade. All the yams were applied with 10 kg per plant of organic manure.

Fodder grass was planted all along the contour bunds. The harvesting of the fodder was undertaken once in every 30 days. An area of 40 m^2 was set apart for the cultivation of ginger. The other major crop in the homestead was banana. It is seen from Table 1(a) that there were 14 plants of variety Nendran and 12 plants of variety Palayankodan. They were well managed and irrigation was given during the early stages of planting, i.e. during August, when there was shortage of rainfall, thereafter no irrigation was given. The farmer applied approximately 20 kg of NPK fertilizer to the plants in two split doses, first in September and then in November. Furadan was also applied at the rate of 25 g per plant at the time of planting and thereafter two months after planting. Half of the produce was taken for household consumption and the rest sold to the nearby shops in the area. The price of the bunches varied between Rs. 30 to 40. The suckers produced were used for planting in the subsequent season. The leaves and pseudostem after the harvest of bunches were used for feeding the cattle.

The farmer also maintained a kitchen garden in an area of 80 sq.m. Vegetables such as brinjal, bhindi, chilli , amaranthus, drumstick and cowpea were grown and used for household consumption. The garden was maintained by the farmer's wife and hence no extra labour was involved except for the planting. The vegetables produced from the garden didn't meet their home demand. The kitchen garden was well maintained but it resulted in a net loss to the farmer, mainly due to the severe incidence of many pests and diseases.

5.1.4 Livestock and Poultry

It can be seen from Table 1(b) that there were two milch cows, their calves, a goat with kids, 20 poultry birds and 600 broiler chicks in the homestead. One of the cows is a Jersey breed aged five years and the other a local breed aged eight years. With the introduction of improved breeds of cattle and subsequent white revolution, improved breeds of cows are maintained by farmers in Kerala. The cows were maintained mainly for milk. The Jersey breed on an average gave eight litres of milk per day, while the other cow gave three litres per day. The farmer had constructed cattle shed to house these animals. He also maintained a local breed of goat with its two kids. The goat gave on an average 0.7 litres of milk per day. The goat and its kids were also housed in a goat house. The above animals were fed with green fodder, paddy straw and concentrates.

The fodder available in the homestead was insufficient to meet their demand and hence supplemented by paddy straw and at times by dried tapioca leaves. During the time of harvest of banana, pseudostem and leaves were also fed to the cattle. The concentrates given was cattle feeds, marketed through Milma. About 150 kg of cattle feeds was required for a month. The paddy straw was locally purchased at a cost of Rs. 0.5/- per kg. About 2 tonnes of paddy straw was purchased per year. The goats were supplied with the leaves of erythrina, jack and mimosa, collected by the permanent labourer in the house from the nearby fields. Two litres of cow's milk and the entire goat's milk was consumed by the household. The rest was sold to the Co-operative Milk Marketing Society near the house at a price of Rs. 5.50 per litre.

There were 20 poultry birds reared on the backyard system. They laid about 1000 eggs during the period of investigation. All the eggs were consumed by the household. A broiler chicken farm with a total of 600 birds in a year was also maintained by the farmer. The chicks were supplied regularly to the homestead by the agents of AVM Hatcheries, Tamilnadu. Hundred birds each were brought in every two months. The chicks will be ready for sale by the sixth week. The chicks were reared on a special house with provisions for temperature control. The chicks were fed with poultry feed. Hundred birds required on an average five kg of feed per day. The feeds alone cost him about 75 per cent of the total expenditure. There was good demand for the chicken and as such the farmer did not experience any difficulty in marketing the chicken.

5.1.5 The labour utilization potential

It can be seen from the Table 27 and Fig. 5 that among the farming activities the maximum labour was required for the livestock, followed by poultry and annual crops. The least labour requirement was for maintaining the perennial crops including tree species. This is in conformity with the reports of Nelliat and Krishnaji (1976) and Nair and Sreedharan (1986), that the tree crops are less labour intensive. The labour cost during the period was Rs. 50/- per day (a day of 8 hours) in the homestead while it was only Rs. 45/- per day in some other places of the same district. The high labour cost is a common phenomenon in Kerala. But the still higher labour cost in the homestead may be due to the presence of Instructional Farm, Vellayani near the place, where the wages were very high (Rs. 55/- per day). This high wage invariably had an influence on the wages of labourers in the area. The farm family could provide a labour saving of the order of Rs. 5625/- per year. The provision of labour by farm family was reported by Abdul Salam et al. (1991), Nair (1979) and Nair and Sreedharan (1986). The total labour requirement for the household is estimated to be 367.75 man days. The high labour utilization may be due to the presence of large number of enterprises

Table 27. Labour utilisation pattern in the homestead

(Area - 2057.5 m^2)

Crop/Enterprise	Population/ Area	Labour utilisation (man days)*	Cost per year (Rs.)**
Adult Coconut -	27		
Cultural operations		15.00	750.00
Harvesting		-	432.00
Young coconut -	8		
Cultural operations		5.00	250.00
Banana -			
Nendran	14	5.00	250.00
Palayankodan	12	5.00	250.00
Tapioca	620	16.00	800.00
Fodder grass	2,00,000 hills	2.00	100.00
Elephant foot yam	18	4.00	200.00
Dioscorea	44	5.00	250.00
Ginger	40 m^2	2.00	100.00
Kitchen garden	80 m^2	10.00	500.00
Mango, Mango + Pepper, Jack and Jack + Pepper	4	1.50	75.00
Breadfruit	1		
Pappaya	3	0.25	12.50
Portia	3		
Cow	2 Units	182.00	9100.00
Goat	1 Unit	45	2250.00
Poultry	20	2	100.00
Broiler chicken	600	68	3400.00
Total		367.5	18819.50

* A day of 8 hours

** Labour cost @ Rs. 50 per day

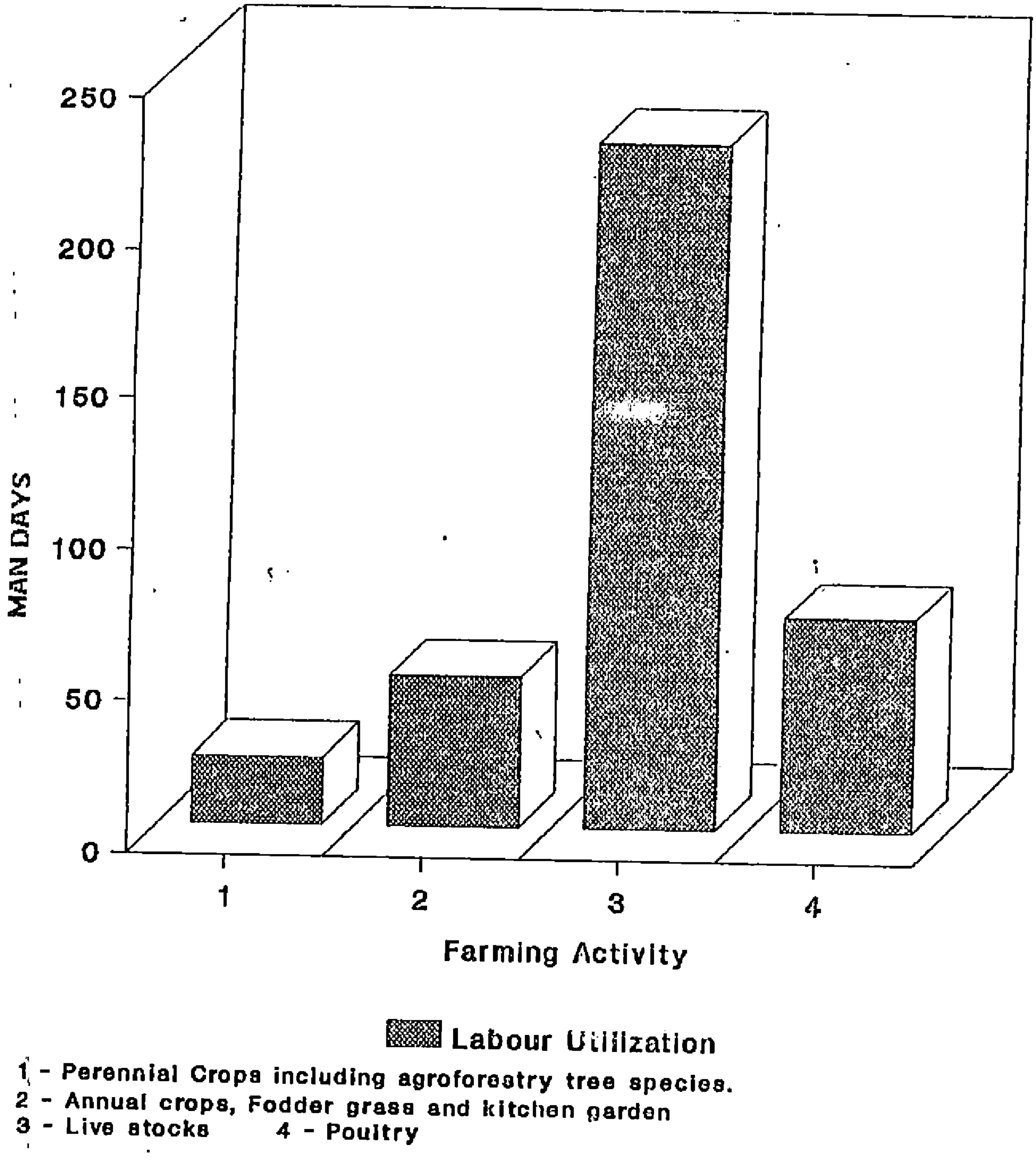


Fig. 5. Labour profile of farming activities in the homestead (from June 1991 to May 1992)

including a broiler chicken farm. The observation of the present investigation is similar to the report of Nair (1979) wherein it was reported a high labour requirement of about 1000 man days for a hectare of coconut plantation with mixed farming, while that for a pure coconut plantation was about 150 days. The low labour requirement for perennial crops including coconut is due to comparatively less management, the crop requires. The low labour cost in case of jack, mango and breadfruit is due to the fact that these crops don't require any cultural operation in contrast to annuals, apart from the low incidence of the pests and diseases. The cost of labour was the major expense in the case of livestock and poultry. More than 50 per cent of the expense incurred on livestock was by labour cost alone. The high labour cost incurred has been reported by Nelliat and Krishnaji (1976).

5.1.6 Credit and Marketing

Table 26 showed that the farmer had to pay a sum of Rs. 1200/- as interest. This was the interest for a sum of Rs. 10000/- which he obtained as agricultural loan for maintaining the broiler farm. The rate of interest was 12 per cent and the money was paid back with interest after one year. The income for the livelihood and paying back the loan was obtained by the sale of surplus agricultural commodities by the farmer. The different enterprises in the homestead namely crops, livestock and poultry together gave the farmer a net return of Rs. 23490/- (Table 24). A high net return by mixed farming has been reported by Abdul Salam et al., 1991 and 1992 (b); Nair, 1976; and Nelliat and Krishnaji, 1976.

The major commodities involved in marketing are coconut, cassava, yam, milk and broiler chicken. Sizeable quantity portion of the produces like cassava, yam, breadfruit, jack fruit and mango were sold in the homestead itself. The sale of coconut also took place in the homstead itself during the months of September and December, when the demand was maximum due to Onam and Christmas festivals respectively. During other months the produce was sold in the Balaramapuram market about Seven km from the homestead. In the case of the commodities like yam, cassava and breadfruit they were not marketed through organised channels. The sale of produce mainly took place by negotiation and bargaining.

5.2 Nutrient cycling

One of the main principles in soil management in agroforestry is to make the best use o' resource conserving and resource sharing potential of trees. Therefore, it is extremely useful to have a nutrient budget for the whole system based on the nutrient requirements of individual components and the nutrient dynamics in the system. Nutrient cycling process that takes place in varying degrees in all land use systems become particularly relevant in the agroforestry context because of the likely effect of trees in such processes. Nutrients taken up by the plants are either stored in increment (storage) compartments or are used for the production of non storage organs. Part of the nutrients that are taken up by the plants are also returned to the soil through two avenues. First, through litterfall and secondly through the process of plant cycling. Plant cycling represents that part of the total uptake of nutrients which is again leached out from the vegetative parts through crown wash, occuring as canopy drip and stemflow. The presence of this fraction which is circulated within the ecosystem is a sort of 'necessary waste' (Nair 1979) and it indicates large amount of losses of nutrients that must be accounted for, while calculating nutrient budget in plant communities. The total amount involved in cycling depends on the nutrient content of leaves, intensity and frequency of rainfall, the age and arrangement of leaves and so on (Ulrich et a , 1977). From the point of view of plant nutrition this process is very important. The result of the nutrient cycling processes, obtained in the present study are discussed hereunder.

5.2.1 Litterfall

The litterfall from the multipurpose trees form a major component of the nutrient cycling in any agroforestry system. Litterfall, nutrient content and nutrient addition through litterfall by different tree species in the homestead are depicted in Fig. 6,7 and 8 respectively.

It is evident from Fig. 6 that the litterfall by coconut added higher amount of organic matter to the homestead. The total addition by leaffall was estimated to be 550.56 $kg.yr^{-1}$ in the homestead. The litter addition by mango trees was the lowest (88.26 $kg.yr^{-1}$). Thus it is clear that the canopy area of the

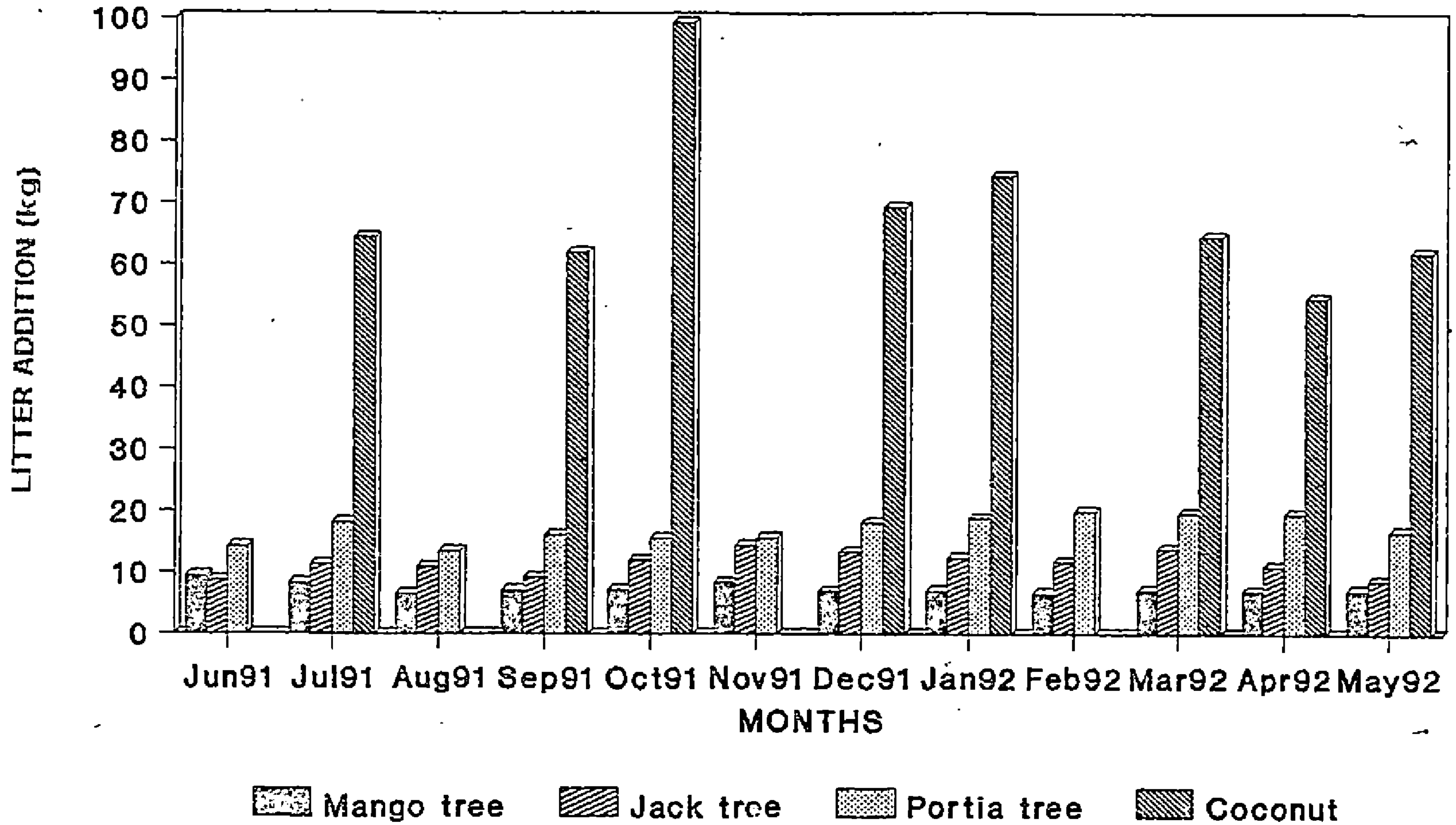


Fig. 6. Variation in litterfall between four agroforestry species in the homestead.

coconut trees was the maximum (972 m^2), while it was the lowest for mango trees (105 m^2). On a unit basis of canopy area, it can be seen that the maximum litterfall was for portia trees, followed by jack and mango. The lowest value was for coconut. Assuming as a pure stand of these crops, on a per hectare basis, the litterfall works out to be 8.4, 11.2, 11.8 and 5.6 $t \cdot ha^{-1} \cdot yr^{-1}$ for mango, jack, portia and coconut respectively. Although this is comparable with litter production rate (5.5 - 15.3 $t.ha^{-1} \cdot yr^{-1}$) reported by William and Gray (1974) in equatorial forest tree species, is greater than the values reported by Rodin and Bazilevich (1967) for tropical forest trees (2 $t.ha^{-1} \cdot yr^{-1}$). The favourable temperature and rainfall condition prevailing in the tropics and the higher primary productivity can account for the higher amount of litter production (Bray and Gorham, 1964; Das and Ramakrishnan, 1985).

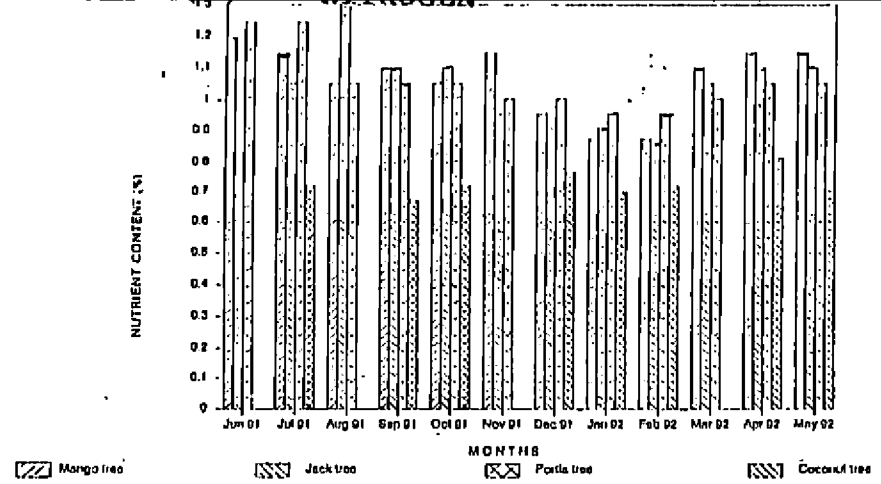
There was variation between the litterfall during different months (Fig. 6). Maximum litterfall was noticed in the month of October for coconut, but the value was maximum in the month of June for mango, in February for portia tree and in November for jack. The variations may be due to the genetical variation of the different species, variation in the leaf shedding nature, specific effect of climate on different species etc. The leaf fall in portia was found to be more during the months of January, February and March, with a peak value in February. Ashton (1975) reported that for Eucalyptus regans leaf fall was maximum in summer months. In mango the maximum value was observed in the month of June. Excess rain and the effect of rain on the leaf shedding in jack could be attributed to higher litterfall, during this month. A higher litterfall was also noticed in the rainy months of July, September, October and November. Dunham (1989) reported that litterfall of Acacia albida showed a peak in the wet season. Pockriyal et al. (1989) reported that the seasonal litterfall varied with water stress. In jack, the maximum litterfall was observed during the month of November and a minimum in June. Shajikumar and Ashokan (1992) reported the same observation in subabul and glyricidia.

Thus, it can be concluded that the litterfall in the preset study varied between species and season. The results are in conformity with that of Pushp and Surendra (1987).

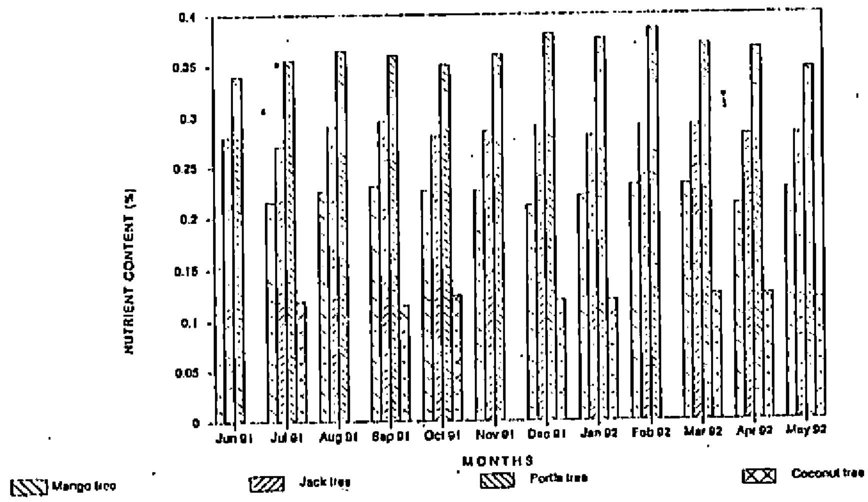
The total litter addition by the tree species in the homestead is estimated to be 981.35 $kg.yr^{-1}$. It is to be pointed in this connection that the major portion of the litter is derived from coconut.

The nutrient content in litterfall and the total nutrient addition by litterfall in the homestead are depicted in Figs. 6 and 7, respectively. The nutrient content in leaf litter was found to vary between the species and between months in the same species. An appraisal of the Tables 2,3,4 and 5 and Fig. 8 reveals variation in nutrient return by the different species at monthly intervals.

The content of the various nutrients was the lowest in coconut leaves, among the tree species studied. The annual nutrient input by leaf fall for one hectare of a pure plantation of the tree species grown under the same condition as in homestead would work out to 40, 6.9 and 22.6 $kg.ha^{-1}.yr^{-1}$ of N, P and K respectively for coconut. These values are higher than the values of 33.1, 3.8 and 13.4 $kg.ha^{-1}.yr^{-1}$ of N, P and K respectively estimated by Khanna and Nair (1977) in pure plantations of coconut. The observed variation in the nutrient content in the present investigation may be due to the fact that the observations were



(b) PHOSPHORUS



(c) POTASSIUM

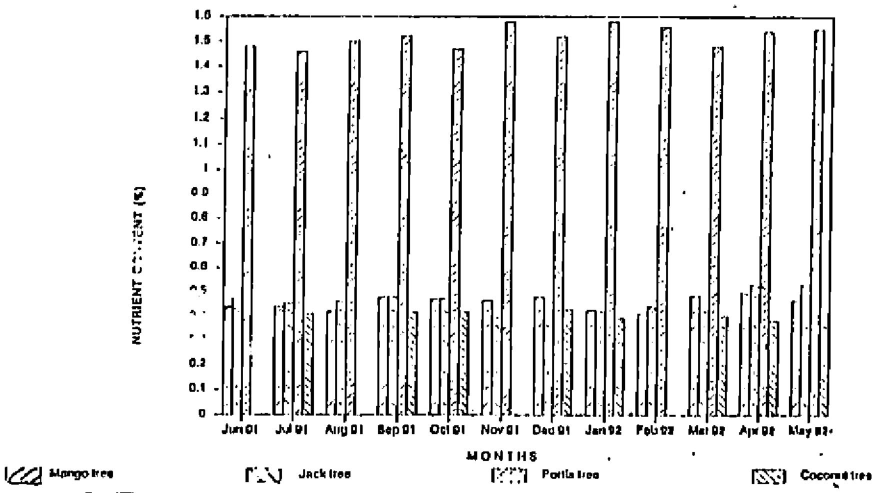
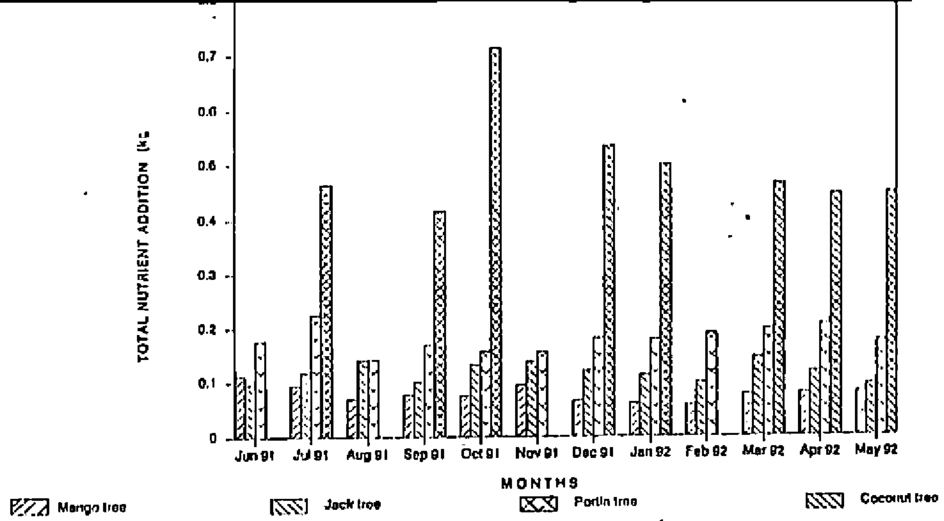


Fig. 7. Variation in nutrient content in the litter between four agroforestry species.



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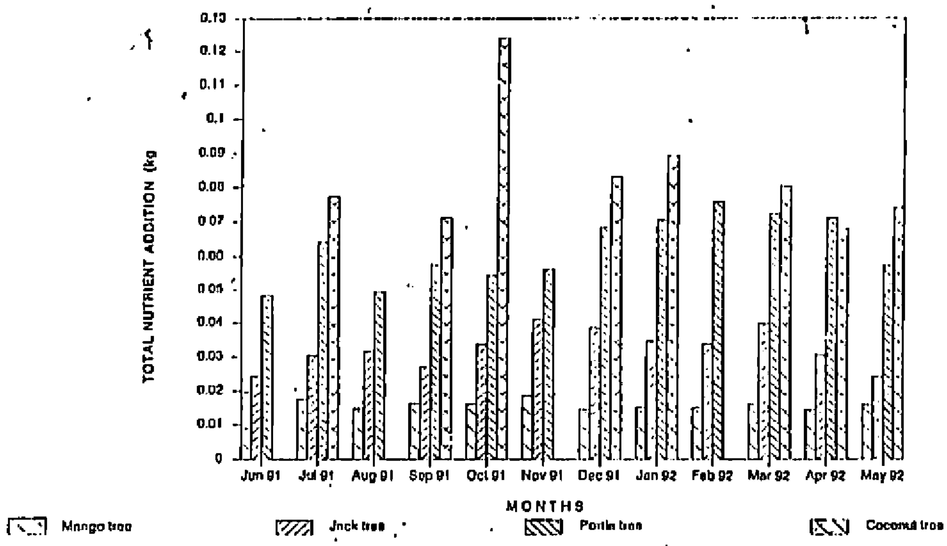

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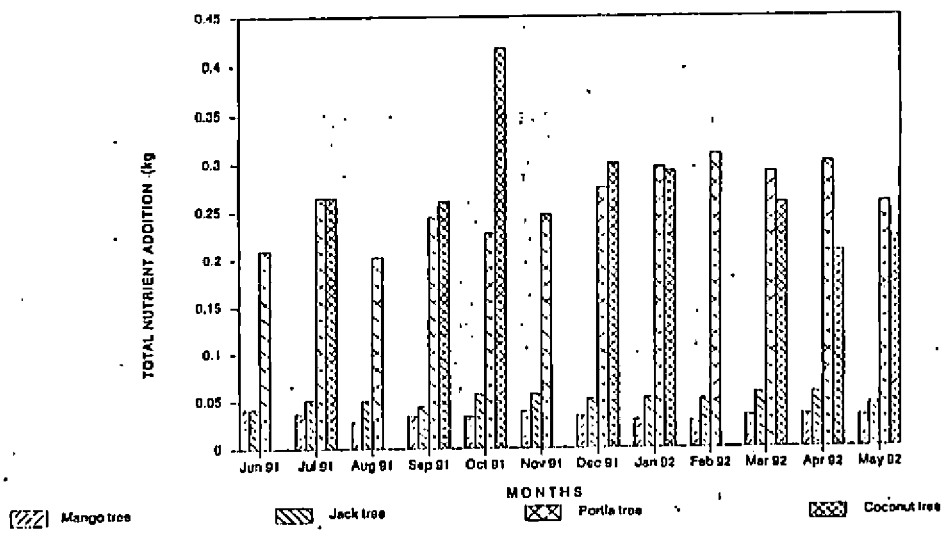


Fig. 8. Variation in nutrient addition by litterfall between four agroforestry species in the homestead.

undertaken in the home garden with a number of plants. Invariably the homestead was well managed with intensive cultivation (cropping intensity -1.56) and addition of large quantities of organic manures besides the inorganic fertilizer application. This may be the reason for a higher nutrient return by coconut in the homestead system.

The nitrogen content in jack, mango and portia litter showed variation between different months (Fig. 7). The phosphorus and potassium contents were higher in portia leaves than mango, jack and coconut. In general it is observed that the nutrient content of litter vary with tree species and season. The reason for the variation might be due to tissue longevity, species life forms and fertility of the sites (Pushp and Surendra, 1987; Sharma and Pande, 1989). The nutrient uptake capability, the rooting pattern and the nutrient availability in soil would also be attributed to this variation.

Accordingly the amount of addition of N in soil by different tree species (assuming a pure plantation of these trees grown under the same condition as in the homestead) would work out to be 90.0, 116.39 and 123.5 kg . ha^{-1}. yr^{-1} by mango, jack and portia trees respectively. The values although are comparable with the values estimated (25 to 103 $kg \cdot ha^{-1} \cdot yr^{-1}$) by Shajikumar and Ashokan (1992) in four agroforestry species, is less than the value for tropical forests (250-325 $kg \cdot ha^{-1} \cdot yr^{-1}$) estimated by Rodin and Bazilevich (1967).

The phosphorus addition by litterfall in the homestead is estimated to 0.19, 0.38 and 0.74 $kg \cdot yr^{-1}$ by mango, jack and portia respectively. These values on a per hectare basis (assuming as a pure plantation) worked out to be 18.1, 31.14 and 42.5 $kg \cdot ha^{-1} \cdot yr^{-1}$ by mango, jack and portia tree respectively. These values are much higher than the estimates by Shajikumar and Ashokan (1992) (1.8-5.3 $kg \cdot ha^{-1} \cdot yr^{-1}$) for four agroforestry species. The possible higher values for P may be due to the very high level of P in the soil (Table 18). Chapin _et al_. (1980), Procter _et al_. (1985) and Pushp and Surendra (1987) reported that site characteristics is an important factor which determine the nutrient return by litterfall.

In the case of potassium, the nutrient addition to the homestead was to the tune of 0.40, 0.61 and 0.3 $kg \cdot yr^{-1}$ by mango, jack and portia respectively. This addition of nutrients, if estimated for a hectare of pure plantation, the value would work out to 38.1, 50.0 and 178 kg.ha^{-1}. yr^{-1} by mango, jack and portia respectively. Again the estimated values were less than that of by Shajikumar and Ashokan (1992) and Cole and Rapp (1980) for pure plantations. But the values of jack and mango were comparable with the estimates (42 kg.ha^{-1}. yr^{-1}) by Cole and Rapp (1980) for temperate deciduous forests. The higher values for these crops might be due to the high leaf shedding rate in these trees, along with the higher nutrient content in leaves. Bray and Gorham (1964) reported that tropical trees shed leaves throughout the year at a steady rate. The increased rate of leaffall and consequent high nutrient content may be the reasons for increased nutrient return. If the fertility status of the soil is high, then the nutrient retranslocation during ageing and senescence of leaves will be less, resulting in a higher nutrient content in leaf litter (Chapin et al. (1980), Pushp and Surenda (1987). Comparatively high amount of litterfall can be attributed to high nutrient return especially in case of portia trees. The total nutrient return is dependent on total litterfall than by the content of nutrients in litter (Procter et al. (1985).

It has to be pointed out that the estimates of nutrient addition recorded so far are for pure plantations, mostly in forest ecosystem and no attempt has been made to study the nutrient addition in a mixed farming situation as in homesteads. The management practices, fertility status of soil and intercultural operations differ in a homestead system, when compared with a pure plantation, with little or no disturbance in the system. So it is logical to expect a higher value in the homestead which is mostly fertilized and manured heavily. The nutrient return by litterfall in a protected plantation was found higher than that in a natural forest (Chaubey et al., 1988). The management practices and other features of a mixed farming situation may probably play an important role in determining the total nutrient return by litterfall.

5.2.2 Throughfall, Stemflow and Rainfall

In addition to litterfall, throughfall and stemflow are the other two important avenues of nutrient addition in soil. Rain, striking on plant surfaces, either drips to the soil as throughfall or is channelled to the ground as stemflow. Water drops which are not falling on the plants, drops to soil.

The results of the study on the throughfall and stemflow and the variations in total nutrient addition by these processes to the homestead by different tree species are given in Tables 6-13. The variation in nutrient content in throughfall between four tree species is depicted in Fig. 9. The data revealed that there existed variation in the nutrient content in throughfall between the four species. In case of mango and jack the maximum concentrations of N, P and K were observed in the month of April. N content in coconut throughfall was maximum in June while the nutrients K and P were maximum during the month of April. In portia tree, the maximum N and K contents were observed in April, while that of P was maximum during the month of March. The nutrient content in stemflow by all the tree species were maximum in April except for K in coconut (maximum in June) and for N in mango (maximum in May). The reason for a generally high nutrient status in the month of April, may be due to the absence of rain during the previous months. The nutrient content of throughfall and stemflow included contribution from particulate matter deposited on the leaves by sedimentation (Charley and Richards, 1983). The absence of rain during the months of January, February and March, might have resulted in the deposition of more particulate matter on the stem and

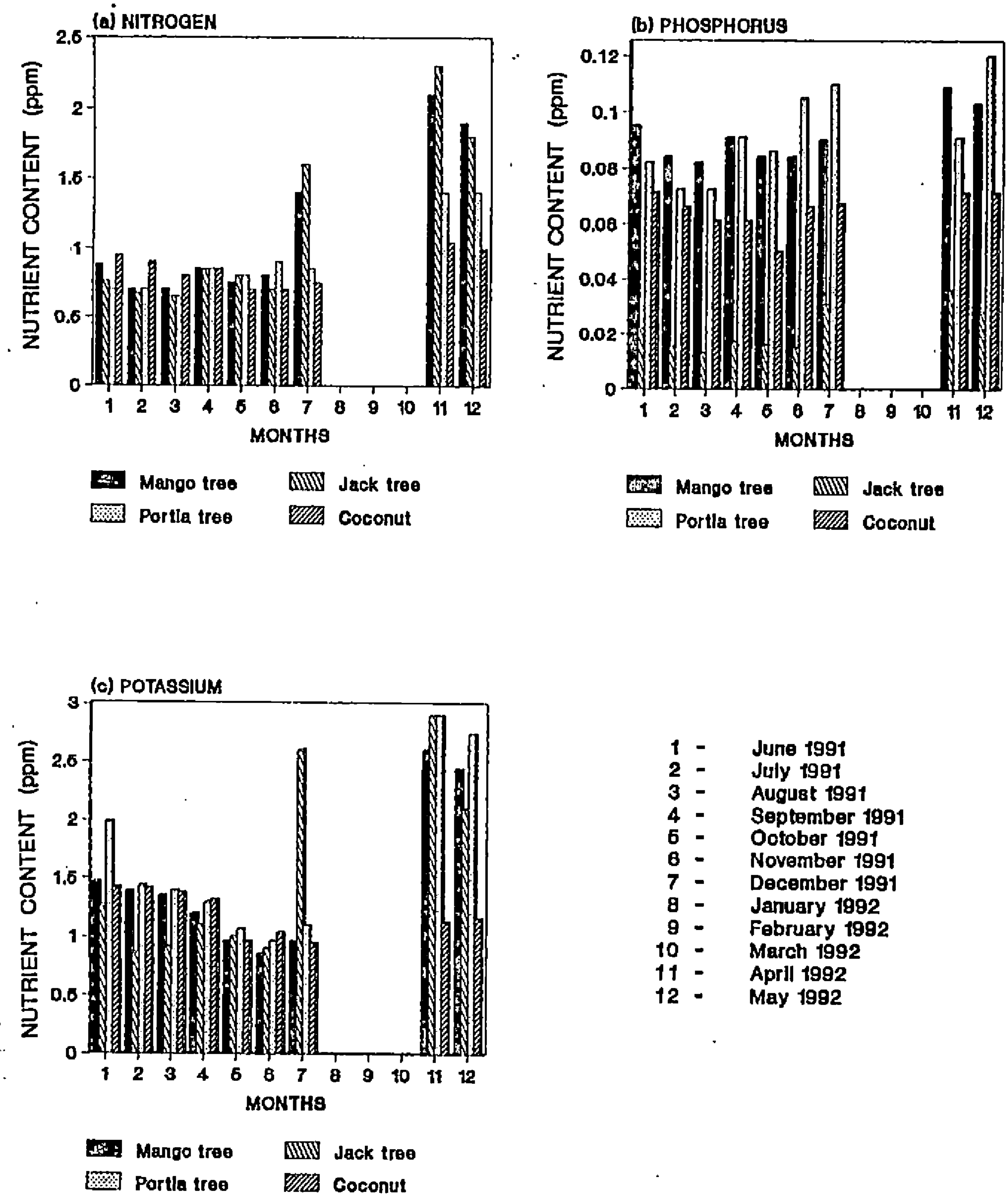


Fig. 9. Variation in nutrient content of throughfall between four agroforesty species.

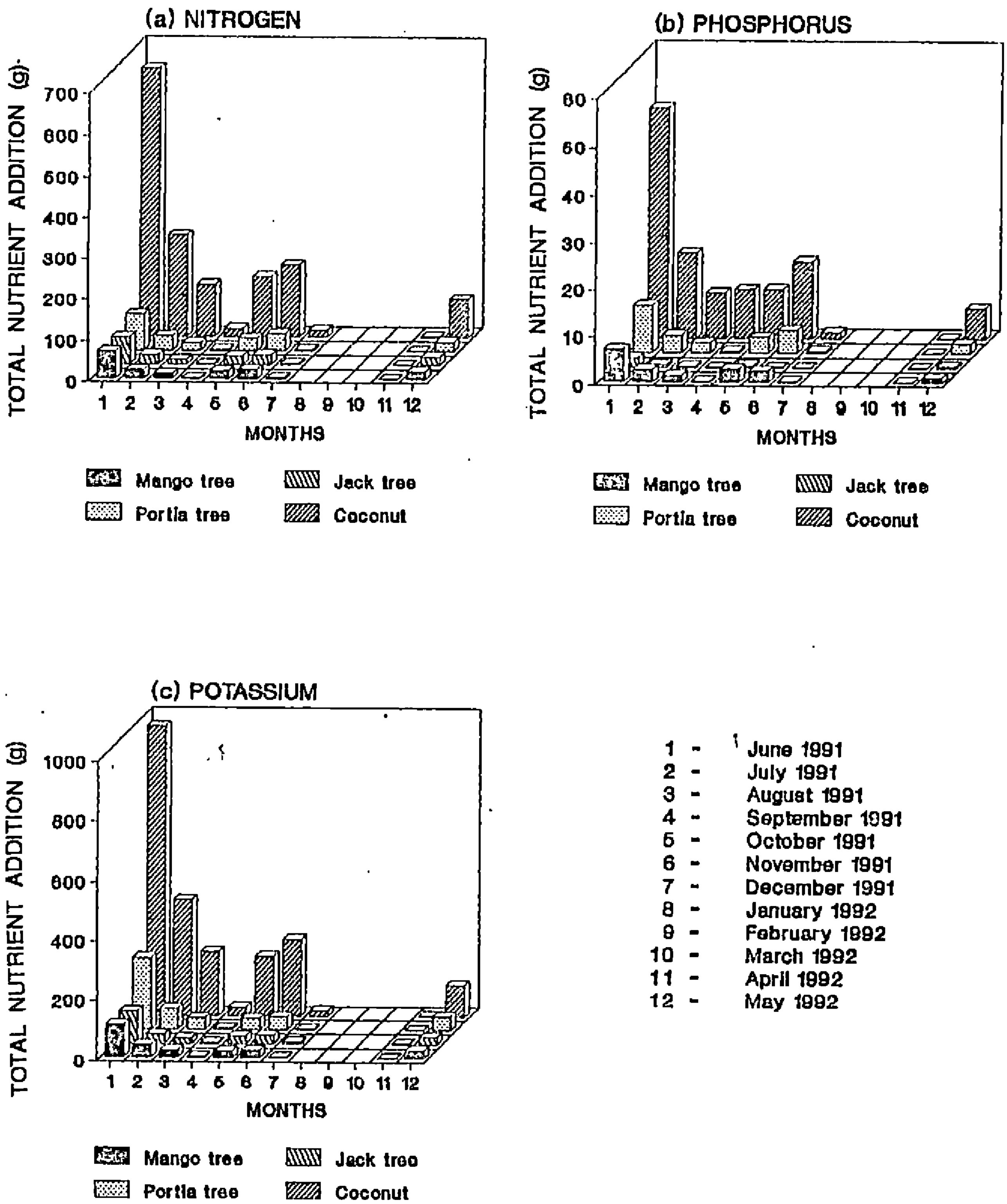


Fig. 10. Variation in nutrient addition by throughfall between four agroforesty species in the homestead.

leaves. The exception to this level of high concentration in April, may be due to some exudations from the stem or leaves during the periods of higher concentrations. However, a general trend of increased nutrient content was observed when there was a gap in the occurence of rainfall (Tables 6-13). It can also be seen that the variation in the nutrient contents in the same species was less when there was continuous rainy periods or the interval between two rains was short. Duration of rain was a primary factor affecting leaf leaching (Turkey, 1970).

Further, the variation in the nutrient content between species in both stemflow and throughfall was noticed (Fig. 9 and 11). The concentration of N in throughfall was higher in jack, P in mango and that of K in portia. The maximum values for stemflow were in jack, portia and mango respectively for N, P and K. The variation might be due to the difference in the species, tissue longevity, wettability of leaves and stem and metabolic activity of leaves (Turkey, 1970). Cole and Rapp (1980) reported that the variation in cycling rates between species is largely because of inherent differences between species relative to nutrient requirement and cycling strategies.

It is evident from the Figs. 9 and 11 that there existed a variation between throughfall and stemflow in the same species. Generally it was found that the stemflow water contain more nutrients than throughfall water. This was observed in all the species and also for all the nutrients studied. The same observation had been reported by Baker and Attiwill (1987), George (1979) and Miller et al. (1979). The higher concentration in stemflow might be due to the more contact between the water and the stem of trees, so that there is possibility for more nutrients to leach out from the plant. This was in confirmity with the report of George (1979).

Among the concentration of nutrients in stemflow and throughfall, a higher concentration was always observed for K followed by N and P. Artificial leaching experiments in some forest species revealed that the leachability of K was the maximum. (Eaton et al., 1973; Henderson et al., 1977 and Wells et al., 1975). Among the nutrients, the value for P was the lowest in throughfall and stemflow. This has been found by Henderson et al. (1977) and Wells et al. (1975). Higher concentration of nitrogen and potassium in throughfall may be due to the greater mobility of N

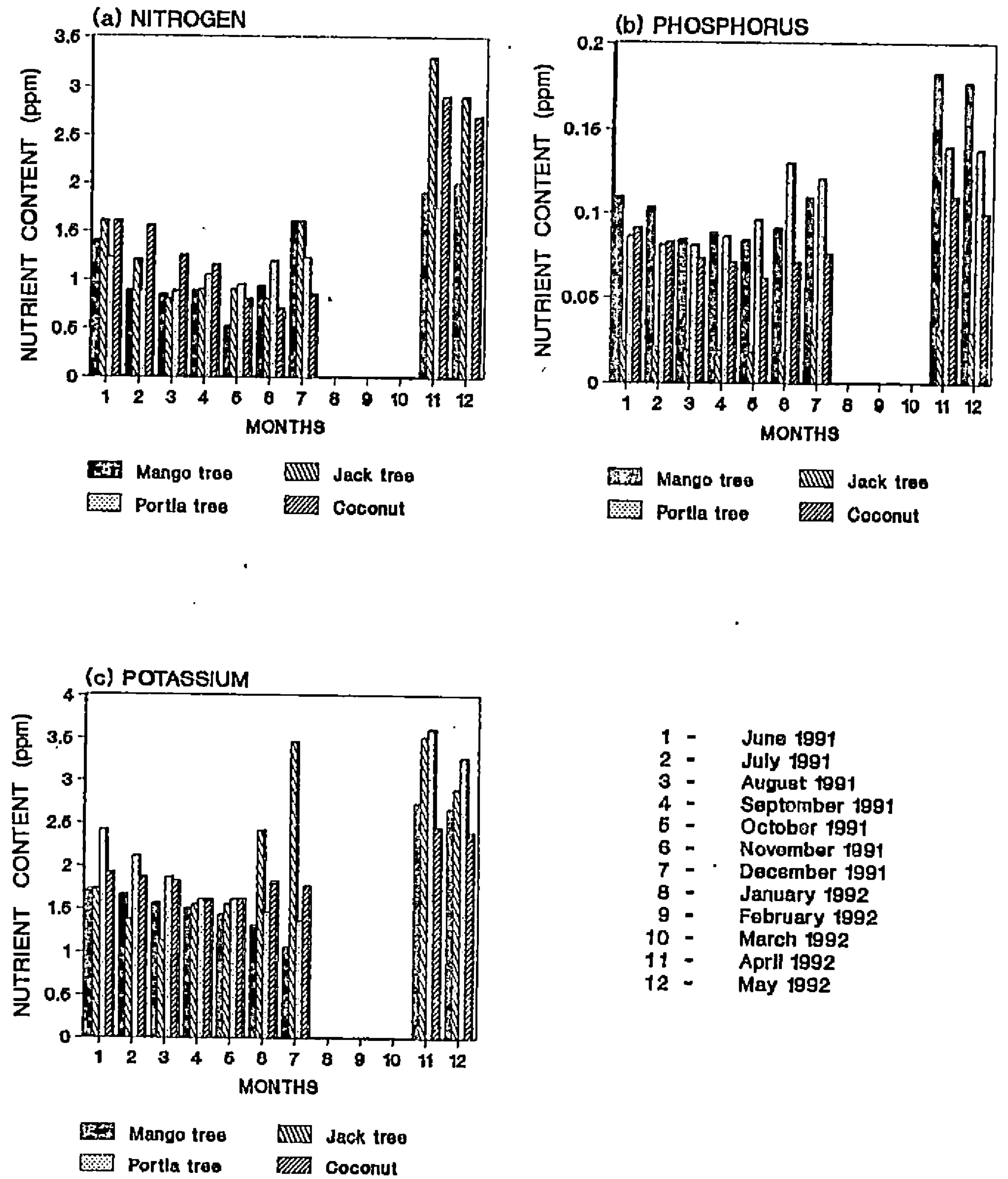


Fig. 11. Variation in nutrient content of stemflow between four agroforesty species.

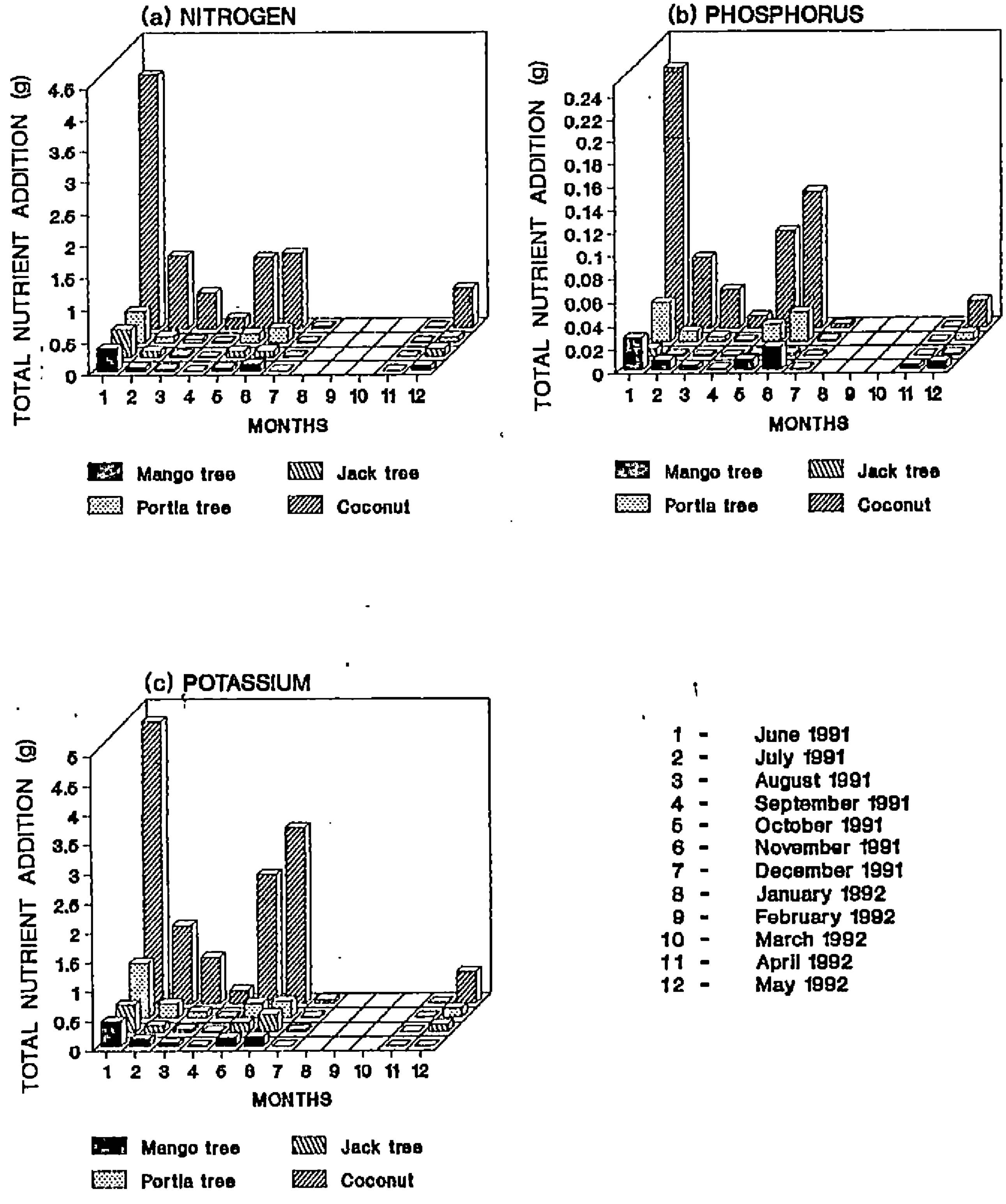


Fig. 12. Variation in nutrient addition by stemflow between four agroforesty species in the homestead.

and K, when compared with P. Phosphorus in plant is found in immobile organic form (Epstein, 1972). Potassium generally showed the highest throughfall concentration of the inorganic nutrients (Parker, 1983).

Rainfall forms an important natural phenomenon by which substantial quantities of nutrients are added to the soil. The variation in nutrient content and nutrient addition in the homestead by rainfall is given in Table 14. The monthly variation in nutrient content and total nutrient addition by rainfall is depicted in Figs. 13 and 14. It is evident that the nutrient contents in rainfall were higher during the months of June and July and during April and May. Thus the nutrient content was found to be higher for the water collected after a prolonged non rainy period. The nutrient content was found to decrease when the interval between rains decreases. The higher concentration of N in the month of July, even after continuous and heavy rains in June, may be due to the occurence of lightning during that period. Lightning is found to fix nitrogen naturally, which is washed down to the soil during rains. There was no appreciable quantity of P in the rainwater, when

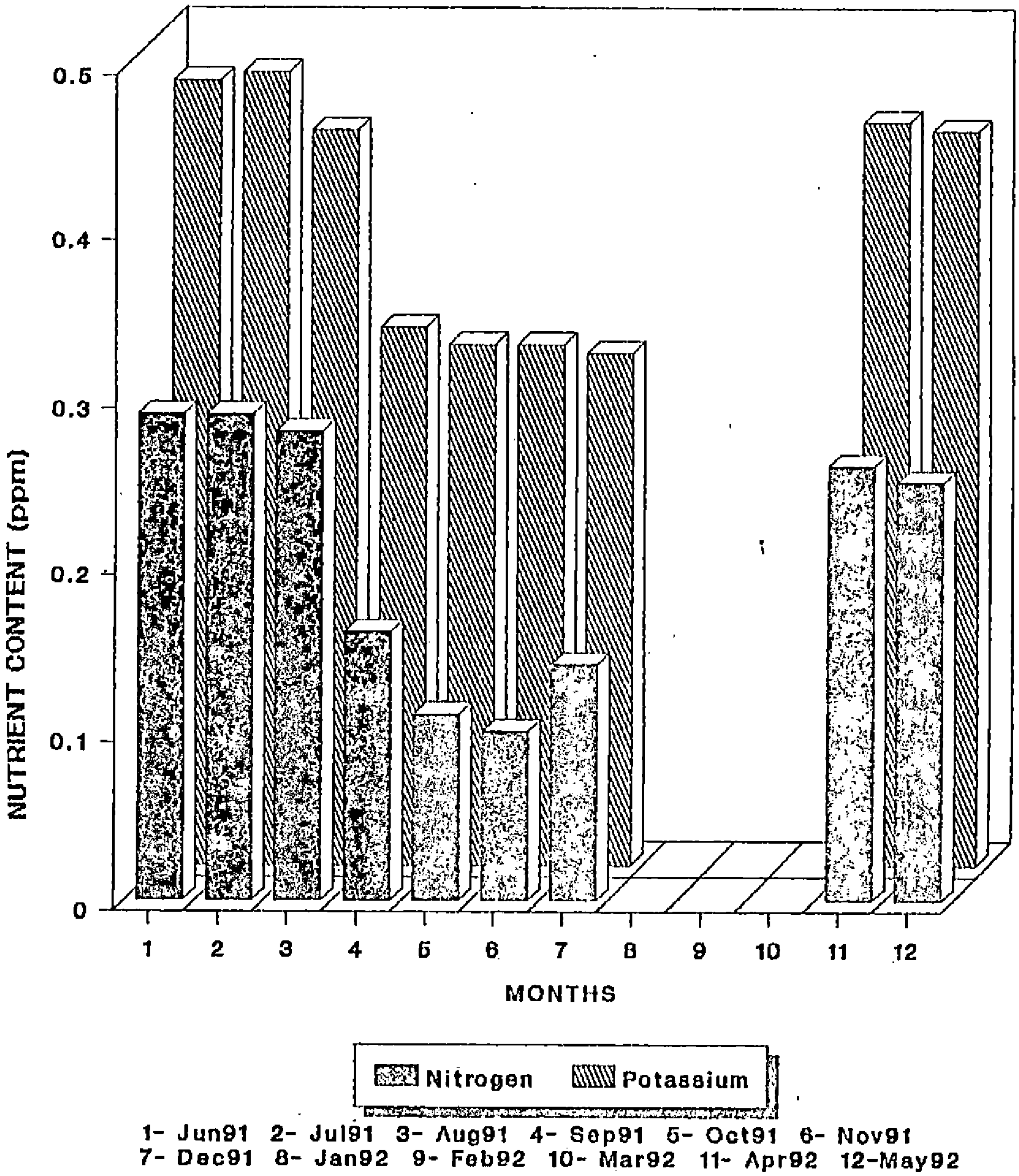
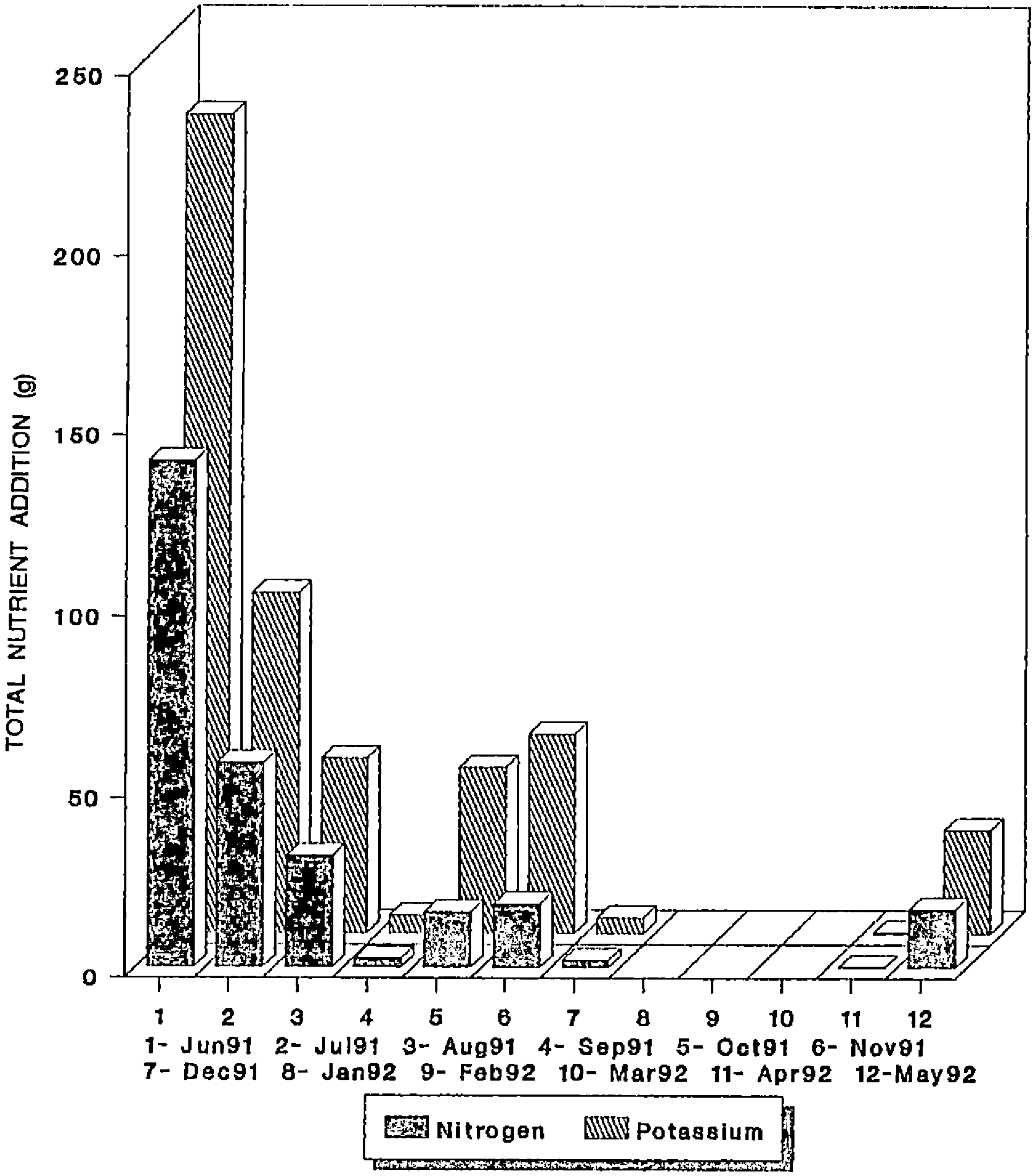


Fig. 13. Variation in nutrient content in the rainfall.



• Homestead area excluding the canopy area of major tree species. (684.5 m^2)

Fig. 14. Variation in nutrient addition by rainfall in the homestead.

compared with the nutrient content of stemflow and throughfall. The nutrient content in rainfall was always lower. The higher value of nutrients in stemflow and throughfall is due to leaching of nutrients from plant parts (Eaton et al., 1973). Baker and Attiwill (1987) reported the least value of nutrients in rainfall, when compared with throughfall and stemflow. Bulk of the nutrients in throughfall and stemflow probably derives by leaching, where maritime influence and dust deposition are minimum.

The total nutrient addition by throughfall, stemflow and rainfall are depicted in Figs. 10, 12 and 14 respectively. It is evident that among the three nutrient cycling processes, ie. throughfall, stemflow and rainfall, the former was the major component of nutrient input in the present study. The nutrient input by throughfall was 2.1, 0.16 and 3.2 $kg.yr^{-1}$ of N, P and K respectively. The nutrient addition by rainfall was calculated for an area of 684.5 m^2 (excluding the area of the homestead occupied by tree canopies). The nutrient input by rainfall was of the order of 0.28, 0.0 and 0.51 $kg.yr^{-1}$ of N, P and K respectively. Assuming a situation of pure plantation of these trees, in the conditions and level of management, as in the homestead, the total nutrient addition by stemflow and throughfall would amount to 15.6, 23.7 kg.ha^{-1} of N, P and K respectively by mango, 14.2, 0.3 and 20.2 kg.ha^{-1}.yr^{-1} of N, P and K respectively by jack, 13.8, 1.5 and 28.3 kg.ha^{-1}.yr^{-1} of N, P and K respectively by portia and 15.2, 1.2 and 22.5 kg.ha^{-1}.yr^{-1} of N, P and K respectively by coconut.

The nitrogen input by these trees seems to be a little higher than the estimates of Manokaran (1980) ie. 6.7 kg.ha^{-1}.yr^{-1} in low land tropical rainforests and the values (6 kg.ha^{-1}.yr^{-1}) estimated by Cole and Rapp (1980), in temperate forests. However these values are less than those given by Bernhard - Reversat (1975) ie, 64 kg in Rainforests of Ivory Coast and Westman (1978) in a Eucalyptus forest of Australia (35 kg.ha^{-1}.yr^{-1}).

The phosphorus addition was found to be the lowest. But these values were found to be lower than the estimated value of 9.1 kg.ha^{-1}.yr^{-1} in rain forest of Ivory Coast (Bernhard - Reversat, 1975). However, these values were comparable with the estimate of 2.1 kg.ha^{-1}.yr^{-1} in rain forests of New Guinea and Pine forests of Newzealand (Edwards, 1977).

The potassium input to the homestead is comparable with the estimated value of K addition of the order of 71.1 $kg \cdot ha^{-1} \cdot yr^{-1}$ in rainforest of New Guinea (Edwards, 1977). Manokaran (1980) estimated a nitrogen input of 24.6 $kg \cdot ha^{-1} \cdot yr^{-1}$ in low land tropical rainforests and Turvey (1979) found an addition of 36 $kg \cdot ha^{-1} \cdot yr^{-1}$ of nitrogen in Eucalyptus forests of Australia. Khanna and Nair (1977) estimated an addition of 151 $kg \cdot ha^{-1} \cdot yr^{-1}$ of potassium by coconut washout. The value for K obtained in homestead is much less than this value. The lower value might be due to the low K content in the homestead soils (Table 18) and a possible lower K content in leaves and other parts of the trees.

The total nutrient addition by stemflow was always less than that by throughfall, eventhough the concentrations of nutrients in stem flow is much higher (Table 28). This is because of the lower volume of stemflow compared to throughfall (Helvey and Patric, 1965). The total nutrient addition by throughfall, stemflow or rainfall is a function of nutrient concentration and the total volume. When compared to rainfall, both stemflow and throughfall are enriched in nutrient elements and their combined contribution to the annual mineral cycle may be substantial. Stemflow is more frequently enriched than throughfall, because

Table 28. Nutrient addition by various components in the homestead

Source	Nutrient addition (kg.yr^{-1})		
	N	P	K
I. Organic manures			
1. Cows	23.543	8.943	15.148
2. Goats	7.628	1.168	1.570
3. Poultry	18.000	9.000	4.500
Total	49.171	19.111	21.218
II. Litterfall/Leaf fall			
1. Mango trees (2 Nos.)	0.9479	0.1950	0.4020
2. Jack trees (2 Nos.)	1.4202	0.3895	0.6161
3. Portia trees (3 Nos.)	2.1547	0.7472	3.1251
4. Coconut palms (27 Nos.)	3.9718	0.6685	2.2230
Total	8.4946	2.0002	6.3662
III. Throughfall			
1. Mango trees (2 Nos.)	0.1632	0.0164	0.2477
2. Jack trees (2 Nos.)	0.1738	0.0036	0.2447
3. Portia trees (3 Nos.)	0.2393	0.0263	0.4915
4. Coconut palms (27 Nos.)	1.4778	0.1127	2.1944
Total	2.0541	0.1590	3.1783
IV. Stemflow			
1. Mango trees (2 Nos.)	0.0007	0.0002	0.0011
2. Jack trees (2 Nos.)	0.0009	0.0000	0.0013
3. Portia trees (3 Nos)	0.0011	0.0000	0.0020
4. Coconut palms (27 Nos.)	0.0087	0.0006	0.0129
Total	0.0114	0.0008	0.0173
V. Rainfall			
(excluding canopy area of trees)	0.2825	0.0000	0.5092
VI. Inorganic fertilizers			
1. 70 kg. 10:5:20 NPK mixture	7.0000	3.5000	14.0000
2. 40 kg. 10:10:10 NPK mixture	4.0000	4.0000	4.0000
Total	11.0000	7.5000	18.0000
Grand Total	71.0136	28.7710	49.2890

of its lower volume (Charley and Richards, 1983; Helvey and Patric, 1965 and Jordan, 1978). Neverthless, because of the localised nature of input, it can have relatively powerful influence on soil chemical characteristics immediately around the bole of the trees (Patterson, 1975). The stemflow volume was found to vary between species (Tables 10-13). This might be due to the difference in canopy area, branching nature of trees and the diameter of the tree trunk (Harry et al., 1978). It is evident from the table that the individual tree species with maximum canopy area (jack) recorded maximum stemflow, while it was the lowest for coconut.

The nutrient addition by rainfall was to the order of 0.28, 0 and 0.51 kg of N, P an K respectively in the homestead area excluding the area covered by trees canopy (where the estimates are made as throughfall and stemflow). On a per hectare basis the estimates came to 4.1, 0 and 7.4 $kg \cdot ha^{-1} \cdot yr^{-1}$ of N, P and K respectively. The value of N was less than what was estimated (7.6 Kg) by Babukutty (1966). However it was more than the estimates (2.3 kg) by Vijayalakshmi and Pandalai (1962). The difference in values might be due to the difference in the total rainfall during the period of study or due to occurrence of lightning. The level of P was not appreciable in the rainfall, but a high value of 4.8 $kg \cdot ha^{-1} \cdot yr^{-1}$ was reported by Vijayalakshmi and Pandalai (1962). The estimates of K was comparable with the value of 7.3 $kg \cdot ha^{-1} \cdot yr^{-1}$ estimated by Edwards (1977) in New Guinea. Thus it is logical to believe that rainfall made a substantial contribution of nutrients to any system, but the nutrient input may depend on factors such as intensity, interval and duration of rainfall, presence of dust in the atmosphere, maritime influence etc. Actually in an intensively cropped homesteads with a multitude of perennial tree crops, most of the area will be covered by tree crops and hence all the rain water falling in the homestead is channelled to the ground as stemflow or throughfall. So the estimate for rainfall does not rise eventhough it is a known fact that rain water contain many nutrients.

To conclude, it may be emphasised that the increase in the proportion of plant cycling fraction of nutrients as discussed above as a consequence of increased plant cover on the ground as in the home garden, facilitates not only a direct loss of nutrients but also enables the plant to meet the requirements of highly mobile nutrients like potassium, when the plants metabolic needs are not fully met through external input, as for example, in seasons of continued heavy rains (Nair and Khanna, 1978). One of the ways in which this phenomenon operates in a mixed community of plants is through a larger rooting volume. Since the transport of nutrients below the rooting zone is a major avenue for the direct loss of nutrients in sedentary agriculture, the rate of that process can be considerably reduced in mixed plant community systems when the total soil volume of root exploitation will be larger and consequently the amounts of nutrient loss is less.

5.2.3 Livestock and Poultry

An appraisal of the data on the results of nutrient addition by livestock and poultry revealed that the major avenues of addition of nutrients was livestock and poultry (Tables 15 and 28, Fig. 15). Of the total nutrients added in the homestead, amounting to 71.01, 28.77 and 49.29 kg of N, P and K respectively, as much as 49.17, 19.11 and 21.21 kg of N, P and K respectively were added by livestock and poultry alone. Among these components, major source of nutrients were cowdung and urine followed by poultry

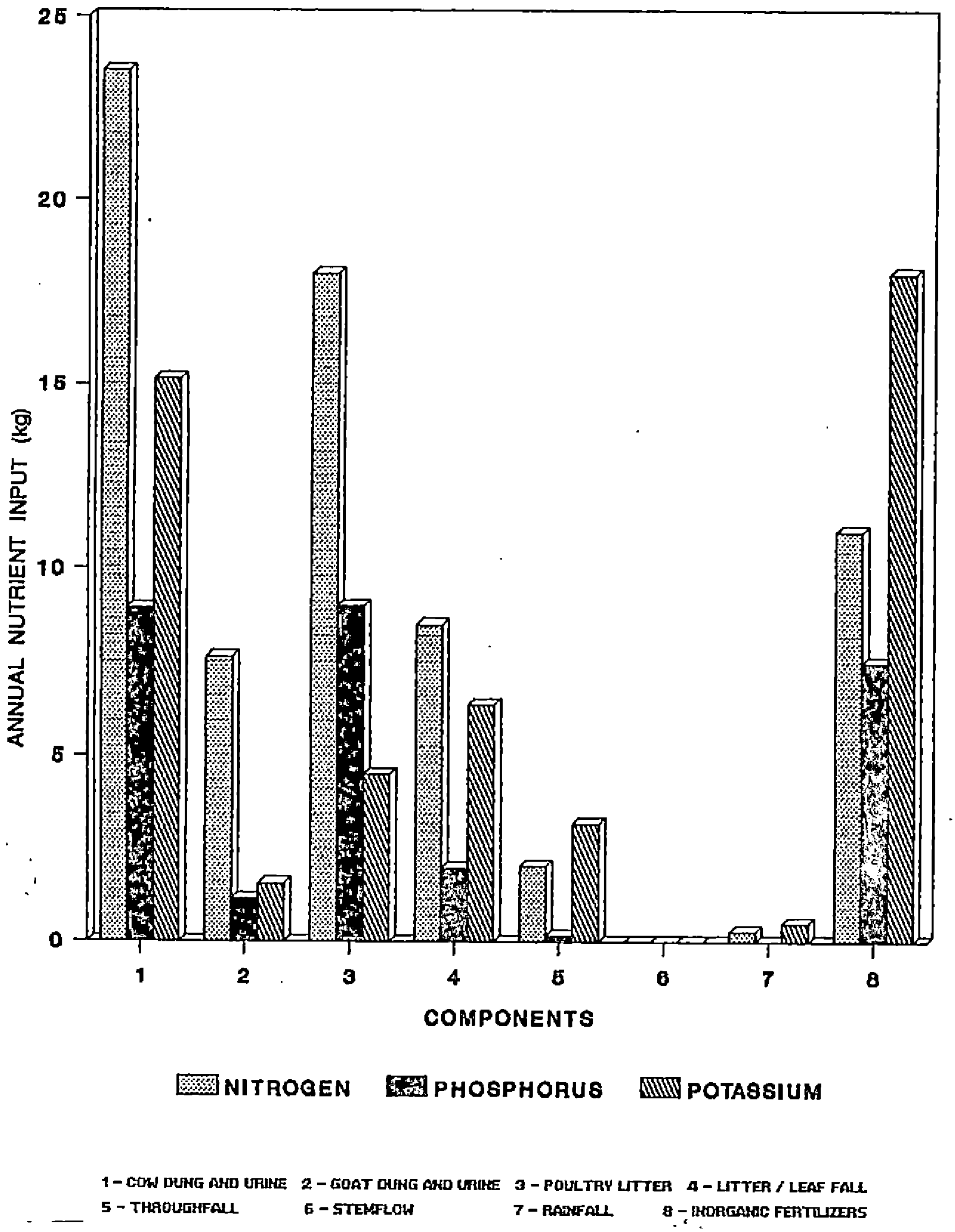


Fig. 15. Annual input of nutrients by various components in the homestead.

litter. Comparatively higher nutrient addition could naturally be expected from cattle because of the higher amount of excretion by cows (Table 15). It was also found that the entire quantity of livestock and poultry manures produced were used in the homestead itself, for various crops, reducing the cost on inputs, such as inorganic fertilizers. The farmer thus showed a keen interest in organic farming and this homestead can be considered as a classical example for sustainable agriculture.

5.2.4 Inorganic fertilizers

The results obtained from the study (Tables 16 and 27 and Fig. 15) showed that the nutrient addition by inorganic fertilizers is lower as compared to other components. 110 kg of NPK mixture was applied to the homestead during the period under study. Of the total nutrient addition in the homestead, 15 % of N was added by inorganic fertilizers. The values for P and K were 26 and 36 % respectively.

5.3 Soil physico chemical properties

5.3.1 Physical properties

The results of the investigation on the changes in the physical properties of homestead soil, observed at quarterly intervals are given in Table 17 and Fig. 16.

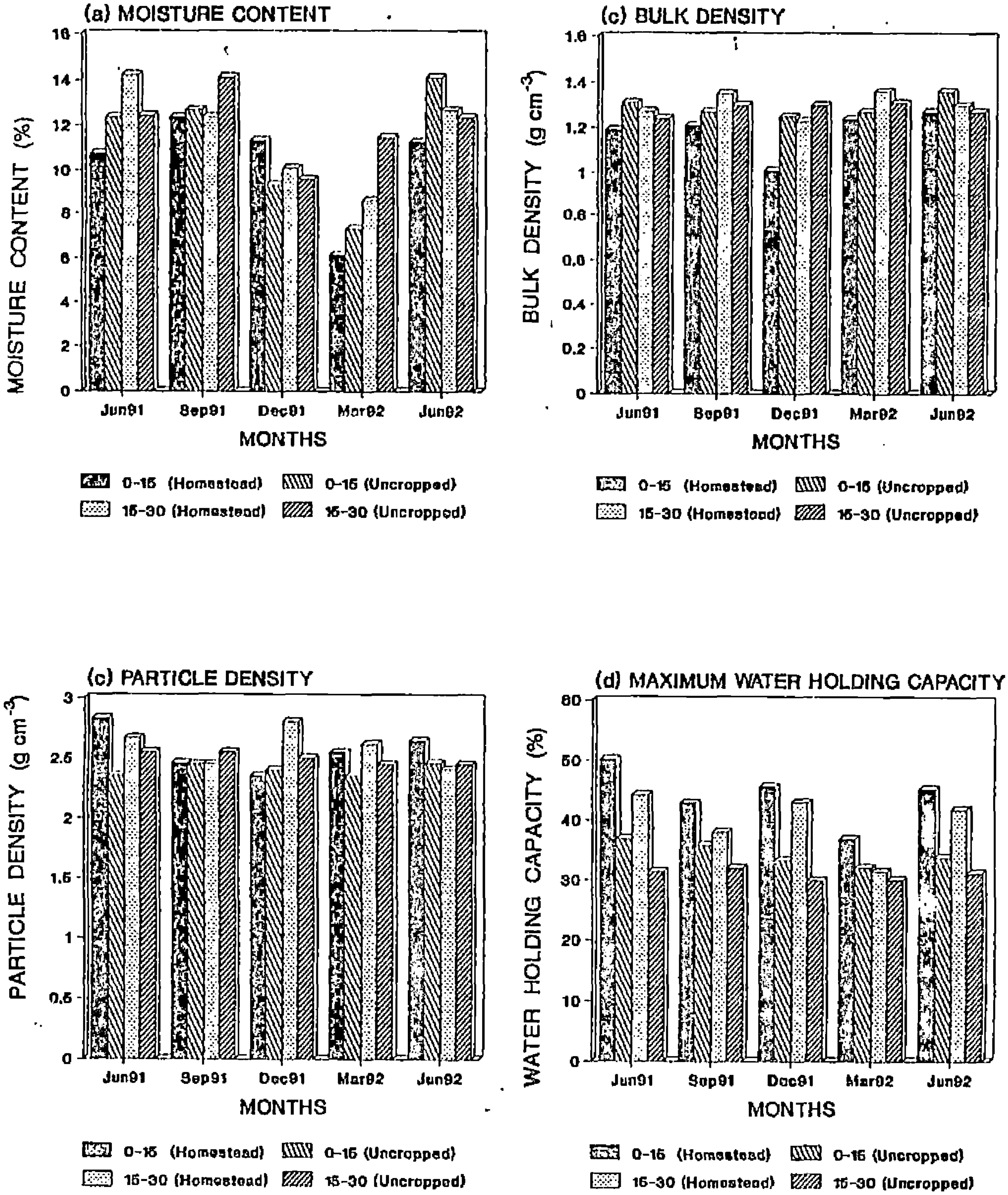


Fig. 16. Seasonal variation in the physical properties of the homestead soil.

The results indicate that the moisture content on fresh weight basis in the homestead soil was generally lower than those in the control. A variation to this general trend was noticed during the month of June, that too in the 15-30 cm soil layer. The lower level of moisture content in the homestead soil may be due to large quantities of moisture absorbed by the various crops in the homestead, planted at a high cropping intensity of 1.56. The observed deviation during the month of June, could be attributed to the moisture storage in the deeper layers during rainy periods (Appendix - I). The frequent cultural operations would have resulted in increased infiltration of water to deeper layers during rainy period.

The frequent cultural operations, addition of substantial quantities of organic manures and litterfall would facilitate moisture storage in the soil layers. Further, the evaporation from the soil surface was less on the top soil layers of the homestead due to the shading effect of the trees and subsequent low air temperature in crop floors. This has been reported by Nair and Balakrishnan (1977). The high rate of transpiration from the plants will contribute to substantial loss of water from plants. This might also be a reason for the low level of moisture in the homestead soils.

The results on the changes in bulk density (Table 17, Fig. 16(b)) indicate that the bulk density was always found to have a lower value in the 0-15 cm deep soil layer of the homestead, than the control. Because of the addition of large quantities of organic matter in the homestead by litterfall and organic manures, it is logical to expect a high bulk density. The results are in conformity with the reports of Mazurak et al. (1975); Nambiar and Ghosh (1984) and Rajput and Sastry (1987). The bulk density on the deeper layers was found to be higher than those on the top layers. The main reason may be the lower organic matter content in the lower layers (Table 18), resulting in an increased mass per unit volume of soil. More compaction of deeper soil layers may also result due to absence of deep tillage in homesteads. The bulk density on the top soil layers of the control showed a higher value. Low organic matter content and lesser addition of organic matter to this soil may result in a higher bulk density.

The particle density generally showed a higher value in the homestead soils than the control, especially in the upper soil layers (Fig. 16(c)). This may be due to higher percentage of pore space in the homestead soil, especially due to high organic matter addition and frequent tillage operations. This has been found in conformity with the report of Morachan (1978).

The maximum water holding capacity was always found to have a much higher value in the homestead soil in both the top and bottom soil layers irrespective of the season of observation (Table 17, Fig. 16(d)). As discussed earlier the higher organic matter content (Table 18) of the homestead soil and the subsequent retention of moisture may be the reason for this phenomenon. The effect of FYM in increasing the water holding capacity of soil has been reported by Biswas and Khosla (1971); Pathak (1954); Rajput and Sastry (1987); Salter et al. (1965) and Singh et al. (1976).

5.3.2 Chemical properties

An appraisal of the results on the variation in the chemical properties of the homestead soil given in Table 18 and Fig. 17 revealed that the fertility status of the homestead soil was higher than that in the control.

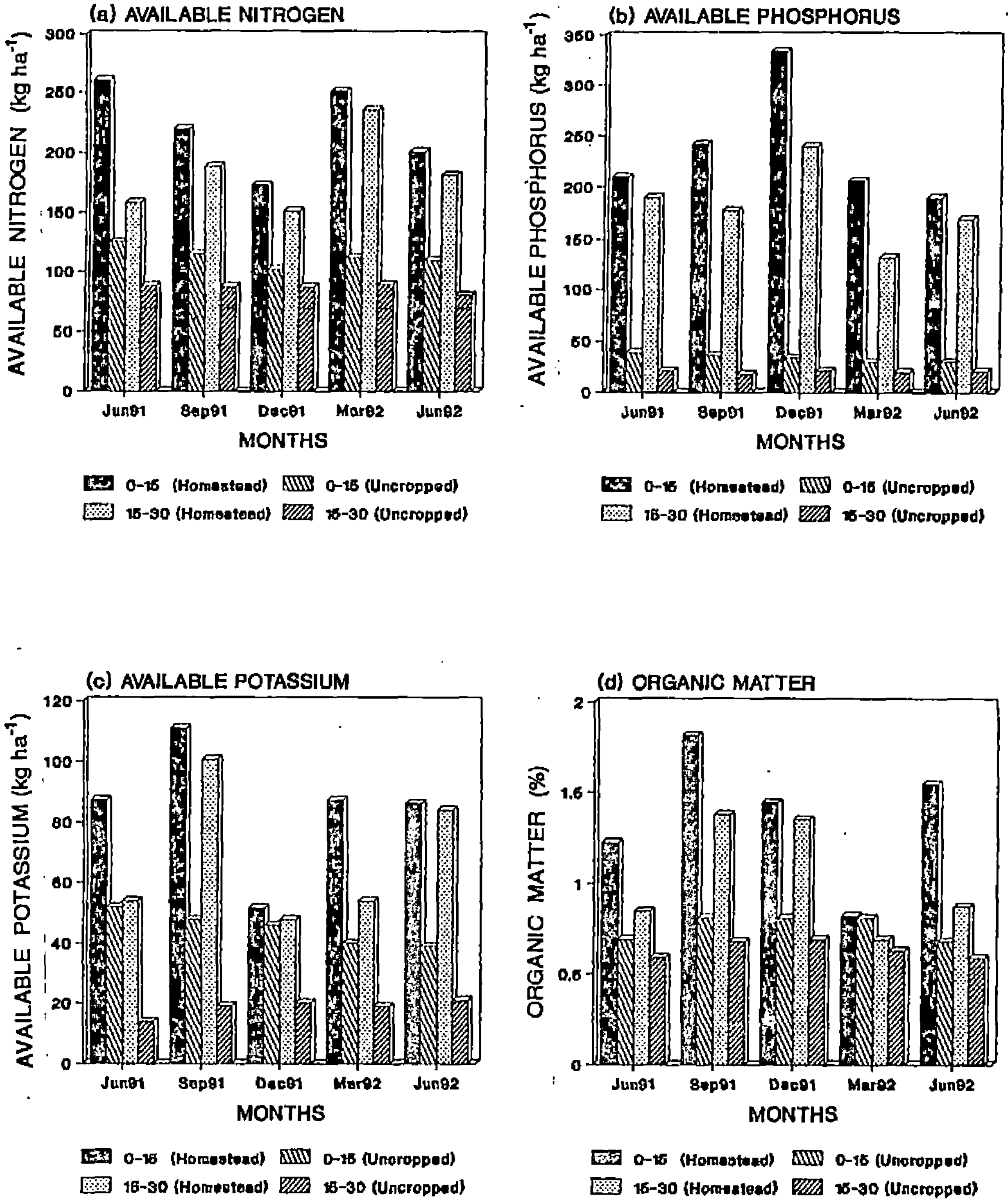


Fig. 17. Seasonal variation in the chemical properties of the homestead soil.

The available nitrogen content in the homestead soil was much higher than that in the control. The variation was much pronounced in the top 0-15 cm deep soil layers (Fig. 17(a)). The variation in the phosphorus status was highly pronounced (Fig. 17(b)). The phosphorus status in the homestead soil was rated as very high. Available potassium status in the soil also followed the same trend as in the case of available nitrogen and available phosphorus. The higher nutrient status in the homestead soil may be due to the combined addition of organic manures, inorganic fertilizers and litterfall (Table 28). Eventhough the large number of crops take away substantial quantities of nutrients, still the higher value may be due to the return of nutrients back to the soil by the various nutrient cycling processes.

The results are in conformity with the reports of Fagerstorm and Lohm (1977); Mitchell et al. (1975); Ovington et al. (1962) and Switzer and Nelson (1972). Litterfall has been reported as the major avenue for nutrient addition (Brinson et al., 1980). The effect of trees on soil enrichment has also been reported by Nair (1984). It can be seen that in the present study the nutrient status of top soil was always much higher than that in the bottom layers. This may be due to the fact that much of the organic matter by litterfall, organic manures and inorganic fertilizers are added to the top soil. According to Folster et al. (1976) the top soils are always having more fertility status. The lower value of potassium may be due to the leaching of the nutrient, due to its mobile nature. Another reason may be the luxury consumption of potassium by plants. The high level of P may be due to its less mobility.

The organic matter content was found to be more in the homestead soils than that in the control irrespective of the depth of sampling (Table 18, Fig. 17(d)). The higher values in the homstead soil is invariably due to the large quantities of organic matter addition in the homestead by organic manures and litterfall. This has been found in conformity with the report of Rajput and Sastry (1987).

The variation in the pH of the soil was not much pronounced. This may be due to the fact that the farmer does not resort to any acidity reclamation measures as the soil had a near neutral pH congenial for crop growth.

5.4 Soil micro-organisms

It is evident from the study on the number and nature of the micro-organisms that the population of all the micro-organisms studied namely fungi, bacteria and actinomycets, recorded a very high value in the homestead soil during all the months, when compared with that in the control (Table 19, Fig. 18). The higher microbial population may be due to the high intensity and multiplicity of cropping in the homestead and the addition of large quantities of organic matter. The high organic matter status of the soil might also help in proliferation of these micro-organisms. The organic matter addition by litter fall may have an added effect on the microbial growth. The effect of leaffall in increasing the number of micro-organisms has been reported by Nair and Rao (1977) in an intensively cropped coconut - cocoa mixed plantation. The effect of organic matter to increase the population of micro-organisms has also been reported by Gaur and Mukherjee (1980).

Intensive cropping might be another reason for the enhanced microbial activity . As stated earlier the homestead has a high intensity of cropping and the cropping intensity was 1.56. This has been found in

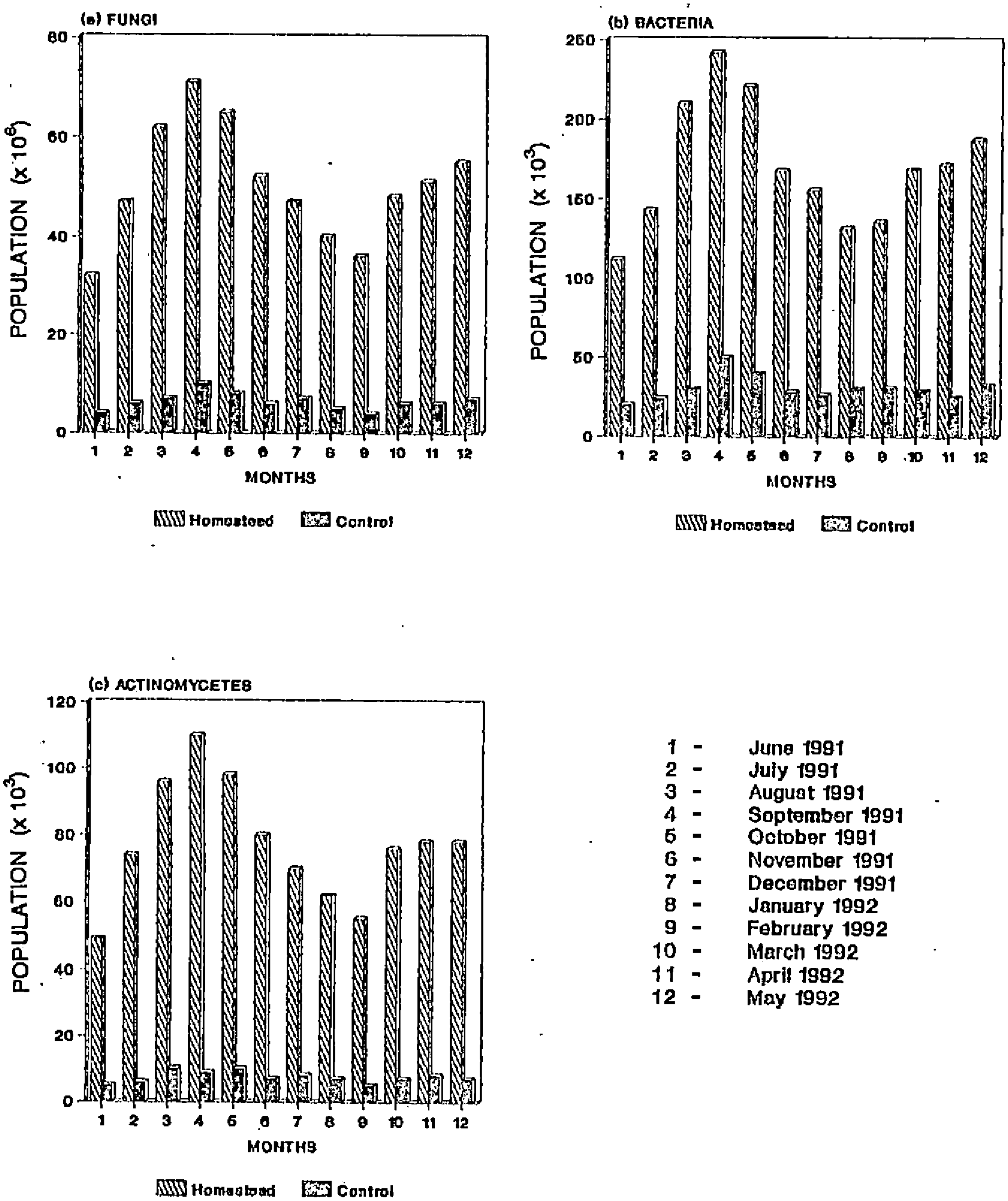


Fig. 18. Monthly variation of microbial population in the homestead.

conformity with the reports of Nair and Rao (1977) and Potty (1977), from intensively cropped coconut plantations.

It was also observed that the population of microbes varied during different months of the year. This variation may be due to the difference in management, fertilizer addition, organic manures added and with the types of crops grown. The variation in microbial population with the type of crops has been reported by Clark (1949) and Nair (1973). The increase in bacterial growth with addition of phosphate fertilizer was reported by Mishustin and Shilnikova (1971).

5.5 Microclimate

5.5.1 Soil temperature

The data on the variation in soil temperature in the homestead, revealed that the soil temperature in the homestead was always less than that in the open system (Table 20). This was true for the soil temperatures recorded both in the morning and in the afternoon hours. An analysis of the results showed that the variation in the homestead and control plots, followed almost a similar pattern (Fig. 19). But the

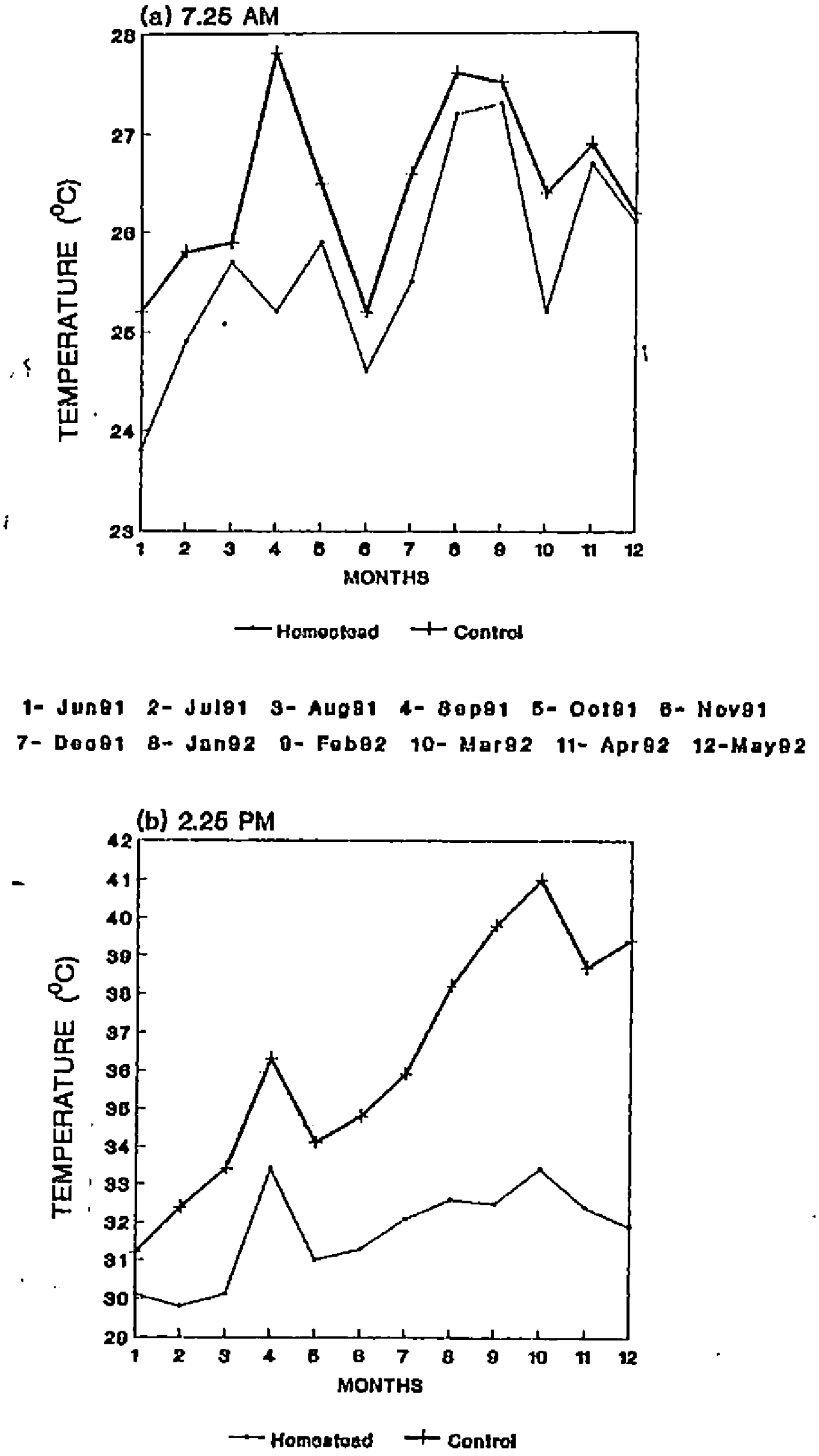


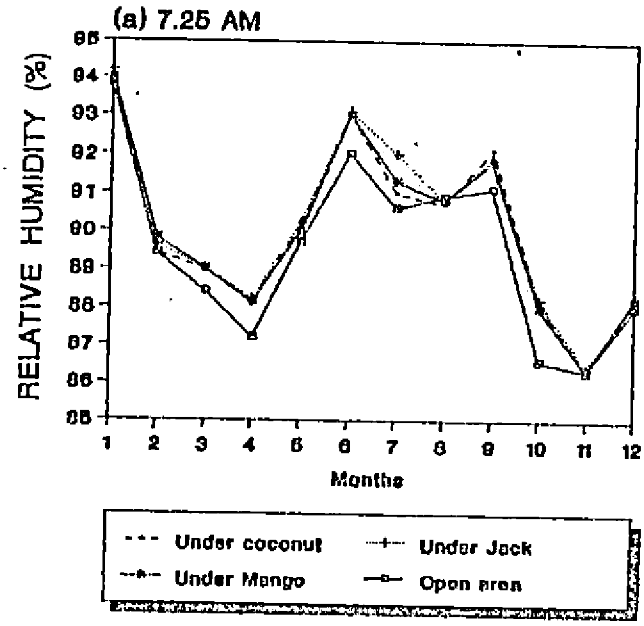
Fig. 19. Variation in soil temperature in the homestead during different periods.

variation was much pronounced for the observations taken at 2.25 p.m., while the variation was comparitively less for the temperatures measured during morning hours. The observed lower temperature in the homestead soil during all the periods of measurement might be due to the more crop cover on the ground by the crops in the homestead, planted at a higher cropping intensity. The canopy cover on the soil helped in reducing the exposure of the soil to incident solar radiation resulting in a reduced soil temperature. This has been found in conformity with the report of Nair (1983); Nair (1984) and Nair and Balakrishnan (1977).

The soil temperature was also found to vary during different months of the year (Fig. 19). The variation was very high for the control plots while the variation in the homestead soil was comparatively less especially in case of temperatures measured in the afternoon hours. The reason might be due to the high intensity of cropping; the crop cover may act as a buffer against drastic changes in the ecoclimate of the homestead system. This was also reported by Nair and Balakrishnan (1977) in coconut-cocoa mixed cropping system.

5.5.2 Relative humidity

The study on the variation in the relative humidity under different tree crops in comparison among themselves and with the control revealed that the mean relative humidity values under the tree canopy always recorded a higher value than that in the control (Table 21, Fig. 20). The relative humidity under jack was the highest followed by mango and coconut. The thick canopy of jack might be the reason for the high relative humidity under jack. This is found in conformity with the reported higher values of relative humidity recorded in cropping systems with coconut by Nair and Balakrishnan (1977). Among the relative humidity measured in the morning and afternoon hours, it was found that, the relative humidity in the morning hours was much higher than that in the afternoon hours. It was also found that the variation in relative humidity values observed under the different tree species and those with control was found to be very less in the morning hours (Fig. 20(a)), while it was much pronounced in the afternoon hours (Fig. 20(b)). It was also observed that the variation in the relative humidity observed between the control and in the ecoclimate of trees in the homestead showed variation during the months of December, January,



1- Jun91 2- Jul91 3- Aug91 4- Sep91
5- Oct91 6- Nov91 7- Dec91 8- Jan91
9- Feb91 10- Mar91 11- Apr91 12- May91

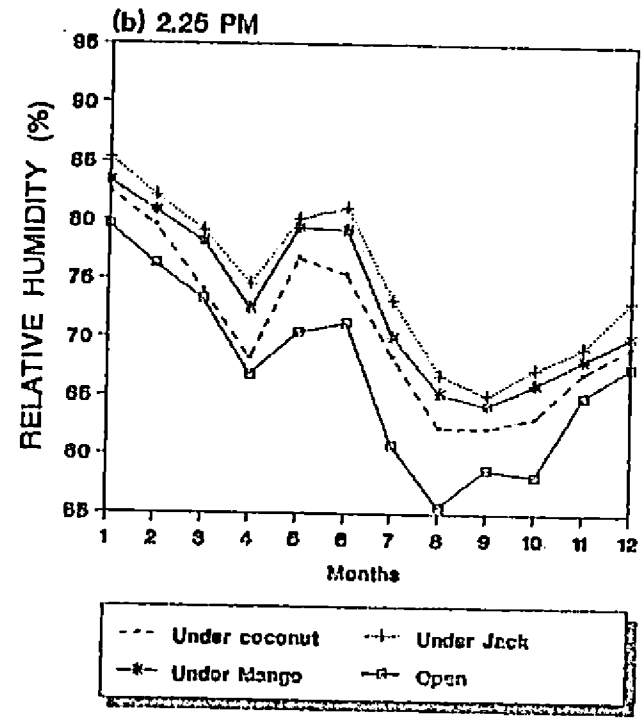


Fig. 20. Variation in relative humidity in the ecoclimate of different tree species in the homestead.

February and March, when the rainfall was very less. The intensity of solar radiation during these months was also found to be more (Table 22). So the rainfall and intensity of solar radiation might have played a role in determining the relative humidity values. The higher humidity in the homestead may be the result of transpiration from the crops planted at high intensity. The crop canopies acted as an agent for creating a humid atmosphere in the homestead. The high humidity might have beneficial effect such as reduction in air temperature and evaporation. The harmful effects might be the increase in the pest and disease incidence. The reduction in evaporation as a result of high humidity has been reported by Nair and Balakrishnan (1977).

5.6 Light intensity

The results of the study on the light intensity under the canopies of different tree species in comparison with the control revealed that the light intensity under the tree canopies was invariably less than that in the control (Table 22, Fig. 21). It was observed that the maximum light intensity measured under the tree canopies was during the period from 12 to 14 hours of a day. Hence the intercrops received

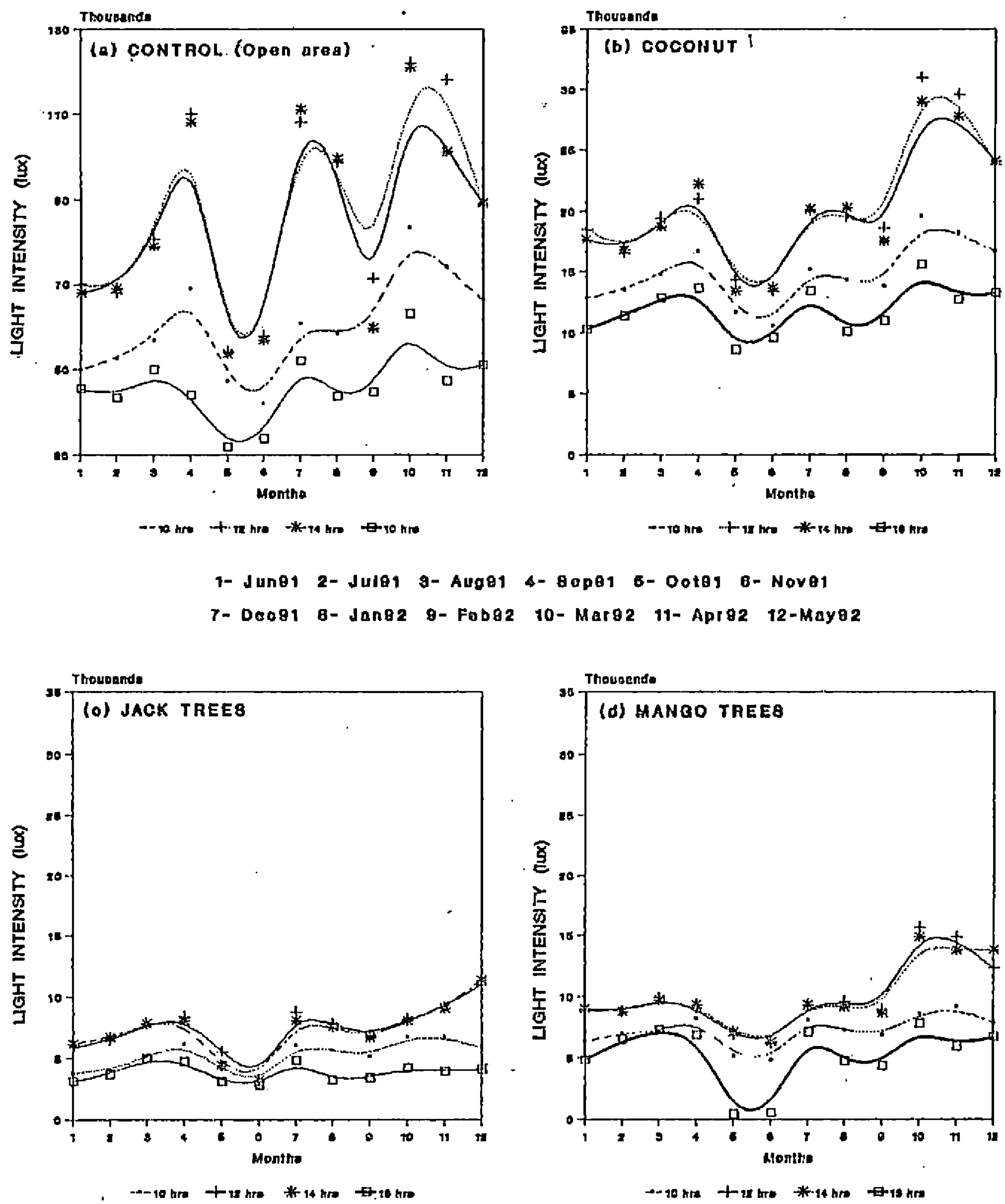


Fig. 21. Light intensity at the floor of different tree crops in the homestead during different times of the day.

maximum quantities of light during these periods. This was found to confirm the report of Nair and Balakrishnan (1976). It was also found that the maximum light infiltration was observed in case of coconut while the light intensity under jack tree was the minimum irrespective of the period of measurement. The variation in the light intensity between different times of a day followed almost a same pattern in case of each of these tree crops (Fig. 21). The maximum variation in the light intensity between diffferent times of measurement was observed in coconut, while minimum variation was for jack tree. With increase in the intensity of solar radiation, the light infiltration also increased.

It is evident that the percentage infiltration of solar radiation by the different tree canopies, during different months of the year, remained almost constant for each of these tree crops (Table 23. Fig 22). It was observed that generally 22-26% of light was infiltrated down the coconut canopy ie. 74-78% of light was intercepted by the coconut canopy, and only the rest 22-26% was available for intercrops. The values of light infiltered was about 8-10% and 10-14% in case of jack and mango respectively (Fig. 22). Jack and mango cause considerable shade and hence only shade

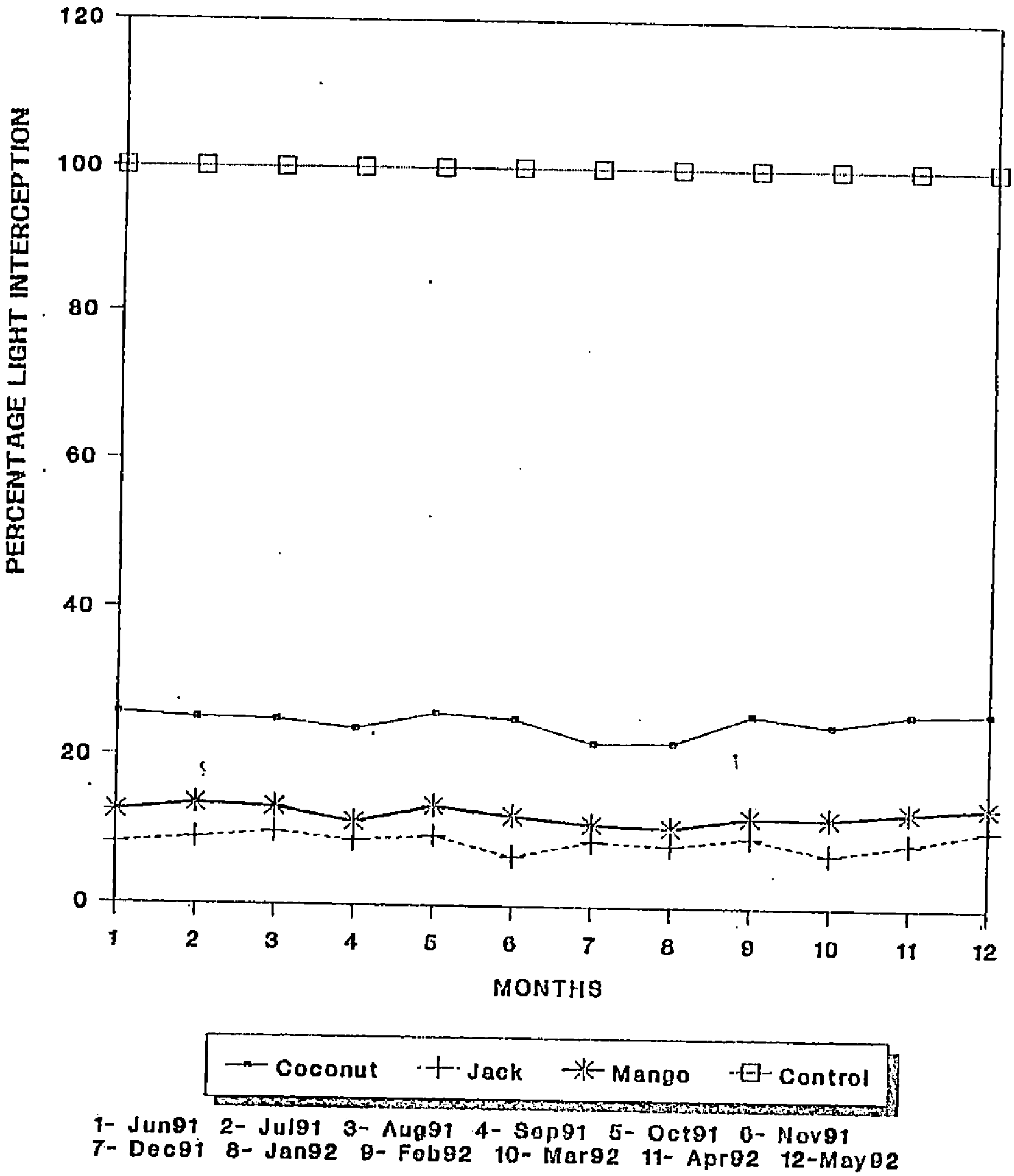


Fig. 22. Percentage light infiltration by different crops during different months of the year.

tolerating crops must be intercropped with them. The coconut, the major crop in the homestead, occupying the largest area facilitated much more infiltration of light making it possible for the growth of annual crops, requiring more light. Similar reports in coconut based cropping systems has been given by Nair and Balakrishnan (1976); Nair and Sreedharan (1986) and Nelliat et al. (1974).

5.7 Economic analysis

The homestead system not only maximises net returns but also meet the multiple demands of the farm family. It is essentially a coconut - based homestead system with mixed farming. The benefit:cost analysis of farming activities revealed that, among the farming activities the net return was maximum in case of poultry (Fig. 23). The gross return was maximum in case of livestock farming but the lesser net return is due to more expenditure on the enterprise (Table 24, Fig. 24). Among the individual enterprises maximum benefit-cost ratio was observed for coconut farming. The reason being its comparatively low total expenditure when compared with gross return (Fig. 23). The low expenditure for the coconut crop has been reported by Nair (1979). It is seen that all the

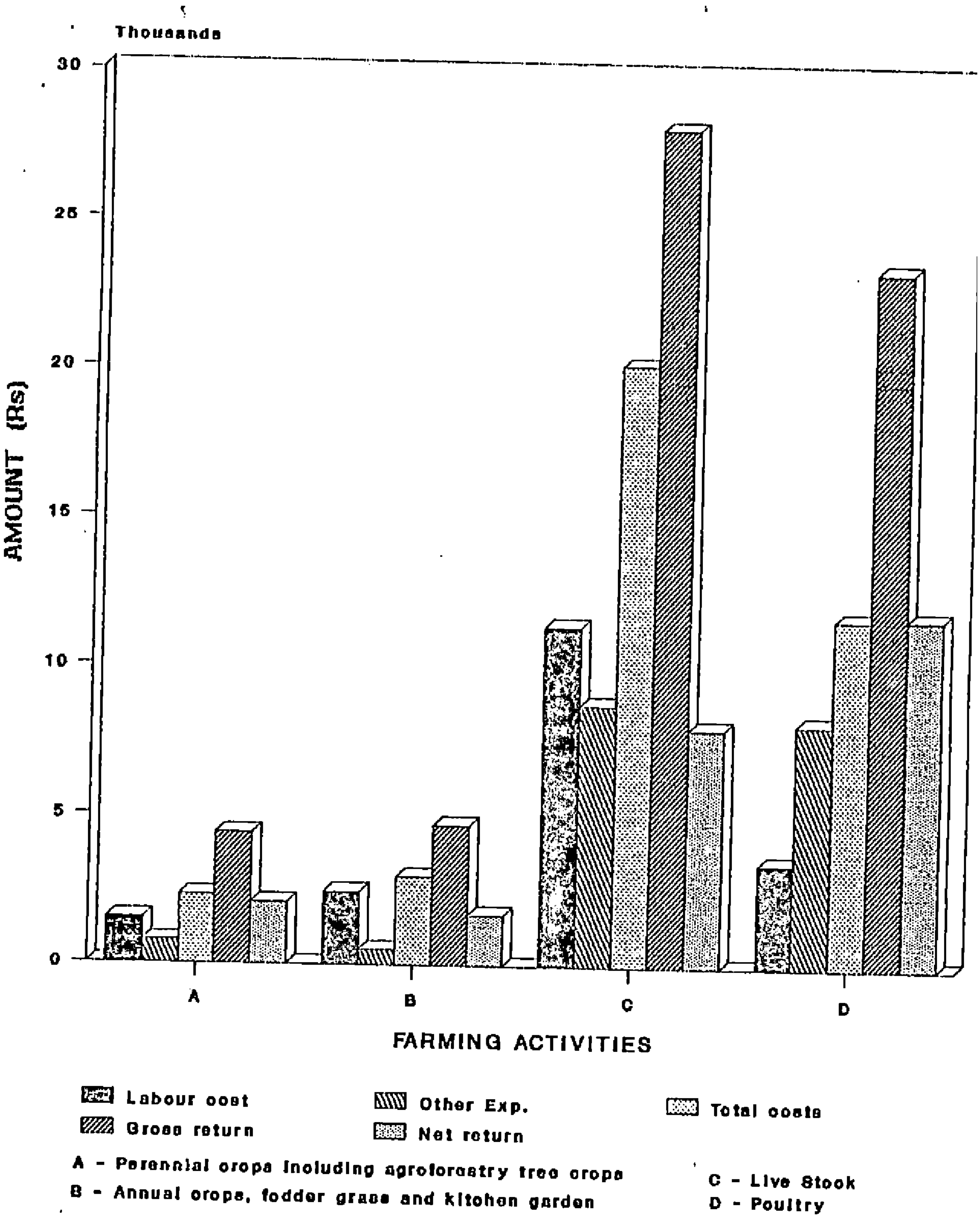


Fig. 23. Cost-benefit analysis of farming activities in the homestead.

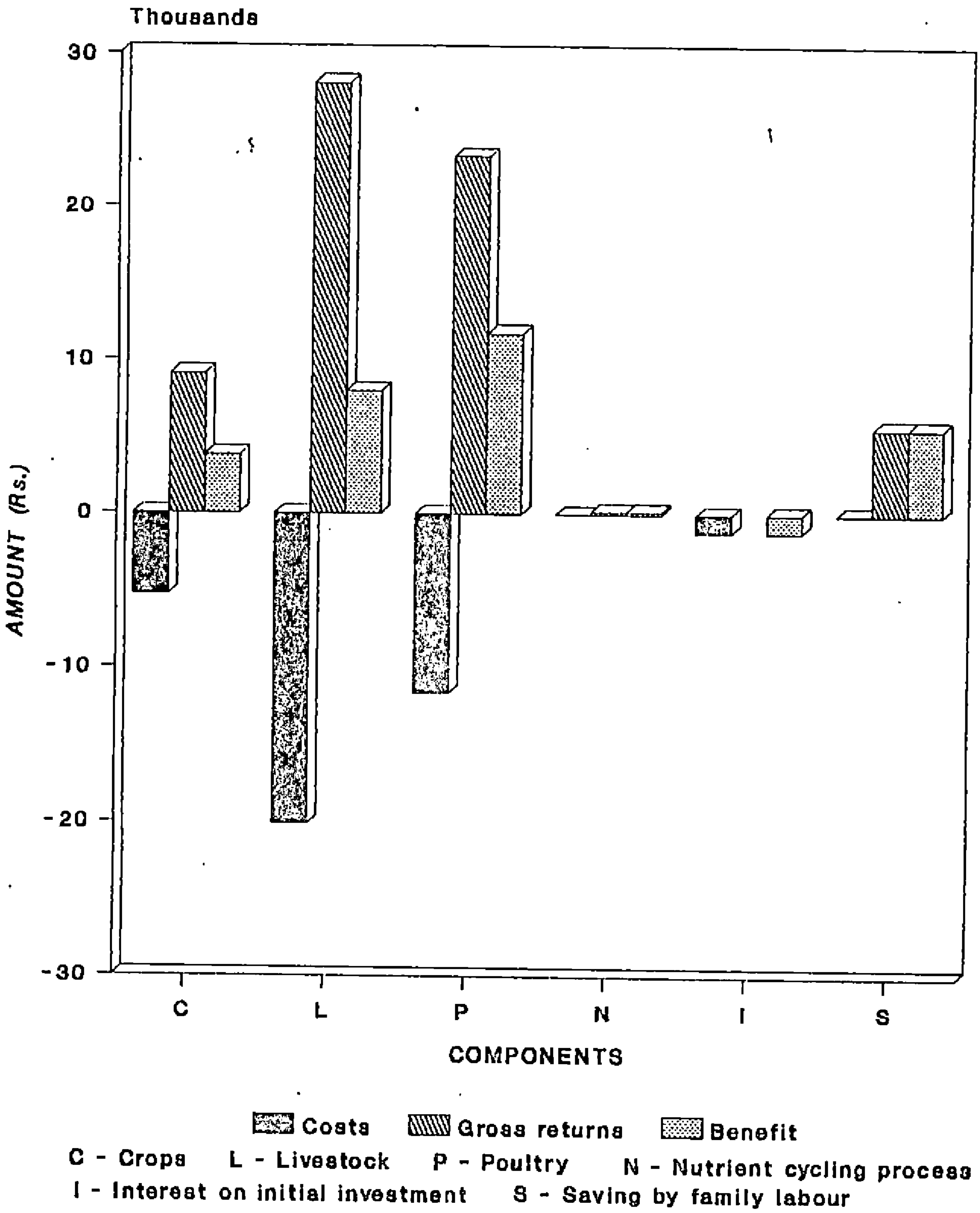


Fig. 24. Abstract of economic analysis of the homestead.

perennial crops in the homestead required a lower labour input. This is in conformity with the report of Nelliat and Krishnaji (1976). As a whole, it can be seen that the total expenditure on homestead activities was almost equally divided between the labour cost and other expenses. In case of broiler chicken, the highest percentage of expenditure was for feed. It is found that in case all the enterprises except poultry, the labour cost alone was the single largest contributor to the total costs on the enterprise (Fig. 23). The benefit:cost ratio for all enterprises except the kitchen garden was more than one, indicating that all these enterprises were managed profitably by the farmer. A high amount of labour is required for managing all the enterprises. The high labour requirement in mixed farming situations has been reported by Nair (1979) and Nelliat and Krishnaji (1976). The mixed farming activities in the homestead resulted in net income generation to the tune of Rs. 23490/-. The nutrient cycling processes viz. litterfall, throughfall, stemflow and rainfall resulted in a net benefit of Rs. 180/- to the system. Substantial addition to net income was found to result from the savings in terms of family labour. When all these were taken into consideration, the homestead system provided a net benefit of Rs. 28095/- (Table

26). The provision for family labour in mixed farming situations has been reported by Abdul Salam et al. (1991); Nair (1979) and Nair and Sreedharan (1986).

The benefit:cost ratio of the whole system was found to be 1.63 considering all the activities in the homestead. The high cropping intensity of 1.56 with mixed farming was the main reason for the higher labour costs and consequently a higher net return. A higher net return in homesteads with mixed farming have been reported by Abdul Salam et al. (1991); Abdul Salam et al. (1992)(a) Kerala Gandhi Smarak Nidhi (1985) and Nair (1976). But the reported values are found to be less than the net return in this homestead. The reason for a higher net return in this homestead may be due to the presence of the broiler chicken farm, that the farmer manages. The benefit:cost ratio worked out was 1.63 which is less than the values reported by Abdul Salam et al. (1992)(b). The higher labour costs, due to the higher wages may be the reason for the low benefit:cost ratio.

As a whole this homestead farming system effectively used the space and resources and was found to be sustainable.

SUMMARY

SUMMARY

An investigation was undertaken on the agronomic resources inventory of a homestead of 0.2 ha size in the southern zone of Kerala, for a period of one year from June 1991 to May 1992. The study consisted among other things, the nutrient cycling by different tree species, the influence and role of various biological components on the soil physical, chemical and biological properties; their influence on the microclimate in the homestead garden and overall economics of the system.

The results of the resources inventory of the homestead are given below:

1. The homestead consisted of an area of 2057.5 sq. m. and comprised of a family of four members that include the husband, the wife and two children.

2. Coconut was the base crop in the homestead with 27 bearing coconut palms and eight young non bearing palms. The other trees include two jack, two mangoes, one breadfruit, three portia trees and three papaya plants.

3. Crop diversification was achieved through intercropping in the interspaces of tree species, resulting in a cropping intensity of 1.56.

4. Cassava, banana, elephant foot yam, dioscorea, ginger and fodder grass were the major intercrops.

5. Two milch cows with their calves and one goat also formed part of the system. Apart from these a poultry unit with twenty birds was reared and a broiler chicken farm with an annual capacity of 600 birds was also managed by the farmer.

6. As part of the nutrient cycling studies litter from the trees were collected with suitable litter traps. Throughfall was collected using special gauges and stemflow with specially designed plastic collars.

7. Litterfall was the major nutrient cycling process. The litterfall by the tree components accounted for an annual input of 8.5, 2.0 and 6.4 kg of N, P and K respectively with a litter addition of 936.3 $kg.yr^{-1}$.

8. Throughfall by the trees accounted for an annual nutrient addition of 2.1, 0.2 and 3.2 kg of N, P and K respectively.

9. The nutrient addition by stemflow was comparatively very small.

10. Rainfall in the homestead area excluding the canopy area of trees resulted in a nutrient addition to the tune of 0.28 0 and 0.51 kg of N, P and K respectively.

11. The quantities of nutrients added by organic manures (livestock dung, urine and poultry litter) amounted to 49.1, 19.1 and 21.1 kg of N, P and K respectively.

12. The moisture content in the top 0-15 cm soil layer in the homestead was found to have a lower value than that of the open system.

13. The bulk density in the top 0-15 cm soil layer in the homestead had a lower value than that in the open system.

14. The bulk density in the bottom 15-30 cm soil layer was found to be more than that in the top 0-15 cm soil layer.

15. The particle density observed a higher value in the homestead soil than that in the open system, especially in the top soil layers.

16. The maximum water holding capacity was found to have a higher value in the homestead soils than that in the open system at all depths.

17. The available N, P and K status in the homestead soil was found to have a higher value than that in the open system, irrespective of the month or depth of sampling.

18. The population of fungi, bacteria and actinomycetes were very high in the homestead soils as compared to the open system, irrespective of the month of sampling. It was also noticed that the population of all the micro-organisms also varied during different months of the year.

19. The soil temperature in the homestead was less than that in the control, during all the months of the year. The variation was much pronounced in the afternoon hours than in the morning hours.

20. It was observed that the relative humidity values were higher than those in the open system.

21. Microclimatic studies showed that the relative humidity under jack tree was more than that under other trees. The least values were recorded under coconut palms.

22. The maximum light penetration was noticed in case of coconut and the least in jack trees.

23. It was observed that about 74-78, 86-90 and 90-92 per cent of the solar radiation was intercepted by the canopies of coconut, mango and jack trees respectively, and only the rest of the solar radiation was available for the annual intercrops.

24. Among the different enterprises in the homestead, maximum net return was obtained from poultry.

25. The maximum labour cost was incurred on livestock.

26. The family labour provided a net saving to the tune of Rs. 5625/-

27. Among the different enterprises the maximum benefit:cost ratio was observed for coconut farming. The benefit:cost ratio of the whole system was worked out to be 1.63.

28. The homestead system resulted in a net benefit of Rs. 28095/- at a total cost of Rs. 38239/-.

Future line of work

The nutrient cycling should be undertaken on the different tree species grown under various homestead conditions, so as to get a comprehensive idea on the role of trees on the nutrient dynamics of the system. It is also worthwhile to replicate the trials under different conditions for a number of years for testing the hypothesis, that the homestead agroforestry system is an ecologically sound, economically viable and socially acceptable system.

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* Originals not seen

APPENDICES

APPENDIX - I

Analysis of soil before starting the investigations

	Depth	
	0-15 cm	15-30 cm.
Available nitrogen (kg ha^{-1})	260.2200	158.1000
Available phosphorus (kg ha^{-1})	210.0000	190.0000
Available potassium (kg ha^{-1})	87.0000	54.0000
Organic caron (%)	0.7125	0.4950
Organic matter (%)	1.2258	0.8514
pH	5.8000	5.8000
Moisture content (%) (Dry weight basis)	10.7600	14.2100
Bulk density (g cm^{-3})	1.1900	1.2700
Particle density (g cm^{-3})	2.8300	2.6700
Maximum water holding capacity (%)	50.2800	44.1000

APPENDIX - II

Meteorological data during June 1991 - May 1992

Month		Temperature(o^{C})		Rainfall (mm)	Rainy days	Mean RH (%)	Mean Suns-hine hours
		Mean maximum	Mean minimum				
June	1991	29.5	24.0	669.3	24	86.7	2.0
July	1991	29.4	23.5	272.0	14	82.8	4.2
August	1991	29.4	23.4	154.5	14	80.9	3.9
September	1991	30.7	24.1	22.4	1	77.0	8.1
October	1991	30.8	23 7	205.8	17	80.1	4.2
November	1991	30.2	23.2	247.1	12	82.6	5.1
December	1991	30.4	21.9	20.2	2	75.7	5.2
January	1992	30.4	20.4	0	0	73.2	8.3
February	1992	30.1	21.8	0	0	74.9	8.3
March	1992	32.2	22.2	0	0	72.4	8.7
April	1992	33.3	25.5	1.5	3	75.7	7.6
May	1992	32.1	24.7	90.9	12	77.8	5.2

AGRONOMIC RESOURCE INVENTORY OF A HOMESTEAD IN THE SOUTHERN ZONE OF KERALA

BY

HAPPY MATHEW. K.

ABSTRACT OF A THESIS

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE

MASTER OF SCIENCE IN AGRICULTURE

FACULTY OF AGRICULTURE

KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

1993

ABSTRACT

An investigation was undertaken on the agronomic resources inventory of a homestead of 0.2 ha area in the Southern zone of Kerala for a period of one year from June 1991 to May 1992.

The study revealed that crop diversification was achieved in the homestead through intercropping in the interspaces of the tree species. The crop diversification helped to meet the multiple demands of the home and minimised the risk of monoculture. The homestead was mainly a coconut based multiple farming system. The agroforestry components consisted of jack, mango, breadfruit and portia in addition to coconut. A multitude of crops including elephant foot yam, cassava, dioscorea, ginger and fodder grass were grown as intercrops. This resulted in a cropping intensity of 1.56.

Crop livestock integration was a special feature of the homestead which helped to achieve sustainability.

The nutrient cycling processes like litterfall, throughfall and stemflow were studied. The annual

litter addition by the major tree components in the homestead amounted to 936.35 kg and the nutrient input was to the tune of 8.5, 2.0 and 6.4 kg of N, P and K respectively. Throughfall accounted for an annual nutrient return of 2.1, 0.2 and 3.2 kg of N,P and K respectively. The nutrient addition by stemflow was comparitively less. The organic manure addition was to the tune of 10.1 tonnes. This resulted in an addition of 49.1, 19.1 and 21.2 kg of N, P and K respectively.

The moisture content and bulk density in the top soil layer was found to have a lower value in the homestead than in the open system. The maximum water holding capacity was always higher in homestead soils. The nutrient (available N, P and K) status and organic matter content, observed a higher value in the homestead. The population of fungi, bacteria and actinomycetes were much higher in homestead soils. The soil temperature in the homestead was found to record a lower value while the values of relative humidity was higher in the ecoclimate of tree crops. The tree species were found to intercept the solar radiation. Maximum light interception was by jack canopies (90-92 per cent) and the least by coconut (74-78 per cent).

The maximum net return was obtained from poultry farm while the maximum benefit:cost ratio was for coconut cultivation. The family labour provided a saving of Rs. 5625/- to the homestead. The net benefit from the homestead system was Rs. 28095/-. The benefit:cost ratio of the farming activities as a whole was 1.60.