LITTER DECOMPOSITION AND NUTRIENT DYNAMICS OF SELECTED MULTIPURPOSE TREES IN HOMESTEADS

By
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THESIS

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DECLARATION

I hereby declare that this thesis entitled "**Litter decomposition and nutrient dynamics of selected multipurpose trees in homesteads**" 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 of any degree, diploma, associate ship, fellowship or other similar title of any other University or society.

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11.06.01

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CERTIFICATE

Certified that this thesis entitled "**Litter decomposition and nutrient dynamics of selected multipurpose trees in homesteads**" is a record of research work done independently by **Mrs. Sheeba Rebecca Isaac** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associate ship to her.

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For my father

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Sheeba Rebecca Isaac

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List of Abbreviations

N	- Nitrogen
P	- Phosphorus
K	- Potassium
Ca	- Calcium
Mg	- Magnesium
Zn	- Zinc
Mn	- Manganese
Fe	- Iron
Cu	- Copper
kg m^{-2}	- kilogram per square metre
m	- metre
m^2	- square metre
m^3	- cubic metre
cm	- centimetre
ppm	- parts per million
%	- per cent
WHC	- Water holding capacity
BD	- Bulk density
PD	- Particle density
C	- Carbon
C:N	- Carbon : Nitrogen ratio
R^2	-Multiple correlation coefficient

INTRODUCTION

1. INTRODUCTION

The relative importance of trees in sustaining the environment was known to mankind from time immemorial. Fast growing woody perennials form the backbone of all forestry and agroforestry systems. They perform productive and protective functions in the agroecosystem. The multipurpose trees not only fulfil the requirements of food, fodder and fuel but are also capable of improving soil fertility, controlling soil erosion and ensure sustainability in the system in which they exist.

The paucity of land for extensive cultivation has compelled the farmers in Kerala to resort to more intensive land use systems in agriculture. With more than 90 per cent of the farmers in the State belonging to the category of small and marginal farmers, the prospect for raising crops on a commercial scale is minimal. Homegardens, one of the most popularised, traditional agroforestry practices, are a predominant feature in the agricultural scenario of the State.

A homegarden is an operational farm unit in which a number of crops (including tree crops) are grown with livestock and/or poultry, mainly for the purpose of satisfying the farmer's basic needs. Farmers utilise the land in and around their homes to undertake different agricultural enterprises. It resembles a multi-storied cropping system with the tree canopies occupying the uppermost vegetation layer and the agricultural crops, the lowermost layers of the atmosphere.

The integration of crops and trees with livestock in the homegardens enables efficient recycling of organic wastes within the system thus reducing dependence on externally procured inputs. Apart from the seed material and water required for the agricultural component, the most important input needed to harvest satisfactory yields from the system is the fertiliser input. Livestock wastes, crop residues and green manure crops form the commonly used organic sources of nutrients. A still more important, yet untapped resource available for use as organic manure, is the litter fall from the tree components of the system.

The trees are characterised by a continuous litter fall, the quantity varying with species, age, canopy spread and season. The surface litter cover serves as an organic mulch conserving soil and moisture, maintaining soil temperature and checking weed growth. It adds organic matter to soil and also functions as a source of nutrients for plants, a substrate for microorganisms and a factor in soil aggregation and root development. On decomposition, the bound nutrients are released for uptake and reuse by the plant community.

It is possible to meet the nutrient requirement of crops through the decomposition and mineralisation of plant residues . Farmers are known to adopt this practice but they do it without any scientific basis. Quantification of litter fall from different tree species and an understanding of the decomposition dynamics of the litter have definite management implications in agroforestry. Annual crops have well defined critical periods of high nutrient demand and if the nutrients can be made available to the crops during this period, the twin objectives of increased nutrient use efficiency and productivity will be realised. Depending upon the decomposition characteristics, tree species can be selected and the application of leaf biomass as a source of manure to the crop can be regulated in such a way that the nutrient release through decomposition is synchronised with the crop's nutrient requirement. Retention of tree litter is thus crucial for maintaining the sustainability of the homegardens. However, research in this regard is meagre. The potential of using the tree leaf biomass as a source of nutrients for the crop components in homegardens and agroforestry systems is still unexploited.

The litter fall and its decomposition are highly influenced by the micro climate of the site. Soil temperature, moisture and microorganisms play a crucial role in deciding the decomposition pattern. Very little effort has so far been made in modeling decomposition characteristics based on these parameters.

Mango (*Mangifera indica*), jack (*Artocarpus heterophyllus*), cashew (*Anacardium occidentale),* Ailanthus *(Ailanthus triphysa*), wild jack *(Artocarpus hirsuta)* and mahogany *(Swietenia macrophylla)* are some of the multipurpose trees commonly grown by farmers in their home gardens. The present investigation was carried out in the above six tree species with the following objectives.

- to quantify the litter production of mature multipurpose trees in three homesteads
- to monitor the decomposition characteristics of mango, jack, cashew, Ailanthus, wild jack and mahogany leaf litters, in homesteads.
- to assess the nutrient release pattern from the leaf biomass
- to monitor the changes in the soil physical, chemical and biological properties in relation to the decomposition.
- to study the influence of soil moisture and temperature on decomposition and
- to prepare mathematical models to predict the decomposition pattern for the different leaf litter studied.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Agroforestry has over the years emerged as an important land use system, the significance owing to the ability of the trees to maintain the soil organic matter and biological activity at satisfactory levels for soil fertility. The litter dynamics contribute significantly to the nutrient pool of the agroforestry system. Among the different agroforestry practices, home gardens form the predominant practice in Kerala. The bio-geochemical nutrient cycling in home gardens is also dominated by litter production and decomposition. This chapter reviews the current status of knowledge on the home garden structure, litter accumulation in different tree systems, its decomposition and impact on the soil properties and also the factors controlling the decomposition of litter.

2.1 Homegardens : definition

Several authors have referred to these practices with different terms. These include mixed garden horticulture (Terra, 1954); homegarden (Ramsay and Wiersum, 1974); Javanese homegarden (Soemarwoto *et al.*, 1976, Soemarwoto, 1987); compound farm (Lageman, 1977); mixed garden/house garden (Stoler, 1975); kitchen garden (Brierley, 1985); household garden (Vasey, 1985) and homestead agroforestry (Nair and Sreedharan, 1986). There are also several other types of homegardens in other geographical locations, each with its own characteristic features.

Ninez (1984) defined homestead as a production sub system, which aims at the production of household consumption items. According to Soemarwoto and Soemarwoto (1984), homegarden is an agroforestry system, which ideally combines the ecological functions of forests with those of providing the socio-economic needs of the people. Hanman (1986) described homestead as the home and its adjoining land owned and occupied by the household including the immediate area surrounding the dweller's unit and the space used for cultivation of trees and vegetables. Fernandes and Nair (1986) referred it to the intimate association of multipurpose trees and shrubs with annual and perennial crops and invariably with livestock, within the compounds of individual houses, with the whole crop-tree-animal unit being managed by family labour. Nair and Sreedharan (1986) defined homestead as an operational farm unit in which a number of crops (including trees) are grown with livestock, poultry and/or fish production mainly for the purpose of satisfying the farmer's basic needs. Soemarwoto (1987) described homestead as a system for the production of subsistence crops for the farmer and his family, which may or may not have the additional production of cash crops.

2.2 Homegardens : Structure

Homegardens are very complex systems with a very sophisticated structure and large number of components. Fernandes and Nair (1986) based on the evaluation of the structure and function of ten selected homegardens in different eco-graphics of the tropics, opined that homegardens are characterised by a mixture of several annual or perennial crops grown in association, and exhibited a three to five layered vertical structure of trees, shrubs and ground cover plants, which recreates some of the properties of nutrient cycling, soil protection and effective use of space above and below the soil surface.

Jambulingam and Fernandes (1986) reported that farmers in Tamil Nadu integrated numerous species of multi-purpose trees and shrubs in close association with agricultural crops. The integration on the farmlands represented the strategy to minimise the risk of crop failure.

A unique study on the structure and function of agroforestry homegardens of Kerala by Nair and Sreedharan (1986) revealed that the size of the holdings ranged from 0.02 to 1.00 ha, with coconut as the most dominant and important tree crop. The other perennial crops in the homesteads were arecanut, black pepper, cocoa, cashew and various tree species such as teak, jack, wild jack, casuarina, portia, silver oak, and erythrina. Cattle and poultry rearing were also undertaken in most of the homesteads. Thus a four-tier structure was commonly noticed. Mathew (1993) conducted an agronomic resource inventory of a homestead of 0.2 ha in southern Kerala and observed various agroforestry components such as jack, mango, bread fruit, portia and coconut intercopped with a multitude of understorey crops; elephant foot yam, cassava, dioscorea, ginger and fodder grass, resulting in a cropping intensity of 156 per cent. Babu (1995) reported that 47.78 per cent of the homesteads surveyed in north Kerala were with crops and livestock, and 51.67 per cent of the homegardens were coconut based.

An agroforestry systems' inventory description survey in 400 homegardens of Thiruvananthapuram district was undertaken by John (1997). The results of the survey revealed that majority of the holdings (58.25 per cent) were small sized. Tuber crops dominated the crop category in the homesteads, followed by fruit trees. Oilseeds ranked third with rubber, spices, vegetables and fodder crops occupying the lower positions. The homegardens presented a multi – tier canopy configuration with poultry and livestock components. However, there was no specific pattern or arrangement.

Homegardens represent multi-tier cropping systems with trees being the major and most predominant component. Agricultural crops and livestock components are included according to the whims and interests of the farmer. The structure would be complex and dense resulting in high cropping intensities.

2.3 Litter fall

The major recognized avenue for the addition of organic matter and hence nutrients to the soil is through litter fall; dead and falling leaves, twigs, branches, fruits and so on (Brinson *et al.,* 1980). Litter production varies with species, stand age, growth rate, climatic condition and soil properties (O'Connell and Sankaran, 1997). The authors have also stated that litter accumulation across a broad range of species, stand age and locality generally falls within the range less than 1.0 to 22.0 t ha^{-1}.

In tree stands, the annual litter fall increases with age, until the canopy closes and then remains constant over long periods before decreasing in old stands (Bray and Gorham, 1964). Supporting this view Gholz *et al.* (1985) observed that needle litter fall increased with stand age in a slash pine (*Pinus ellioti*) plantations (age sequence 3-36 years old) to a peak of 4453 kg ha^{-1} $year^{-1}$ at the age of 15-16 years, then declined in older stands. Studies on annual litter production by Omkar Singh *et al.*, (1994) revealed that leaf litter production was more for a 17 year old *Dalbergia sissoo* plantation than a 20 year old *Bombax ceiba* plantation.

Bray and Gorham (1964) reviewing the world literature on litter production reported that *Eucalyptus tereticornis* hybrid produces more litter compared to most other species of the same genus.

A comparison of the annual litter production in *Acacia meerusii* and *Eucalyptus globulus* in Nilgiris made by Venkataraman *et al.* (1983) revealed higher amounts of litter production in Eucalyptus (1935 kg ha^{-1}) than in acacia (900 kg ha^{-1}).

However, Gill *et al.* (1987) observed that the litter production and cycling of nutrients in a 3-6 years old acacia plantation was higher than in an eucalyptus plantation of the same age. Premakumari (1987) investigated the annual litter fall in eucalyptus, teak and rubber plantations and reported maximum litter fall for eucalyptus (14 t ha^{-1}) followed by teak (8.17 t ha^{-1} and rubber (3.24 t ha^{-1}).

Studies on the litter production in the moist deciduous forests (Grewia-*Dalbergia* community) of Coimbatore forest division showed that *Grewia tillifolia* contributed maximum quantity of leaf litter among the different species present, owing to this species dominating in the community with the highest importance value index (Singh *et al.*, 1993). *Albizzia lebbek* and *Leucaena leucocephala* though belonging to the same family, under similar climatic conditions showed great variation in their annual litter production (Varshney and Garg, 1996).

Bimodal and unimodal pattern of litterfall in tree species have been reported by several authors and leaf shedding is generally characterised by a heavy fall during dry season (Pascal, 1988). Sandhu and Sinha (1990) observed an annual litter fall of 10 t ha^{-1} in a two year old *Leucaena leucocephala* stand, with the maximum fall in the dry summer months.

The litter fall from *Ailanthus triphysa*, *Eucalyptus tereticornis, Glyricidia sepium* and *Leucaena leucocephala* grown in a coconut based agroforesty system was estimated by Vinayan (1992). Maximum amount of litter fall was observed during February-March in all species and it decreased subsequently. Results on increased litter fall during the dry months in a number of tree species have earlier been documented (O'Connell and Menage, 1982; Das and Ramakrishnan, 1985; Sugur, 1989; Swamy,1989; Kumar and Deepu, 1992; Sankaran *et al.,* 1993).

Singh *et al.* (1993) reported maximum litterfall in poplar (66 per cent) and teak (93 per cent) during winter months, whereas in sal, maximum litterfall was recorded during mid February to mid May (95 per cent). The annual litter production for sal, teak and poplar were 6.86, 7.70 and 5.29 t ha^{-1} on oven dry basis. Similar reports on maximum litter fall in winter was also given by Varshney and Garg (1996) in *Albizzia lebbek.* Unimodal pattern of litter fall in acacia (peak during October-November) and natural forests (peak during December-January) and bimodal pattern in eucalyptus (peaks in October-November and in June) were reported by Moosa (1997).

A detailed study on the litter production of multi purpose trees involving 8-9 year-old wood lots of nine fast growing tree species in Kerala, was undertaken by Jamaludheen and Kumar (1999). The results revealed an annual litter production ranging from 3.43 Mg ha^{-1} (Pterocarpus) to 12.69 Mg ha^{-1} (Acacia) respectively. Litter fall of acacia, ailanthus, pterocarpus and casuarina followed a unimodal distribution pattern with a distinct peak during November – February and a lean period from April to August. The tree species such as emblica, paraserianthes, leucaena, jack and wild jack did not exhibit any characteristic periodicity and litter fall was effectively continuous.

Detailed investigations on the annual litter fall in homegarden agroforestry systems are not many. A study on the litter fall pattern of various tree species in an agroforestry system carried out by Shajikumar (1991) revealed *Eucalyptus tereticornis* produced more litter compared to the other tree species viz., *Ailanthus triphysa, Glyricidia sepium* and *Leucaena leucocephala.* The quantity of litter produced by Eucalyptus, Glyricidia, Ailanthus and Leucaena were 4059, 3323, 1751 and 1593 kg ha^{-1} respectively. Mathew (1993) quantified an annual input of 981 kg litter from the different tree components in a 0.20 ha homestead. The annual litter addition by the various tree components in a 0.48 ha homestead, investigated by Nair *et al.* (1996) amounted to only 384 kg. Subsequently, John (1997) assessed the annual litter fall in two homegardens at two locations in Thiruvananthapuram District, Kerala. The total annual litter addition in the first homegarden averaged 454 kg from 12 tree components in the system. The maximum amount of litter was obtained from nutmeg *(Myristica fragrans)* followed by wild jack *(Artrocarpus hirsuta).* In the second homegarden, the total annual litter addition was 326 kg from 11 tree components with the maximum being from cashew, followed by anona. Abraham (1998) reported a positive correlation between the litter addition and the canopy area of the trees in homegardens.

2.3.1 Nutrients cycled through litter

A substantial portion of the nutrients accumulated in the plant biomass is returned to the soil through litter fall. According to Charley and Richards (1983), leaves accounted for most of the total litter fall and also for most of the nutrient inputs (nitrogen, phosphorus, potassium, calcium, magnesium and sulphur) that reached the floor in organic debris. Beer (1988) reported that the annual nutrient return in the litter fall of *Erythrina poeppigiana*, a leguminous shade tree in coffee and cocoa plantation, represented 90-100 per cent of the nutrient store in its above-ground biomass. Nitrogen was the most important nutrient added through litter (Vinayan, 1992) and this was substantial where plantations included nitrogen- fixing species (O'Connell and Sankaran, 1997). Species show great variation in their nutrient contents and this along with the total quantity of litter produced, decide the amount of nutrients added to soil. Abraham (1998) also stated that the nutrient contents varied with the tree species and season and the total nutrient return from the trees is more dependent on the total litter fall than on the nutrient contents of the litter.

Rodin and Bazilevick (1967) found that about 50-70 kg ha^{-1} nitrogen is added by litter fall in coniferous forests and 250-325 kg N ha^{-1} in tropical, and subtropical forests. Cole and Rapp (1980) quantified the nutrient return by way of litter fall as 61.0, 4.0 and 42.0 kg ha^{-1} $year^{-1}$ of nitrogen, phosphorus and potassium, for temperate deciduous forests and 370.0, 40.0 and 26.0 kg year^{-1} of nitrogen, phosphorus and potassium for temperate coniferous forests. Bartos and DeByle (1981) estimated approximately 1397 kg ha^{-1} leaves and 213 kg ha^{-1} twigs being shed during each summer and autumn in aspen (*Populus tremuloides*). The litter fall added 8 kg ha^{-1} N, 1 kg ha^{-1} P, 7 kg ha^{-1} K, 30 kg ha^{-1} Ca and 2 kg ha^{-1} Mg. Leaves supplied nearly 84 per cent of the nutrients in litter. Shajikumar (1991), based on his study pointed out that even though eucalyptus produced more litter, the amount of nutrients added to soil is low, as compared to leucaena and glyricidia because of their low nitrogen, phosphorus and potassium contents.

The rate of nitrogen cycled through litter fall in pure eucalyptus stands were within the range of 25 to 45 kg ha^{-1} year^{-1} and that for albizzia stands 100-240 kg ha^{-1}year^{-1} (Binkley *et al.,* 1992). Mathew (1993) quantified the annual nutrient input by way of litter from the different tree components as 8.5 kg N, 2.0 kg P and 6.36 kg in a 0.2 ha homestead.

Studies on litter accumulation and mineralisation under different vegetational ecosystem undertaken by Saravanan *et al.* (1995) revealed that addition of nutrients followed the order of leaf fall; this being highest in coniferous pine followed by eucalyptus, acacia and apple. The quantum of phosphorus addition was least in all species as compared to that of nitrogen and potassium. Nair *et al.* (1996) reported that the annual nutrient input through litter fall from the tree components in a 0.48 ha homestead was 4.40, 1.20 and 3.00 kg nitrogen, phosphorus and potassium respectively.

Das and Ramakrishnan (1985) observed that nutrient content in needle litter varied considerably throughout the year. The concentration of nitrogen and phosphorus in litter increased from May, reached a maximum in July and remained steady at a lower level during the next few months, with an increase again at a lower level during the next few months, with an increase again starting in March of the following year. Calcium and magnesium on the other hand had slightly higher value during May and in subsequent months, remained steady at a some what lower level. The concentration of all nutrients was lower in older plantation and higher in the youngest one during the entire study period. The maximum return to the pine floor through litter fall occurred during February -April with a major peak during this period and a smaller peak during August-September. The return was in the order N>Ca>K>Mg>P. Khiewtam and Ramakrishnan (1993) reported uniformly low values for nitrogen, phosphorus and potassium in litter samples drawn during the wet season.

George and Kumar (1998) documented significant variation in the nutrient content in the leaf litter of the different tree species studied. Nitrogen, phosphorus and potassium contents of leucaena litter were significantly higher compared to the other species examined. Nitrogen and potassium contents in the various tree species followed the order: leucaena>casuariana>acacia>ailanthus while phosphorus declined in the order leucanea> ailanthus >casuarina> acacia. They had also observed variations in nutrient contents in the litter with the season. Litter nitrogen and phosphorus contents were higher during the wet season whereas potassium was low during this period. Peak concentration of potassium was observed in March.

The nutrient accretion through litter fall in the stands of nine multipurpose trees in Kerala was worked out to the tune of 38-203 kg N ha^{-1} $year^{-1}$, 0.8-6.0 kg P ha^{-1} $year^{-1}$ and 3.4-15.7 kg K ha^{-1} $year^{-1}$(Jamaludheen and Kumar, 1999). Seasonal changes in nitrogen, phosphorus and potassium of foliage litter were significant, with the wet period accounting for higher nitrogen concentration and potassium content being lower during this period. The nitrogen content of litter was generally high during summer (up to April), whereas that of phosphorus and potassium were low during the wet reason, May-August.

The above literature reveal that substantial quantity of litter is added to the soil by different tree species. The pattern of litterfall may be unimodal or bimodal varying with the species with peaks in most situations being in the dry period.

The nutrient status of the litter prove them to be a potent source of the major nutrients especially nitrogen and phosphorus. Mineralisation will add to the nutrient pool of the soil, improving its fertility and thereby its productivity.

2.4 Litter decomposition

Trees shed leaves periodically or continuously and this litter acts, as an input-output system for nutrients (Das and Ramakrishnan, 1985). Litter serve as a temporary sink for nutrients (White *et al.,* 1988) and functions as a slow release nutrient source (Jamaludheen and Kumar, 1999). The leaf litter on decomposition, release the nutrients contained in them into the soil for re-circulation. Thus litter fall and its subsequent decomposition form the major pathway of nutrient cycling in tree-crop ecosystems.

2.4.1 Litter decomposition in forest ecosystems

The release of nutrient elements from decaying litter is a paramount pathway of nutrient flux in forest ecosystems (Salamanca *et al.,* 1998). A number of investigations on the litter dynamics have been carried out owing to its significant role in the efficient nutrient cycling in forest ecosystems (Pandey and Singh, 1982; Klemmedson *et al.,* 1985; Harmon *et al.,*1990; Kumar and Deepu,1992; Kim *et al.,* 1996; Salamanca *et al.,* 1998) and plantation forestry systems (Gholz *et al.,* 1985; Lugo *et al.,* 1990; Sankaran,1993; Lisanework and Michelsen, 1994; Moosa, 1997).

2.4.2 Litter decomposition in agroforestry systems

Tree components in agroforestry systems improve the soil productivity by their nutrient cycling pathways, of which, litter decomposition is the major recognised avenue. In agroforestry, both senescent materials (fallen litter) and green foliage (prunings) are available for decomposition, unlike the natural and agricultural system (Mafongoya *et al.,* 1998).

Budelman (1988) conducted decomposition studies with the leaf mulches of *Leucaena leucocephala, Glyricidia sepium* and *Flemengia macrophylla* under field conditions and observed high persistence for flemengia mulch, the half life value was 53 days, while that of leuceaena and glyricidia were 31 and 22 days respectively. Decomposition pattern of the leaves of three tropical legumes, *Inga edulis, Cajanus cajan* and *Erythrina sp.* was determined by the litter bag study in an alley cropping experiment conducted in the Peruvian Amazon. *Inga* and *Cajanus* exhibited similar patterns of decomposition (k = 0.91 and 1.72 $year^{-1}$ respectively) but was significantly different from that of *Erythrina,* whose k value was 3.45 $year^{-1}$ (Palm and Sanchez, 1990). Decomposition studies in a tropical agroforestry system revealed that during 274 days of exposure of litter in the field, the mass loss in *Leucaena sp., Populus deltoides, Prosopsis juliflora* and *Eucalyptus* were 86.3,75.6, 69.0 and 60.5 per cent respectively (Bharadwaj *et al.,* 1992). Leaf litter decomposition of agroforestry fallow species, *Acioa barteri* and *Centrosema pubescens* was studied both under lab and field conditions by Okeke and Omaliko (1992). Under laboratory conditions centrosema attained 100 per cent decomposition in eight weeks while *A. barteri,* 85.3 per cent at week 48, whereas, in the field during this period centrosema attained 85 per cent weight loss and *A. barteri* had 86.7 per cent weight loss at week 48, a trend similar to its decomposition value under laboratory conditions.

Leaf litter decomposition of four multipurpose trees in a coconut based agroforestry system studied by Vinayan (1992) revealed rapid decomposition of *Glyricidia sepium* leaves followed by *Ailanthus triphysa, Leucaena leucocephala* and *Eucalyptus tereticornis.*

The results of decomposition and nutrient release pattern of *Stryphnodendron microstachyum* and *Hyeronima alchorneoides* leaves as mulch materials in maize established the possibility of using these species in agroforestry combination with advantage (Montagnini *et al.,* 1993).

Daniel (1996) explored the biodegradation of jack and mango litter and reported faster rate of decomposition in jack (k =1.52), compared to mango litter (k=1.03). The half lives were 0.46 and 0.67 (years) for jack and mango respectively.

Decomposition is the basic phenomenon by which the plant residues disintegrate and nutrients lodged in them are made available to the associated crops. The time for complete decomposition varies with the species, age and quality of litter and also with the environmental conditions.

2.4.2.1 Rate of decomposition

The decomposition rates of a large number of tree species have been assessed by several authors. However, great variations have been observed in the rate of decomposition between species under similar environmental conditions (Mary and Sankaran, 1991; Lehmann *et al.*, 1995; George and Kumar, 1998) and within species when litter and green foliage from the same plant are used (Constantinides and Fownes, 1994). A number of factors are known to govern the decomposition rate of litter. Those reported included substrate quality, invertebrates and climate (Swift *et al.*, 1979), soil temperature (Heal, 1979; Edmonds, 1980; Moore, 1986), soil moisture (Moore, 1986), soil fertility (Witkamp and van der Drift, 1961), chemical composition of litter (Palm and Sanchez, 1990; Bockheim *et al.*, 1991) and microbial activity (Jensen, 1974; Swift *et al.*, 1979). Litter decomposition is essentially a biological process, which is determined by a set of hierarchically organised factors which regulate the microbial activity in the following order, climate-clay mineralogy and nutrient status of soil-quality of decomposing resources- effect of macro organisms –microorganisms (Lavelle *et al.*, 1993). The higher level factors viz., climate (temperature and moisture), edaphic factors such as clay minerology, physical and chemical characters of decomposing sources and macro organisms (roots and invertebrates) are known to influence the microbial population and activity which is responsible for most of the transformations of decomposition.

2.4.2.2 Effect of environment on rate of decomposition

Upadhay and Singh (1989) based on their decomposition study in *Quercus langinosa* and *Pinus roxvurghii* reported that leaves of subtropical and temperate trees decompose slowly even under tropical condition owing to their inherent resistance to microbial activity. In humid tropics, decomposition is generally considered to be more rapid and complete than in any other ecosystem. However, the basic processes that operate in all ecosystems remain the same, the factors that bring about/control decomposition vary in their dominance in the different ecosystems (Lavelle *et al.,* 1993). They opined that in the humid tropics, where climatic conditions are favourable for decomposition, the effects of resource quality and macro organisms which in other situations are secondary determinants, may become the most important regulators of the rates and pathways of decomposition.

The ecological and environmental factors that influence the decomposition can be grouped under abiotic factors.

2.4.2.2.1 Abiotic factors

Orea *et al.* (1996) opined that environmental factors have more regulatory functions in leaf mulch decomposition than the biotic factors.

Soil moisture, atmospheric temperature and soil temperature are reported to be the paramount abiotic factors controlling the rate of decay under natural conditions (van der Drift, 1963; Singh and Gupta, 1977; Singh and Joshi, 1982; Moore, 1986).

2.4.2.2.1.1 Soil moisture

Soil moisture has profound influence on biomass decomposition. Madge (1965) stated that moisture is often a limiting factor for the break down of angiosperm tree litter in tropical forests. William and Gray (1974) observed that during periods of drought, litter decomposition rates are drastically reduced. Gupta and Singh (1977) found highest disappearance at the rate of 36.25 to 52.85 per cent from July to October, when there was maximum rainfall. In contrast, the weight loss during dry months was only 14.78 to 25.5 per cent. A high rate of litter decay during rainy season in tropical condition has also been observed by Das and Ramakrishnan (1985); Orsborne and Macauley (1988) and Okeke and Omaliko (1992).

Swift *et al.* (1981) stated that where rainfall is seasonal, moisture becomes an important regulator of litter fall and decomposition. This in turn can result in marked pulses in amounts of nutrient available for plant uptake (Lodge, 1987; Lodge *et al.,* 1994).

Pascal (1988) observed a low rate of decomposition throughout the dry period in Attapadi forests of Kerala. He reported that with first pre-monsoon showers, the decay rate was doubled (k values ranged from 0.12 to 0.31) and with the onset of monsoon, the rate of decomposition decreased once again to the level before the rains (0.14). The decomposition rate at the end of the rainy period and before the dry season indicated that the microbial activity renewed abruptly to reach the maximum (0.63), which is twice the rate of the pre-monsoon period.

Sankaran *et al.* (1993) reported that the maximum weight loss in acacia leaf litter occurred during September to November during north east monsoon period in Kerala, India. Sankaran (1993) explored the decomposition pattern of leaf litter of *Paraserianthus falcataria, Eucalyptus tereticornis* and *Tectona grandis* in Kerala, and reported the mass loss in various leaf litter to be positively correlated with litter moisture content and rainfall. Litter moisture content proved crucial for the decomposition and rainy season provides congenial condition for rapid breakdown of leaf litter.

Under saturated conditions, the decomposition is dependent on anaerobic organisms, which are found to be less efficient compared to aerobes (Yoshida, 1975 ; Patrick, 1982). De Boois (1974) found a slower rate of decomposition both under the situations of high moisture content (more than 100 per cent) and low moisture content (less than 30 per cent).

Tarafdar and Rao (1992) studied the decomposition of tree leaves in arid soils at different moisture levels and concluded that the favourable moisture condition for the organic residue decomposition ranged from 50-90 per cent of the water holding capacity. At above 90 per cent, anaerobic condition sets in and this reduces the decomposition rate.

2.4.2.2.1.2 Atmospheric temperature and soil temperature

Mikola (1960) noted that temperature is the most important factor regulating the litter decomposition since rainfall is evenly distributed throughout the year.

Several other studies have also demonstrated that within a wide range of moisture conditions, temperature is the most important abiotic factor affecting forest floor decomposition (Reiners 1968; Edwards, 1975; Singh and Gupta, 1977).

Olson (1963) reported that in subalpine forests, temperature tended to affect the biological activity, finally resulting in lower rates of biomass decomposition.

Floate (1970) observed that the amount of CO_2 evolved over a period of 12 weeks was reduced from 40 per cent to 25 per cent of the original carbon content when temperature decreased from 30^0C to 5^0C.

Soil temperature is an important factor controlling the growth and microbial activity which are finally responsible for decomposition of organic matter. The mesophilic bacteria, actinomycetes and fungi require a temperature below 45^0C for their optimum activities, while thermophilic bacteria, require a temperature range of 45^0 C to 60^0 C (Alexander,1977). Waring and Schlesinger (1985) observed that microbial activity increases exponentially with increasing temperatures and as a result, high temperature results in rapid decomposition.

The combined effect of high temperature and moisture is more pronounced than the temperature alone (Jenney *et al.,* 1949). In tropical climate they found a heavy weight loss in alfalfa leaves due to high temperature and moisture conditions. The microbial activity is favoured during summer due to high moisture and temperature thus accelerating the rate of decomposition (Witkamp and van der Drift, 1961).

According to Flanagan and Veum (1974) temperature and moisture are the most important variables controlling microbial decomposition.

Singh and Joshi (1982) reported that temperature and moisture have paramount role in enhancing the rate of decomposition and these two factors could be considered as critical environmental parameters resulting in the high rates of decomposition in sand dune regions of Rajasthan.

The foregoing review brings to light the definite role both soil temperature and moisture have in controlling decomposition, the magnitude of influence varying with the quality of litter and associated organisms involved in the decomposition process.

2.4.2.2.2 Biotic factors

Soil fauna and flora are the biological mediators for soil organic matter transformations and the action of these biological mediators on organic matter present in the soil is primarily responsible for the biochemical modifications of organic materials.

2.4.2.2.2.1 Soil fauna

The action of soil fauna may have a significant influence on the decomposition of litter entering the soil ecosystem. They create suitable conditions for microbial activity. Lavelle and Kohlmann (1984) opined that in tropical rain forests a diversified and abundant litter fauna is an evidence of the active litter system. The epigeic litter fauna includes a great variety of macro and micro arthropods and detritivorous earthworms. They disseminate fungal propagules and increase surface area accessible to microbial attack by fractionating and comminuting the litter.

Bocock (1964) found that litter decomposition by earth worms and millipedes was more rapid during the initial five months of decomposition. These fauna accounted 40 per cent of the decomposition of *Fraxinus excelsio* litter. Seastedt and Crossley (1983) reported that the soil fauna stimulated the litter decomposition rate, resulting in increased nutrient concentration of the decomposing litter. The animal groups such as earthworms, insects and snails bring about mechanical reduction. They bite and eat the organic matter and thus pulverize the material (Rangaswamy and Bagyaraj, 1993). With increasing dryness, the termitosphere system becomes increasingly dominant as earthworm communities and population decline. Termites essentially feed on leaf and wood litter (Lepage, 1982). They may ingest upto 30-70 per cent of the above ground production and compete for this resource with large vertebrate herbivores (Lepage, 1974; Ohiagu and Wood, 1979; Josens, 1983).

Butler and Buckerfield (1979) reported that termites have metabolised 63 per cent of maize lignin to CO_2 within 6 to 69 days. They also found that the decomposition of lignin occurred in the termites and not externally in their faeces.

2.4.2.2.2.2 Soil microorganisms

Micro organisms perform most of the chemical transformations of the decomposition processes. Jensen (1974) and Swift *et al.* (1979) have stated that the decomposition of plant litter on the soil surface is brought about by a variety of micro organisms including bacteria, fungi and actinomycetes. Among these microbes, fungi are recognized as the chief coloniser and decomposer (Hayes, 1979). Bacteria act only as secondary decomposers and the role of actionmycetes is described to be limited (Goodfellow and Cross, 1974). Sankaran (1993) studied the decomposition pattern in teak, Albizzia and Eucalyptus and isolated the organisms responsible for decomposition. He reported that main decomposers belonged to the group of fungi, bacteria and actinomycetes.

Decomposition of litter is mediated by soil organisms. The macrofauna have pivotal role in fragmenting the litter and making it amenable to the soil flora. Fungi, bacteria and actinomycetes are the chief micro organisms bringing about the process of decomposition and nutrient release.

2.4.2.3. Effect of species on the rate of decomposition

Differences in the rate of decomposition of detritus from different species have been documented by several authors (Pandey and Singh, 1982; Wylie, 1987). Lisanework and Michelsen (1994) studied the litterfall and nutrient release by decomposition in Ethiopian highlands and found that the decomposition of *Eucalyptus globulus* and *Juniperus procera* were faster compared to *Cupressus lusitanica.* Munshi *et al.* (1987) attributed the variation shown by leaf litter in decomposition to the physical and chemical properties of the litter. Rout and Gupta (1987) studied the leaf biomass decomposition of deciduous tree species and two shrubs' litter by measuring CO_2 evolution rates from the soil using three and correlated the decay rates with various chemical constituents of the litter. They found differences in the rates of decomposition among the species and concluded that the lignin, nitrogen and C:N ratio of the litter had significant effect on decomposition.

Litter production and decomposition dynamics in moist deciduous forest of Kerala were investigated by Kumar and Deepu (1992). They found that among the six species studied, litter of *Pterocarpus marsupium* decomposed rapidly. Litters of *Tectona grandis, Dillenia pentagyna* and *Terminalia paniculata* recorded slower rate of decomposition compared to *Grewia tiliaefolia* and *Xylia xylocarpa.*

Studies carried out by Vinayan (1992) on litter decomposition revealed rapid decomposition in *Glyricidia sepium* (3 months) followed by *Ailanthus triphysa, Leucaena leucocephala* and *Eucalyptus tereticornis.* Species differences in litter decay rates were demonstrated by George and Kumar (1998). Based on the decay rate coefficients they divided the four multipurpose trees included in the study into three categories: quick (Casuarina and Leucaena), medium (Acacia) and slow (Ailanthus) decomposers.

2.4.2.4. Effect of stand age on the rate of decomposition

Edmonds (1979) examined the decomposition rates and changes in nutrient content of needles in a stand of Douglas-fir of age sequence of 11, 24, 75 and 97 years in western Washington. Litter bags were collected after 3, 6, 12 and 24 months and decomposition constants worked out. The maximum rate of decomposition was observed in the stand of 24 year old. Later Gholz *et al.* (1985) in a slash pine plantation age sequence (3-36 years old) observed organic matter losses from decomposing needle litter to be similar in all stands for the first 18 months and at 24 months stage, significant stand age effect was noticed with needles in older stands showing slower mass losses than those in younger stands. Bargali *et al.* (1993) studied the pattern of decomposition and nutrient release from decomposing litter in eucalyptus plantations of different ages and found significant difference in decomposition with respect to age and time. The rate of decomposition was faster in one year old plantation and the rate decreased with the progress in age. The rate of decomposition was significantly correlated with initial nutrient contents.

2.4.2.5. Effect of litter quality on the rate of decomposition

Decomposition rates are highly dependent on the chemical quality of the decomposing resource. Many workers have recognized the composition of the decomposing material as a critical factor determining the rates of decomposition (Waksman and Jenney, 1927; Meentemeyer,1978 ; Kretzschmar and Ladd, 1993).

2.4.2.5.1 Nitrogen content

Nitrogen content of the material has been found to be an important factor controlling the rate of decomposition in most of the species (Cowling and Merril, 1966 ; Aber and Melillo, 1980).

Kumar and Deepu (1992) stated that nitrogen content of the detritus could be taken as a better predictor of the decay rate constant and Constantinides and Fownes (1994) opined that initial nitrogen is the best determinant for the decomposition dynamics of the litter. Jamaludheen (1994) in his studies also established a positive relationship between the rate of decomposition with initial nitrogen content of the leaf litter.

Fresh plant material vary considerable in their nitrogen content. Tropical tree leaf biomass has a higher nitrogen content compared to temperate tree leaf biomass (Nye, 1961). Nitrogen content of deciduous leaves is relatively higher than that of conifers (Alway *et al.,* 1933). Bahuguna *et al.* (1990) found that the higher initial nitrogen content of eucalyptus litter led to faster decomposition, compared to sal, which had low initial nitrogen.

Sharma *et al.* (1997) observed rapid decomposition and release of nutrients from nutrient rich litter of nitrogen fixing species. Jamaludheen and

Kumar (1999) based on their study confirmed that the initial nitrogen content exerted a positive influence on litter decay rate coefficients of the nine species studied, leucaena with the highest initial nitrogen content decomposed completely in the shortest time. However, some authors have expressed their doubts on the regulatory effects of nitrogen on the litter decomposition (Johansson, 1994).

2.4.2.5.2 Carbon : nitrogen ratio

The C:N ratio of plant residue plays a crucial role in biomass decomposition. Plant litters with high initial content and low C:N ratios are known to decompose rapidly (Singh and Gupta, 1977; Meentemeyer,1978).

Knapp *et al.* (1983) suggested that decomposition was regulated by N during the initial period and by C during the prolonged period.

Fog (1988) established that plant materials with high C:N ratio do not provide the sufficient nitrogen needed for metabolism of decomposer populations, particularly under conditions of rapid microbial activity.

Contrary to the above studies, Mafongoya *et al.* (1998) opined that in most agroforestry studies, C:N ratio is a poor predictor of decomposition and nutrient release.

2.4.2.5.3 Lignin

Lignin is one of the plant components most resistant to decomposition and its abundance is inversely linked to decomposition rates (Fogel and Cromack, 1977; Berg *et al.*, 1993)

Several studies have indicated that compared to nitrogen, the initial lignin content of the litter has more control over the rate of decomposition (Bollen, 1953; Fogel and Cromack, 1977; Berg *et al.*, 1982; Melillo *et al.*, 1982; Stott *et al.*, 1983).

Tian *et al.*(1992) found negative correlation between decomposition rate constants and percentage of lignin content of the plant residues. However, the litter decomposition study conducted by Kunhamu (1994) in home gardens of Vellanikkara revealed that the lignin content of leaf biomass greatly influenced the rate of decomposition.

2.4.2.5.4 Lignin: nitrogen ratio

Melillo *et al.* (1982) and Parton *et al.* (1983) opined that in litter with a low nitrogen and high lignin contents, the lignin to nitrogen ratio has a predictive value for decomposition rates . Taylor *et al.* (1991) reported that the lignin and N concentration was better than lignin : nitrogen ratio.

Kumar and Deepu (1992) found that high lignin:nitrogen ratio was associated with lower rate of mineralisation. Similarly, Edmonds (1987) had earlier observed a negative relationship between rate of decomposition and initial lignin:nitrogen ratio when compared to lignin alone.

The quality of litter decides the rate of decomposition. The chemical constituents exerting significant influence have been reported to be initial nitrogen, C:N ratio, lignin and lignin: nitrogen though there are differences of opinion about the magnitude and predominance of influence.

2.4.3 Pattern of biomass decomposition

Decomposition of litter follows a biphasic pattern (Berg and Staaf, 1981; Kumar and Deepu, 1992; Sankaran *et al.,* 1993 ; Kunhamu, 1994).

The decomposition dynamics involve a rapid initial decomposition phase which is due to the metabolization of readily digestible water soluble compounds such as simple sugars, proteins, amino acids and polysaccharides (Alexander,1977; Rangaswamy and Bagyaraj, 1993). During the later slower phase, the compounds resistant to biodegradation were found to be metabolized (Brady, 1984).

Singh *et al.(*1993) observed a typical biphasic pattern of biomass decomposition of four species studied for a period of one year. Among the four species, sal lost 87 per cent of the original biomass during the period studied, followed by teak (72 per cent), poplar (50 per cent) and Eucalyptus (50 per cent). The weight loss of sal was rapid during the first 3 to 6 months. An almost similar trend was observed in teak also. There was a slow rate of decomposition of Eucalyptus as compared to other species. Poplar exhibited a steady rate of decay during the first six months.

Kunhamu *et al.* (1994) studied the decomposition dynamics of *Acacia auriculiformis* and reported that 90 per cent of the litter disappeared within six months and the residual mass remained up to 16 months. In *Acacia mangium,* Hegde (1995) reported 90 per cent rapid loss in the first 3 months followed by a prolonged slow phase of decomposition.

A similar trend of rapid initial mass loss during the first four to five months followed by a slower mass loss in six to twelve months was elucidated by Jamaludheen and Kumar (1999) in Ailanthus, Casuarina, Pterocarpus and Leucaena litter dynamics.

2.4.4. Nutrient release pattern

Generally the rate of decomposition governs the nutrient release pattern, but various nutrients are found to be released at different rates and hence tended to show differential release patterns (Swift *et al.,* 1979; Kunhamu, 1994).

Attiwill (1968) studied the rate and extent of loss of dry matter, nitrogen, phosphorus, potassium, calcium, magnesium and sodium during the decomposition in *Eucalyptus obliqua* forest in Australia. Maximum loss was seen for nitrogen, followed by potassium, calcium, magnesium and phosphorus and this was attributed to the differential behaviour of these elements in terms of mobility and leachability.

Edmonds (1980) examined the decomposition rates and changes in the nutrient content of needles and leaf litters of Douglas fir, Western hemlock, Pacific silver fir and red alder under various ecosystems. He found a varied pattern of loss of elements with regard to ecosystems. In general, all the species recorded maximum mineralisation of potassium followed by magnesium, calcium, phosphorus, nitrogen and manganese in red alder; magnesium, calcium, phosphorus, manganese and nitrogen in Douglas fir;

calcium, magnesium, nitrogen, manganese and phosphorus in Western hemlock and magnesium, calcium, manganese, phosphorus and nitrogen in Pacific silver fir.

In scots pine, phosphorus was found to be the most limiting element for microbial activity during the initial phase. There appeared to be little initial leaching from the litter and the differential behavior of these elements could largely be explained by their extent of solubility and concentration in litter in relation to the needs of micro organisms. Generally, potassium and magnesium were found to be released at rates similar to the weight loss of organic matter (Staaf and Berg, 1982). They also found that nutrients in the decomposing litter were retained (to a weight loss of about 75 per cent) in the order of manganese followed by calcium, potassium, magnesium, sulphur, nitrogen and phosphorus. During the first 18 months, there was a net increase in nitrogen and phosphorus, followed by a net decrease emphasizing the fact that phosphorus is the most limiting element for microbial activity.

In tropical sal forest, Shukla and Singh (1984) found that calcium content of the litter declined throughout the year while phosphorus was released almost in a steady state.

The nutrient release patterns in *Eucalyptus obliqua* and *Pinus radiata* were studied by Baker and Attiwill (1985). In pine, nitrogen was immobilised for two years, whereas eucalyptus litter showed a net nitrogen release after one year. Moreover, within first three months, about 20 per cent of the phosphorus were mineralised, after which there was only a little change. Potassium and sodium were reduced rapidly during the initial stages. The calcium and magnesium losses were found to be quite comparable with losses in organic matter content.

Sharma and Ambasht (1987) studied the decomposition of *Alnus nepalensis* in Eastern Himalaya and found that the initial labile fraction of nutrient in decomposing biomass declined in the sequence of potassium followed by phosphorus, calcium and nitrogen. In their study, potassium showed a short half-life (2.4 months) followed by phosphorus (2.7 months), whereas nitrogen had a half life of 21 months. Attempts were made to monitor the nutrient flux in the decomposing leaf biomass of sal, teak, pine and Eucalyptus (Pande and Sharma, 1988). In general, all the species exhibited maximum release of calcium followed by potassium, nitrogen, magnesium and phosphorus.

Variation in the nutrient release pattern among fir and cedar litter species was reported by Stohlgren (1988). He noticed the immobilisation of nitrogen in all the species at varying degrees. Phosphorous was strongly immobilised in two species viz., sequoia and white fir; potassium and magnesium were quickly released in all the species; calcium was immobilised in sugar pine, whereas it was quickly released in cedar leaf litter. A strong linear or negative exponential relationship was found to exist between initial concentrations of nitrogen, phosphorus, potassium and calcium and per cent of original biomass that remained after decomposition. Bahuguna *et al.* (1990) studied the nutrient release patterns in plantations of sal and eucalyptus under similar eco-climatic and edaphic conditions and observed that magnesium recorded the highest elemental mobility in sal followed by potassium, phosphorus, calcium and nitrogen, whereas in eucalyptus, potassium showed faster mobility followed by magnesium, phosphorus, calcium and nitrogen. The rates of nutrient loss in the leaves of tropical legumes, *Inga edulis, Cajanus cajan* and *Erythrina sp.* followed the general trend K > P = N = Mg > Ca (Palm and Sanchez, 1990).

Bargali *et al.* (1993) investigated the nutrient release patterns in decomposing leaf litters of eucalyptus. They found an increase in nitrogen and phosphorus contents and towards the end of the study the nutrient contents were twice compared to the initial values. Potassium was actively leached, resulting in lower contents as compared to the content in the original litter.

Lisanework and Michelsen (1994) explored the nutrient release on decomposition in three plantations in Ethiopian highland and found that the loss of potassium was fastest, followed by magnesium and calcium. Interestingly, the rate of loss of nitrogen was similar to that of phosphorus.

Mwinga *et al.* (1994) studied the nitrogen mineralisation pattern in decomposing leaf litter of six multipurpose tree species and noticed that during the first week the amount of nitrogen released from *Gliricidia sepium* and *Leucaena leucocephala* foliage was high compared to *Sesbania sesban,* *Precipes angolensis, Cassia siamea* and *Flemingia congesta.* After four weeks of decomposition *Gliricidia sepium, Sesbania sesban, Precipes angolensis, Flemingia congesta* and *Cassia siamea* had released 107, 104, 72, 57, 50 and 42 kg N ha^{-1} respectively.

Orea *et al.* (1996) observed that on decomposition, residues of desmodium and peuraria cover crops grown for 12 months released nutrients faster than those grown for 18 months. The general order of nutrient release was K > P > N > Mg > Ca.

The nutrient element dynamics during decomposition of oak (*Quercus serrata*) and pine (*Pinus densiflora*) was assesed by Salamanca *et al.* (1998). The order of elemental mobility after 12 months for oak was P > K > Mg > C > Mn > Ca > N > Al > Cu > Zn > Fe and for pine K > Mg > C > Mn > N > P > Cu > Zn > Al > Fe.

Investigating the nutrient dynamics of decomposing litter of seven tree species, Jamaludheen and Kumar (1999) reported that either a biphasic or triphasic pattern of release existed for nitrogen, phosphorus and potassium characterised by an initial accumulation, followed by a rapid release and a final slower release phase.

The above literature reveal that decomposition of leaf litter leads to the release of nutrients trapped in them, the order and magnitude of release varying with the species. Potassiun being highly mobile is unanimously reported as the element to be most easily released on decomposition, nitrogen, phosphorus, calcium, magnesium and micronutrients show trends of accumulation and /or release which may be rapid or slow.

2.5 Effect of litter on soil properties

Tree distribution pattern is known to influence the different soil properties such as pH , bulk density, organic carbon content, total nitrogen, exchangeable cations and cation exchange capacity (Ryan and McGarity, 1983). Species difference have been identified as having negative, positive or no effect on soil physical and chemical properties due to different qualities of litter of the various species (Lugo *et al.*,1990). According to O'Connell and Sankaran (1997) nutrient rich litter showed faster rates of decomposition resulting in low soil accumulations. Eucalyptus and pine stands with low nutrient contents showed greater accumulation of litter, whereas the soil tended to have less organic carbon and exchangeable cations. Comparison of soil properties under teak, bombax and eucalyptus in Kerala by Balagopalan *et al.* (1992) revealed a greater decline in soil pH, organic carbon and exchangeable bases under eucalyptus stands. Mittal *et al.* (1992) in their study on the substitution of chemical nitrogen requirement of maize with leucaena leaf biomass, observed a build up of organic matter and better physical properties of soil with the leaf addition. This was reflected in the growth performance and yield of the maize crop in the treatments receiving leucaena compared to fertilisers alone.

Reports on the lowering of soil pH in agroforestry systems compared to vegetationless sites have been documented by Sharma and Gupta (1989) in *Acacia senegal*; Sharma *et al.* (1990) in *Zizhipus nummeleria*; Venkatachalam *et al.* (1990) in *Casuarina equsetifolia* and Parthiban and Rai (1994) in *Cassia siamea.* Soils under an agroforestry system involving albizzia, sisso, teak, Eucalyptus and Casuarina were reported to be highly acidic due to the decomposition of the litter .

Moosa (1997) reported increase in soil pH with litter decomposition in Acacia, Eucalyptus and natural forest soils, the highest pH (5.49) being in natural forest followed by Acacia (5.19) and Eucalyptus (5.08).

Lal (1989) evaluating the effect of three agroforestry systems : plow till, contour hedge rows of leucaena and glyricidia, reported decline in soil organic matter, total nitrogen, pH and exchangeable bases over the period of study. During the third and fourth years of establishment, he observed an increase in soil pH and exchangeable bases due to recycling of bases from the deep subsoil to surface horizons. He also reported lower bulk density, higher soil moisture retention and available water under alley cropping practices compared to non alley cropping practices.

Hegde (1995) examined the decomposition pattern of *Acacia mangium* leaf litter for ten months in a homegarden and observed an initial slight decrease in pH owing to the formation of organic acids and release of carbon dioxide associated with the rapid decomposition followed by slight increase in the final stages. The soil organic carbon content increased during both seasons (south west and north east), and reached a peak in the homegarden, while that in the open was found to decrease. In the first season, the soil nitrogen decreased in the initial stages of decomposition in the homegarden but remained almost stable in the open. However, a steady decrease was noted in the second season throughout the period of study in both areas. The available phosphorus, potassium, exchangeable calcium and magnesium status of the soil were found to increase with litter decomposition. During the rainy months heavy leaching losses leading to reduced potassium contents in soil was also noticed.

A monthly progressive increase in the soil organic carbon on decomposition of Eucalyptus, Acacia and forest leaf litter was illustrated by Moosa (1997). Vijaya and Naidu (1995) earlier reported a similar trend in albizzia. The variation in organic carbon under decomposing litter during the period of the above study ranged from 1.30 to 1.68 per cent, whereas that of the control soil was in the range 1.25 to 1.29 per cent.

Wang *et al.* (1991) found that casuarina accumulated large amounts of nutrients in litter and adds significantly to soil organic carbon and nitrogen . Soil physical properties such as moisture content, porosity and water holding capacity were reported to be better under tree cover than in open fields (Bronstern,1984 ; Pushkala and Sumam,1996).

Clark (1949) stated that the nature and activity of microflora and fauna in a given soil environment depend upon the crops grown and the management practices adopted. Clear felling of a scot's pine stand resulted in long lasting detrimental effect on the size of bacterial population (Lundgren, 1982).

Significant increase in the microbial activity under tree systems have been established by several authors (Yamoah and Mulongoy,1984; Bavappa *et al.*, 1986; Mathew, 1993). According to Susan and Alice (1996) application of organic materials to soil stimulated the microbial proliferation, the population and activity of microorganisms varied with the species under study.

Byju (1989) compared the biological activity in the surface soils under eucalyptus, acacia and cultivated / forest soils and the results revealed lowest activity under eucalyptus followed by acacia.

Animon (1992) also observed low microfloral activity in eucalyptus soils compared to that under acacia and cashew. Khan and Kapur (1992) investigated the microbial associations with the decomposition of forest litter. The total fungal population varied from 57.06 to 87.31 $x10^3$ depending upon the species. Bacterial counts varied from 62.35 to 96.09 $x10^3$ and the maximum population for both flora were observed during the fifth month of decomposition .

Vijaya and Naidu (1995) reported an initial rapid increase in fungal population in decomposing *Albizzia amara* leaf litter during the first month of litter decay. This initial increase during decomposition of leaf litter was confirmed by Moosa (1997). He also observed a decline in the fungal and bacterial population in the final stages of decomposition. Owing to their weak competitive ability, the actinomycetes were active only in the advanced stages of decomposition.

Microbial studies in homegardens also revealed intense microbial activity compared to open fields on account of the additions of large quantities of organic matter from the component crops (Mathew, 1993; John, 1997; Abraham, 1998). Nair and Rao (1979) in an intensively cropped coconut-cocoa mixed plantation reported the positive effect of litter fall in increasing microbial population.

Evidences are available to show that soil properties in the tree-crop systems are altered due to the litter addition and decomposition. Tree litter affects the soil properties and in some cases, reduces the stores and flux rates of available plant nutrients in the soil. The extent of changes in soil fertility depends on initial soil conditions, on the tree species and management practices followed. The density and diversity of decomposer organisms primarily influence the rate of litter decay.

The literature on the litter dynamics and nutrient cycling in tree based systems indicate substantial differences in nutrient recycling through litter fall with the species. The litter decay is controlled by several biotic and abiotic factors along with the litter quality. The rate of nutrient turnover and the pattern of nutrient release; accumulation or mineralisation on decomposition, differs between elements and is influenced by the physical and biochemical characteristics of the litter and the heterotrophic demand of the decomposer organisms. The characterization of litter fall, decay, nutrient dynamics and resulting changes in soil nutrient pools of homegardens have rarely been investigated. This investigation is intended to fill the lacunae in agroforestry systems.

MATERIALS AND METHODS

3. Materials and Methods

The investigation was initiated with the objectives of quantifying the litter of selected multipurpose trees commonly planted in homegardens and characterising the decomposition pattern of the leaf biomass in mango (*Mangifera indica*), jack (*Artocarpus heterophyllus*), cashew (*Anacardium occidentale*), wild jack (*Artocarpus hirsuta*), Ailanthus (*Ailanthus triphysa*) and mahogany (*Sweitenia macrophylla*). The materials used and the methodology adopted are detailed below.

3.1. Homegardens - Survey and Selection

A preliminary survey of 20 homegardens was done in the Kalliyur Panchayat, of Thiruvananthapuram District, Kerala to identify the trees required for the study. Based on the survey, three homegardens with mature trees of mango, jack, cashew, wild jack, Ailanthus and mahogany were selected. The information needed for the study was collected through personal interview with the farmers and by visual observation, by adopting the technique of random sample survey.

3.1.1 Site description

Three homegardens in Kalliyur Panchayat were identified as the experimental sites for the study. The homegardens comprised of an intense mix of a variety of multipurpose trees and agricultural crops. The sites located at an altitude of 40 m above mean sea level, 8.5^0 N latitude and 76.9^0

E longitude enjoy a warm humid climate receiving an annual rainfall of 1619 mm. The soil type of the area was oxisol with a sandy clay loam texture.

All the mature trees of different species grown in each homegarden were selected for the litter production study and for the litter decomposition study, the mature trees mango, jack, cashew, wild jack, ailanthus and mahogany with sufficient canopy spread were selected. An adjacent open area served as the control.

3.2 Litter dynamics of the homegardens

3.2.1 Litter fall

The monthly litter fall of mature trees in the homegardens were quantified from May 1998 to April 1999. Litter collection from the different tree species were made with litter traps devised locally and set under the trees. Litter traps, each of 0.75m diameter fabricated from plaited coconut leaves were used for the purpose. Sufficient number of traps were set below the trees in a random manner, one trap per 2 m^2 canopy area, secured on tripods at a height of 1m above the ground to collect the falling litter. The positions of the traps were interchanged at weekly intervals to account for the spatial variations encountered beneath the canopy. The quantity of litter collected at monthly intervals per unit area under the tree canopies were quantified separately for each species and the annual litter fall was computed after oven drying at 70^0C for 24 h using the following formula adopted by Mathew (1993), *Annual litter fall (kg year^{-1} tree area^{-1})*

$$= \frac{\text{Canopy area } (m^2) \times \sum_{1}^{n} \text{Monthly litter collection in the traps (kg)}}{\text{Total area of the litter traps } (m^2)}$$

n= number of months (12)

3.2.2 Nutrient addition

The litter samples from the different traps were pooled for each species, large twigs removed, dried in air oven at 70^{0}C for 24 h, powdered and analysed for nitrogen, phosphorus and potassium contents. The chemical analyses were done as per the standard procedures (Table 1a.). The nutrient addition by litter fall to the system was calculated by multiplying the total quantity of the litter added with its nutrient content and expressed as kg year^{-1} tree area^{-1} for each species.

3.3 Leaf litter decomposition

The decomposition pattern of leaf litter of mango, jack, cashew, wild jack, Ailanthus and mahogany in the homegardens were ascertained. Freshly fallen leaves in each species were collected during February to April 1998 to prepare the litter as the study material. The dry weight equivalents were determined by oven drying the stock litter samples at 70^{0}C for 48 h. Triplicate samples of the oven-dried litter in each species were kept apart for the initial biochemical analysis.

Litter decomposition study was initiated in the homegardens beneath the tree canopies and in the open area during the last week of April 1998.

Litter decomposition study was initiated in the homegardens beneath the tree canopies and in the open area during the last week of April 1998.

The standard litter bag technique (Bocock and Gilbert, 1957) was used for assessing the decomposition characteristics of leaf litter. Litter bags of size 25 x 20 cm were made from nylon nets (mesh size 4mm) and 20 g of air dried leaf litter filled in each bag. The bags were sealed by stitching the open ends. Two hundred such bags were prepared for each tree species under study and placed in the litter layer on the soil surface. These were fastened to the ground with 10-15 cm long bamboo stakes beneath the canopies of the appropriate species.

In the open area, where fodder grasses were grown for the last three seasons, six plots (each of 10 x 5 m^2) were marked as control plots for each litter species and placed for decomposition. Two hundred litter bags filled with 20g of the litter were placed in each plot for decomposition.

Samples were drawn at fortnightly intervals in the homegardens and control plots from the month of May 1998 until May 1999 completing the observations as and when 95 percent decomposition occured. Five bags in each species were retrieved during every sampling and brought to the lab for analysis.

3.3.1 Weight Loss

The samples retrieved during each sampling were sieved to remove soil and other extraneous material, dried at 70^{0}C for 48 h and weighed to assess the dry weight loss during decomposition.

3.3.2 Decay rate coefficients

It is assumed that there is a constant fractional weight loss from the material in litter bags as time elapsed (Anderson, 1973). Based on this, mathematical models (Appendix II) were fitted to find out the best equation and hence the decomposition model relating the weight loss and time elapsed. The decay rate coefficient (k) was computed as dy/dx from the best fit for each of the species studied at the two sites. The calculated k value estimated from the initial and final mass of litter recorded in the experiment was compared with the predicted k values based on the values derived from the equations.

3.3.3 Half-life

The half lives ($t_{0.5}$) of decomposing litter samples of each species were estimated from the best fit identified as the decomposition model for each species.

3.3.4 Nutrient release pattern

Samples of green leaves of each species, freshly fallen leaf litter and the residual litter mass collected during each sampling were subjected to chemical analysis in the lab after oven drying and grinding. Nitrogen, phosphorus, potassium, calcium, magnesium, zinc, manganese, iron and copper contents of the samples were analysed adopting the standard analytical methods (Table 1a.). In order to assess whether nutrients are lost from the litter in the bags or whether added from exogenous sources, the nutrient release and absolute amounts (amount of nutrients remaining in the decomposing leaf on decomposition) at various time intervals were estimated using the equation proposed by Bockheim *et al.* (1991)

Nutrient release or Relative concentration (%) $= (C_t/C_0) \times 100$

Nutrients remaining or Absolute concentration (%)

$$= (C_t/C_0) \times (DM_t/DM_0) \times 100$$

where C_0 *-Initial concentration of nutrient*

C_t *- Concentration of the nutrient after a time t*

DM_0 *- initial weight of dry matter kept for decomposition*

DM_t *- weight of dry matter after a time t*

3.3.5 Biochemical Analysis.

Leaf samples (green, freshly fallen and sampled litter from the litter bags) were analysed for cellulose, hemicellulose and lignin as per the procedures given in Table 1b.

3.3.6 Soil Analysis

Soil samples beneath each tree species included in the study and in the control plot were analysed for their physical, chemical and biological properties before the start of the field study. Further samples were taken as the decomposition proceeded, at monthly and tri-monthly intervals.

3.3.6.1 Physical properties

The soil lying immediately below the litter bags kept for decomposition were analyzed to assess the physical parameters of soil. The physical parameters such as bulk density, particle density, porosity, maximum water holding capacity were ascertained using Keen and Raczkowoski (1921) method.

3.3.6.2 Chemical properties

The chemical properties of the soil beneath the litter bags were analysed at monthly intervals. The soil pH was determined using the digital pH meter, organic carbon, available phosphorus, and potassium status following the methods suggested by Jackson (1973) and available nitrogen following the method of Subbiah and Asija (1956).

3.3.6.3 Biological Properties

3.3.6.3.1 Earthworm count

Soil samples of 1 m^2 area and 1 m deep were taken from beneath the tree canopy and from control plots and the counts of earthworms and cocoons were made to assess the earthworm population. The samples were sorted against a pale coloured background for easy detection of the earthworms. The counts were taken before the start of the experiment and subsequently at

Table.1a Chemical analysis of leaf and litter samples.

Nutrients	Method of estimation	Reference
Nitrogen	Modified microkjeldahl method	Jackson (1973)
Phosphorus	Vanado molybdate phosphorus yellow method	Jackson (1973)
Potassium	Flame photometer method	Jackson (1973)
Calcium Magnesium, Zinc, Manganese, Copper and Iron	Atomic absorption spectro photometry method	Lindsay and Norwal (1978)

1b. Biochemical analysis of leaf and litter samples

Cellulose	Acid-detergent fibre method	Sadasivan and Manickam (1992)
Hemicellulose	Neutral detergent fibre method	Sadasivan and Manickam (1992)
Lignin	Acid-detergent fibre method	Sadasivan and Manickam (1992)

monthly intervals. Counts from five different parts served as replications during each assessment.

3.3.6.3.2 Microbial population

The microbial population (bacteria, fungi and actinomycetes) from the soil beneath the canopy of each tree species in the homegardens and from the open area was estimated, before the start of the experiment and at monthly intervals. The dilution plate technique (Parkinson *et al.*,1971) was employed for the isolation. Fungi were cultured in Rose bengal agar media, bacteria in Soil extract agar media and actinomycetes in Conn's glycerol asparaginate agar media. The colony counts were taken after incubation at room temperature (28-32^{0}C) for five, seven and twelve days respectively. The data was used to compute the average number of microorganisms per gram of oven dry weight of soil.

3.3.7 Soil moisture and temperature

Soil moisture and temperature of the experimental site were recorded at fortnightly intervals.

The soil samples beneath the litter bags were analysed for their moisture content during each litter bag sampling, adopting the gravimetric method. Soil thermometers installed at 15 cm and 30 cm depth in the soil were used to record the soil temperature at these depths.

3.4 Statistical Analysis

The data pertaining to the different characteristics were statistically analysed applying the technique of analysis of variance (Panse and Sukathme, 1967). Statistical analysis for comparing the data between open and homegarden was done for the period during which data were available in both the sites, open and homegarden. The values for the remaining periods are the means of the replications and these are presented in the tables.

The decomposition model of leaf litter and release pattern of the different nutrients were worked fitting different regression equations using the software curve fit. Twenty four equations generally used for the growth curve analysis when there is only one dependent and one independent variable were used for working out the models. The best fit based on the multiple correlation coefficient (R^2) relating the weight loss over the different periods in the two situations was identified as the prediction model for decomposition for the different tree species. The twenty-four equations fitted are given in Appendix II.

Correlation studies were done to study the influence of soil temperature and soil moisture on the weight loss of litter during decomposition and also to assess the influence of the litter quality (nitrogen, lignin, carbon: nitrogen ratio and lignin : nitrogen ratio) on the decay rate. The contents of nitrogen, lignin, carbon : nitrogen ratio and lignin : nitrogen ratio in the initial litter samples of the different tree species are given in Table 2.

Table 2. Contents of nitrogen, lignin, lignin : N and C:N ratio in the initial litter samples

Species	lignin (%)	Nitrogen (%)	lignin : N ratio	C:N ratio
Mango	19.31	1.320	14.63	33.17
Jack	15.18	0.908	16.72	46.89
Cashew	13.38	1.278	10.47	37.10
Ailanthus	17.98	1.458	12.33	32.48
Wild jack	28.86	1.102	26.19	52.34
Mahogany	32.10	1.300	24.69	41.54

i) Homegarden I

ii) Homegarden II

iii) Homegarden III

Plate 1. General view of homegardens

RESULTS AND DISCUSSION

4. Results and Discussion

Litter production and decomposition is well documented as the means of sustaining the soil productivity in tree- crop systems. The homegardens in Kerala are characterized by an intimate mix of trees, agricultural crops and animals. The tree components utilize inorganic nutrients from soil to build biomass and simultaneously return a substantial portion of the nutrients to the soil through litter fall. The relative importance of litter as a source of organic material and nutrient inputs needs justification in homegardens. The present chapter describes the results on the structure of three homegardens, litter quantification in the homesteads and nutrient release from leaf litter of six commonly grown tree species- mango, jack, cashew, ailanthus, wild jack and mahogany, on decomposition.

4.1 Structure of homegardens

Detailed inventory of the various components in the homegardens I, II and III are given in Tables 3a, 3b and 3c respectively.

The net area of the homestead I was 5400.0 m^2. The house, road and other permanent structures (cattle shed etc.) together occupied an area of 1400.0 m^2. The net area available for crop cultivation was 4000.0 m^2. The area occupied by the various tree/crop components was 7481.65 m^2 resulting in a cropping intensity of 187.04 per cent. The major perennial tree crop in the homegarden was coconut (adult palms), which constituted 56.6 per cent of the gross cropped area. The second important species was

Table 3a. Inventory of homegarden I

Sl. No.	Enterprise	Scientific name	Population (nos)	Space used (m^2)
1.	Coconut	*Cocos nucifera*	150	4239.00
2.	Wild jack	*Artocarpus hirsuta*	9	233.13
3.	Mango	*Mangifera indica*	4	118.00
4.	Jack	*Artocarpus heterophyllus*	2	141.89
5.	Cashew	*Anacardium occidentale*	2	101.56
6.	Mahogany	*Swietenia macrophylla*	1	9.62
7.	Ailanthus	*Ailanthus triphysa*	5	25.77
8.	Tamarind	*Tamarindus indicus*	1	20.26
9.	Morinda	*Morinda tinctoria*	2	22.06
10.	Banana	*Musa sp.*	200	2267.08
11.	Amorphophallus	*Amorphophallus paenifolius*	40	125.60
12.	Pepper	*Piper nigrum*	110	trailed
13.	Curry leaf	*Murraya koenigii*	3	8.35
14.	Moringa	*Moringa oleifera*	6	23.55
15.	Papaya	*Carica papaya*	2	6.15
16.	Coconut nursery	*Cocos nucifera*		120.00
17	Pineapple	*Ananas comosus*	25	19.63
	TOTAL			7481.65

wild jack. The canopy configuration of the homegardens could be categorized into five layers; uppermost >25 m, second layer 10-25 m, third layer 3-10 m, fourth layer 1-3 m and the fifth layer, <1 m. In this homegarden, the perennials, coconut, mango and wild jack formed the uppermost layer of the canopy (>25m). Jack, tamarind, mahogany and black pepper formed the second layer; morinda, cashew and ailanthus the third layer, papaya, curry leaf, moringa, tapioca and banana the fourth layer. Fodder grasses grown in the inter spaces of the perennials along with amorphophallus and pineapple constituted the lowermost layer (Fig. I). Coconut seednuts were planted in an area of 120 m^2.

The homegarden II comprised of a net area of 5000 m^2. The house, roads and other permanent structures (store, sheds etc.) occupied an area of 2000 m^2 and the net cropped area was worked out as 3000 m^2. The gross cropped area occupied by the tree crop components was 5600.17 m^2 and this resulted in a cropping intensity of 186.67 per cent. Wild jack and coconut were the major perennial species in the homegarden and coconut occupied 61 per cent of the gross cropped area. Coconut and wild jack occupied the uppermost layer of the canopy. Tamarind, mahogany, jack and black pepper formed the second layer. Mango, erythrina, cashew and morinda, constituted the third layer. Coffee, sapota, nutmeg, curry leaf, bilimbi, papaya, cherry, dioscorea, tapioca and banana formed the fourth layer. The fifth layer was constituted by the annual agricultural crops viz., ginger, turmeric, amorphophallus and colocasia (Fig. I).

Table 3b. Inventory of homegarden II

Sl.No.	Enterprise	Scientific name	Population (nos)	Space used (m^2)
1.	Coconut	*Cocos nucifera*	120	3391.2
2.	Wild jack	*Artocarpus hirsuta*	12	120.25
3.	Mango	*Mangifera indica*	2	102.87
4.	Jack	*Artocarpus heterophyllus*	1	93.61
5.	Cashew	*Anacardium occidentale*	3	94.18
6.	Mahogany	*Swietenia macrophylla*	1	35.24
7.	Sapota	*Acras sapota*	1	5.31
8.	Tamarind	*Tamarindus indicus*	2	72.46
9.	Morinda	*Morinda tinctoria*	2	12.26
10.	Bilimbi	*Averrhoia bilimbi*	2	11.64
11.	Cherry	*Malphigia glabra*	1	9.51
12.	Coffee	*Coffea arabica*	2	26.28
13.	Nutmeg	*Myristica fragrans*	1	11.58
14.	Erythrina	*Erythrina indica*	3	49.84
15.	Curry leaf	*Murraya koenigii*	15	26.49
16.	Papaya	*Carica papaya*	10	45.22
17.	Banana	*Musa sp.*	80	1004.80
18.	Colocasia	*Colocasia esculenta*	25	78.50
19.	Tapioca	*Manihot esculenta*	50	76.93
20.	Amorphophallus	*Amorphophallus paenifolius*	30	76.30
21.	Dioscorea	*Dioscorea alata*	20	15.70
22.	Ginger	*Zingiber officinale*		200.00
23.	Turmeric	*Curcuma longa*		40.00
24.	Black pepper	*Piper nigrum*	80	Trailed
	TOTAL			5600.17

At homegarden III, the net area was 7600.0 m^2. The house, roads and other permanent structures occupied 1000.0 m^2. The net area available for cultivation was 6600.0 m^2 and the gross cropped area of trees and crops, 11694.09 m^2. Cropping intensity at this location was worked out to be 177.18 per cent. Adult coconut palms occupied an area of 3532.50 m^2 and young palms 1360.25 m^2. The uppermost canopy in the homegarden was that of coconut, wild jack and jack. Mango and mahogany formed the second layer. The third layer was constituted by cashew, morinda, erythrina, vatta and ailanthus. Clove, breadfruit, tapioca and banana formed the fourth layer; guinea grass, ginger and colocasia the fifth layer and floor crops of this homegarden (Fig. I).

The cropping pattern adopted by the farmers reveal the structural complexity and species diversity of homegardens, which is unique to tropical homegardens. Several authors have earlier illustrated this. The design of the gardens has been based on the preference of the individual farmer. However, each garden has maintained a high cropping intensity ensuring that not much land/ space is left unused. The reports of Nair and Sreedharan (1986) and Abdulsalam *et al.* (1992) support the observation of high cropping intensity in homegardens.

The selection of species grown in each garden was done by the farmer based on his interest and needs and the spatial arrangement based on the space available. The three homegardens studied represent a coconut based multi-tier cropping system as the canopies of the different tree species' are layered ensuring annidation in space. Agricultural crops

Species	Height
Coconut, Mango, Wild jack	>25 m
Jack, Tamarind, Black pepper, Mahogany	10-25 m
Morinda, Cashew, Ailanthus	3-10 m
Papaya, Curry leaf, Moringa, Banana, Tapioca	1-3 m
Amorphophallus, Pineapple, Fodder Grass	<1 m

Homegarden I

Species	Height
Coconut, Wild Jack	>25 m
Tamarind, Jack, Black pepper, Mahogany	10-25 m
Mango, Erythrina, Cashew, Morinda	3-10 m
Coffee, Sapota, Nutmeg, Cherry, Papaya, Curry leaf, Bilimbi, Tapioca, Dioscorea, Banana	1-3 m
Ginger, Turmeric, Amorphophallus, Colocasia	<1 m

Homegarden II

Species	Height
Coconut, Wild jack, Jack	>25 m
Mango, Mahogany	10-25 m
Cashew, Morinda, Erythrina, Vatta, Ailanthus	3-10 m
Clove, Bread Fruit, Banana, Tapioca	1-3 m
Guinea grass, Colocasia, Ginger	<1 m

Homegarden III

Fig . Canopy configurations in the three homegardens.

Table 3c. Inventory of homegarden III

Sl.No.	Enterprise	Scientific name	Population (nos)	Space used (m^2)
1.	Coconut	*Cocos nucifera*	125	3532.50
2.	young palms	*Cocos nucifera*	30	1360.25
3.	Wild jack	*Artocarpus hirsuta*	3	80.23
4.	Mango	*Mangifera indica*	2	57.22
5.	Jack	*Artocarpus heterophyllus*	3	188.76
6.	Cashew	*Anacardium occidentale*	1	49.26
7.	Mahogany	*Swietenia macrophylla*	1	9.29
8.	Ailanthus	*Ailanthus triyphysa*	2	13.27
9.	Clove	*Eugenia caryophylla*	3	8.10
10.	Bread fruit	*Artocarpus altilis*	3	52.28
11.	Morinda	*Morinda tinctoria*	2	16.45
12.	Erythrina	*Erythrina indica*	3	46.31
13.	Vatta	*Macarenga peltata*	3	33.51
14.	Banana	*Musa sp.*	300	3768.00
15.	Colocasia	*Colocasia esculenta*	100	346.19
16.	Guinea grass	*Panicum maximum*		1200.00
17.	Tapioca	*Manihot esculenta*	75	132.47
18.	Ginger	*Zingiber officinale*		400.00
19.	Turmeric	*Curcuma longa*		400.00
	TOTAL			11694.09

comprised mostly of banana, fodder grasses, spices viz. black pepper, ginger and turmeric and tuber crops. Of these, grasses and tuber crops are known to perform well even under low input and management conditions. Grasses conserve the soil and are feeds for the livestock unit, and tubers provide nutritional security to the farm family. Banana and the spice crops viz., ginger, turmeric, black pepper etc. are remunerative and contribute to the farm family income.

4.2 Litter and nutrient dynamics of the homegardens

4.2.1 Litter fall

The annual litter additions by the different tree species in the three homegardens are given in Tables 4a, 4b and 4c.

The annual litter addition at homegarden I was 473.60 kg from the eight tree species grown in the homegardens. The maximum amount of litter was from wild jack 151.34 kg and this accounted for 32.0 per cent of the total litter fall during the period of study. This was followed by jack (103.10 kg) and mango (102.42 kg). The large amount of litter additions by wild jack is due to the more number of wild jack trees present in the homegarden.

In homegarden II, the annual litter addition was 425.37 kg from 13 trees, the maximum was from mango (81.35 kg) followed by wild jack (78.18 kg), jack (66.81 kg) and tamarind (65.06 kg). Sapota added the least amount of litter.

In homegarden III, with eleven species of trees, the addition was 345.11 kg of litter during the period of study. Jack was observed to add

Table 4a. Litter and nutrient addition in homegarden I

Tree species	Litter addition	Nutrient addition		
		Nitrogen	Phosphorus	Potassium
	kg yr^{-1} tree $area^{-1}$	kg yr^{-1} tree $area^{-1}$	kg yr^{-1}tree $area^{-1}$	kg yr^{-1}tree $area^{-1}$
Wild jack	151.34	1.611	0.0722	0.385
Mango	102.42	1.068	0.0531	0.351
Jack	103.10	1.219	0.0553	0.312
Cashew	73.36	0.896	0.0351	0.163
Mahogany	6.29	0.067	0.0015	0.025
Ailanthus	9.87	0.165	0.0044	0.033
Tamarind	16.62	0.267	0.0184	0.049
Morinda	10.60	0.121	0.0093	0.041
Total	473.60	5.414	0.2493	1.359

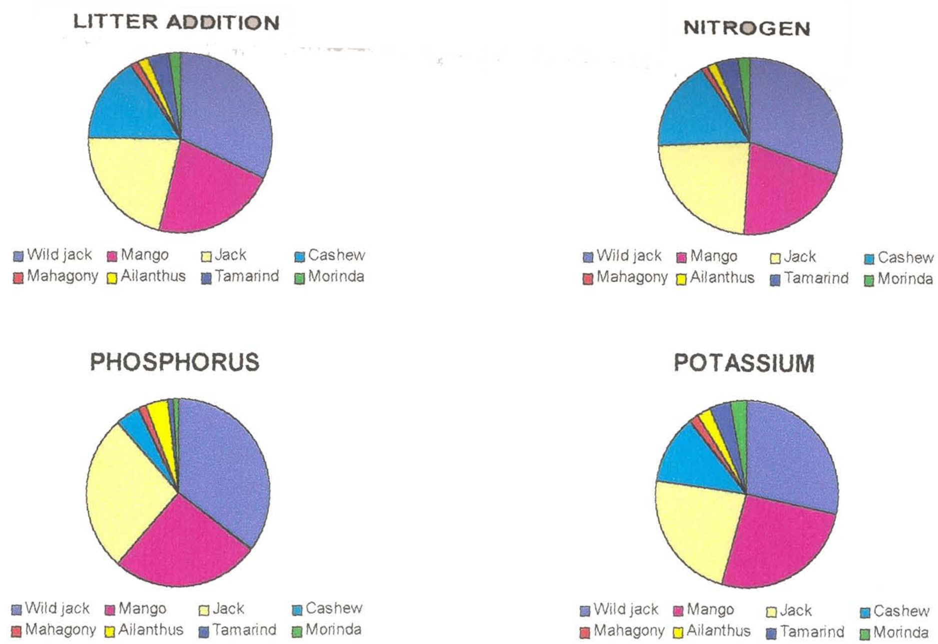

Fig. 2. Contribution of litter and nutrients by the different tree species at homegarden I (%)

maximum amount of litter (118.72 kg), which was 34 per cent of the annual litterfall. Wild jack added 62.78 kg of litter annually and breadfruit added 42.14 kg litter. The addition of litter in the other species decreased in the order mango>cashew > erythrina >macarenga >morinda >ailanthus >mahogany >clove.

4.2.2 Nutrient addition

The nutrient addition (nitrogen, phosphorus and potassium) through litter fall is presented in Table 4a,4b and 4c.

The nutrient addition via tree litter in homegarden I was worked out to be 5.414 kg N, 0.249 kg P and 1.359 kg K. Wild jack added the maximum amount of nutrients (1.611 kg N, 0.072 kg P and 0.385 kg K) followed by jack (1.219 kg N 0.055 kg P and 0.312 kg K) and mango (1.068 kg N, 0.053 kg P and 0.351 kg K).

Data on the nutrient addition in homegarden II (Table 4b) revealed that 5.892 kg nitrogen, 0.267 kg phosphorus and 1.358 kg potassium were added by 13 tree species grown during one year. Tamarind added the largest amount of nitrogen (17.7 per cent), and phosphorus (27.0 per cent) while mango litter added the highest amount of potassium (14.3 per cent). The lowest amount of nutrient addition was by sapota in the case of nitrogen, phosphorus and potassium.

The annual nutrient input from 11 tree species in homegarden III was 3.759 kg N, 0.182 kg P and 1.224 kg K. Considering the canopy area of the trees, the nutrient addition through litter was highest for jack (nitrogen, phosphorus and potassium). Wild jack added the second largest

Table 4b.Litter and nutrient addition in Homegarden II

Tree species	Litter addition	Nutrient addition		
		Nitrogen	Phosphorus	Potassium
	kg yr^{-1}tree $area^{-1}$	kg yr^{-1}tree $area^{-1}$	kg yr^{-1}tree $area^{-1}$	kg yr^{-1}tree $area^{-1}$
Wild jack	78.18	0.837	0.0373	0.194
Mango	81.35	0.898	0.0432	0.283
Jack	66.81	0.762	0.0337	0.199
Cashew	35.61	0.430	0.0160	0.054
Mahogany	31.08	0.329	0.0089	0.126
Sapota	1.93	0.025	0.0014	0.006
Tamarind	65.06	1.043	0.0717	0.194
Morinda	6.86	0.779	0.0060	0.027
Bilimbi	5.30	0.060	0.0030	0.014
Cherry	2.48	0.026	0.0028	0.018
Coffee	16.33	0.270	0.0145	0.079
Nutmeg	6.55	0.142	0.0049	0.027
Erythrina	27.83	0.291	0.0234	0.137
Total	425.37	5.892	0.2668	1.358

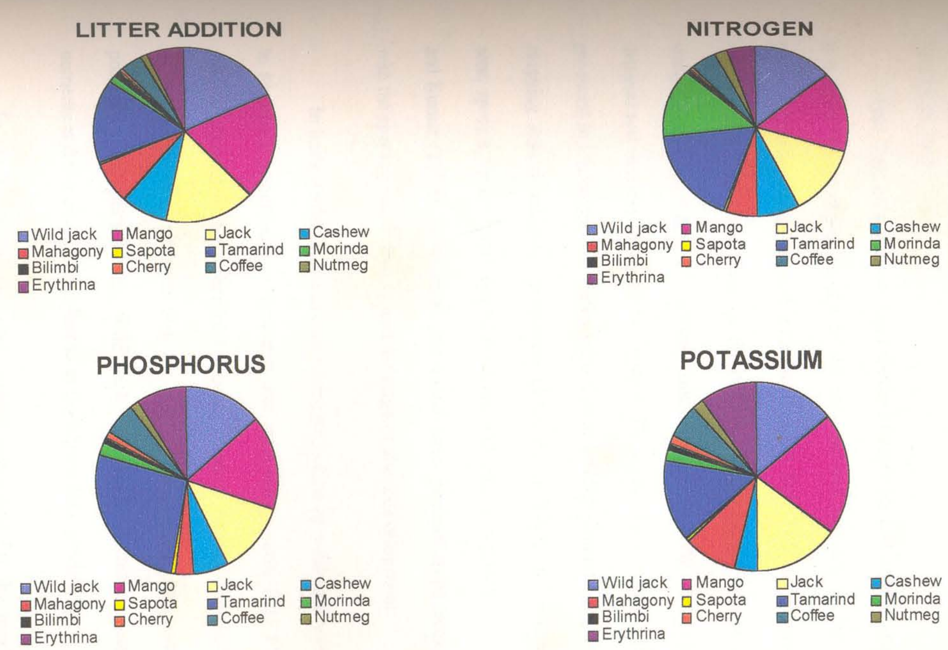

Fig. 3. Contribution of litter and nutrients by the different tree species at homegarden II (%)

amount of nitrogen and phosphorus through its litter and breadfruit litter added second largest amount of potassium. The least input of nutrients was from clove litter.

Tree litter serves as a critical source of nutrients and organic matter in homesteads. A major portion of the accumulated nutrients in the tree biomass is returned to the soil through the litter fall. The key feature of homegardens is the high rate of litter production, leading to an almost complete ground cover of decomposing litter, increasing the organic material and nutrient inputs of the system. However, the quantity of litter produced in a homegarden varies from that in another depending upon the cropping system adopted, prevailing climatic conditions, net cultivated area, species, density and age of the trees and crop components. George and Kumar (1998) documented that annual litter production of trees vary with the species, stand density and /or stage of stand development.

In homegarden I, maximum litter production by wild jack was due to its higher population (9 numbers) and total canopy area (233.13 m^2) when compared to the other tree species present. Among the nutrients added by litterfall, nitrogen was the predominant element followed by potassium and phosphorus. Wild jack added the highest amount of nutrients and this could be attributed to the higher litter production.

In the second homegarden, mango accounted for the maximum amount of litter added in the homegarden (19.1 per cent), followed by, wild jack (18.4 per cent), jack (15.7 per cent) and tamarind (15.3 per cent).

Table 4c. Litter and nutrient addition in homegarden III

Tree species	Litter addition	Nutrient addition		
		Nitrogen	Phosphorus	Potassium
	kg yr^{-1}tree $area^{-1}$	kg yr^{-1}tree $area^{-1}$	kg yr^{-1}tree $area^{-1}$	kg yr^{-1} tree $area^{-1}$
Wild jack	62.78	0.558	0.0281	0.148
Mango	37.31	0.407	0.0195	0.127
Jack	118.72	1.395	0.0642	0.368
Cashew	25.39	0.312	0.0118	0.039
Mahogany	6.56	0.071	0.0014	0.023
Ailanthus	6.65	0.111	0.0031	0.022
Clove	3.74	0.056	0.0016	0.018
Bread fruit	42.14	0.452	0.0182	0.298
Morinda	8.99	0.102	0.0114	0.035
Erythrina	19.25	0.201	0.0158	0.099
Vatta	13.58	0.094	0.0067	0.047
Total	345.11	3.759	0.1818	1.224

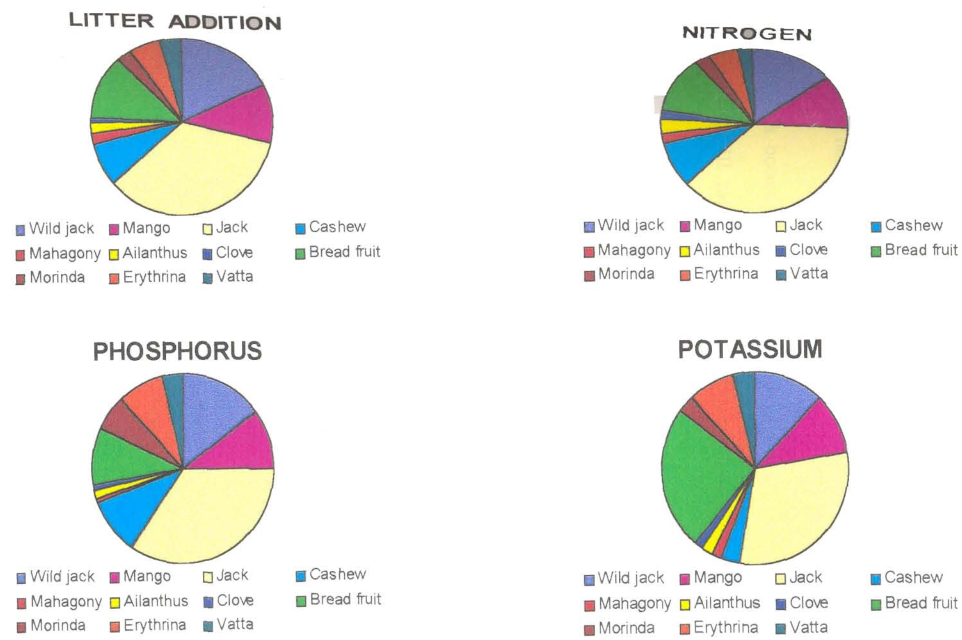

Fig. 4. Contribution of litter and nutrients by the different tree species at homegarden III (%)

Sapota added the least amount of litter owing to the low population and canopy area (5.31 m^2). The amount of nitrogen added via litter was highest followed by potassium and phosphorus. Nutrient addition (nitrogen, phosphorus and potassium) was maximum via tamarind litter owing to their higher nutrient contents and litter production of the species.

Jack occupied the first position in annual litter production in homegarden III followed by wild jack and breadfruit. The litter fall accounted for maximum input of nitrogen and least for phosphorus. The largest contribution of the nutrient inputs was from jack litter and this could be attributed to the higher quantity of litter fall that occurred in the species.

Of the three homesteads investigated, the maximum amount of litter fall was recorded at homegarden I (473.60 kg). The total nutrient addition was also more in this location (7.02 kg). The data tabulated on litter fall and nutrient additions are comparable with the results of Mathew *et al.* (1996), Nair *et al.* (1996) and John (1997). Abraham (1998) recorded positive correlation between the litter addition and canopy area of the trees. The present study also gave the same results. The higher litter production by certain species is due to various factors like age of the tree, leaf area, texture, canopy exposure, basal area etc. (Van Cleve and Noonan, 1975 ; Bell *et al.*, 1978)

Of the three major nutrients, nitrogen was the most important nutrient accrued to soil through the litter and phosphorus the least in all the locations studied. This is in conformity with the reports of Das and Ramakrishnan (1985), Vinayan (1992), Saravanan *et al.* (1995) and Nair *et al.* (1996). Potassium in the above ground mass is known to be stored in the tree stems contributing to lower inputs in the litter. The same was reported in the case of *Calliandra allidora,* a shade tree in coffee plantations by Beer (1988). The quantum of phosphorus addition was the least as compared to nitrogen and potassium and it could be deduced that this is due to the comparatively low phosphorus content in the leaves.

Although many authors have strongly argued that the amount of nutrients added through litter is more dependent on the quantum of litter produced by the tree species than on the nutrient content, in this study it has been found to hold good only in two homegardens, I and III. In the second homegarden, it was observed that in spite of mango producing the maximum amount of litter during the period of study, the nutrient return through litter was lesser (1.22 kg), the highest being for tamarind (1.31 kg), emphasizing that the nutrient content of the litter also had a significant role in deciding the nutrient turn over. A similar observation was documented by Shajikumar (1991). In his study even though Eucalyptus was found to produce more litter compared to that by Leucaena and Glyricidia, the amount of nutrients added to soil was low owing to its low nitrogen, phosphorus and potassium contents. Thus, the quantity of litter produced and the nutrient content of the litter are both important in finally deciding the amount of nutrients added through litter fall. The variation in the amounts of nutrients added by different species could also be due to the differences in age, canopy area and inherent differences between the species.

The data of the study emphasize that presence of tree components in homegardens is desirable as the litter can serve as an important nutrient resource. Trees accumulate substantial amount of nutrients in their different organs during their growth period and a portion of these reach the soil by way of litterfall. Reports on litterfall being a major nutrient pathway were given by Cole and Rapp (1980) and Okeke and Omaliko (1991). Moreover, Singh *et al.* (1993) reported that herbaceous litter contributes appreciable quantities of nitrogen, phosphorus and potassium. The litter on decomposition is capable of releasing the nutrients entrapped in them for use by associated crops. Thus the relative importance of litterfall as an input-output system for nutrients in the tree- crop communities in homegardens is justified.

4.2.3 Chemical and biochemical composition of leaf litter

The data on the chemical and bio chemical status of green leaves and freshly fallen litter are given in Table 5.

Perusal of the data revealed significant differences in the chemical composition of the fresh leaves and fallen litter among the different species. Nitrogen content was highest in Ailanthus leaves, fresh and fallen (1.526 and 1.458 per cent respectively) followed by mahogany and mango. Phosphorus, potassium, calcium and magnesium contents were highest and significantly superior in jack compared to all other species. Among the

Table 5. Chemical and biohemical composition of green leaves and fallen litter of the different tree species.

Tree species	N%	P%	K%	Ca%	Mg %	Zn ppm	Mn ppm	Cu ppm	Fe ppm	lignin %	cellulose%	hemicellulose%
Fresh leaves												
Mango	1.438	0.042	0.472	0.772	0.090	2.008	3.304	8.50	211.60	13.94	30.70	28.26
Jack	1.144	0.140	0.772	1.000	0.182	2.860	2.236	6.92	174.60	10.26	33.92	21.02
Cashew	1.402	0.053	0.165	0.272	0.112	1.850	3.708	4.72	220.00	9.80	40.08	14.26
Ailanthus	1.526	0.062	0.487	0.282	0.078	3.040	2.064	2.24	110.80	13.60	22.82	23.96
Wild jack	1.240	0.059	0.688	0.384	0.089	1.222	1.842	3.74	146.00	20.50	31.24	24.94
Mahogany	1.364	0.063	0.636	0.826	0.077	3.794	0.342	6.36	183.00	27.00	27.26	22.60
CD	0.166	0.083	0.042	0.061	0.009	0.276	0.383	0.819	26.86	1.44	2.705	1.57
Fallen leaf litter												
Mango	1.302	0.030	0.36	0.84	0.086	2.138	4.060	9.60	2 61.40	19.30	33.88	31.02
Jack	0.908	0.126	0.60	0.96	0.147	3.750	2.704	7.57	168.60	15.18	41.38	25.80
Cashew	1.278	0.040	0.13	0.30	0.096	2.042	4.256	5.20	269.20	13.38	46.56	15.52
Ailanthus	1.458	0.052	0.37	0.38	0.066	3.998	2.608	3.00	133.80	17.98	31.40	25.56
Wild jack	1.102	0.049	0.59	0.49	0.075	1.484	2.164	4.64	160.20	28.86	36.30	28.66
Mahogany	1.300	0.051	0.58	0.91	0.070	4.748	0.366	7.40	196.40	32.10	33.80	27.50
CD	0.144	0.025	0.102	0.083	0.059	0.686	0.724	3.543	57.23	0.425	0.894	0.577

micronutrients, fresh and fallen leaves of mahogany had the maximum amount of zinc, mango, copper and cashew, manganese and iron.

It was further noticed that the contents of the major mineral elements in fallen leaves were lower than that of fresh foliage while micronutrient contents were greater in the litter.

The nitrogen contents of leaf decreased as leaf age increased irrespective of the species. Phosphorus and potassium concentrations in the leaves also exhibited the same inverse relationship with age. Calcium content increased with ageing of the leaves, whereas magnesium contents were higher in the younger green leaves. The micronutrient concentrations (zinc, manganese, copper and iron) were observed to be higher in the fallen litter compared to the green leaves in all species.

The trends observed in the nutrient contents in the green leaves and litter are in line with those reported by Moosa (1997). Differences in nutrient contents in the fresh and fallen leaves may be due to the differences in the mobility of these elements within the plants. Helmissari (1992) attributed the low nutrient content of the foliage fraction of litter in comparison to fresh foliage as due to re-translocation of mineral nutrients from ageing foliage to other tissues before senescence. Accordingly, the low contents of nitrogen, phosphorus, potassium and magnesium in the leaf litter may be attributed to the mobility of these elements. This results in their greater concentrations in the fresh leaves. The transportation to younger leaves is slow in the case of the immobile elements (calcium, zinc, manganese, copper and iron) which leads to the lower contents of these elements in the fresh leaves compared to the older leaves (litter).

Young (1997) and Mafongoya *et al.* (1998) had opined that litter differs from green foliage in that it has lower nutrient content due to translocation of nutrients before litter fall. Hence the quality and decomposition rates of litter and green foliage from the same plant will be markedly different.

The biochemical constituents (cellulose, lignin and hemicellulose) in the green leaves and litter also varied significantly between the different species. The cellulose content was highest in cashew, lignin content was highest in mahogany and hemicellulose in mango. As compared to the fresh leaf the biochemical parameters were high in the leaf litter in all species. Similar reports on the accumulation of cellulose and lignin with ageing have been given by Moosa (1997).

The composition of organic compounds in leaves is of great significance in litter decomposition. Organic compounds present in litter serve as energy sources for soil organisms responsible for decomposition. These soluble carbon compounds promote microbial growth. Celluloses and other structural polysaccharides are attacked by the microbes after the soluble fractions have been depleted (Swift *et al.*, 1979). Lignin on its own provides no energy to the decomposers until the late stages of decomposition and is thus degraded more slowly than most litter constituents. It can also interfere with the rate of decomposition as lignin is found to intertwine with the cell wall, physically protecting cellulose and other cell wall constituents from degradation (Chesson, 1997). Litter which is mostly composed of old leaves, will be highly lignified and hence decomposition rate and nutrient release will be comparatively slower than from fresh foliage.

4.3 Leaf litter decomposition

The decomposition of mango, jack, cashew, Ailanthus, wild jack and mahogany leaf litter were studied in the selected homegardens and open site. The results of the same are presented and discussed below

4.3.1 Weight loss

4.3.1.1 Mango

The weight loss of mango leaf litter on decay at fortnightly intervals is given in Table 6 a.

Critical analysis of the data showed that there was significant difference in the decomposition in the two situations. The weight loss was more pronounced and rapid in the homegarden compared to that in the open condition. In the open plot more than 95 per cent decomposition occurred in 17 fortnights whereas in the homegarden the same took only 12 fortnights.

The weight loss in the open was gradual in the early fortnights and 50 per cent loss of dry weight occurred in eight fortnights. Mango leaf litter in the homegarden lost 58 per cent of its weight in the first seven fortnights.

Table 6a. Quantity of litter of mango, jack and cashew after decomposition at fortnightly intervals (g)

	Mango		Jack		Cashew	
Fortnight	Open	Homegarden	Open	Homegarden	Open	Homegarden
0	20.000 (100.00)	20.000 (100.00)	20.000 (100.00)	20.000 (100.00)	20.000 (100.00)	20.000(100.00)
1	18.736 (93.68)	19.400 (97.00)	19.202 (96.01)	18.334 (18.33)	18.61 (93.04)	18.70 (93.51)
2	17.642 (88.21)	18.898 (94.49)	17.228 (86.14)	16.15 (80.50)	17.35 (86.74)	17.34 (86.72)
3	16.112 (80.56)	18.268 (91.34)	15.936 (79.68)	14.718 (73.59)	16.33 (81.64)	15.31 (76.55)
4	14.540 (72.70)	16.896 (84.48)	15.160 (75.8)	12.366 (61.83)	15.21 (76.06)	14.40 (72.02)
5	13.652 (68.26)	13.928 (69.64)	13.148 (65.74)	7.544 (37.72)	14.78 (73.88)	4.50 (22.49)
6	12.568 (62.84)	10.838 (54.19)	11.374 (56.87)	6.282 (31.41)	12.72 (63.61)	3.92 (19.58)
7	11.090 (55.45)	5.770 (28.85)	10.196 (50.98)	5.308 (26.54)	11.26 (56.31)	3.74 (18.72)
8	10.098 (50.49)	4.596 (22.98)	6.462 (32.31)	3.168 (15.84)	7.16 (35.78)	3.13 (18.72)
9	7.294 (36.47)	2.844 (14.22)	5.230 (26.15)	2.898 (14.49)	3.45 (17.26)	1.57 (7.83)
10	5.454 (27.27)	2.688 (13.44)	4.042 (20.12)	0.592 (2.96)	1.74 (8.69)	0.97 (4.83)
11	4.658 (23.29)	1.196 (5.98)	2.516 (12.58)	-	1.32 (6.60)	0.49 (2.43)
12	3.898 (19.49)	0.446 (2.23)	1.972 (9.86)	-	0.74 (3.69)	-
13	3.288 (16.44)	-	1.064 (5.32)	-	0.22 (1.08)	-
14	1.970 (9.85)	-	0.666 (3.33)	-		
15	1.410 (7.07)	-				
16	1.960 (9.83)	-				
17	0.384 (1.92)	-				

The figures in parenthesis represent the relative mass of litter (%) at fortnightly intervals

4.3.1.2 Jack

The residual weight in jack litter varied significantly in the open and in the homegarden. (Table.6 a)

In the open the weight loss was gradual compared to that in the homegarden. Sampling was done until 95 per cent weight loss occurred and this took 14 fortnights in the open whereas the same took only 10 fortnights in the homegarden. The relative weight loss was 97 per cent at the end of decomposition in both situations.

4.3.1.3 Cashew

The data pertaining to the weight of leaf litter remaining at the time of sampling at fortnightly intervals are presented in Table 6 a.

Analysis of variance revealed significant decline in the residual weight of litter in the open and homegarden. In the open 20 g air dried cashew leaf litter decomposed 95 per cent of its original weight in 13 fortnights whereas in the homegarden the same was completed in 11 fortnights. The weight loss over the months was more rapid in the homegarden compared to that under open condition. The decomposition was gradual in the open and the relative mass loss was highest during the months of August and September (6-9 fortnights), the relative mass at the end of the fifth fortnight being 74 per cent and at the end of the ninth fortnight being 17 per cent. However, in the homegarden the residual weight was 4.498 g by the end of the fifth fortnight ensuring 78 per cent decomposition within this period.

4.3.1.4 Ailanthus

The data pertaining to residual weight of ailanthus leaf litter at fortnightly intervals are presented in Table 6 b.

The loss in weight of the litter kept for decomposition followed a linear pattern (Fig.5). In the open, 95 per cent of the weight loss occurred in 16 fortnights and in 15 fortnights in the homegarden. Fifty percent loss was observed by the eighth fortnight in both situations. Further decay was completed in another eight fortnights in the open, whereas, the same took only seven fortnights in the homegarden.

4.3.1.5 Wild jack

Table 6 b. gives the weight loss pattern of wild jack leaf litter.

The initial weight of 20 g was reduced to 0.368 g in the open in 19 fortnights and to 0.504 g in 17 fortnights in the homegarden. The rate of weight loss was more in the open in the early stages compared to that in the homegarden, but more rapid during the sixth, seventh and eighth fortnights in the latter situation. The weight remaining relative to the original weight was 55 per cent by the eighth fortnight in both situations, and then on, decomposition was completed more quickly in the homegarden. It took eleven more fortnights to complete 95 per cent decomposition in the open while only nine fortnights more in the homegarden.

4.3.1.6 Mahogany

The data on the residual weight of mahogany litter remaining during the different fortnights are given in Table 6 b. Ninety five per cent

Table 6b. Quantity of litter of ailanthus, wild jack and mahogany after decomposition at fortnightly intervals (g)

Fortnight	Ailanthus		Wild jack		Mahogany	
	Open	Homegarden	Open	Homegarden	Open	Homegarden
0	20.000 (100.00)	20.000 (100.00)	20.000 (100.00)	20.000 (100.00)	20.000 (100.00)	20.000 (100.00)
1	19.428 (7.14)	18.784 (93.92)	19.722 (98.61)	19.906 (99.53)	19.382 (96.91)	19.812 (99.06)
2	17.328 (86.64)	18.384 (91.92)	19.350 (96.75)	19.610 (98.05)	18.090 (90.45)	19.238 (96.19)
3	16.396 (81.98)	16.780 (83.90)	18.522 (92.61)	18.428 (92.14)	17.778 (88.89)	18.518 (92.59)
4	15.322 (76.61)	15.628 (78.14)	18.192 (90.96)	18.218 (91.09)	17.070 (85.35)	18.272 (91.36)
5	14.796 (73.98)	14.658 (73.29)	17.158 (85.790	14.152 (70.76)	16.460 (82.3)	17.174 (85.87)
6	12.090 (60.45)	12.430 (62.15)	15.480 (77.40)	12.598 (62.99)	14.104 (70.52)	15.594 (77.97)
7	11.572 (57.86)	11.346 (56.73)	14.230 (71.15)	12.162 (60.81)	12.998 (64.99)	14.650 (73.25)
8	9.882 (49.41)	10.142 (50.71)	11.062 (55.31)	11.010 (55.05)	11.384 (56.92)	13.606 (68.03)
9	9.084 (45.42)	8.362 (41.81)	9.210 (46.05)	10.292 (51.46)	10.378 (51.89)	13.220 (66.10)
10	6.092 (30.46)	7.076 (35.38)	8.292 (41.46)	8.272 (41.36)	9.042 (45.21)	12.856 (64.28)
11	5.374 (26.87)	6.208 (31.04)	7.444 (37.22)	7.128 (35.64)	8.038 (40.19)	11.400 (57.00)
12	4.850 (24.25)	4.292 (21.46)	7.014 (35.07)	6.522 (32.61)	7.778 (38.89)	10.612 (53.06)
13	4.106 (20.53)	3.274 (16.37)	6.338 (31.69)	5.706 (28.53)	7.094 (35.47)	8.938 (44.69)
14	2.620 (13.10)	1.556 (7.78)	5.312 (26.56)	4.574 (22.87)	7.090 (35.45)	5.790 (28.95)
15	1.246 (6.23)	0.438 (2.19)	3.792 (18.96)	2.292 (11.46)	6.510 (32.55)	4.842 (24.21)
16	0.564 (2.82)	-	2.510 (12.55)	1.578 (7.89)	6.438 (32.19)	3.188 (15.94)
17			1.650 (8.25)	0.504 (2.52)	6.092 (30.46)	3.016 (15.08)
18			0.830 (4.15)	-	5.808 (29.04)	2.152 (10.76)
19			0.368 (1.84)	-	5.276 (26.38)	1.478 (7.39)
20					4.722 (23.61)	1.042 (5.21)
21					4.080 (20.40)	0.370 (1.85)
22					2.330 (11.65)	-
23					1.390 (6.95)	-
24					0.670 (3.35)	-

The figures in paranthesis represent the relative mass of litter (%) at fortnightly intervals of the initial litter weight disappeared in 24 fortnights in the open and the same took 21 fortnights in the homegarden.

Mahogany leaf litter lost its weight more rapidly in the open in the early stages of decomposition compared to that in the homegarden. By the tenth fortnight nearly 50 per cent of its original weight had decomposed while the same took 13 fortnights in the homegarden. However, during the next few fortnights the rate of decomposition was significantly more in the homegarden resulting in 95 per cent decomposition of the initial weight in 21 fortnights. The weight loss was gradual during this period in the open situation and it took 24 fortnights to reach 95 per cent decomposition.

The decomposing litter of all tree species declined steadily in weight with time during the experimental period. Mahogany recorded the slowest decay and jack the fastest. The decomposition rates in the homegarden were significantly greater than those for open situations. The differential decomposition is primarily due to variations in the microclimatic conditions of the two sites. However, within the same region litter from different tree species varies in the rate of decomposition (O'Connell and Sankaran, 1997). This would explain the differential rate of decomposition of the different species litter within each site. The sudden decline noticed in the amount of litter remaining during fourth to fifth fortnights in mango, cashew and jack in homegardens is due to permeation of litter bags by earthworms.

4.3.2 Decay rate coefficients (k)

It is assumed that there is a constant fractional weight loss from the material in litter bags (Anderson, 1973). Based on this, mathematical models were fitted to find out the best equation and hence the decomposition model relating the residual mass and time elapsed.

The R^2 values gave the straight-line equation as the best fitting one and the decay rates (k) of each species litter were worked out.

A linear decrease in weight (Fig. 5) was observed in the litter decomposition of mango, jack, cashew, ailanthus, wild jack and mahogany unlike the exponential model of decomposition reported by several other authors (Shajikumar, 1991; Vinayan, 1992; Moosa, 1997 ; Jamaludheen and Kumar,1999). Nevertheless, Okeke and Omaliko (1991) had recorded the same observation of the exponential model showing low R^2 values and linear equations describing better the decrease in dry weights.

The calculated and predicted values of k are furnished in Table 7.

On comparing the k values, except for that for cashew in the homegarden, the calculated and predicted decay rate constants were comparable. Higher the value of k, faster is the rate of decomposition. The worked out values for the different species varied from -1.941 to -0.805 (predicted values –0.776 to –2.024). The highest k was for jack liter kept in the homegarden followed by cashew and mango indicating that, of the 6 species studied in the (two sites, decomposition was most rapid for jack, cashew and mango, in the homegarden. Perusal of data on the mass loss of the above mentioned species in the homegarden revealed that

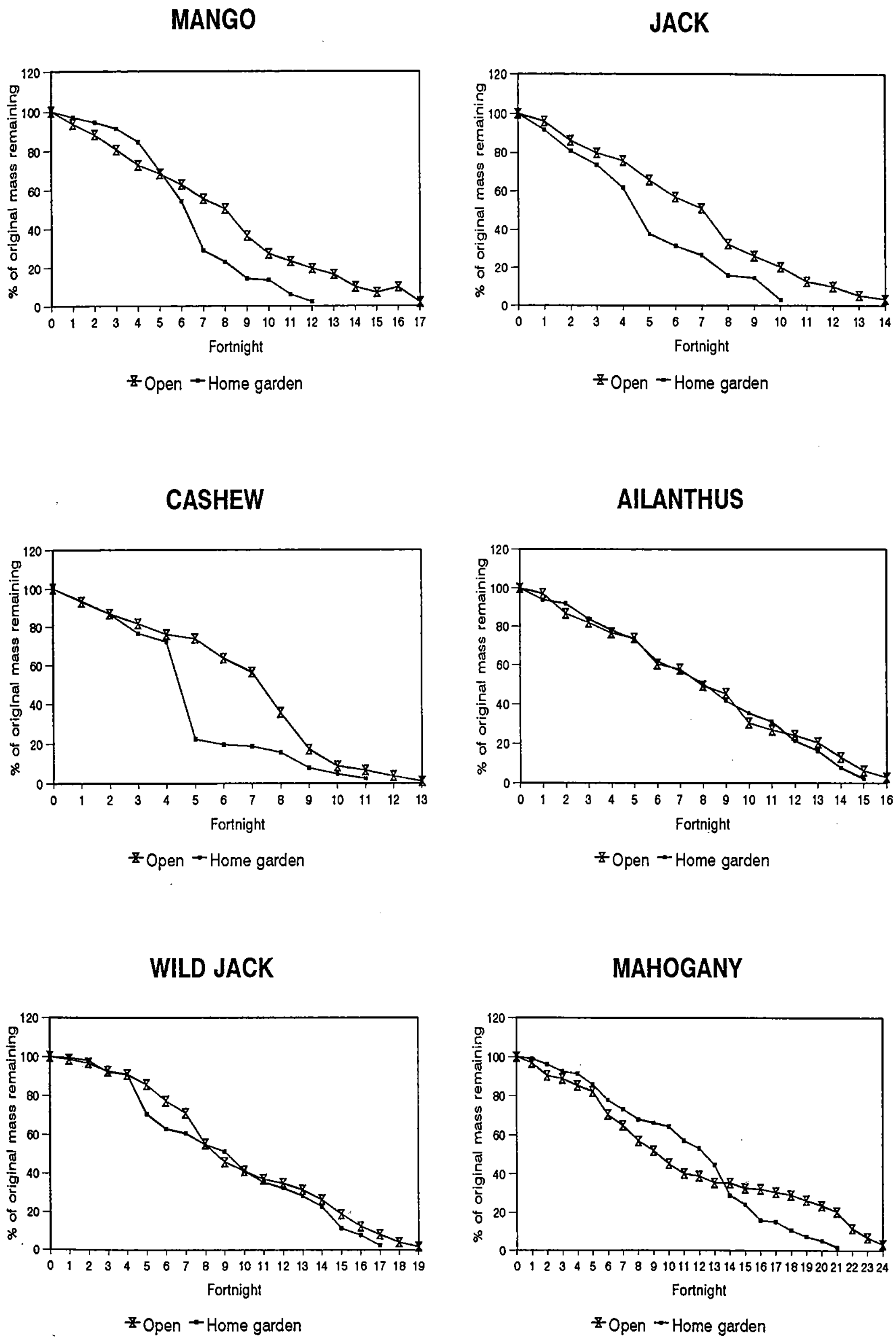

Fig. 5. Changes in the dry weight of litter of the different tree species at fortnightly intervals

in jack 95 per cent decomposition was completed in 5 months, cashew in 5 1/2months and mango in 6 1/2 months. Mahogany litter recorded lowest k value, both in the open situation and homegarden elucidating the longest period taken for 95 per cent decomposition. The initial litter quality as stated above is mainly responsible for this difference in k values among the different species (Table 5).

The decay constants in tropical plantations range between -0.11 and -2.0 (O'Connell and Sankaran, 1997). The k values worked out at the end of decomposition in the present study corroborate with this range. The k values recorded for jack and mango are in concurrence with that reported by Daniel (1996). She had earlier observed faster decomposition of jack litter (k=1.52) compared to mango (1.03).

4.3. 3 Half-life

The half life values (calculated and predicted) are given in Table 7. A general observation that can be made from the table is that the half-life values for the different tree species were lower in the homegardens compared to that in the open. Of the different species jack, cashew and mango took the shortest time for 50 per cent decomposition (predicted- 0.201 years, 0.207 years and 0.256 years respectively) and mahogany the longest (0. 349 years), in accordance with the k values.

The differences in the time taken for 95 per cent decomposition in the different species may be attributed to the differences in the litter quality and microclimatic conditions prevailing beneath the tree canopies. The canopies of mango, jack and cashew were dense compared to

Table 7. Decay constants and half life values of tree litter under open and homegarden conditions

Tree species	Decay constant		Half life ($t_{0.5}$) fortnights		Half life ($t_{0.5}$) years	
	calculated	predicted	calculated	predicted	calculated	predicted
Mango						
Open	-1.090	-1.218	8.724	7.808	0.359	0.321
Home	-1.630	-1.935	7.399	6.233	0.304	0.256
Jack						
Open	-1.381	-1.529	7.473	6.750	0.307	0.277
Home	-1.941	-2.024	5.090	4.881	0.209	0.201
Cashew						
Open	-1.522	-1.721	7.392	6.537	0.304	0.269
Home	-1.628	-2.022	6.253	5.035	0.257	0.207
Ailanthus						
Open	-1.215	-1.267	8.379	7.034	0.344	0.330
Home	-1.304	-1.343	8.175	7.938	0.335	0.326
Wild jack						
Open	-1.030	-1.161	11.020	9.785	0.453	0.402
Home	-1.147	-1.228	9.721	9.080	0.400	0.373
Mahogany						
Open	-0.805	-0.776	14.584	15.029	0.599	0.623
Home	-0.935	-1.052	9.540	8.479	0.392	0.349

ailanthus, wild jack and mahogany leading to higher humidity and soil moisture accumulation in the former situation. This creates a congenial environment for the activity of soil fauna and flora, the chief decomposer organisms. The effect of tree canopies on the radiation budgets at the soil floor is well documented by Reifsnyder and Lull (1965). Furthermore, the presence of decomposition resistant materials like lignin, polyphenols and tannins would retard decomposition in the early stages resulting in longer time for disappearance of litter mass (Mafongoya *et al.*, 1988; Palm and Sanchez, 1990). Earlier Mellilo *et al.*(1982) had also stated that plant materials with high lignin concentrations decompose more slowly than materials with low lignin contents. The lignin content in mahogany (32.10 per cent) and wild jack (28.86 per cent) were significantly greater than the other species leading to its slow decay in both sites (Table 5).

4.3.4 Nutrient dynamics on litter decomposition

4.3.4.1 Changes in nutrient contents

The observations on the nutrient contents in the initial and residual litter retrieved at fortnightly intervals under the various study situations are tabulated and presented in tables 8 to 16.

In all the species studied, 95 per cent decomposition was completed in a shorter period in the homegarden compared to the open. The statistical analysis to compare the two situations could be done only during the period for which data was available in both conditions. Hence comparative study was made, up to the period of 95 per cent decomposition in the homegarden in each species and the means of the replications of the corresponding values in the open are presented in the tables 8 to 16.

4.3.4.1.1 Nitrogen

4.3.4.1.1.1 Mango

The mean nitrogen content of residual leaf litter was significantly different in the open and homegarden during the period of comparative study (Table 8 a.). The fortnightly variation was also significant. There was a significant increase during the first three months and then a decline.

Mango leaf litter decomposition in the open and homegarden showed a diphasic pattern of nitrogen dynamics. The nitrogen content increased significantly initially in the open and in the homegarden. Thereafter it decreased. The absolute concentrations at fortnightly intervals were worked out in proportion to the original concentration and relative mass of litter remaining so as to confirm whether nitrogen was lost from the litter sample on decomposition or whether exogenous nitrogen entered litter through immobilisation. The absolute amount of nitrogen decreased significantly in both situations, to 0.28 per cent in the open and to 0.75 per cent in the homegarden, as the mass of litter remaining after decomposition declined (Appendix IVa. and Fig.6).

4.3.4.1.1.2 Jack

Nitrogen dynamics of jack litter are presented in Table 8 a. The mean nitrogen values did not vary significantly between the two sites, open and homegarden. However, the fortnightly variations were significant. Initially, the nitrogen content of the litter in the open increased

Table 8a. Nitrogen contents in mango, jack and cashew litter at fortnightly intervals on decomposition (%)

	Mango			Jack			Cashew		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	1.320	1.320	1.320	0.908	0.908	0.908	1.278	1.278	1.278
1	1.368	1.490	1.429	1.052	1.064	1.058	1.314	1.324	1.319
2	1.538	1.596	1.567	1.358	1.338	1.348	1.256	1.386	1.321
3	1.528	1.688	1.608	1.438	1.402	1.420	1.268	1.444	1.356
4	1.294	1.798	1.546	1.670	1.634	1.652	1.516	1.502	1.509
5	1.490	1.898	1.694	1.326	1.526	1.426	1.054	1.526	1.290
6	1.628	1.926	1.777	1.464	1.272	1.368	1.102	1.234	1.168
7	1.510	1.366	1.438	0.888	1.006	0.944	0.976	0.840	0.908
8	1.184	1.056	1.120	0.692	0.820	0.756	0.726	0.822	0.774
9	1.656	0.680	1.168	0.618	0.764	0.691	0.682	0.724	0.703
10	1.150	0.834	0.992	0.734	0.488	0.611	0.480	0.558	0.519
11	1.186	0.626	0.906	0.774	-	-	0.336	0.246	0.291
12	0.992	0.442	0.717	1.160	-	-	0.230	-	-
13	0.866	-	-	0.918	-	-	0.152	-	-
14	0.746	-	-	0.442	-	-	-	-	-
15	0.512	-	-	-	-	-	-	-	-
16	0.240	-	-	-	-	-	-	-	-
17	0.192	-	-	-	-	-	-	-	-
Mean	1.133	1.286	-	1.029	1.111	-	0.893	1.074	-
CD	C: 0.055	P: 0.166	CP: 0.235	C: NS	P: 0.167	CP: NS	C: NS	P: 0.162	CP: NS

C- Condition (Open/ Homegarden) P- Period CP - Interaction up to the fourth fortnight (1.67 per cent) and subsequently declined to 0.734 per cent. A slight increase was observed towards the end of decomposition. However, the final nitrogen content was 0.442per cent, which was less than the original concentration. The amount of nitrogen remaining in the final litter sample was 1.62 per cent (absolute amount- Fig.6 and Appendix IV b.).

In the homegarden, the litter samples showed the same pattern of nitrogen increase until the fourth fortnight (1.634per cent) and then declined to 0.488 per cent at the end of decomposition. The per cent nitrogen remaining in the litter was 1.59 per cent (Appendix IV b). The nutrient release was almost similar in both situations.

4.3.4.1.1.3 Cashew

The data on the nitrogen content of cashew leaf litter retrieved at fortnightly intervals in the open and homegarden are given in Table 8 a.

The nitrogen content was found to be significantly different during the fortnights of sampling within the two situations. The variation between the open and homegarden was not significant. Cashew leaf litter incorporated in the soil showed an initial increase in the nitrogen content from the original value of 1.278 per cent during the early months of decomposition both in the open and in the homegardens, and subsequently declined. The absolute amount of nitrogen in the litter residues worked out also showed the same trend of an initial increase followed by a decline (Fig.6). The trends exhibited reveal an initial accumulation of nitrogen in the litter followed by release towards the final stages.

4.3.4.1.1.4 Ailanthus

The nitrogen dynamics of ailanthus leaf litter given in Table 8 b. revealed significant difference in the nitrogen content between open and homegarden situation. Fortnightly variations were also significant. The mean nitrogen content showed a triphasic pattern of change- decreased initially, increased and finally decreased.

Comparing the data within each situation the nitrogen content did not show any specific pattern of change in the early stages, though it increased to 1.520 per cent in the open and 1.752 per cent in the homegarden. However, during the last two and a half months the nitrogen content was found to decrease significantly. At the time of final sampling, the nitrogen content in the open was 0.676 per cent and 0.150 per cent in the homegarden. The decrease in the absolute concentration towards the end of decomposition ensures that nitrogen was released after initial immobilization and accumulation (Fig. 6).

4.3.4.1.1.5 Wild jack

The data pertaining to the nitrogen dynamics of wild jack litter are presented in Table 8b.

The nitrogen content of the litter showed fortnightly significant variations but that between open and homegarden was not significant.

The nitrogen content in wild jack litter increased from the initial value of 1.102 per cent to 1.632 per cent by the third fortnight and then decreased to 0.198 per cent with completion of 95 per cent decomposition in the open. The final amount of nitrogen remaining was 0.30 per cent.

Table 8b. Nitrogen content in ailanthus, wild jack and mahogany litter at fortnightly intervals on decomposition (%)

	Ailanthus			Wild jack			Mahogany		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	1.458	1.458	1.458	1.102	1.102	1.102	1.300	1.300	1.300
1	1.480	1.454	1.467	1.244	1.262	1.253	1.296	1.280	1.288
2	1.200	1.252	1.226	1.412	1.412	1.412	1.272	1.258	1.265
3	1.216	1.316	1.266	1.632	1.492	1.562	1.230	1.282	1.256
4	1.452	1.188	1.320	1.606	1.612	1.609	1.360	1.478	1.419
5	1.520	1.212	1.366	1.482	1.410	1.446	1.362	1.688	1.525
6	1.250	1.326	1.288	1.504	1.436	1.470	1.304	1.738	1.521
7	1.496	1.244	1.370	1.418	1.138	1.278	1.616	1.382	1.499
8	1.042	1.536	1.289	1.384	1.128	1.256	1.690	1.32	1.505
9	0.940	1.600	1.270	1.134	1.298	1.216	1.494	1.296	1.395
10	1.482	1.752	1.617	1.042	1.386	1.214	1.376	1.248	1.312
11	1.272	1.726	1.499	0.956	1.026	0.991	1.236	1.242	1.239
12	0.864	1.336	1.100	0.790	0.874	0.832	1.166	1.232	1.199
13	0.886	1.046	0.966	0.568	0.734	0.651	1.192	1.16	1.176
14	0.728	0.676	0.702	0.540	0.632	0.586	1.372	1.07	1.221
15	0.754	0.150	0.452	0.388	0.514	0.451	1.162	0.936	1.049
16	0.676	-	-	0.494	0.436	0.465	0.934	0.89	0.912
17	-	-	-	0.322	0.412	0.367	1.028	0.858	0.943
18	-	-	-	0.310	-	-	0.944	0.846	0.895
19	-	-	-	0.198	-	-	0.902	0.840	0.871
20	-	-	-	-	-	-	0.856	0.832	0.844
21	-	-	-	-	-	-	0.970	0.806	0.888
22	-	-	-	-	-	-	0.980	-	-
23	-	-	-	-	-	-	0.806	-	-
24	-	-	-	-	-	-	0.768	-	-
Mean	1.160	1.267	-	0.976	1.072	-	1.15	1.181	-
CD	C: 0.077	P: 0.217	CP: 0.306	C: NS	P: 0.118	CP: 0.166	C: NS	P: 0.638	CP: 0.364

C- Condition (open/ homegarden) P- Period CP- Interaction

In the homegarden the value increased to 1.612 per cent in 4 fortnights, showed slight fluctuations during the next few fortnights and then on decreased to 0.412 per cent at the time of final sampling. The amount of nitrogen was remaining in the litter at the time of final sampling was computed as 0.90 per cent (Fig.6).

4.3.4.1.1.6 Mahogany

The data on changes in nitrogen contents in the decomposing of mahogany litter are presented in Table 8b.

The nitrogen dynamics did not vary significantly between the open and homegarden during the 21 fortnights of decomposition. The fortnightly variations were significant.

In mahogany litter kept in the open, the nitrogen content decreased to 1.230 per cent during the three fortnights of decomposition initially, increased to 1.690 per cent in the next five fortnights and then declined to 0.768 per cent by the end of complete decomposition. The absolute content of nitrogen was found to decline relative to the decrease in residual mass of litter (Fig.6). At the time of final sampling 1.98 per cent of the element remained in the undecomposed litter (Appendix IV f).

In the homegarden the nitrogen content decreased from the initial content of 1.300 per cent to 1.258 per cent in two fortnights and subsequently increased to 1.738 per cent in the next four fortnights. This accumulation was followed by a release in the final fortnights lowering the nitrogen content of the litter to 0.806 per cent. The percent nitrogen

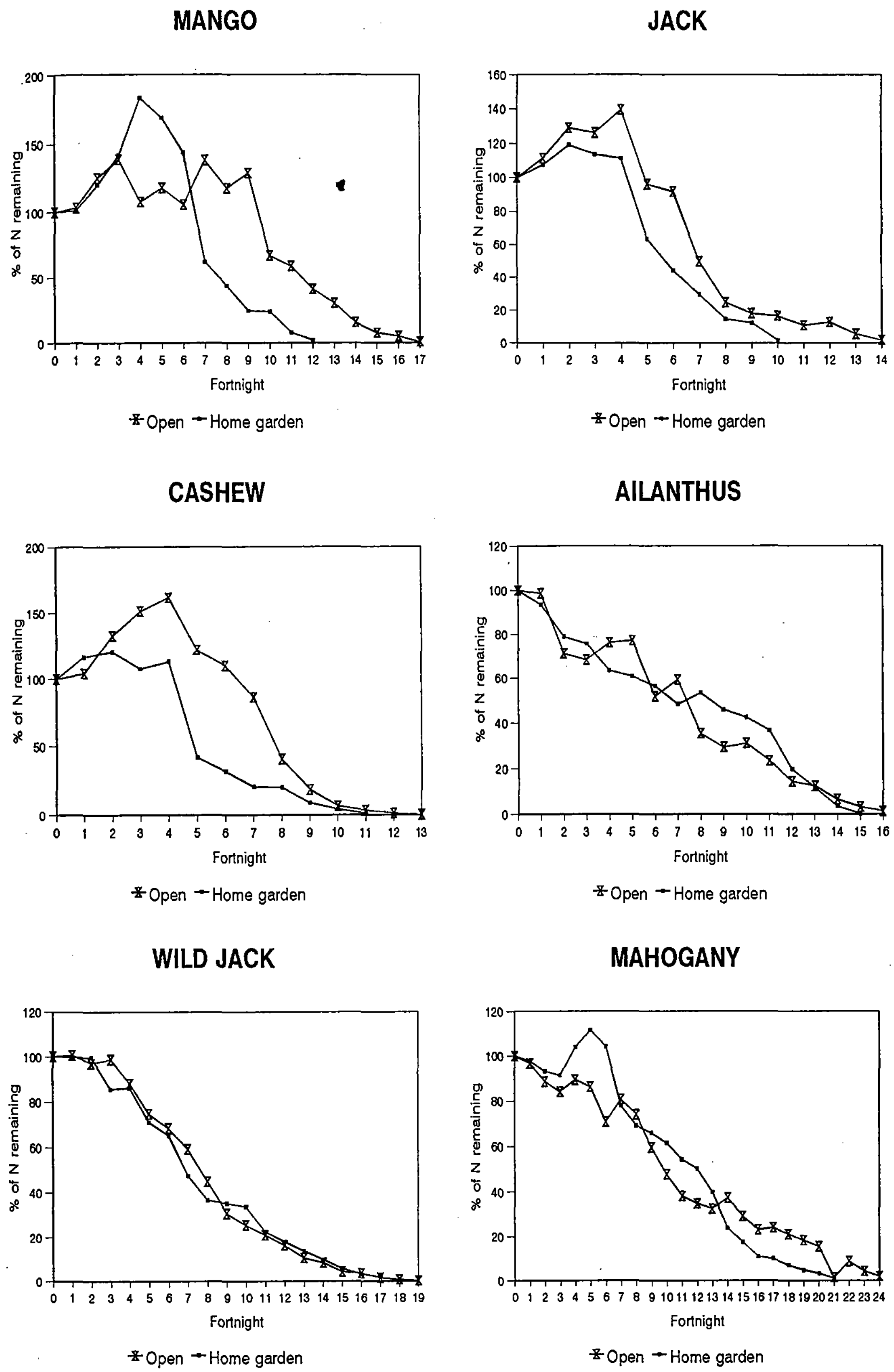

Fig. 6. Nitrogen release on litter decay in the open and homegarden sites at fortnightly intervals

remaining in the residual litter was 1.16 per cent ensuring a slightly better release under homegarden condition compared to the open.

The nitrogen concentration of the litter of the different species increased in comparison to the initial concentration during the first phase of decomposition and thereafter decreased. In mahogany, the change was more complex. The nitrogen content exhibited a fluctuating trend showing an initial reduction and then a gradual increase and finally decreased. In all litter samples there was release of nitrogen after accumulation.

Many workers have noticed the increased content of nitrogen in litter on decomposition (Gosz *et al.*, 1973 ; Edmonds, 1979).

The data reflecting the gain and loss of nitrogen in the six species exhibited a diphasic model of change in most species' litter; mango, jack, cashew, ailanthus and wild jack, while that in mahogany showed a triphasic pattern, an initial decrease followed by an increase and finally release.

The changes in nitrogen content with litter decomposition with final release adding to soil pool are in line with that reported by Jamaludheen and Kumar (1999). They studied the nitrogen dynamics of seven tree species' decomposing litter and reported that nitrogen concentration declined rapidly after a brief initial increase and this was followed by a final slower release phase in wild jack, acacia and casuarina. The other species, ailanthus, jack, leucaena, pterocarpus and paraserianthus showed a biphasic pattern of release.

The relative increase in nitrogen concentrations in decomposing litter is a well established phenomenon (Bocock, 1963; Gosz *et al.*, 1973) and explained the causes as nitrogen fixation (Granhall and Lindberg, 1977); uptake from surroundings by fungal hyphae growing in litter (Berg and Soderstrom, 1979; Gosz *et al.*, 1973); or atmospheric precipitation, insect frass and plant material falling from leaf canopy (Bocock, 1963). The assumption of nitrogen addition by atmospheric deposition and due to microbial and non-microbial immobilisation was proven true by Joergenson and Meyer (1990). Of the above, fungal mycelia on the litter is the major source of increased nitrogen in the decomposing litter. The fungal mycelia contain 3 – 5 per cent nitrogen on dry mass basis and have the capacity to translocate nitrogen from organic and mineral soils during decomposition (Berg and Soderstrom, 1979; Lodge, 1987; Berg, 1988). Fungi were predominant in the soil samples taken from beneath the litter bags and thus could support this theory.

Similar reports on the triphasic model of nitrogen, decrease increase and subsequent decrease in concentrations, as noted in mahogany were earlier given by Berg and Staaf (1981) and Rustad and Cronan (1988).

The initial release may be attributed to the leaching losses. Palm and Sanchez (1990) opined that in the initial phase soluble forms of nitrogen are leached / mineralized and the second phase is explained by the binding of nitrogen to lignin and polyphenols in the leaves. This is applicable in mahogany litter owing to its high initial lignin content.

The decomposing litter of the six tree species revealed to act as short term sinks for nitrogen and this nitrogen retention process is essentially controlled by microbial immobilisation.

4.3.4.1.2 Phosphorus

4.3.4.1.2.1 Mango

Phosphorus dynamics in mango leaf litter on decomposition are presented in Table 9 a. The phosphorus content varied significantly between the two situations and also showed fortnightly variations. The phosphorus content of the litter in the open increased until the tenth fortnight and then declined though slight fluctuations were noticed in between. In the homegarden, increase occurred until the seventh fortnight and then decreased. However, in either situation the initial value of 0.030 per cent was found to decline after the increase in the first four months, to 0.015 per cent in the open and 0.028 per cent in the homegarden by the time decomposition was complete. The fortnightly variations were significant compared to that of the preceding values in the open and homegarden during the period of comparative analysis.

The absolute concentrations were found to increase initially and then were reduced (Fig.7). Nutrient release was more complete after accumulation and immobilization in the open compared to that in the homegarden, the percentage of phosphorus remaining in litter being 0.96 in the open and 2.03 in the homegarden (Appendix IVa).

Table 9a. Phosphorus content in mango, jack and cashew litter at fortnightly intervals on decomposition (%)

	Mango			Jack			Cashew		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	0.030	0.030	0.030	0.126	0.126	0.126	0.040	0.040	0.040
1	0.039	0.042	0.041	0.104	0.010	0.102	0.035	0.038	0.036
2	0.051	0.048	0.049	0.098	0.064	0.081	0.028	0.075	0.051
3	0.056	0.055	0.056	0.062	0.046	0.054	0.020	0.101	0.060
4	0.098	0.062	0.080	0.029	0.066	0.047	0.036	0.090	0.063
5	0.110	0.072	0.091	0.029	0.078	0.053	0.038	0.075	0.057
6	0.094	0.091	0.093	0.048	0.077	0.063	0.018	0.056	0.037
7	0.059	0.122	0.091	0.058	0.105	0.082	0.017	0.047	0.032
8	0.100	0.091	0.096	0.065	0.066	0.065	0.018	0.025	0.021
9	0.106	0.080	0.091	0.072	0.052	0.063	0.034	0.020	0.027
10	0.129	0.062	0.091	0.073	0.045	0.059	0.045	0.032	0.039
11	0.081	0.043	0.096	0.077	-	-	0.066	0.036	0.051
12	0.052	0.028	0.062	0.051	-	-	0.074	-	-
13	0.047	-	0.040	0.041	-	-	0.049	-	-
14	0.040	-	-	0.026	-	-	-	-	-
15	0.036	-	-	-	-	-	-	-	-
16	0.016	-	-	-	-	-	-	-	-
17	0.015	-	-	-	-	-	-	-	-
Mean	0.065	0.063	-	0.064	0.075	-	0.037	0.053	-
CD	C: 0.006	P: 0.014	CP: 0.002	C: NS	P: 0.02	CP: 0.028	C: 0.005	P: 0.011	CP: 0.016

C- Condition (open/ homegarden) P- Period CP- Interaction

4.3.4.1.2.2 Jack

Table 9 a. gives the changes in phosphorus content present in jack litter on decomposition. There was no significant variation in the mean phosphorus per cent between the open and homegarden but varied significantly between the fortnights of sampling. The mean phosphorus content showed a triphasic trend- initial decline followed by an increase and then a decrease.

The initial phosphorus value of 0.126 per cent in the open, decreased to 0.029 per cent, increased to 0.077 per cent and then finally declined to 0.026 per cent revealing a triphasic change on decomposition. The nutrient release relative to initial concentration was worked out as 79.4 per cent.

In the homegarden, the maximum concentration of 0.105 per cent was attained during the seventh fortnight, which was lowered to 0.045 per cent at the time of final sampling. The concentration of phosphorus relative to the initial concentration was 35.7 per cent at this stage ensuring 64.3 per cent phosphorus release. The absolute concentrations also recorded similar trends as that of the phosphorus concentration under both situations (Fig. 7).

4.3.4.1.2.3 Cashew

The phosphorus dynamics of cashew leaf litter (Table 9 a.) was significantly different in the open and in the homegarden. The changes in the phosphorus content of leaf litter over the period of study showed a wide fluctuation, with a general decrease followed by an increase. The phosphorus content of residual litter in the open site showed an abrupt decrease during the three fortnights, an increase in the next two fortnights followed by a gradual decline and finally a slight increase towards the last stages of decomposition. In addition, the final phosphorus percent was higher than the initial value, indicating accumulation relative to the initial concentration. The same trend was observed in the homegarden also, the final phosphorus content being 0.036 per cent.

The absolute concentration of phosphorus showed a three phasic trend – an initial decrease followed by an increase and finally a decrease in both the open and homegarden situation (Fig. 7), indicating that the phosphorus in litter was released after accumulation.

4.3.4.1.2.4 Ailanthus

Data on phosphorus dynamics (Table 9 b.) show that phosphorus content of the residual ailanthus litter and absolute amounts decreased during the initial months (Appendix IVd), increased to a maximum value and then reduced to less than original value during the last months of decomposition. On comparative analysis, the fortnightly variations alone were significant.

In the open, the phosphorus content after an initial decrease, increased to a maximum of 0.101 per cent after twelve fortnights and then on declined sharply to a value of 0.007 per cent during the first fortnight of January (16 fortnights).

The trend remained the same in the homegarden also. The maximum value attained was 0.116 per cent during the ninth fortnight of

Table 9b. **Phosphorus content in ailanthus, wild jack and mahogany litter at fortnightly intervals on decomposition (%)**

	Ailanthus			Wild jack			Mahogany		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	open	Homegarden	Mean
0	0.052	0.052	0.052	0.049	0.049	0.049	0.051	0.051	0.051
1	0.041	0.033	0.037	0.040	0.046	0.043	0.048	0.046	0.047
2	0.040	0.034	0.039	0.047	0.051	0.049	0.047	0.047	0.047
3	0.040	0.032	0.036	0.066	0.054	0.060	0.046	0.049	0.047
4	0.041	0.039	0.040	0.048	0.053	0.050	0.044	0.045	0.045
5	0.033	0.055	0.044	0.040	0.055	0.048	0.049	0.042	0.076
6	0.038	0.062	0.050	0.031	0.045	0.038	0.055	0.053	0.054
7	0.050	0.087	0.069	0.014	0.040	0.027	0.058	0.054	0.056
8	0.061	0.099	0.080	0.016	0.036	0.026	0.066	0.064	0.065
9	0.094	0.116	0.105	0.021	0.021	0.021	0.056	0.054	0.055
10	0.088	0.087	0.086	0.030	0.023	0.026	0.056	0.052	0.054
11	0.098	0.064	0.081	0.076	0.019	0.048	0.059	0.047	0.053
12	0.101	0.048	0.075	0.109	0.026	0.067	0.044	0.055	0.049
13	0.078	0.022	0.050	0.060	0.040	0.050	0.060	0.050	0.055
14	0.043	0.018	0.031	0.052	0.052	0.052	0.047	0.051	0.049
15	0.016	0.007	0.012	0.048	0.031	0.039	0.037	0.040	0.039
16	0.007	-	-	0.034	0.020	0.027	0.041	0.042	0.042
17	-	-	-	0.023	0.008	0.016	0.029	0.033	0.031
18	-	-	-	0.014	-	-	0.034	0.035	0.035
19	-	-	-	0.008	-	-	0.020	0.021	0.021
20	-	-	-	-	-	-	0.024	0.021	0.022
21	-	-	-	-	-	-	0.018	0.012	0.015
22	-	-	-	-	-	-	0.032	-	-
23	-	-	-	-	-	-	0.028	-	-
24	-	-	-	-	-	-	0.020	-	-
Mean	0.054	0.053	-	0.041	0.037	-	0.043	0.044	-
CD	C: NS	P: 0.040	CP: 0.020	C: 0.003	P: 0.010	CP: 0.014	C: NS	P: 0.039	CP: NS

C- Condition (open/ homegarden) P- Period CP- Interaction

decomposition and the final value was 0.007 per cent by the end of December (15^{th} fortnight).

4.3.4.1.2.5 Wild jack

The significant variations of phosphorus content in wild jack litter are given in Table 9 b. The phosphorus concentration varied significantly between open and homegarden and also within each situation during the different fortnights.

The phosphorus showed wide fluctuations of decrease and increase as decomposition proceeded under both situations. However, during the final stages in both the open and homegarden the phosphorus content was lowered ensuring a nutrient release of 84 per cent in the open and homegarden(Appendix IV e). The percent of phosphorus remaining in the residual litter was 0.30 per cent in the open and 0.41 per cent in the homegarden (Fig.7.).

4.3.4.1.2.6 Mahogany

The phosphorus content in residual litter in the open and homegarden are presented in Table 9 b. Statistical analysis revealed that there was no significant variation in phosphorus content of litter between the two situations but that between the fortnights within each situation was significant.

The general pattern of phosphorus change in mahogany was an initial decrease followed by an increase and final decrease, with slight fluctuations in between.

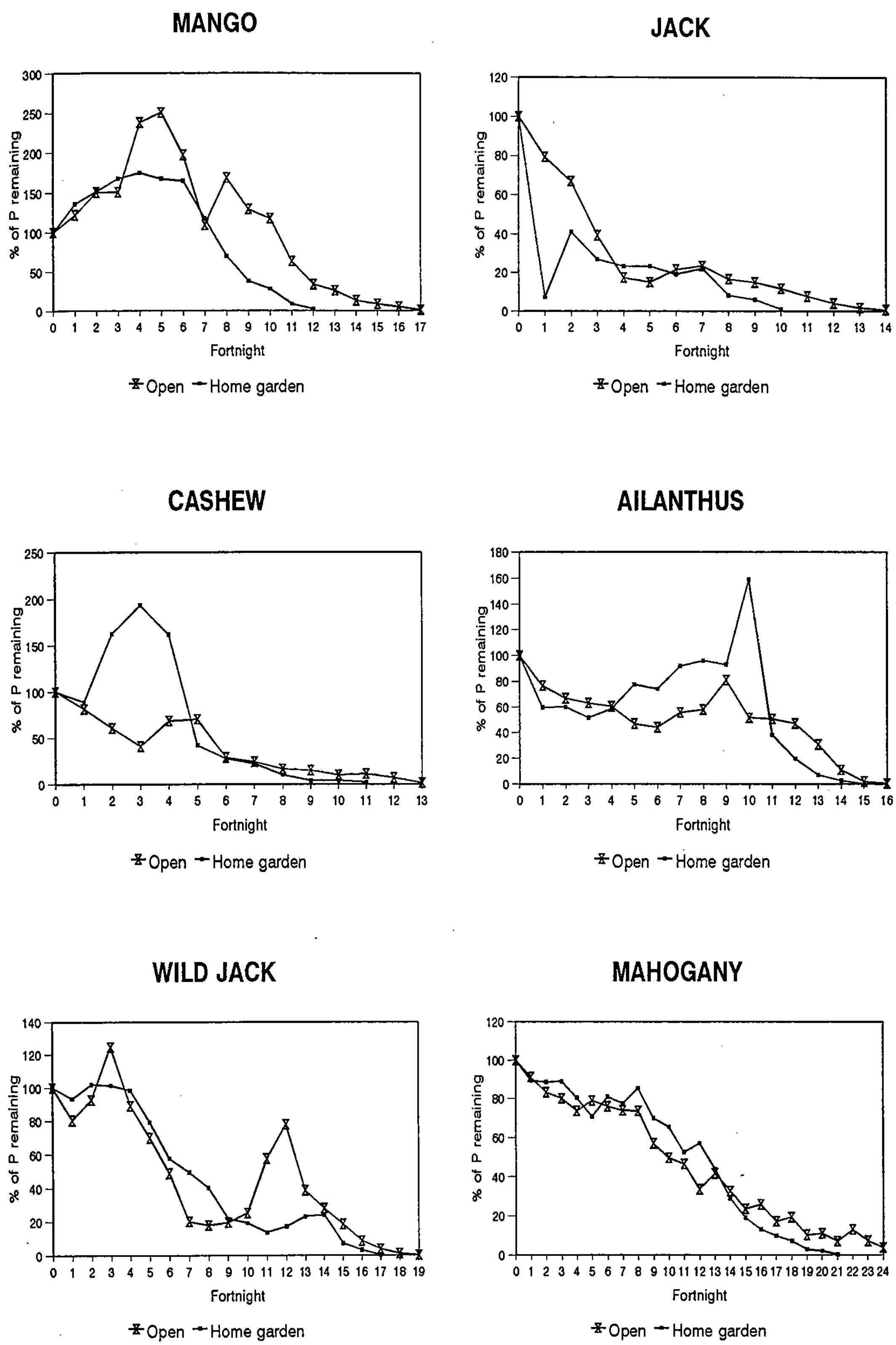

Fig. 7. Phosphorus release on litter decay in the open and homegarden sites at fortnightly intervals

The phosphorus dynamics in the different tree species studied was found to be highly complex. However, in the entire six tree species studied there was no long-term immobilization of phosphorus, although wide fluctuations were noticed in cashew litter. In the decaying litter, phosphorus was accumulated after an initial release. The initial decrease shown is in accordance with the works of Hodkinson (1975) and Maheswaran and Gunatilleke (1988). They attributed this to the loss of phosphorus in the easily leachable forms. Rustad and Cronan (1988) in their study on red maple, red spruce and mixed species litter decay observed 71per cent of original phosphorus to be released during the first 6 months. The increase in phosphorus noted in the second phase months would have occurred due to microbial immobilization. In the final stage of decomposition phosphorus was released and this is in accordance with the works of Jamaludheen and Kumar (1999).

4.3.4.1.3 Potassium

4.3.4.1.3.1 Mango

The potassium release from decomposing leaf litter as given in Table 10 a. show that unlike nitrogen and phosphorus, the potassium content of the litter decreased as decomposition proceeded. The variation between potassium content in the residual litter kept in the open and homegarden was not significant between them while the fortnightly variations were significant.

In the open, during the nine months taken for complete decomposition, the potassium content of mango leaf litter was reduced to

Table 10a. Potassium content in mango, jack and cashew litter at fortnightly intervals on decomposition (%)

	Mango			Jack			Cashew		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	0.362	0.362	0.362	0.601	0.601	0.601	0.125	0.125	0.125
1	0.337	0.312	0.325	0.486	0.596	0.541	0.082	0.110	0.096
2	0.278	0.245	0.262	0.397	0.564	0.48	0.088	0.100	0.094
3	0.261	0.230	0.246	0.346	0.516	0.431	0.084	0.081	0.082
4	0.166	0.157	0.162	0.231	0.331	0.281	0.070	0.072	0.071
5	0.154	0.130	0.142	0.172	0.175	0.174	0.052	0.046	0.049
6	0.100	0.108	0.104	0.113	0.092	0.103	0.044	0.024	0.034
7	0.101	0.075	0.088	0.102	0.089	0.096	0.043	0.025	0.034
8	0.063	0.063	0.063	0.223	0.108	0.092	0.045	0.021	0.033
9	0.056	0.046	0.051	0.066	0.062	0.064	0.043	0.016	0.029
10	0.049	0.076	0.063	0.054	0.023	0.039	0.040	0.009	0.025
11	0.050	0.109	0.08	0.043	-	-	0.040	0.003	0.022
12	0.049	0.010	0.03	0.034	-	-	0.032	-	-
13	0.044	-	-	0.021	-	-	0.012	-	-
14	0.036	-	-	0.010	-	-			
15	0.013	-	-						
16	0.027	-	-						
17	0.008	-	-						
Mean	0.120	0.148	-	0.193	0.287	-	0.064	0.053	-
CD	C: NS	P: 0.041	CP: NS	C: 0.025	P: 0.058	CP: 0.082	C: 0.008	P: 0.018	CP: 0.026

C- Condition (open/ homegarden P- Period CP- Interaction

0.008 per cent from the initial concentration of 0.362 per cent. Decomposition in the homegarden was completed in 12 fortnights and the potassium content during final sampling was 0.01per cent, the absolute concentration being 0.06 per cent as against 0.04 per cent in the open. (Appendix IV a and Fig.8). The potassium release in the litter kept in both situations was nearly 98 per cent by the time 95 per cent of the initial litter mass decomposed.

4.3.4.1.3.2 Jack

The potassium dynamics presented in Table 10 a. reveal significant influence of the condition and period under which decomposition occurred. The critical analysis shows a potassium release of 98.4 per cent in the open and 96.2 per cent in the homegarden (Appendix IVb). The initial concentration of 0.601 per cent decreased to 0.010 per cent in the open and to 0.023 per cent in the homegarden. On comparing the two situations, potassium release was more complete in the open than in the homegarden.

4.3.4.1.3 .3 Cashew

The potassium content of litter samples collected are presented in Table 10 a .

The potassium content varied significantly with the period and situation. It was found to decrease as decomposition proceeded. The change was similar both in the open and homegarden. The initial value of 0.125 per cent declined to 0.012 per cent in the open in 13 fortnights and to 0.003 per cent in eleven fortnights in the homegarden. The absolute concentrations of potassium also followed the same pattern of decline as that of potassium concentration (Fig. 8 and Appendix IVc).

4.3.4.1.3.4 Ailanthus

The data on changes in potassium content of ailanthus litter are presented in Table 10 b. The fortnightly variations and that between open and homegarden were statistically significant.

The potassium content was found to significantly decline as decomposition proceeded, both in the open and homegarden. In both situations a two-phase release was observed – an initial rapid release phase followed by a slow release phase. Nearly 50 per cent of potassium in litter was released during the first four fortnights. Thereafter, the release was comparatively slow. The percentage of potassium remaining in the litter at the time of final sampling was 0.09 per cent in the open and 0.04 per cent in the homegarden. The nutrient release that occurred was 96.8 per cent in the open and 98.2 per cent in the homegarden. The absolute content declined to less than 1 per cent in both situations (Appendix IV d and Fig.8).

4.3.4.1.3 .5 Wild jack

The mean potassium per cent in wild jack litter kept for decomposition in the open and homegarden were significantly different between the sites and within each site during the different fortnights (Table 10 b).

The initial mean potassium content of the litter kept for decomposition was analyzed and computed as 0.593per cent. As

Table 10b. **Potassium content in ailanthus, wild jack and mahogany litter at fortnightly intervals on decomposition (%)**

	Ailanthus			Wild jack			Mahogany		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	0.372	0.372	0.372	0.593	0.593	0.593	0.578	0.578	0.578
1	0.292	0.360	0.325	0.533	0.516	0.524	0.542	0.482	0.512
2	0.262	0.319	0.290	0.531	0.446	0.488	0.471	0.427	0.449
3	0.280	0.266	0.273	0.494	0.386	0.440	0.424	0.440	0.432
4	0.158	0.187	0.172	0.414	0.141	0.178	0.306	0.386	0.346
5	0.145	0.137	0.141	0.405	0.079	0.242	0.291	0.283	0.287
6	0.056	0.128	0.092	0.283	0.059	0.171	0.258	0.188	0.223
7	0.052	0.081	0.067	0.232	0.058	0.145	0.207	0.150	0.179
8	0.058	0.061	0.060	0.194	0.056	0.125	0.190	0.104	0.147
9	0.049	0.050	0.050	0.171	0.049	0.110	0.150	0.100	0.125
10	0.042	0.035	0.038	0.111	0.031	0.071	0.073	0.081	0.077
11	0.043	0.027	0.035	0.100	0.042	0.072	0.064	0.083	0.074
12	0.037	0.024	0.030	0.062	0.024	0.043	0.065	0.067	0.066
13	0.025	0.023	0.024	0.054	0.023	0.038	0.055	0.053	0.054
14	0.017	0.013	0.015	0.052	0.023	0.038	0.064	0.051	0.057
15	0.012	0.007	0.009	0.050	0.023	0.036	0.059	0.050	0.055
16	0.012	-	-	0.042	0.010	0.026	0.054	0.036	0.045
17				0.036	0.008	0.022	0.068	0.035	0.051
18				0.022	-	-	0.046	0.019	0.032
19				0.012	-	-	0.034	0.019	0.027
20							0.043	0.011	0.027
21							0.036	0.007	0.022
22							0.024	-	-
23							0.014	-	-
24							0.006	-	-
Mean	0.112	0.131	-	0.220	0.143	-	0.165	0.166	-
CD	C: 0.011	P: 0.032	CP: 0.045	C: 0.009	P: 0.027	CP: 0.038	C: 0.011	P: 0.037	CP: 0.052

C- Condition (open/ homegarden) P- Period CP- Interaction

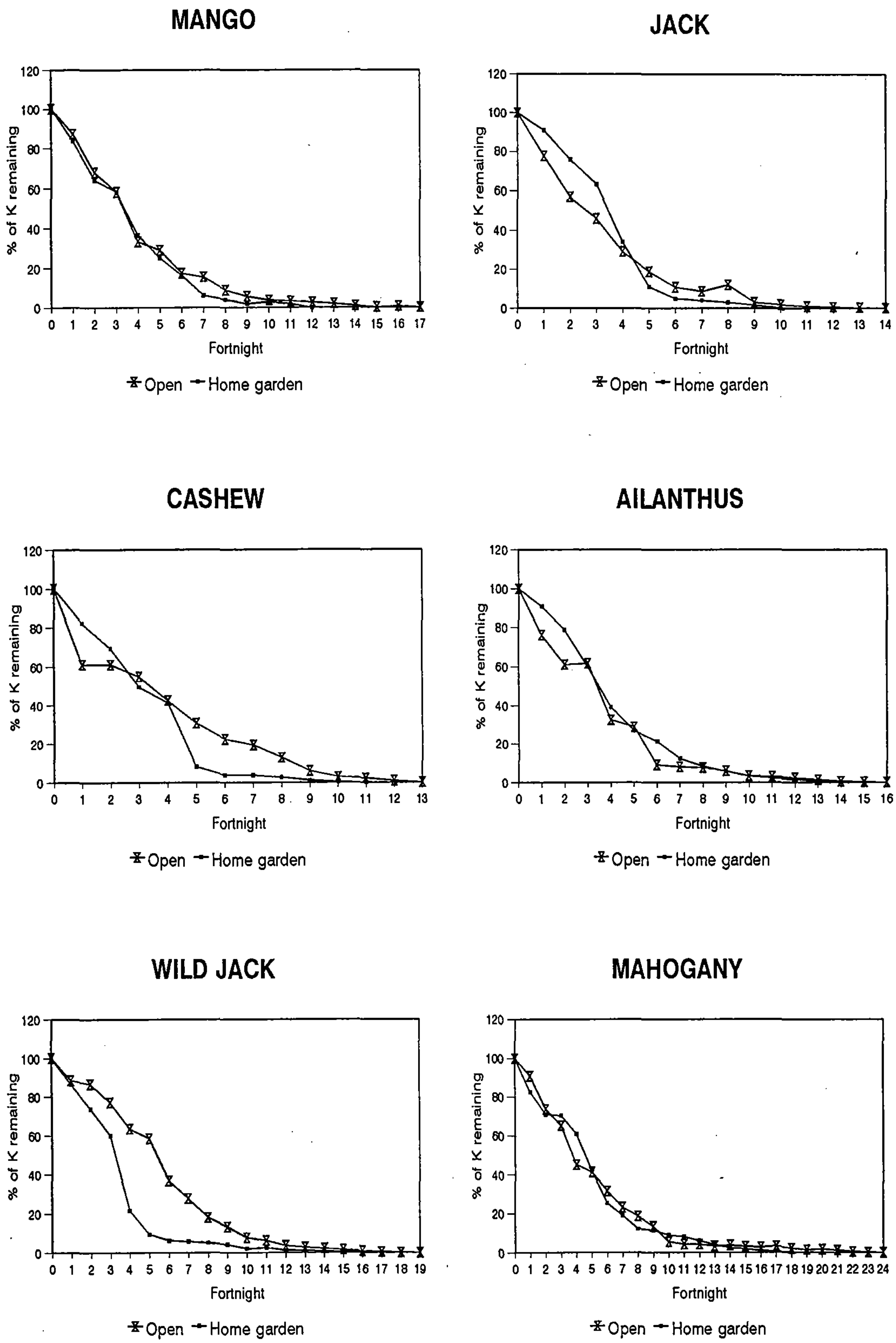

Fig. 8. Potassium release on litter decay in the open and homegarden sites at fortnightly intervals

decomposition proceeded, this value was observed to significantly decrease from the initial concentration to 0.012 per cent and 0.008 per cent in the open and homegarden respectively. The release was 98 per cent under both situations on completion of decomposition (Appendix IVe).

4.3.4.1. 3.6 Mahogany

The potassium dynamics in mahogany litter on decomposition are given in Table 10 b. Significant decline in potassium content of mahogany leaf litter was recorded in both the study areas and the variation between the two was also significant. The potassium content decreased from an initial concentration of 0.578 per cent to 0.006 per cent per cent in the open and to 0.007 per cent in the homegarden by the time 95 per cent of the kept mass decomposed. Nearly 98 per cent of the nutrient content was released under both situations. The data also revealed that only less than 0.05 per cent of the potassium content remained in the litter at the time of final sampling (Appendix IVf).

The potassium concentrations decreased in all litter types in both the study areas. Potassium in the plant is not a structural component and is highly mobile in the plant (Tisdale *et al.*, 1993). This would pave way for its easy loss from the litter by leaching while decomposing (Kunhamu, 1994 ; Jamaludheen, 1994) and hence a rapid decline in the potassium levels in the residual litter mass. Attiwill (1968) reported potassium to be the most mobile element during decomposition and hence is returned to the soil at the earliest. Highest mobility of potassium was also reported by Stephan *et al.* (1992) and Edmonds and Ted (1995).

Potassium in all situations revealed a rapid loss in the early stages and a gradual decline during the final stages (Fig.8). This trend also supported the claim that leaching is the primary process influencing losses of potassium.

4.3.4.1.4 Calcium

4.3.4.1.4 .1 Mango

The data on calcium content of the residual litter at fortnightly intervals in the open and homegarden are presented in Table 11 a. Significant variation was observed on statistical analysis between open and homegarden and also with the fortnights.

In the open, calcium content increased until the third fortnight (0.962 per cent), decreased during the next three fortnights and then increased by the end of decomposition. The final value was two fold greater than the initial value. The absolute concentration showed decreasing trends (Fig. 9) as the residual litter mass declined as decomposition proceeded.

The increase in calcium in the decomposing litter in homegarden followed the same pattern as in the open with the final calcium content being 2.45 times that of the initial value. The amount of calcium remaining in litter decreased as in the open and were worked out as 4.0 and 5.5per cent in the open and homegarden respectively (Fig. 9 and Appendix IVa).

4.3.4.1.4.2.Jack

The data on the changes in calcium content of jack litter on decomposition is presented in Table 11 a.

Table 11a. Calcium content in mango, jack and cashew litter at fortnightly intervals on decomposition (%)

	Mango			Jack			Cashew		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	0.836	0.836	0.836	0.962	0.962	0.962	0.298	0.298	0.298
1	0.838	0.970	0.904	0.968	1.022	0.995	0.312	0.314	0.313
2	0.904	1.282	1.093	0.994	1.054	1.024	0.304	0.478	0.391
3	0.962	1.164	1.063	0.758	0.916	0.837	0.312	0.452	0.382
4	0.822	1.306	1.064	0.782	0.646	0.714	0.310	0.664	0.487
5	0.790	1.552	1.171	0.858	0.744	0.801	0.288	0.594	0.441
6	0.746	1.848	1.297	0.970	0.666	0.818	0.290	0.528	0.409
7	0.832	1.638	1.235	1.004	0.740	0.872	0.318	0.752	0.535
8	0.634	1.874	1.254	1.026	0.846	0.936	0.334	0.780	0.557
9	0.930	1.930	1.430	1.018	1.002	1.010	0.414	0.826	0.620
10	0.984	1.846	1.415	1.128	1.120	1.124	0.432	0.834	0.633
11	1.272	1.848	1.560	1.084	-	-	0.484	0.848	0.666
12	0.958	2.048	1.503	1.198	-	-	0.538	-	-
13	1.054	-	-	1.204	-	-	0.554	-	-
14	1.156	-	-	1.292	-	-			
15	1.250	-	-						
16	1.690	-	-						
17	1.740	-	-						
Mean	1.022	1.549	-	1.016	0.883	-	0.371	0.614	-
CD	C: 0.052	P: 0.131	CP: 0.186	C: 0.042	P: 0.098	CP: 0.138	C: 0.019	P: 0.046	CP: 0.065

C- Condition (open/ homegarden) P- Period CP- Interaction

Significant variation was recorded in the calcium content between the open and homegarden .The fortnightly variations were also significant.

The calcium content of litter k ept in the open and homegarden showed similar trends with the relative concentration values computed based on the initial concentrations being more than 100 revealing accumulations in both situations. The absolute amount was found to decline owing to the loss in weight of litter on decomposition (Fig. 9).

4.3.4.1.4 .3 Cashew

The variations in calcium content of cashew litter with decomposition are furnished in Table 11 a.

The statistical analysis of data until the eleventh fortnight revealed that there was significant variation in calcium content of litter between open and homegarden and also between the fortnights within each situation. The mean calcium content increased significantly from the initial value of 0.298 per cent to 0.666 per cent during this period.

In the open the calcium content of litter on complete decay increased significantly to 0.554 per cent resulting in an absolute content of 2.01per cent (Fig.9). The increase in concentration recorded revealed the accumulation of the element with decomposition and the decrease in absolute amount is because of the decline in mass of litter on decomposition.

A similar trend was observed in the homegarden also. The final concentration was 0.848 per cent with the absolute concentration being 6.92 per cent (Appendix IVc).

4.3.4.1.4 .4 Ailanthus

The data on the changes in calcium content of the ailanthus litter at fortnightly intervals in the open and homegarden are presented in Table (11 b). Significant variations were observed on statistical analysis between open and homegarden and also with the fortnights.

The data on calcium content of the litter in the open revealed significant increase and the final content in the litter kept in the open and homegarden were 0.782 and 0.888 per cent respectively. The increased values for relative concentrations computed from initial values in both situations revealed accumulation of the element (Appendix IVd).

4.3.4.1.4 .5 Wild jack

Table 11 b. gives the changes in calcium content of wild jack litter on decomposition in the open plot and in the homegarden.

The fortnightly variation and that between the means in the open and homegarden were statistically significant.

A significant increase in the calcium content of wild jack leaf litter was recorded both in the open and homegarden. The final values were 0.794 and 0.812 per cent in the open and homegarden respectively. The increase would lead to a relative contentration value of more than 100, revealing accumulation of calcium. The absolute concentrations decreased after slight increase in the early stages, corresponding to the final weight of litter remaining (Fig.9).

Table 11b. Calcium content in ailanthus, wild jack and mahogany litter at fortnightly intervals on decomposition (%)

	Ailanthus			Wild jack			Mahogany		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	0.384	0.384	0.384	0.486	0.486	0.486	0.904	0.904	0.904
1	0.410	0.422	0.416	0.494	0.484	0.489	0.876	0.948	0.912
2	0.522	0.478	0.500	0.506	0.500	0.503	1.020	1.000	1.008
3	0.538	0.530	0.534	0.540	0.566	0.553	0.864	0.750	0.809
4	0.658	0.422	0.540	0.548	0.598	0.573	0.838	0.780	0.809
5	0.612	0.378	0.495	0.604	0.632	0.618	0.802	0.736	0.769
6	0.568	0.386	0.477	0.584	0.578	0.581	0.854	0.892	0.873
7	0.584	0.462	0.523	0.630	0.584	0.607	0.892	1.044	0.968
8	0.604	0.528	0.566	0.574	0.596	0.585	0.916	1.124	1.020
9	0.668	0.606	0.637	0.532	0.682	0.607	0.950	1.080	1.015
10	0.598	0.644	0.621	0.614	0.692	0.653	1.042	1.200	1.121
11	0.638	0.694	0.666	0.614	0.706	0.660	1.060	1.246	1.153
12	0.660	0.736	0.698	0.634	0.716	0.675	0.944	1.280	1.112
13	0.688	0.810	0.749	0.676	0.736	0.703	0.944	1.374	1.159
14	0.784	0.856	0.820	0.726	0.734	0.730	1.092	1.466	1.279
15	0.788	0.888	0.838	0.756	0.750	0.753	1.138	1.530	1.334
16	0.782	-	-	0.740	0.804	0.772	1.286	1.568	1.387
17				0.756	0.812	0.784	1.416	1.724	1.570
18				0.766	-	-	1.386	1.920	1.653
19				0.794	-	-	1.510	1.928	1.719
20							1.526	1.978	1.752
21							1.580	2.024	1.802
22							1.732	-	-
23							1.838	-	-
24							1.966	-	-
Mean	0.606	0.576	-	0.628	0.648	-	1.172	1.295	-
CD	C:0.199	P:0.056	CP:0.079	C:0.008	P:0.025	CP:0.035	C:0.031	P:0.102	CP:0.144

C- Condition (open/ homegarden P- Period CP- Interaction

4.3.4.1.4 .6 Mahogany

The data pertaining to the changes in calcium content of mahogany litter are given in Table 11 b.The influence of the condition and period under which decomposition occurred were found to be statistically significant during the period of comparative study.

In mahogany litter, the calcium content was found to increase after slight decrease in the early stages, and as the decomposition proceeded a final value of 1.966 per cent was attained in the open and 2.024 per cent in the homegarden. This proves that calcium in the litter is initially released (until the fifth fortnight in the open and homegarden) and then accumulated. The absolute concentration decreased owing to the decrease in the relative mass of litter as decomposition neared completion (Fig.9).

The existing data showed calcium accumulations to a large extent in the litter of all species. The increase in calcium concentrations suggests that calcium were immobilised or could have been added from exogenous sources.

The behaviour of calcium was found to be erratic in most species and such behaviour with respect to calcium in different species was noted by earlier workers (Gosz *et al.*, 1973; Cromack and Monk, 1975; Pandey and Singh, 1982). In some species part of calcium is lost through leaching in the initial phase of decomposition and immobilization occurred during the later stages of decay. MacLean and Wein (1978) observed increase in calcium in decomposing litter of *Acer, Prunus* and *Populus.* Adding to this, Graustein *et al.* (1977) collected evidence from the litter layers of

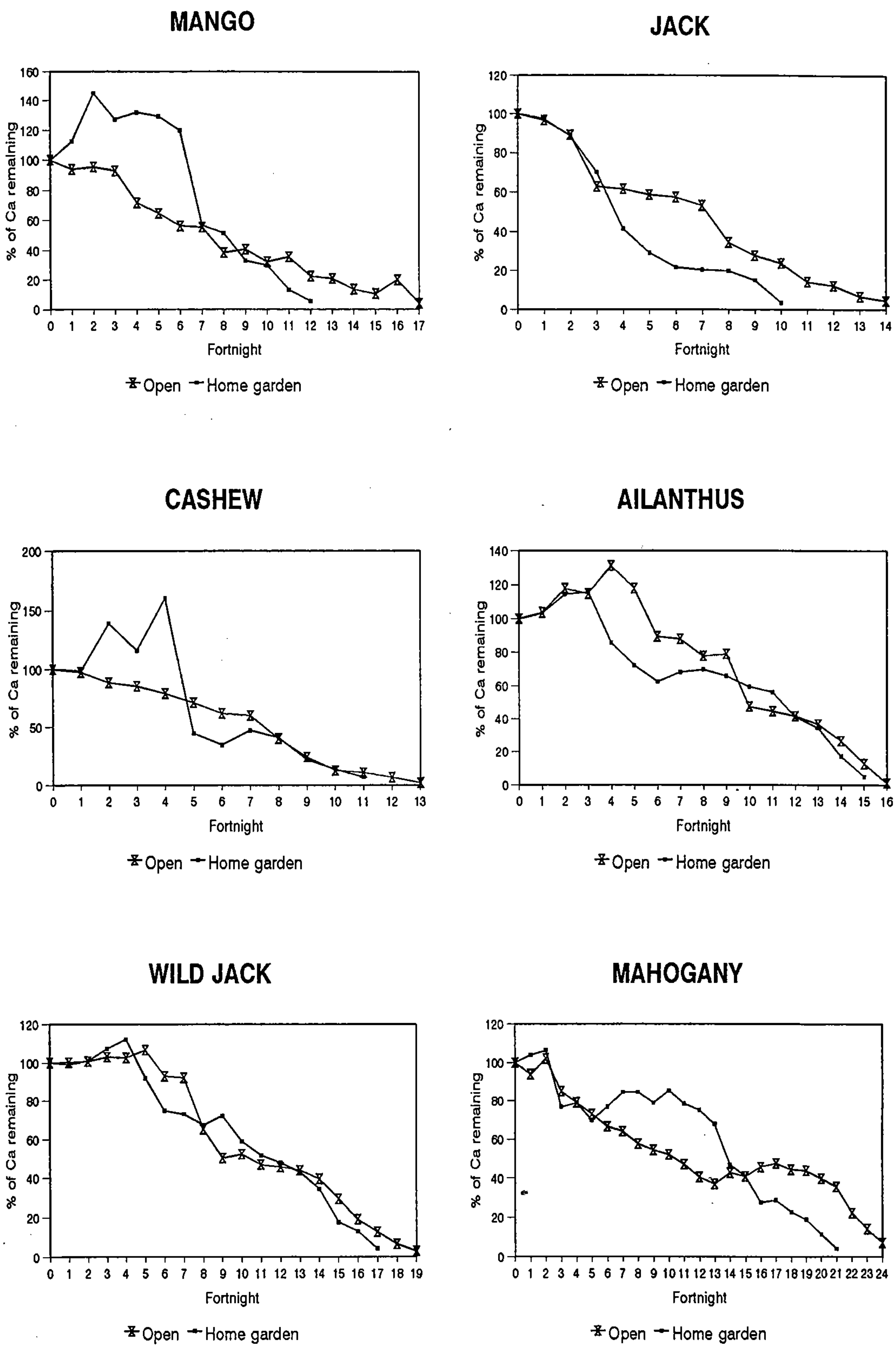

Fig. 9. Calcium release on litter decay in the open and homegarden sites at fortnightly intervals

several forests to show that the associated fungi exude oxalic acid or oxalates abundantly enough to cause precipitation of calcium. The production of oxalates helps to retain calcium. Microorganisms can accumulate high concentrations of calcium. The immobilization of calcium in sugar pine litter was reported by Stohlgren (1988) and he observed that the fir pines released calcium very slowly leading to its low concentrations in the litter. Contamination of the litter with dust and sediments is also responsible for the increase in calcium content in decomposing litter (Klemmedson *et al.*, 1985). Leaching losses of calcium noted in the early stages is in line with works of Maheswaran and Gunatilleke (1988) and Ward *et al.* (1991).

4.3.4.1.5 Magnesium

4.3.4.1.5.1 Mango

The magnesium content in mango litter remaining after decomposition in the open and homegarden are given in Table 12 a.

The variation in the magnesium content of residual litter was significant between that in the open and homegarden and also that collected during the different fortnights of comparative study.

The initial value declined to 0.013 per cent in the open revealing a Mg release of 84.89 per cent and the amount of magnesium remaining in the final litter was 0.29 per cent (Fig.10).

The final magnesium content in the residual litter in the homegarden was 0.009 per cent, the nutrient release being 89.5 per cent and the absolute concentration 0.233 per cent (Fig.10).

Table 12a. Magnesium content in mango, jack and cashew litter at fortnightly intervals on decomposition (%)

	Mango			Jack			Cashew		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	0.086	0.086	0.086	0.147	0.147	0.147	0.096	0.096	0.096
1	0.086	0.089	0.088	0.161	0.160	0.160	0.097	0.089	0.093
2	0.056	0.083	0.070	0.158	0.165	0.162	0.105	0.084	0.095
3	0.073	0.073	0.073	0.155	0.154	0.154	0.085	0.068	0.077
4	0.065	0.061	0.063	0.158	0.144	0.151	0.099	0.064	0.082
5	0.054	0.054	0.054	0.163	0.136	0.149	0.094	0.060	0.077
6	0.037	0.058	0.048	0.151	0.138	0.145	0.084	0.046	0.065
7	0.063	0.054	0.059	0.144	0.134	0.139	0.074	0.041	0.057
8	0.044	0.049	0.047	0.134	0.126	0.130	0.080	0.029	0.054
9	0.015	0.044	0.030	0.137	0.111	0.124	0.064	0.016	0.040
10	0.016	0.031	0.024	0.129	0.068	0.098	0.164	0.011	0.038
11	0.017	0.016	0.017	0.122	-	-	0.069	0.011	0.040
12	0.015	0.009	0.012	0.089	-	-	0.044	-	-
13	0.017	-	-	0.143	-	-	0.021	-	-
14	0.019	-	-	0.109	-	-			
15	0.020	-	-						
16	0.017	-	-						
17	0.013	-	-						
Mean	0.040	0.054	-	0.140	0.099	-	0.076	0.051	-
CD	C: 0.003	P: 0.007	CP: 0.010	C: 0.005	P: 0.010	CP: 0.014	C: 0.059	P: 0.049	CP: 0.040

C- Condition (open/ homegarden) P- Period CP- Interaction

4.3.4.1.5.2 Jack

The data on variation in magnesium content of jack litter furnished in Table 12 a reveal significant variation in the values between the open and homegarden and within each site between the fortnights of sampling.

In the open, the increase noticed during the first fortnight was not significant and subsequently a decline was observed in the magnesium content of residual litter.

The homegarden data also showed similar trends of magnesium fluctuation, and the final lower value prove nutrient release. The absolute amount of magnesium also declined by the time of 95 per cent disappearance of jack litter (Fig.10).

4.3.4.1.5.3 Cashew

The magnesium content of decomposing cashew litter are presented in Table 12 a. The mean values declined significantly though slight fluctuations were noticed in between.

The variations were significant between open and homegarden at one per cent level with the open site litter recording higher mean values. The fortnightly variations were significant one and five per cent levels.

The magnesium content decreased significantly from the initial value of 0.096 per cent to 0.021 per cent in the open and to 0.011 per cent in the homegarden. The decrease confirms magnesium release in both situations. The absolute amounts also declined as depicted in Fig.10.

4.3.4.1.5.4 Ailanthus

The magnesium content in ailanthus litter differed significantly between open and homegarden and also exhibited significant fortnightly variations (Table 12 b).

The final content in the open was 0.017 per cent, which is 25.8 per cent of initial concentration, and this divulges a release of 74.30 per cent of the initial magnesium content (Appendix IV d). The fig 10. reveals the trend in decline of absolute value in 16 fortnights.

In the homegarden, the decline in magnesium content to 0.048per cent made it apparent that release of magnesium occurred with ailanthus litter decomposition. This was very much lower than that in the open (27.3 per cent).

4.3.4.1.5.5 Wild jack

The magnesium dynamics of decomposing wild jack litter are presented in Table 12 b .

The influence of the condition and period of decomposition were significant. The mean value was found to decrease steadily from an initial concentration of 0.075 per cent to 0.023 per cent after an abrupt increase noted during the fourteenth fortnight.

4.3.4.1.5.6 Mahogany

The data on the variation in magnesium content of mahagony litter presented in Table 12 b reveal significant variation in the values between the open and homegarden and within each condition between the fortnights of sampling.

Table 12b. Magnesium content in ailanthus, wild jack and mahogany litter at fortnightly intervals on decomposition (%)

	Ailanthus			Wild jack			Mahogany		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	0.066	0.066	0.066	0.075	0.075	0.075	0.070	0.070	0.070
1	0.065	0.068	0.067	0.073	0.074	0.073	0.080	0.072	0.076
2	0.085	0.079	0.082	0.071	0.075	0.073	0.076	0.074	0.075
3	0.077	0.087	0.082	0.068	0.073	0.070	0.073	0.073	0.073
4	0.069	0.079	0.074	0.070	0.072	0.071	0.064	0.068	0.066
5	0.066	0.080	0.073	0.066	0.072	0.069	0.069	0.063	0.066
6	0.067	0.086	0.077	0.074	0.062	0.068	0.066	0.065	0.066
7	0.066	0.119	0.081	0.067	0.059	0.063	0.060	0.067	0.064
8	0.070	0.107	0.084	0.061	0.058	0.060	0.058	0.053	0.055
9	0.053	0.104	0.073	0.060	0.048	0.054	0.056	0.048	0.052
10	0.047	0.098	0.065	0.057	0.044	0.051	0.053	0.046	0.049
11	0.042	0.094	0.055	0.050	0.042	0.046	0.053	0.034	0.043
12	0.039	0.083	0.050	0.045	0.034	0.039	0.056	0.031	0.044
13	0.033	0.068	0.040	0.046	0.026	0.036	0.045	0.031	0.038
14	0.032	0.061	0.028	0.054	0.026	0.040	0.040	0.027	0.034
15	0.020	0.048	0.016	0.044	0.021	0.033	0.036	0.024	0.030
16	0.017	-	-	0.036	0.016	0.026	0.032	0.022	0.027
17				0.030	0.016	0.023	0.032	0.013	0.023
18				0.024	-	-	0.027	0.013	0.020
19				0.020	-	-	0.024	0.014	0.019
20							0.023	0.011	0.017
21							0.022	0.008	0.015
22							0.017	-	-
23							0.016	-	-
24							0.012	-	-
Mean	0.054	0.083	-	0.055	0.050	-	0.046	0.042	-
CD	C: 0.003	P: 0.008	CP: NS	C: 0.005	P: 0.005	CP: 0.070	C: 0.001	P: .005	CP: 0.007

C-Condition (open/ homegarden) P- Period CP- Interaction

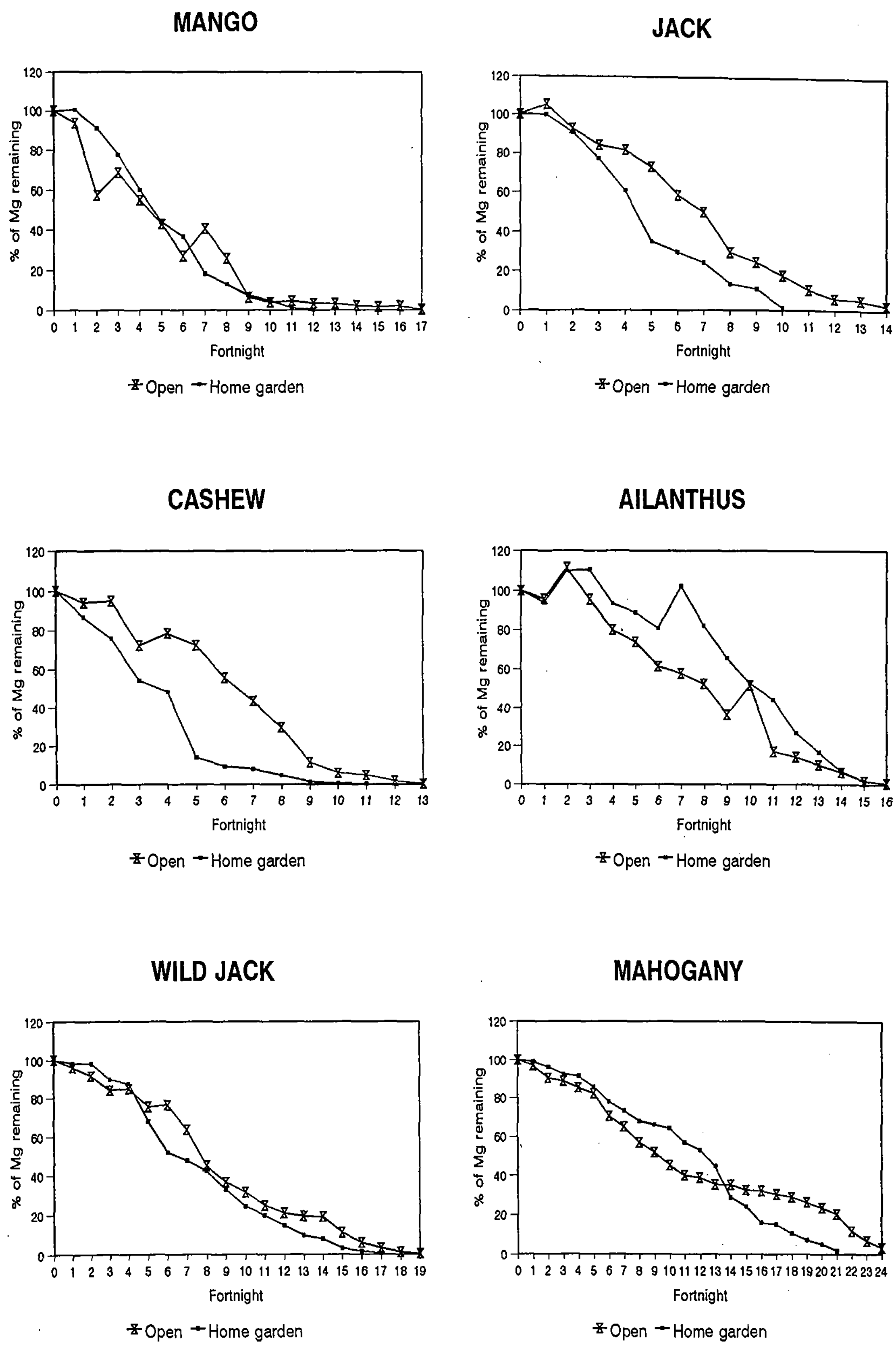

Fig. 10. Magnesium release on litter decay in the open and homegarden sites at fortnightly intervals

Magnesium release was 83 per cent in the open as the content decreased to 0.012 per cent from the initial 0.070 per cent in 24 fortnights and the absolute concentration was 0.57 per cent (Fig.10 and Appendix IVf). In the homegarden, 88 per cent of magnesium in the initial litter was released in 21 fortnights, as the magnesium content of the litter at the time of final sampling was 0.008per cent. The absolute amount at this stage was 0.222 per cent.

In all species studied at the two sites, litter magnesium content was found to decrease with decomposition after an abrupt initial increase indicating net loss of the element. This can be attributed to the high mobility of the element in the decomposing leaves. Similar reports of magnesium being highly mobile in decomposing litter and at times more mobile than nitrogen and phosphorus were given by Attiwill (1968) and Baker and Attiwill (1985). Slight increases in magnesium noticed might be due to microbial immobilization (Berg and Staaf, 1982) or sediment contamination (Klemmedson *et al.,* 1985).

4.3.4.1.5 Micro nutrients

4.3.4.1.6.1 Mango

The changes in zinc content in residual litter over time in decomposing mango leaf litter are given in Tables 13 to 16.

Statistical analysis of the data divulged significant variation in zinc content of the litter sampled at fortnightly intervals and between the open and homegarden (Table 13a.).

Table 13a. Zinc content in mango, jack and cashew litter at fortnightly intervals on decomposition (ppm)

	Mango			Jack			Cashew		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	2.138	2.138	2.138	3.750	3.750	3.750	3.998	3.998	3.998
1	1.674	2.218	1.946	2.918	3.056	2.987	3.830	3.944	3.887
2	2.056	2.158	2.107	3.318	3.488	3.403	3.502	3.320	3.411
3	2.154	2.66	2.407	3.570	3.292	3.431	3.054	2.918	2.986
4	2.86	2.892	2.876	3.570	3.710	3.640	3.942	3.550	3.746
5	2.42	3.172	2.796	3.104	4.366	3.735	3.556	3.674	3.615
6	2.324	3.626	2.975	3.160	4.568	3.864	3.172	4.716	3.944
7	2.65	3.818	3.234	3.136	4.392	3.764	4.508	4.690	4.599
8	2.734	4.288	3.511	2.896	5.142	4.019	3.412	3.752	3.582
9	2.818	4.886	3.852	2.960	5.836	4.398	3.472	3.576	3.524
10	3.124	5.466	4.295	4.118	6.210	5.164	3.704	3.558	3.631
11	3.286	5.192	4.239	4.606	-	-	3.986	3.910	3.948
12	4.062	6.044	5.053	4.732	-	-	4.148	3.684	3.916
13	4.98	-	-	5.112	-	-	4.204	4.858	4.531
14	5.01	-	-	5.972	-	-	4.824	4.828	4.826
15	5.458	-	-				5.808	5.752	5.780
16	5.526	-	-				6.114	-	-
17	5.424	-	-						
Mean	3.372	3.735	-	3.795	4.346	-	4.073	3.808	-
CD	C: 0.112	P: 0.286	CP: 0.404	C: 0.145	P: 0.341	CP: 0.482	C: NS	P: 0.442	CP: 0.156

C- Condition (open/ homegarden) P- Period CP- Ineraction

In the open the initial content decreased to 1.674 ppm during the second fortnight and increased to 5.424 ppm by the time 95 per cent decomposition occurred. The relative content increased while absolute contentdecreased (Appendix IVa).

With respect to the litter in the homegarden, the initial zinc content of 2.138 ppm increased to 6.044 ppm at the time of completion of decomposition. The relative content of zinc increased indicating that the element accumulated in the litter as decomposition proceeded. The absolute content decreased owing to the decrease in weight of residual litter (Fig.10).

The manganese release from mango litter is presented in Table14a. The data reveal significant variation in manganese content of litter in the open and homegarden. The variation was significant between the different fortnights of sampling also.

The data on manganese variation in mango litter indicate that significant accumulation of manganese occurred on decomposition both in the open and homegarden. The accumulation recorded was more in the homegarden compared to that in the open.

The copper dynamics while mango litter decomposed is given in Table 15a. The mean values of the open and homegarden were significantly different. Fortnightly variations in the open and homegarden were also significant. In the open the initial copper content of 9.60 ppm increased to 27.10 ppm in 17 fortnights and that in the homegarden increased to 29.70 ppm in 12 fortnights.

Table 13b . Zinc content in ailanthus, wild jack and mahogany litter at fortnightly intervals on decomposition (ppm)

	Ailanthus			Wild jack			Mahogany		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	3.998	3.998	3.998	1.484	1.484	1.484	4.748	4.748	4.748
1	3.830	3.944	3.887	1.486	1.456	1.471	4.618	4.018	4.318
2	3.502	3.320	3.411	1.498	1.530	1.514	4.868	4.214	4.541
3	3.054	2.918	2.986	1.504	1.846	1.675	4.476	4.646	4.561
4	3.942	3.550	3.746	1.372	1.876	1.624	4.744	4.946	4.845
5	3.556	3.674	3.615	1.354	2.254	1.804	4.304	5.262	4.783
6	3.172	4.716	3.944	1.702	2.344	2.023	4.604	5.040	4.822
7	4.508	4.690	4.599	1.664	2.426	2.045	4.816	5.514	5.165
8	3.412	3.752	3.582	2.362	2.706	2.534	5.124	5.814	5.469
9	3.472	3.576	3.524	2.616	3.038	2.827	5.266	5.566	5.416
10	3.704	3.558	3.631	2.768	2.912	2.840	5.270	5.650	5.460
11	3.986	3.910	3.948	3.114	3.382	3.248	5.850	5.896	5.873
12	4.148	3.684	3.916	3.256	3.422	3.339	5.990	6.464	6.227
13	4.204	4.858	4.531	3.360	4.352	3.856	6.304	6.598	6.451
14	4.824	4.828	4.826	3.620	4.742	4.181	5.842	6.888	6.365
15	5.808	5.752	5.780	3.722	5.256	4.489	5.940	7.254	6.597
16	6.114	-	-	4.024	5.232	4.624	6.508	7.344	6.926
17				4.214	5.714	4.964	6.716	8.046	7.381
18				4.224	-	-	6.708	8.314	7.511
19				4.756	-	-	7.210	8.700	7.955
20							7.416	8.792	8.104
21							7.576	9.362	8.469
22							7.850	-	-
23							7.950	-	-
24							8.106	-	-
Mean	4.073	3.808	-	2.705	3.110	-	5.952	6.322	-
CD	C: 0.145	P: 0.341	CP: 0.482	C: 0.097	P: 0.29	CP: 0.41	C: 0.093	P: 0.308	CP: 0.435

C – Condition (open/ homegarden) P-Period CP- Interaction

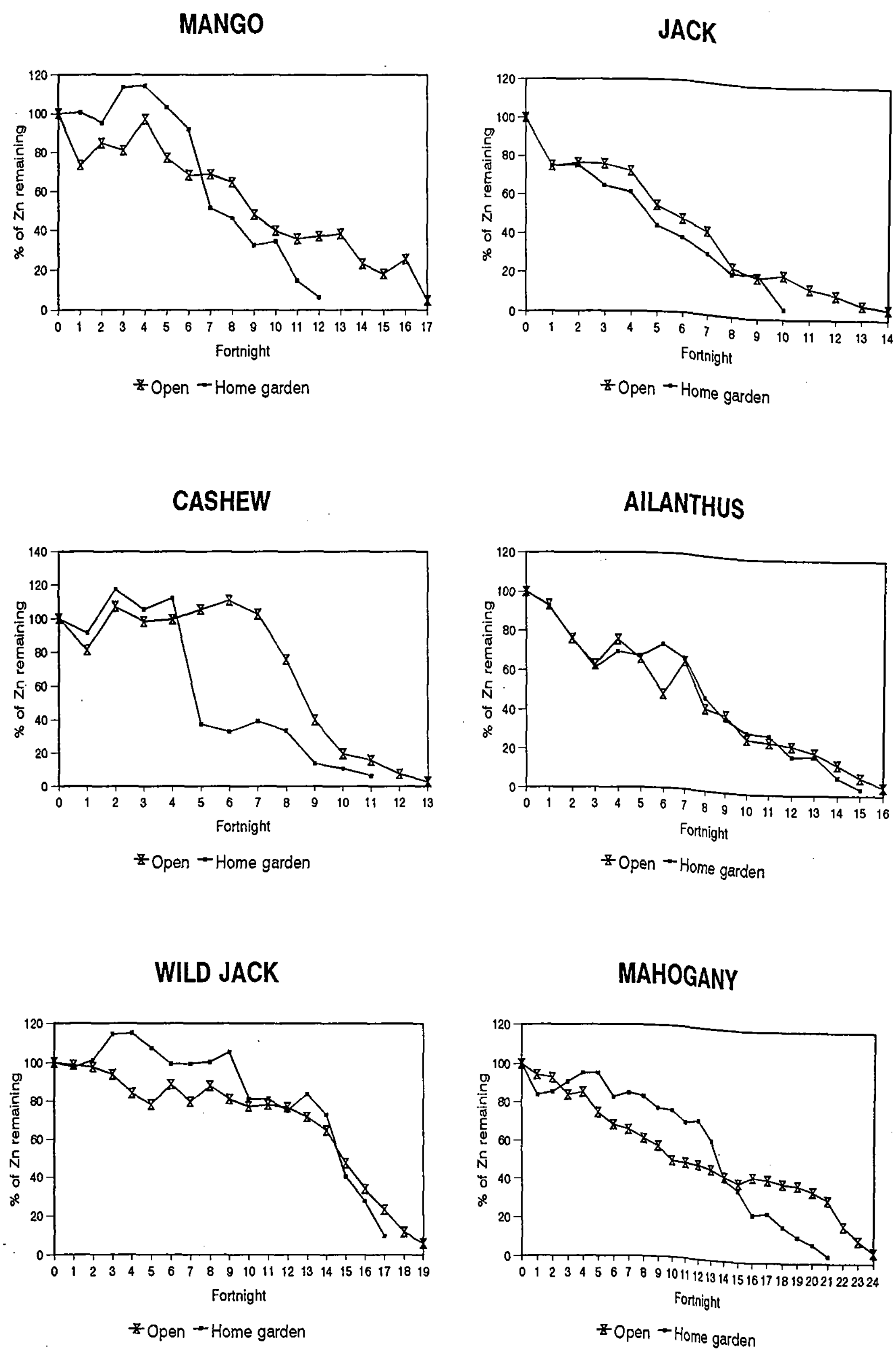

Fig. 11. Zinc release on litter decay in the open and homegarden sites at fortnightly intervals

Table 16a. gives the changes in the iron concentration of residual mango litter at fortnightly intervals on decomposition.

Statistical analysis revealed significant variation in the iron content of open and homegarden litter and also that between the different fortnights. The increase was 1.34 times the initial in the open (349.20 ppm) and 1.4 times that of the initial in the homegarden (361.40 ppm) resulting in increased values for the relative concentration. The absolute concentrations declined in both situations as evident from Fig. 13.

4.3.4.1.6.2 Jack

The data furnished in the tables (13 a to 16 a) reveal significant increase in the micronutrient contents in the litter in the open and homegarden. The influence of the site of experiment and period of sampling were both significant.

The zinc content of jack litter increased on decomposition revealing accumulation of the element during decay (Table 13a). The fortnightly variation and that between the two situations were significant.

In the open, the increase was from 3.75 to 5.972 ppm, whereas in the homegarden it was to 6.210 ppm. The data reveals 59 per cent accumulation in the former and 66 per cent in the latter situation.

The variations in manganese, copper and iron contents of jack litter were significant in the open and homegarden and also between the fortnights of sampling. The data are presented in Tables 13a,14a,15a and 16a. The micronutrients were found to accumulate in the litter as decomposition proceeded.

Table 14a. Manganese content in mango, jack and cashew litter at fortnightly intervals on decomposition (ppm)

	Mango			Jack			Cashew		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	4.052	4.052	4.052	2.704	2.704	2.704	3.886	3.886	3.886
1	4.452	3.510	3.981	3.108	3.126	3.117	3.544	3.580	3.562
2	3.882	3.798	3.840	3.594	4.064	3.829	3.580	3.504	3.542
3	3.738	3.984	3.861	3.420	4.552	3.986	3.072	3.750	3.411
4	4.476	4.112	4.294	3.400	4.964	4.182	3.234	3.820	3.527
5	3.652	4.862	4.257	3.874	6.150	5.012	3.430	3.840	3.635
6	4.170	5.090	4.630	3.900	6.778	5.339	2.988	3.848	3.418
7	3.952	6.504	5.228	3.676	6.828	5.252	2.546	3.916	3.231
8	4.062	7.040	5.551	4.042	6.686	5.364	2.564	4.296	3.430
9	4.572	7.134	5.853	4.772	7.462	6.117	3.020	4.588	3.804
10	4.876	7.962	6.419	5.048	8.504	6.776	3.676	4.960	4.318
11	4.870	8.260	6.565	5.750	-	2.875	3.880	6.034	4.957
12	5.084	9.270	7.177	5.796	-	2.898	3.966	-	-
13	5.352	-	-	5.586	-	2.793	4.256	-	-
14	6.000	-	-	6.482	-				
15	6.052	-							
16	6.792	-							
17	7.586	-							
Mean	4.868	5.184	-	4.343	5.620	-	3.403	4.169	-
CD	C: 0.168	P: 0.429	CP: 0.607	C: 0.163	P: 0.383	CP: 0.543	C: 0.23	P: 0.56	CP: 0.79

Condition (open/ homegarden) P- Period CP- Interaction

Manganese in the open increased from an initial value of 2.704 to 6.482 ppm in the open and to 8.504 ppm in the homegarden revealing accumulation in either situation.

The mean copper content in the open was 21.46 ppm and in the homegarden was 20.91 ppm. In both situations the initial value of 9.5 ppm increased significantly as jack litter decomposed. The final values were 30.9 and 36.3 ppm respectively

The data on iron content reveal significant increase from 202.8 ppm to 324.8 ppm and to 346.4 ppm in the open and homegarden respectively.

4.3.4.1.6.3 Cashew

Tables 13a to 16a give the changes in the micro nutrient contentrats of residual cashew litter at fortnightly intervals on decomposition. Statistical analysis reveal that the variation in manganese, copper and iron contents in the open and homegarden were significant and that of zinc was observed to be non significant. Fortnightly variations of all four elements were significant. The concentrations of the different elements were found to increase as decomposition proceeded, resulting in accumulation of the elements. The absolute amounts decreased, owing to the decline in residual mass as decomposition neared completion (Fig.11 to 14)

The increase was 2.5 times in zinc, 1.10 times in manganese, 3.53 times in copper and 1.3 times in iron in the open and 2.6, 1.6, 3.42 and 1.2 times in zinc, manganese, copper and iron and in the homegarden

Table 1. 5. Manganese content in ailanthus, wild jack and mahogany litter at fortnightly intervals on decomposition (ppm)

	Ailanthus			Wild jack			Mahogany		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	2.608	2.608	2.608	2.164	2.164	2.164	0.366	0.366	0.366
1	2.478	2.428	2.453	2.086	2.174	2.130	0.460	0.432	0.446
2	2.448	2.640	2.544	2.220	2.140	2.180	0.630	0.662	0.646
3	2.362	2.670	2.516	2.260	2.300	2.280	0.598	0.756	0.677
4	2.360	2.748	2.554	2.470	2.356	2.413	0.522	0.852	0.687
5	2.430	2.910	2.670	2.800	2.342	2.571	0.626	0.840	0.733
6	2.488	2.952	2.720	3.260	3.224	3.242	0.644	0.930	0.787
7	2.246	3.086	2.666	2.930	2.972	2.951	0.758	0.982	0.870
8	2.540	3.242	2.891	2.496	2.672	2.584	0.944	1.282	1.114
9	2.888	3.870	3.379	2.412	3.470	2.941	0.964	1.532	1.248
10	2.884	3.834	3.359	2.358	3.926	3.142	1.240	1.802	1.521
11	3.164	3.996	3.580	2.368	4.438	3.403	1.150	1.684	1.417
12	3.212	4.294	3.753	2.596	4.760	3.678	1.104	2.188	1.646
13	3.658	4.300	3.979	2.574	4.912	3.743	1.228	2.146	1.687
14	4.152	4.874	4.513	2.630	5.304	3.832	1.140	1.910	1.525
15	4.050	4.906	4.478	2.894	5.130	4.012	1.210	1.886	1.548
16	4.324	-	2.162	3.332	5.234	4.283	0.996	2.170	1.583
17				3.966	5.754	4.860	0.938	2.138	1.538
18				3.928	-		1.976	2.354	2.165
19				4.936	-		1.902	2.590	2.246
20							1.966	2.722	2.344
21							2.888	3.312	3.100
22							2.796	-	
23							2.786	-	
24							3.232	-	
Mean	2.958	3.256	-	2.834	3.611	-	1.323	1.615	-
CD	C: 0.094	P: 0.266	CP: 0.376	C: 0.088	P: 0.264	CP: 0.372	C: 0.061	P: 0.203	CP: 0.287

C- Condition (open/ homegarden) P- Period CP- Interaction

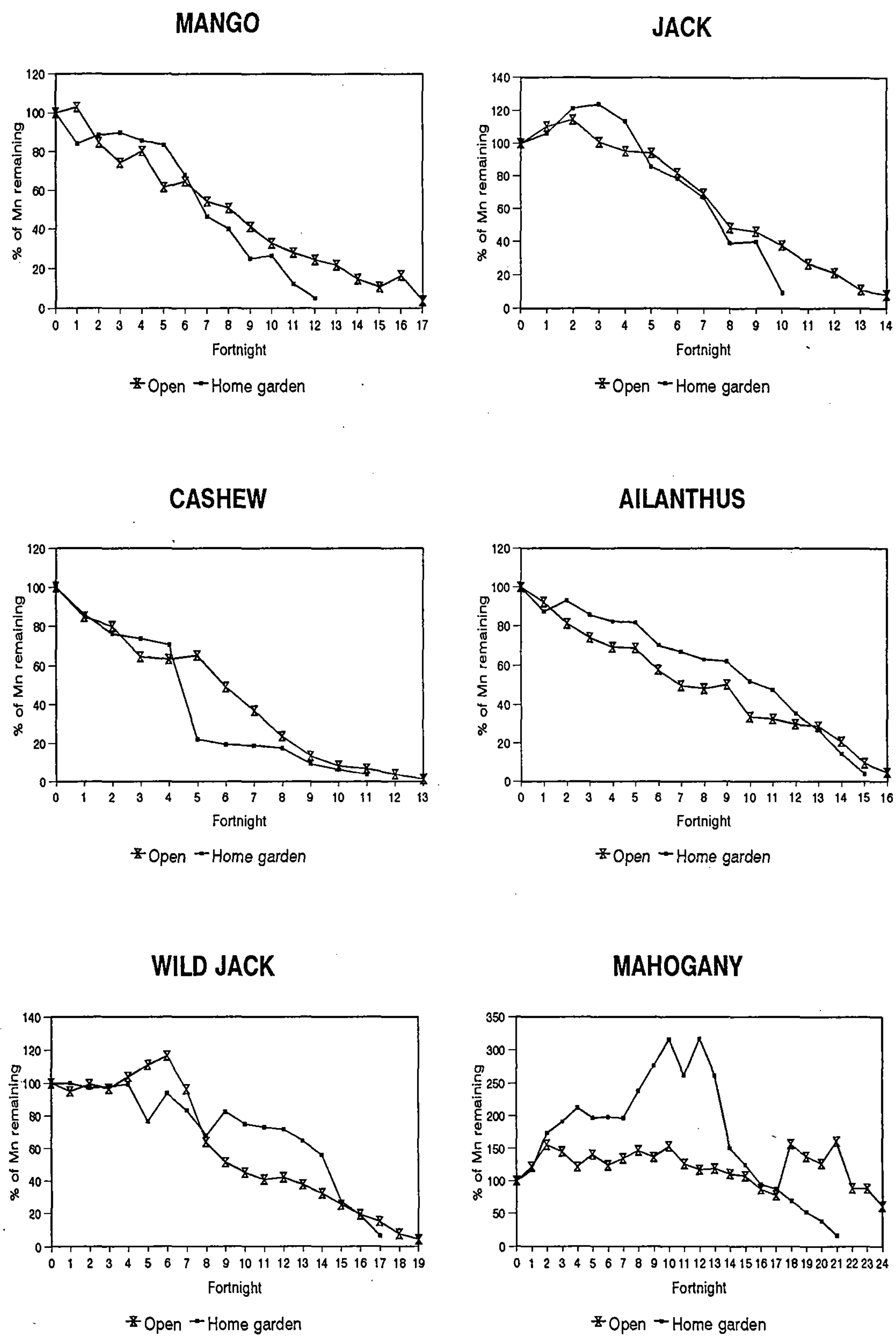

Fig. 12. Manganese release on litter decay in the open and homegarden sites at fortnightly intervals

respectively. The increase recorded for each element at both sites remained in the same range.

4.3.4.1.6.4 Ailanthus

Tables 13 b to 16 b give the changes in the zinc, manganese, copper and iron concentration of residual ailanthus litter at fortnightly intervals. Data reveal that the concentrations of manganese, copper and iron varied significantly between open and homegarden and also significant fortnightly variations in zinc, manganese, copper and iron.

In the open, the increase was nearly two fold in Zn and Mn, four fold in Fe and ten fold in Cu. The high contents of these elements prove significant accumulation of these elements. The absolute contents declined in each situation for each element as the corresponding relative masses were lowered (Fig. 11 to 14).

Similar trends of accumulations of the above micronutrients and decline in absolute contents were recorded in the homegarden. The magnitude of increase in zinc content was 1.4 times, nearly twice for manganese, thrice for iron and ten fold for copper.

4.3.4.1.6.5 Wild jack

The data on the fortnightly changes in zinc, manganese, iron and copper associated with wild jack litter decomposition are presented in Table 13 b to 16 b. The above four micronutrients varied significantly between open and homegarden and also showed fortnightly variations. The values indicate that accumulation of zinc, manganese, and iron and copper occurred on decomposition of wild jack litter. The magnitude of increase

Table 15a. Copper content in mango, jack and cashew litter at fortnightly intervals on decomposition (Cu ppm)

	Mango			Jack			Cashew		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	9.60	9.60	9.60	9.50	9.50	9.50	5.20	5.20	5.20
1	10.20	10.60	10.40	9.20	10.00	9.60	5.80	7.10	7.10
2	11.60	15.50	13.55	12.90	14.90	13.90	7.30	8.90	8.90
3	11.90	17.80	14.85	15.70	15.10	15.40	7.50	12.50	12.50
4	12.70	18.20	15.45	23.00	17.90	20.45	9.20	13.00	13.00
5	13.20	20.60	16.90	17.80	20.80	19.30	8.60	14.70	14.70
6	13.80	21.10	17.45	17.40	22.20	19.80	9.90	16.00	16.00
7	13.50	22.80	18.15	21.80	24.90	23.35	10.30	16.10	16.10
8	13.40	24.50	18.95	23.60	28.10	25.85	11.20	16.30	16.30
9	14.50	23.00	18.75	25.90	30.30	28.10	13.00	18.80	18.80
10	14.30	27.80	21.05	29.50	36.30	32.90	16.10	17.90	17.90
11	14.20	25.40	19.80	28.90	-	-	17.00	17.80	17.80
12	14.40	29.70	22.05	27.50	-	-	18.30	-	-
13	15.80	-	-	28.30	-	-	18.40	-	-
14	16.30	-	-	30.90	-	-			
15	20.30	-	-						
16	20.60	-	-						
17	27.10	-	-						
Mean	14.86	20.51	-	21.46	24.45	-	11.27	11.74	-
CD	C: 0.887	P: 2.26	CP: 3.20	C: 0.883	P: 2.07	CP: 2.93	C: 0.655	P: 1.604	CP: 2.268

C- Condition (open/ homegarden) P- Period CP- Interaction

were 3.2 times for zinc, 2.3 times for manganese, 3.1 times for copper and 2.6 times for iron in the open and 3.9, 2.7, 3.0 and 2.3 times for zinc, manganese, and iron and copper respectively in homegarden.

4.3.4.1.6.6 Mahogany

The changes in micro nutrient contents in mahagony litter on decomposition are presented in Tables 13 b,14 b 15 b and 16 b.

Critical analysis of the data revealed significant fortnightly variation in the micronutrient contents in the litter and also between open and homegarden except for iron. The mean iron content in the open and homegarden did not vary significantly.

The data on micronutrient contents showed accumulations of these four elements on decomposition. The increase was nearly nine fold in manganese, six fold in the case of copper, five fold in iron and two fold in zinc.

The increase in contents of heavy metals such as zinc, manganese, iron and copper during decomposition of organic materials as observed in this study is not a rare observation (Gosz *et al.*, 1973; Lousier and Parkinson, 1978; Staaf, 1980; Rustad, 1994). According to Bockheim and Leide (1986) forest floor acts as a sink for micronutrients.

Zinc increase on decomposition is attributed to microbial activity. This element is considered to play an important role in several fungal metabolic processes and hence is readily accumulated by fungi (Byrne *et al.*, 1976).

Table 15b.. Copper content in ailanthus, wild jack and mahogany litter at fortnightly intervals on decomposition (ppm)

	Ailanthus			Wild jack			Mahogany		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	3.00	3.00	3.00	4.64	4.64	4.64	7.40	7.40	7.40
1	9.70	6.30	8.00	5.92	5.00	5.46	15.30	7.90	11.60
2	19.80	6.50	13.15	6.40	5.50	5.95	17.90	10.00	13.95
3	17.30	9.00	13.15	7.30	7.10	7.20	20.10	9.90	15.00
4	17.70	10.50	14.10	8.30	7.60	7.95	23.50	13.40	18.45
5	20.50	11.70	16.10	11.00	7.90	9.45	30.00	12.70	21.35
6	23.30	13.90	18.60	12.00	8.80	10.40	30.80	15.70	23.25
7	23.70	16.50	20.10	12.70	10.50	11.60	31.80	12.30	22.05
8	23.80	18.20	21.00	13.50	11.40	12.45	29.20	15.40	22.30
9	26.30	17.80	22.05	14.90	11.60	13.25	41.70	17.10	29.40
10	28.00	19.30	23.65	13.30	12.30	12.80	23.50	19.70	21.60
11	25.70	22.90	24.30	12.10	12.60	12.35	28.50	22.90	25.65
12	25.20	25.50	25.35	14.50	12.40	13.45	32.80	20.70	26.75
13	28.40	27.10	27.75	14.30	11.30	12.80	28.10	23.30	26.20
14	26.30	30.10	28.20	15.90	11.50	13.70	26.30	28.90	27.60
15	28.61	30.30	29.45	16.20	13.50	14.85	23.80	27.80	25.80
16	28.50	-	-	14.30	13.80	14.05	25.80	28.00	26.90
17				14.30	14.10	14.20	26.40	34.20	30.30
18				13.20	-		23.70	30.90	27.30
19				14.20	-		21.60	37.00	29.30
20							30.60	43.50	37.05
21							41.70	44.30	43.00
22							37.90	-	-
23							32.60	-	-
24							43.60	-	-
Mean	22.11	16.79	-	11.95	10.90	-	27.82	21.95	-
CD	C: 1.156	P: 3.270	CP: 4.625	C: 0.41	P: 1.24	CP: 1.76	C: 1.65	P: 5.46	CP: 7.72

C- Condition (open/ homegarden) P- Period CP- Interaction

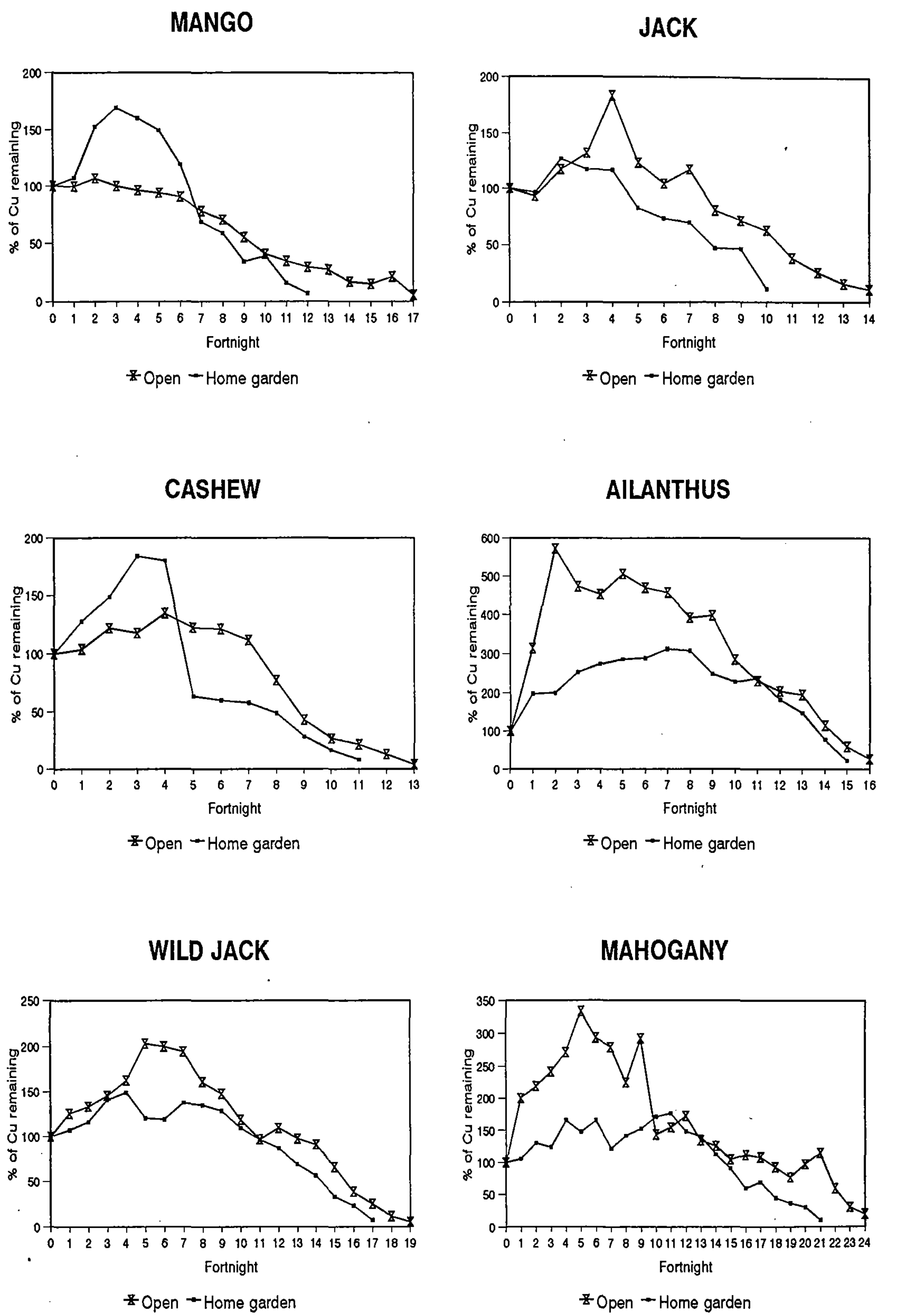

Fig. 13. Copper release on litter decay in the open and homegarden sites at fortnightly intervals

The increase in manganese must also probably be due to microbial immobilization and /or addition of manganese from exogenous sources (foliar leaching, dust, green litter fall, weathering of parent material) as documented by Lousier and Parkinson (1978).

Iron is widely reported to increase during decomposition and the most probable cause is ascribed to exogenous sources. According to Rustad (1994) the sources by which iron is incorporated into residue litter are : foliar leaching, dust, green leaf litter fall, weathering of parent material, upward diffusion from underlying mineral soils and inputs of mineral soils, interactions with low molecular weight organic acids, humic and pulvic acids.

Copper was found to increase in the residual litter of all tree species as it is known to be chelated by organic matter and hence tended to accumulate in the surface of soil layers in forest (Gosz *et al.*, 1973). The divalent ion is known to be strongly bound to fulvic acids in soils thus forming copper- organic matter complexes (Marshner,1975). Sporocarps (Cromack *et al.*, 1975), rhizomorphs, slime moulds (Stark, 1972) and macro fungi (Hinneri, 1975) are also known to accumulate copper.

The study thus reveal the conservation of micronutrients in decomposing litter mostly from exogenous sources.

Table 16a. Iron content in mango, jack and cashew litter at fortnightly intervals on decomposition (ppm)

	Mango			Jack			Cashew		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	261.40	261.40	261.40	202.80	202.80	202.80	269.20	269.20	269.20
1	260.20	261.80	261.00	209.80	207.40	208.60	234.40	268.00	251.20
2	250.40	286.80	268.60	131.80	189.20	160.50	240.60	253.00	246.80
3	265.00	306.20	285.60	183.80	219.40	201.60	245.00	255.60	250.30
4	275.40	295.00	285.20	242.40	247.60	245.00	251.00	269.00	260.00
5	278.40	322.80	300.60	247.80	253.40	250.60	267.80	275.20	271.50
6	285.40	311.40	298.40	253.80	259.80	256.80	267.00	286.20	276.60
7	283.80	314.40	299.10	248.20	274.00	261.10	283.80	288.60	286.20
8	288.40	317.20	302.80	257.20	274.60	265.90	297.00	300.20	298.60
9	303.00	319.40	311.20	250.40	291.80	271.10	295.40	295.20	295.30
10	302.40	312.20	307.30	256.20	346.40	301.30	289.40	297.60	293.50
11	299.40	331.20	315.30	266.60	-	-	309.60	320.80	315.20
12	317.80	361.40	339.60	266.60	-	-	327.00	-	-
13	326.40	-	-	306.20	-	-	352.40	-	-
14	335.00	-	-	324.80	-	-			
15	339.60	-	-						
16	348.20	-	-						
17	349.20	-	-						
Mean	298.19	307.79	-	243.23	251.49	-	280.69	281.55	-
CD	C: 5.77	P: 14.72	CP: 20.81	C: 8.98	P: 21.07	CP: 29.8	C: 7.93	P: 19.41	CP: NS

C- Condition (open/ homegarden) P- Period CP- Interaction

Table 16 b. *Iron content in residual ailanthus, wild jack and mahogany litter at fortnightly intervals (Fe ppm)*

	Ailanthus			Wild jack			Mahogany		
Fortnight	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	133.80	133.80	133.80	160.20	160.20	160.20	196.40	196.40	196.40
1	134.80	120.40	127.60	188.20	189.40	188.80	217.40	267.60	292.50
2	187.60	162.40	175.00	198.60	202.40	200.50	404.60	286.60	345.00
3	241.60	191.20	216.40	202.20	206.20	204.20	490.80	357.80	424.30
4	264.80	192.20	228.50	200.80	201.20	201.00	512.00	434.50	473.20
5	280.60	187.60	234.10	206.40	215.60	211.00	510.20	555.00	532.60
6	311.20	173.60	242.40	220.60	213.80	217.20	818.80	651.40	735.10
7	318.80	207.60	263.20	221.60	234.60	228.10	875.60	714.40	795.00
8	355.40	237.60	296.50	235.20	262.00	248.60	760.80	845.40	803.10
9	358.40	280.60	319.50	236.60	258.00	247.30	1195.20	805.60	1000.40
10	493.40	375.80	434.60	246.40	266.80	256.60	1871.40	910.80	1391.10
11	393.80	384.00	388.90	250.60	272.80	261.70	662.60	919.20	790.90
12	401.00	410.20	405.60	254.00	275.00	264.50	633.80	710.80	672.30
13	396.40	409.40	402.90	260.80	279.40	270.10	771.00	809.00	790.00
14	409.80	412.00	410.90	273.60	328.20	300.90	657.00	839.00	748.00
15	414.20	410.60	412.40	290.60	327.80	309.20	820.60	880.00	850.30
16	427.00	-	-	315.20	362.20	338.70	851.40	877.00	864.20
17				324.80	372.60	348.70	881.80	1024.60	953.20
18				359.00	-		835.80	823.40	829.60
19				410.80	-		831.40	596.00	713.70
20							1023.40	570.60	797.00
21							1052.60	882.00	967.30
22							917.80	-	
23							948.00	-	
24							955.80	-	
Mean	324.86	268.06	-	252.81	257.12	-	787.85	679.80	-
CD	C: 14.59	P: 41.27	CP: 58.37	C: 4.95	P: 14.96	CP: 21.16	C: NS	P: 314.59	CP:NS

C- Condition (open/ homegarden) P-Period CP- Interaction

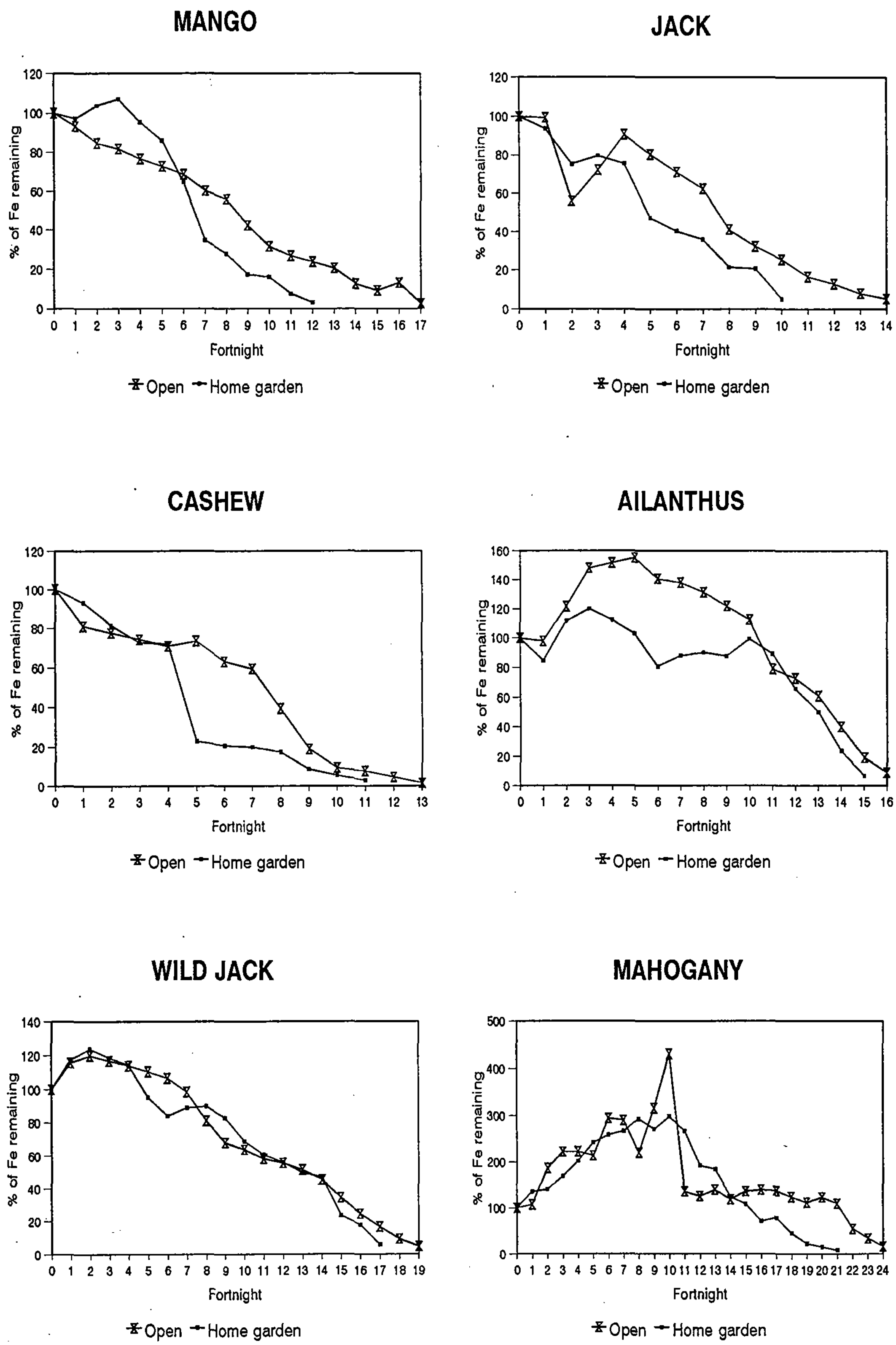

Fig. 14. Iron release on litter decay in the open and homegarden sites at fortnightly intervals

4.3.4.2 Pattern of nutrient release

The pattern of nutrient release from the various species of litter kept for decomposition at both sites were worked out and is furnished in Table 17.

Of the nine elements studied, all species recorded maximum mineralisation of potassium. The pattern of release of the other elements varied with the species and ecosystem. The release of nutrients in the mango litter, in the open and homegarden followed a general trend of K followed by N/ Mg, P, Fe, Mn, Ca, Zn and Cu. The general order of nutrient release in jack was K>P>N/ Mg> Ca> Zn/ Fe> Mn> Cu; cashew K>N/Mg>P/Mn/Fe>Ca/Zn>Cu;AilanthusK>P/N/Mg>Zn>Mn>Ca>Fe>Cu; wild jack K>N/P/Mg>Ca>Fe>Mn>Cu>Zn and mahogany K>Mg>N/P>Zn>Ca>Fe> Cu>Mn.

The variation in nutrient release pattern can be attributed to the differential mobility and leachability of the elements in the different species litter. Maheswaran and Gunatilleke (1988) attributed this to the varying nutrient requirements of the decomposer organisms of different areas, the nutrient status of the decomposing substrate and the availability of these nutrients from the soils.

Generally, three sequential phases are known to occur during mineralisation of nutrients from decomposing litter: i) an initial phase when leaching and nutrient release predominate; ii) a net immobilization phase during which nutrients are imported into the litter by microbes or added from exogenous sources; and iii) a net release phase when the

Table 17. Nutrient release pattern in different tree species during decomposition in the open and homegarden (%)

Tree species	Absolute contents of nutrients remaining after 95% decomposition									Pattern of nutrient release
	N	P	K	Ca	Mg	Fe	Cu	Zn	Mn	
Mango										
Open	0.28	0.96	0.04	4.00	0.29	2.56	5.42	4.87	3.6	K>N>Mg>P>Fe>Mn>Ca>Zn>Cu
Home	0.75	2.03	0.06	5.46	0.22	3.08	6.9	6.3	5.1	K>Mg> N>P>Fe>Mn>Ca>Zn>Cu
Jack										
Open	1.62	0.69	0.06	4.47	2.47	5.33	10.83	5.3	7.98	K>P>N>Mg>Ca>Zn>Fe>Mn>Cu
Home	1.59	1.06	0.11	3.45	1.37	5.06	11.31	6.21	9.31	K>P>Mg>N>Ca>Fe>Zn>Mn>Cu
Cashew										
Open	0.128	1.32	0.1	2.01	0.24	1.41	3.82	2.74	1.18	K> N>Mg>Mn>P>Fe>Ca>Zn>Cu
Home	0.468	2.19	0.06	6.92	0.28	2.9	8.32	6.32	3.77	K>Mg> N>P>Fe>Mn>Zn>Ca>Cu
Ailanthus										
Open	1.31	0.38	0.09	5.74	0.73	9.0	26.79	4.31	4.68	K>P>Mg>N>Zn>Mn>Ca>Fe>Cu
Home	0.23	0.3	0.04	5.06	1.59	6.72	22.12	3.15	4.12	K>N>P>Mg>Zn>Mn>Ca>Fe>Cu
Wild jack										
Open	0.30	0.3	0.04	3.01	0.49	4.72	5.63	5.9	4.2	K> N/P>Mg>Ca>Fe>Mn>Cu>Zn
Home	0.90	0.41	0.03	4.21	0.54	5.86	7.66	9.7	6.7	K>P>Mg>N>Ca>Fe>Mn>Cu>Zn
Mahogany										
Open	1.98	3.88	0.04	7.29	0.57	16.3	19.74	5.72	3.95	K>Mg>N> P>Zn>Ca>Fe>Cu>Mn
Home	1.16	0.44	0.02	4.14	0.22	8.31	11.08	3.65	16.74	K>Mg>P>N> Zn>Ca>Fe>Cu>Mn

nutrient mass decreases (Swift *et al.*, 1979; Staaf and Berg, 1982). However, not all these phases occur for all nutrients and all types of litter. This is evident in the present study also. Potassium was found to be the most mobile element and was found to leach out in large proportions without immobilisation during decomposition. Nitrogen in mahogany showed the three-phase release pattern whereas in other species, there was an immobilization followed by release. Phosphorus dynamics, though highly variable, in general showed initial leaching followed by immobilization and release towards the end of decomposition. The secondary nutrient, magnesium at times was more mobile than phosphorus as recorded for mango, cashew and mahogany while in the other species these were less mobile. Calcium in most species after an initial loss by leaching was found to accumulate. All the micronutrients examined increased in decomposing litter by the time of complete disappearance of litter revealing low mobility and hence accumulations. Different patterns of mobility and mineralisation of nutrient elements during decay can be attributed to the variation in carbon to nitrogen ratios, nutrient requirements of decomposer organisms, resource quality, general availability of nutrients from soil, the physical environment and its effect on decomposer organisms as documented by O'Connell and Sankaran (1997).

The order of release of the major nutrients, phosphorus, potassium, calcium and magnesium in jack and wild jack tallied with that in desmodium and pueraria residues documented by Orea *et al.* (1996).

The high elemental mobility of magnesium noticed in mango, cashew, wild jack and mahogany corroborate with those of Bahuguna *et al.* (1990) and Lisanework and Michelsen (1994).

Copper revealed least elemental mobility in mango, jack, cashew and ailanthus, whereas it was zinc in wild jack and manganese in mahogany. The micronutrients were found to accumulate in the litter on decomposition and this could be deduced to be responsible for the least mobility shown by the nutrients in the litter. Similar trends of micronutrient accumulation in leaf litter on decomposition were given by Salamanca *et al.* (1998). The order of micronutrient release (accumulation) was B>Mn /Zn>Cu>Fe=Al in the four species litter explored by Bockheim *et al.* (1991).

The study supports the finding of Rustad and Cronan (1988) that decaying litter serve as a short term sink for nitrogen and phosphorus with these elements being released as decay progressed along with potassium and magnesium, while calcium and micronutrients accumulated in the litter mostly from exogenous sources. Thus the six species litter are important sources of nitrogen, phosphorus, potassium and magnesium and sinks for calcium, zinc, manganese, copper and iron.

4.3.5 Changes in the biochemical constituents

The fortnightly changes in the biochemical constituents of leaf litter are given in Tables 17 a to 17 f. Analyses were done only until the period during which samples were sufficiently available for the bio chemical analysis.

4.3.5.1 Mango

The significant variations in the cellulose, hemicellulose and lignin contents over the period and between the sites are depicted in Table 18 a.

The cellulose concentration of mango litter was found to decrease significantly from an initial value of 33.88 per cent to 17.06 per cent in 14 fortnights in the open and to 15.88 per cent in ten fortnights in the homegarden. The range of decrease in mean hemicellulose was from 31.02 to15.45per cent. Lignin content increased as decomposition proceeded and the variation between the two sites were non significant. The increase was 30.36 per cent in the open and 22.07 per cent in the homegarden.

4.3.5.2 Jack

The results of the statistical analysis (Table 18 b) reveal significant changes in the bio chemical constituents as jack litter decayed. The differences between the contents in the open and homegarden were also significant. Cellulose and hemicellulose content declined indicating breakdown of the carbon compounds by the activity of the soil fauna and flora, whereas lignin content increased. Significant increases in lignin content of the residual litter were observed after the second and fourth months in the open and after first and third months in the homegarden. The contents were 18.52 and 17.96 per cent respectively towards the final stages of decomposition

4.3.5.3 Cashew

A close observation of the data (Table 18 c) divulges that the cellulose content of cashew litter was highest compared to the other litter

Table 18a. Variation in the cellulose, hemicellulose and lignin contents in litter of mango on decomposition (%)

Month	Cellulose			Hemicellulose			Lignin		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	33.88	33.88	33.88	31.02	31.02	31.02	19.30	19.30	19.30
1	32.20	32.52	32.36	30.04	30.82	30.43	19.34	19.54	19.44
2	31.18	31.48	31.33	29.68	30.32	30.00	19.54	20.32	19.93
3	30.02	28.86	29.44	28.32	28.66	28.49	20.3	20.86	20.58
4	28.20	25.94	27.07	27.30	26.64	26.97	20.72	21.40	21.06
5	27.70	24.20	25.95	27.32	23.78	25.55	20.94	22.10	21.52
6	26.60	23.38	24.99	26.62	20.54	23.58	21.32	22.14	21.73
7	24.54	23.70	24.12	22.68	17.78	20.23	25.08	23.06	24.07
8	22.96	19.30	21.13	21.54	16.82	19.18	22.4	23.36	22.88
9	21.04	16.62	18.83	18.52	15.02	16.77	22.5	23.44	23.01
10	19.04	15.88	17.46	16.78	14.12	15.45	23.36	23.56	23.46
11	18.68	-	-	16.52	-	-	24.38	-	-
12	18.32	-	-	15.74	-	-	24.82	-	-
13	17.48	-	-	15.3	-	-	25.28	-	-
14	17.06	-	-	14.4	-	-	25.16	-	-
Mean	24.59	25.07	-	22.79	23.23	-	22.30	21.73	-
CD	C: 0.388	P: 0.91	CP: 1.287	C: 0.183	P: 0.429	CP: 0.606	C: NS	P: 0.90	CP: NS

Table 18b. Variation in the cellulose, hemicellulose and lignin contents in litter of jack on decomposition (%)

Month	Cellulose			Hemicellulose			Lignin		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	41.38	41.38	41.38	25.80	25.80	25.80	15.18	15.18	15.18
1	39.48	35.84	37.66	25.78	25.44	25.61	15.52	15.26	15.39
2	35.78	31.10	33.44	25.42	23.94	24.68	15.74	15.80	15.77
3	31.60	28.96	30.30	25.10	21.74	23.42	15.92	15.98	15.95
4	29.44	26.66	28.05	24.86	19.34	22.10	16.48	16.22	16.35
5	27.71	22.28	25.02	22.66	15.42	19.04	16.54	16.68	16.61
6	26.28	19.46	22.83	21.54	13.90	17.72	16.74	17.44	17.09
7	25.48	19.02	22.25	19.38	12.44	15.91	16.82	17.74	17.28
8	23.20	18.50	20.85	16.12	11.66	13.89	17.28	17.96	17.62
9	21.62	-	-	16.12	-	-	17.52	-	-
10	18.86	-	-	15.10	-	-	18.18	-	-
11	17.74	-	-	14.84	-	-	18.52	-	-
Mean	28.21	27.02	-	21.06	18.85	-	16.7	16.47	-
CD	C: 0.239	P: 0.507	CP: 0.717	C: 0.180	P: 0.383	CP: 0.541	C: 0.090	P: 0.190	CP: 0.268

C -Condition (open/ homegarden) P- Period CP- Interaction species studied. However, with the start of decomposition this was found to decline and during the final sampling, decreased by more than 65per cent in both sites. Hemicellulose content also decreased, whereas, lignin got accumulated. The increase remained almost same in both sites. The variations in concentrations were significant between the two sites and within each site, between the fortnights.

4.3.5.4 Ailanthus

The significant variations in cellulose, hemicellulose and lignin contents are given in Table 18 d. Ailanthus litter accumulated lignin to the tune of 35.0 per cent in open and homegarden while cellulose and hemicellulose were disintegrated, resulting in the weight loss as decay proceeded. The accumulation of this decomposition resistant material increased the time taken for total disappearance of litter mass.

4.3.5.5 Wild jack

As observed in the other species' litter, cellulose and hemicellulose contents decreased while lignin accumulated in wild jack litter on decay (Table 18 e). The initial content of 36.30 per cent cellulose fell to 13.52 per cent in 16 fortnights in the open and to 13.66 per cent in 15 fortnights in the homegarden. The initial hemicellulose content of 28.66 per cent also declined to nearly 14 per cent in both sites, whereas lignin value of 28.86 per cent increased to about 38 per cent in wild jack litter. The fortnightly variations and that between the two sites were significant.

Table 18c. Variation in the cellulose, hemicellulose and lignin contents in litter of cashew on decomposition (%)

Month	Cellulose			Hemicellulose			Lignin		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	46.56	46.56	46.56	15.52	15.52	15.52	13.38	13.38	13.38
1	42.68	42.48	42.58	14.78	14.6	14.69	13.88	13.58	13.73
2	37.74	38.48	38.11	13.98	13.92	13.95	14.04	14.14	14.09
3	33.82	31.26	32.54	13.38	13.42	13.4	14.62	14.48	14.55
4	27.84	29.86	28.85	12.74	12.5	12.62	15.16	15.34	15.25
5	27.3	27.68	27.49	12.32	11.8	12.06	15.54	15.6	15.57
6	26.74	20.8	23.77	12.16	10.98	11.57	15.84	15.66	15.75
7	22.5	17.72	20.15	11.86	10.18	11.02	16.2	16.1	16.15
8	18.58	17.08	17.83	11.4	10.1	10.75	17.42	16.36	16.89
9	16.38	16.22	16.3	10.42	9.92	10.17	17.52	16.84	17.18
10	15.68	-	-	10.06	-	-	17.94	-	-
Mean	28.71	28.81	-	12.60	12.29	-	15.59	15.15	-
CD	C: 0.188	P: 0.419	CP: 0.593	C: 0.108	P: 0.242	CP: 0.342	C: 0.072	P: 0.162	CP: 0.229

Table 18d. Variation in the cellulose, hemicellulose and lignin contents in litter of ailanthus on decomposition (%)

Month	Cellulose			Hemicellulose			Lignin		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	31.40	31.40	31.40	25.60	25.60	25.60	17.98	17.98	17.98
1	29.66	28.78	29.22	23.30	24.48	23.89	17.84	18.20	18.02
2	27.42	22.00	24.71	21.20	23.54	22.40	18.12	18.70	18.41
3	25.86	25.40	25.63	20.76	22.76	21.76	18.34	19.68	19.01
4	24.42	23.84	24.13	19.08	21.64	20.36	18.56	20.00	19.28
5	23.76	23.44	23.60	18.08	20.56	19.32	19.22	21.50	20.36
6	22.48	19.50	20.99	17.50	18.72	18.11	19.68	22.10	20.89
7	22.18	19.12	20.65	17.20	18.36	17.81	20.46	22.72	21.59
8	19.68	18.42	19.05	16.64	17.26	16.95	21.68	23.06	22.37
9	18.60	17.56	18.08	16.44	15.32	15.88	25.14	23.56	24.35
10	16.74	16.18	16.46	15.80	14.92	15.36	22.42	23.72	23.07
11	16.22	15.02	15.62	13.66	14.58	14.12	23.26	24.08	23.67
12	15.78	14.76	15.27	15.46	14.46	14.96	23.28	24.10	23.69
13	14.60	14.14	14.37	15.02	14.00	14.51	23.48	24.50	23.99
14	14.00	-	-	14.70	-	-	24.46	-	-
Mean	21.52	20.68	-	18.03	19.01	-	20.93	21.71	-
CD	C: 0.335	P: 0.887	CP: 1.25	C: 0.293	P: 0.774	CP: 1.095	C: 0.296	P: 0.784	CP: 1.11

C – Condition (open/ homegarden) P- Period CP- Interaction

Table 18e Variation in the cellulose, hemicellulose and lignin contents in litter of wild jack on decomposition (%)

Month	Cellulose			Hemicellulose			Lignin		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	36.30	36.30	36.30	28.66	28.66	28.66	28.86	28.86	28.06
1	35.2	34.44	34.82	27.92	28.28	28.1	28.66	28.86	28.76
2	33.42	33.62	33.52	27.08	27.70	27.39	29.32	29.42	29.37
3	31.34	32.26	31.80	25.44	25.58	25.51	29.88	29.82	29.85
4	30.10	30.92	30.51	23.76	24.92	24.34	30.50	30.68	30.59
5	28.22	28.22	26.87	20.78	20.30	20.54	30.78	30.40	30.59
6	26.00	25.52	24.75	20.22	18.86	19.54	31.14	30.80	30.97
7	22.24	23.50	22.43	19.76	18.20	18.98	31.48	31.56	31.52
8	19.28	22.62	20.12	19.36	17.74	18.55	32.26	31.8	32.03
9	18.26	20.96	18.50	18.62	16.88	17.75	33.36	32.36	32.86
10	17.68	18.74	17.14	17.60	16.56	17.08	33.64	33.42	33.53
11	16.24	16.60	15.67	17.50	16.56	16.62	34.40	33.74	34.07
12	14.8	15.10	14.80	16.56	15.50	16.03	35.80	34.38	35.09
13	13.34	14.68	14.01	15.78	14.86	15.32	37.48	37.56	37.52
14	14.64	13.74	14.19	15.64	14.50	15.07	37.70	37.88	37.79
15	14.26	13.66	13.96	14.58	13.92	14.25	38.12	38.18	38.15
16	13.52	-	-	14.18	-	-	37.80	-	-
Mean		22.97	-	00	19.89	-		32.46	-
CD	C: 0.171	P: 0.480	CP: 0.689	C: 0.095	P: 0.270	CP: 0.382	C: 0.090	P: 0.252	CP: 0.356

C- Condition (open/ homegarden) P- Period CP- Interaction

4.3.5.6 Mahogany

Table 18 e presents the changes in the contents of cellulose, hemicellulose and lignin in mahogany litter as weight loss occurred. The decrease in cellulose and hemicellulose contents and increase in lignin content were significant. The loss of cellulose and hemicellulose as litter decayed is in proportion to the weight loss.

The above results revealed that the lignin contents in the litter of all species increased as time elapsed, whereas, that of cellulose and hemicellulose decreased. This clearly indicates the profound influence lignin has on the rate of decomposition. Barry *et al.* (1989) opined that the initial litter mass loss during decay is controlled by the nitrogen present in soluble carbon compounds while the second half by lignin.

Lignin exerts its control on decomposition rate through its resistance to enzymatic attack, and by physically interfering with the decay of other chemical fractions of the leaf cell. Therefore, its influence will be much stronger and sooner for high lignin materials than for those of low lignin. Similarly, as decomposition proceeds, the proportion of lignin increases as microbes preferentially metabolise other chemical fractions. The lignin control of decomposition becomes stronger over time (Berg *et al.*,1993). Cellulose and hemicellulose provide carbon for the decomposing microorganisms and so get degraded with the initiation of microbial activity under warm and wet climatic conditions. However, lignin is less energy rich and so is not primarily attacked and hence degraded more slowly. Consequently, climatic conditions that favour high

Table 18f. Variation in the cellulose, hemicellulose and lignin contents in litter of mahogany on decomposition (%)

Month	Cellulose			Hemicellulose			Lignin		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	33.80	33.80	33.80	27.56	27.56	27.56	32.10	32.10	32.10
1	32.34	32.26	32.30	27.12	26.68	26.90	32.34	32.26	32.30
2	31.04	31.52	31.28	26.50	25.62	26.06	32.78	33.08	32.93
3	31.26	30.96	31.11	26.44	24.40	25.42	33.10	33.42	33.26
4	30.48	29.06	29.77	25.58	24.28	24.93	33.24	33.70	33.47
5	29.44	28.96	29.20	24.58	23.82	24.20	33.48	34.50	33.99
6	26.38	27.72	27.05	22.34	22.64	22.49	33.74	34.64	34.19
7	24.76	26.72	25.74	19.50	21.34	20.42	34.20	34.60	34.45
8	23.52	23.82	23.67	19.06	18.48	18.77	34.60	35.32	34.96
9	21.78	22.80	22.29	18.50	17.32	17.91	35.22	35.90	35.56
10	19.64	21.56	20.60	17.32	16.30	16.81	35.78	36.12	35.95
11	19.26	20.80	20.03	16.54	15.78	16.16	36.08	36.12	36.10
12	18.46	19.52	18.99	15.38	14.46	14.92	36.82	36.96	36.89
13	18.28	18.06	18.17	14.68	12.52	13.60	37.40	37.38	37.39
14	17.58	15.58	16.58	14.54	12.22	13.38	37.68	37.46	37.57
15	17.44	14.50	15.97	14.34	11.66	13.00	38.00	38.52	38.26
16	17.14	13.74	15.44	13.56	11.40	12.48	38.10	38.34	38.22
17	16.32	13.48	14.90	13.34	11.14	12.24	38.28	39.72	39.00
18	15.64	13.18	14.41	12.66	10.86	11.76	38.66	40.48	39.57
19	15.50	-	-	11.82	-	-	38.86	-	
20	14.50	-	-	11.42	-	-	39.82	-	
21	13.92	-	-	11.40	-	-	39.96	-	
22	13.46	-	-	11.31	-	-	40.76	-	
Mean	21.82	23.06	-	18.06	18.34	-	36.13	35.83	
CD	C: 0.115	P: 0.355	CP: 0.502	C: 0.066	P: 0.816	CP: 0.286	C: 0.064	P: 0.198	CP: 0.28

C- Condition (open/ homegarden) P- Period CP- Interaction

degradation rate of celluloses would not affect lignin degradation to a comparatively high degree. Thus, there would be a proportionally higher decomposition rate of cellulose fractions and amount of lignin would increase more quickly. As lignin degradation is a slow process, the consequence is that the decomposition rate of the whole litter is low (Berg *et al.*, 1982). The effect will be more pronounced in litters with high lignin contents.

4.3.6 Changes in soil properties

4.3.6.1 Soil physical properties

Analysis of variance done for the different soil parameters studied revealed significant changes in the soil physical properties in the open and homegarden viz., bulk density, particle density, water holding capacity and porosity as litter decomposed. The details of the same are discussed below.

4.3.6.1.1 Mango

The monthly variation in bulk density, particle density, water holding capacity and porosity on mango litter decomposition are given in Table 19 a .

The bulk density of soil varied significantly with the months of decomposition but that between the open and homegarden was non significant. It was [illegible] lower in the homegarden at the end of the comparative study (1.40 gcm^{-3} in the open and 1.282 gcm^{-3} in the homegarden). The initial bulk density of 1.574 gcm^{-3} in the open was reduced to 1.292 gcm^{-3} and in the homegarden 1.512 to 1.282 gcm^{-3}.

Table 19a. Changes in the physical properties of soil after decomposition of mango litter

Month	Bulk density (g cm^{-3})			Particle density (g cm^{-3})			WHC (%)			Porosity (%)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	1.574	1.512	1.543	2.302	2.400	2.351	36.61	42.33	39.47	36.90	35.51	36.20
June'98	1.564	1.336	1.450	2.332	2.392	2.362	39.04	43.99	41.47	37.50	41.23	39.37
July'98	1.504	1.534	1.519	2.488	2.318	2.403	40.41	38.3	39.36	39.70	36.26	37.98
Aug'98	1.424	1.416	1.420	2.490	2.508	2.499	41.68	38.26	39.97	40.07	36.85	38.46
Sept'98	1.494	1.456	1.475	2.552	2.460	2.506	40.83	41.03	40.93	38.48	34.95	36.71
Oct'98	1.512	1.352	1.432	2.598	2.548	2.573	39.47	41.41	40.44	37.19	37.74	37.46
Nov'98	1.400	1.282	1.341	2.500	2.762	2.631	41.78	43.35	42.57	39.25	42.79	41.02
Dec'98	1.382	-	-	2.622	-	-	42.2	-	-	40.14	-	-
Jan'99	1.332	-	-	2.696	-	-	42.36	-	-	41.37	-	-
Feb'99	1.282	-	-	2.722	-	-	42.41	-	-	43.22	-	-
Mean	1.447	1.413	-	2.530	2.484	-	40.68	41.23		39.38	37.90	-
CD	C: NS	P: 0.033	CP: 0.086	C: NS	P: 0.055	CP: 0.077	C : NS	P: NS	CP: 3.41	C :NS	P: 1.594	CP: 2.25

C- Condition (open / homegarden) P – Period CP- Interaction

Particle density of soil beneath litter bags increased significantly from 2.302 to 2.722 gcm^{-3} in nine months in the open and from 2.400 to 2.762 gcm^{-3} in six months in the homegarden. There was no significant variation between the two situations.

Water holding capacity of the soil in the open and homegarden did not show any significant variation between the two sites and during the different months, in the 6 months for which comparative study was made. However, the initial value in the open (36.61 per cent) and homegarden (42.33 per cent) were found to increase with decomposition. The final values attained were 42.41 per cent and 43.35 per cent in the open and homegarden respectively.

Open and homegarden soils showed significant monthly variation in porosity values as decomposition of mango litter occurred. The difference in the mean values between open and homegarden was non significant. The porosity value prior to decomposition study were 36.90 per cent and 35.51 per cent respectively in the open and homegarden soils. They increased to final values of 43.22 per cent in the open and 42.79 per cent in the homegarden by the time 95 per cent decomposition was completed.

4.3.6.1.2 Jack

The changes in soil bulk density, particle density, water holding capacity and porosity with jack litter decomposition at monthly intervals are presented in Table 19 b.

The bulk density of soils were significantly lowered with decomposition and were significantly different in the open and homegarden during the period of comparative study (5 months). The value ranged from 1.574 to 1.464 gcm^{-3} in the open and from 1.570 to 1.402 gcm^{-3} in the homegarden.

Particle density of the soil did not vary significantly between the open and homegarden but the monthly variation was significant. In both situations the particle density was found to improve, though fluctuations in values were noticed in between.

The changes in the water holding capacity of soil in the open and homegarden were significantly different during the period of comparative study. The monthly variation was also significant. Water holding capacity of the soils was found to improve with decomposition of jack litter and the values noted at the end of decomposition in both situations were almost same.

The porosity of soil varied with the decomposition in the open and homegarden and also during the initial 5 months of comparative study of jack litter decomposition. The mean value was greater in the homegarden (39.31 per cent) compared to that in the open (37.11 per cent). Significant increase in porosity was observed in both situations from the initial porosity value during the period of comparative study. The increase was from 36.90 to 39.23 per cent in the open and 37.34 to 41.58 per cent in the homegarden.

Table 19b. Changes in the physical properties of soil after decomposition of jack litter

Month	Bulk density (gcm^{-3})			Particle density (gcm^{-3})			WHC (%)			Porosity (%)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	1.574	1.570	1.572	2.302	2.302	2.302	36.61	36.05	35.55	36.90	37.34	37.12
June'98	1.598	1.496	1.547	2.400	2.406	2.403	37.22	36.43	36.83	35.09	39.05	37.07
July'98	1.522	1.480	1.501	2.504	2.392	2.448	37.98	37.03	37.57	35.86	38.71	37.28
Aug'98	1.514	1.538	1.526	2.466	2.432	2.449	37.96	35.74	36.85	35.22	37.99	36.61
Sept'98	1.482	1.432	1.457	2.332	2.372	2.352	41.87	38.57	40.22	37.23	41.16	39.20
Oct'98	1.476	1.402	1.439	2.468	2.628	2.548	41.05	40.47	40.76	38.25	41.58	39.92
Nov'98	1.450	-	-	2.600	-	-	41.15	-	-	39.08	-	-
Dec'98	1.464	-	-	2.628	-	-	40.46	-	-	39.23	-	-
Mean	1.509	1.486		2.450	2.422	-	39.29	37.29	-	37.11	39.31	-
CD	C: 0.003	P: 0.02	CP: 0.052	C: NS	P: 0.093	CP: NS	C: 0.738	P: 1.477	CP: NS	C:0.609	P:1.218	CP:1.723

C- Condition (open/ homegarden) P- Period CP- Ineraction

4.3.6.1.3 Cashew

Variations in the bulk density, particle density, water holding capacity and porosity of soils due to cashew leaf litter decomposition are presented in Table 19 c.

The bulk density in the homegarden got significantly lowered compared to that in the open. Monthly variation was also significant. During the seven months taken for decomposition in the open, bulk density decreased from 1.574 to 1.338 g cm^{-3} and from 1.502 to 1.282 g cm^{-3} in six months in the homegarden.

Particle density of soil improved with cashew litter decomposition. The effects of the sites and months of decomposition were significant. The mean particle density calculated until the sixth month increased from 2.352 to 2.649 $gcm^{-3}$and this variation observed was also significant.

Water holding capacity of the soil in the open and homegarden differed significantly between them and during the different months. The maximum value of 45.18 per cent was recorded in the homegarden at the end of decomposition. In the open significant increase was noted during all months except third and fourth months and in the homegarden, the increase during the first and third months were significantly higher than the preceding months.

There was significant difference in the porosity of soils in the open and homegarden. Soils in the homegarden recorded highest porosity (42.44 per cent) in the fifth month during the period of comparison. Significant variation was observed during the different months in the open and

Table 19c. Changes in the physical properties of soil after decomposition of cashew litter

Month	Bulk density (g cm^{-3})			Particle density (g cm^{-3})			WHC (%)			Porosity (%)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	1.574	1.502	1.538	2.302	2.402	2.352	36.61	38.74	37.74	36.90	37.96	37.43
June'98	1.256	1.414	1.335	2.364	2.398	2.381	43.84	41.82	42.83	45.30	38.05	41.68
July'98	1.362	1.536	1.449	2.406	2.482	2.444	40.65	39.56	40.11	41.13	38.79	39.96
Aug'98	1.390	1.386	1.388	2.420	2.500	2.460	40.18	42.41	41.30	40.53	40.40	40.46
Sept'98	1.426	1.386	1.406	2.480	2.510	2.495	37.98	42.53	40.26	40.50	40.52	40.51
Oct'98	1.292	1.340	1.316	2.520	2.608	2.564	43.22	42.82	43.02	41.86	42.44	42.15
Nov'98	1.336	1.282	1.309	2.518	2.780	2.649	40.48	45.18	42.83	41.16	42.16	41.66
Dec'98	1.338	-	-	2.626	-	-	44.71	-	-	42.26	-	-
Mean	1.372	1.407	-	2.453	2.526	-	40.96	41.87	-	41.21	40.05	-
CD	C: 0.018	P: 0.034	CP: 0.049	C: 0.029	P: 0.054	CP: 0.076	C: 0.96	P: 1.79	CP: 2.54	C: 0.967	P: 1.81	CP: 2.56

C- Condition (open / homegarden) P- Period CP- Interaction homegarden, the value increasing from 36.90 per cent to 42.26 per cent at the end of study in open garden and from 37.96 per cent to 42.16 per cent in the homegarden.

4.3.6.1.4 Ailanthus

Perusal of the data in Table 19 d. showed that the bulk density of open and homegarden soils were significantly different, with the open soils recording lower mean bulk density values compared to the homegarden. The original value of 1.574 declined to 1.406 gcm^{-3} in the open and from 1.538 to 1.406 gcm^{-3} in the homegarden.

Results of data analyzed reveal that particle density of open and homegarden soils varied significantly between the two sites and also with the different months of decomposition. Mean particle density was comparatively more in the homegarden (2.474 gcm^{-3}) compared to that of the open soil (2.249 gcm^{-3}). The initial value of 2.302 gcm^{-3} increased to 2.398 gcm^{-3} in the open with ailanthus litter decomposition and the increase was from 2.270 to 2.586 $g\ cm^{-3}$ in the homegarden.

Significant variations in water holding capacity of soils with ailanthus litter decomposition in each site were observed, that in the open being slightly greater than that in the homegarden.

Porosity of soils varied significantly in the open and homegarden and also showed monthly variation. The mean of the two sites increased from 36.43 to 39.42 per cent by the end of decomposition.

Table 19d. Changes in the physical properties of soil after decomposition of ailanthus litter

Month	Bulk density (g cm^{-3})			Particle density (g cm^{-3})			WHC (%)			Porosity (%)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	1.574	1.538	1.556	2.302	2.270	2.286	36.61	37.94	37.28	36.90	35.97	36.43
June'98	1.312	1.478	1.395	2.362	2.488	2.425	40.05	37.95	39.00	37.01	36.30	36.65
July'98	1.242	1.520	1.381	2.316	2.682	2.499	41.31	38.01	39.66	38.45	35.60	37.02
Aug'98	1.212	1.638	1.425	2.112	2.520	2.316	40.25	37.10	38.68	39.80	35.49	37.64
Sept'98	1.292	1.660	1.476	2.022	2.516	2.269	37.10	37.60	38.74	39.20	35.75	37.48
Oct'98	1.234	1.824	1.529	2.132	2.496	2.314	40.78	38.16	39.47	38.09	38.12	38.11
Nov'98	1.482	1.792	1.637	2.228	2.228	2.228	39.06	39.09	39.08	36.54	37.91	37.22
Dec'98	1.414	1.486	1.450	2.368	2.484	2.426	35.99	41.46	38.73	37.60	39.36	38.48
Jan'99	1.406	1.386	1.396	2.398	2.586	2.492	40.78	43.07	41.93	38.23	40.61	39.42
Mean	1.352	1.591	-	2.249	2.474	-	39.41	38.93	-	37.93	37.23	-
CD	C-0.03	P:0.063	CP:0.089	C:0.035	P:0.075	CP:0.106	C:NS	P-1.32	CP:1.86	C:0.63	P:1.337	CP:1.931

C- Condition (open/ homegarden) P- Period CP- Interaction

4.3.6.1.5 Wild jack

The data on changes in mean bulk density, particle density water holding capacity and porosity with wild jack litter decomposition are given in Table 19 e.

Bulk density of soils were significantly lowered in both situations during the different months with the percentage of decrease being more in the homegarden. It was 12.5 per cent in the homegarden and 9.5 per cent in the open. There was significant variation between the open and homegarden soils during the period of comparison for statistical analysis. Homegarden soils recorded a mean value of 1.377 gcm^{-3}, whereas it was 1.424 gcm^{-3} in the open soils,.

The particle density of soil beneath the litter bags varied significantly during the different months and between the two situations. On comparison, homegarden recorded higher particle density during the nine months of decomposition. As decomposition proceeded in the open and homegarden the particle density increased initially with a non-significant decline in between and then increased during the final stages. The change was from an initial value of 2.302 to 2.622 g cm^{-3} in the open and from 2.492 to 2.726 gcm^{-3} in the homegarden.

The water holding capacity of soils was found to significantly improve with wild jack litter addition and decomposition. It was significantly more in the homegarden compared to the open. Monthly variation was also significant. Maximum value was observed during the seventh month in the open and fifth month in the homegarden.

Table 19e . Changes in the physical properties of soil after decomposition of wild jack litter

Month	Bulk density (gcm^{-3})			Particle density (gcm^{-3})			WHC (%)			Porosity (%)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	1.574	1.438	1.506	2.302	2.492	2.397	36.61	42.19	39.40	36.90	39.02	37.96
June'98	1.530	1.452	1.491	2.378	2.540	2.459	37.70	40.14	38.92	36.11	38.09	37.10
Aug'98	1.480	1.486	1.483	2.456	2.514	2.485	42.49	40.45	41.47	40.82	38.28	39.55
Sept'98	1.382	1.376	1.379	2.632	2.598	2.615	36.97	41.99	39.48	33.66	38.71	36.18
Oct'98	1.618	1.316	1.467	2.560	2.552	2.556	38.98	42.99	40.98	35.73	41.82	38.78
Nov'98	1.210	1.288	1.249	2.506	2.656	2.581	41.67	43.75	42.71	38.95	42.13	40.54
Dec'98	1.382	1.382	1.382	2.498	2.602	2.550	41.51	40.79	41.15	39.39	37.46	38.42
Jan'99	1.388	1.392	1.390	2.492	2.662	2.577	42.65	42.11	42.38	40.34	37.71	39.03
Feb'99	1.380	1.322	1.351	2.566	2.742	2.654	41.10	43.62	42.36	41.32	41.93	41.63
Mar'99	1.366	1.314	1.340	2.586	2.726	2.656	40.30	42.77	41.54	39.93	42.08	41.01
April'99	1.358	-	-	2.622	-	-	40.56	-	-	39.54	-	-
Mean	1.424	1.377	-	2.509	2.608	-	40.05	42.08	-	38.52	39.72	-
CD	C: 1.80	P: 4.03	CP: 0.057	C: 0.031	P: 0.069	CP: 0.097	C: 0.562	P: 1.257	CP: 1.78	C: 0.708	P: .580	CP: 2.240

C- Condition (open/ homegarden) P- Period CP- Interaction

Fluctuations of change were noticed in between. However, the final value was greater than the initial values, the increase being significant in the open.

The porosity of the soils was significantly different in the open and homegarden with mean value being more in the homegarden compared to the open. Monthly fluctuations were noticed and these were significant except in the second month in the open. In the homegarden, this was significant only during the fourth, sixth and eighth months. The final values were significantly more than the initial values (36.90 and 39.54 per cent respectively in the open and 42.08 per cent respectively in the homegarden).

4.3.6.1.6 Mahogany

Table 19 f. gives the monthly changes in soil bulk density, particle density, water holding capacity and porosity with mahogany litter decomposition. Comparative analysis between open and homegarden were done for eleven months alone as mahogany litter in the homegarden decomposed 95 per cent during this period. The mean of the replication data of open is entered to understand the final change in the values from the initial with decomposition.

Significant changes in bulk density and particle density were observed with litter decomposition. Mean bulk density values in the open and homegarden during the eleven months of decomposition reveal significantly greater values for open condition. In either situation bulk

Table 19f. Changes in the physical properties of soil after decomposition of mahogany litter

Month	Bulk density (gcm^{-3})			Particle density (gcm^{-3})			WHC (%)			Porosity (%)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	1.574	1.610	1.592	2.302	2.350	2.326	36.61	36.99	36.80	36.90	34.38	35.64
June'98	1.482	1.426	1.454	2.366	2.600	2.483	39.11	40.54	39.83	36.65	39.17	37.91
July'98	1.528	1.324	1.426	2.404	2.680	2.542	37.22	42.48	39.85	34.70	39.70	37.20
Aug'98	1.658	1.592	1.625	2.248	2.502	2.375	35.99	36.48	36.24	33.91	34.83	34.37
Sept'98	1.598	1.690	1.644	2.238	2.288	2.263	38.63	35.66	37.14	36.59	32.56	34.57
Oct'98	1.756	1.706	1.731	2.210	2.332	2.271	34.16	35.51	34.84	31.75	32.85	32.30
Nov'98	1.590	1.692	1.641	2.260	2.322	2.291	37.06	34.97	36.01	34.23	33.31	33.77
Dec'98	1.460	1.706	1.583	2.310	2.334	2.322	39.78	34.27	37.03	37.04	32.87	34.96
Jan'99	1.438	1.768	1.603	2.480	2.356	2.418	40.59	33.86	37.22	37.60	31.56	34.58
Feb'99	1.464	1.590	1.527	2.448	2.300	2.374	40.45	36.50	38.47	38.19	33.44	35.81
Mar'99	1.404	1.434	1.419	2.590	2.406	2.498	38.49	41.86	40.18	38.59	38.53	38.96
April'99	1.344	1.388	1.366	2.494	2.586	2.540	39.01	41.46	40.23	38.25	39.84	40.35
May'99	1.368	-	-	2.640	-	-	40.63	-	-	41.50	-	-
Mean	1.513	1.577	-	2.384	2.421	-	38.29	37.55		36.61	35.54	-
CD	C: 0.020	P: 0.048	CP: 0.067	C: 0.029	P: 0.072	CP: 0.102	C:NS	P: 1.466	CP: 0.737	C: 0.582	P: 1.426	CP: 2.017

C- Condition (open/ homegarden) P – Period CP- Interaction density was lowered, this being from 1.574 to 1.368 gcm^{-3} in the open and from 1.610 to 1.388 gcm^{-3} in the homegarden.

Particle density values also revealed significant monthly variation, this being an increase from initial value by the end of decomposition. In the open, the increase was from 2.302 to 2.640 gcm^{-3} and in the homegarden from 2.350 to 2.586 gcm^{-3}.

Water holding capacity of open and homegarden increased significantly with mahogany litter decomposition. However, that between the two was non significant. The monthly variation was significant except during the ninth and eleventh months in the open situation. In the homegarden, this was found to be significant up to the fourth month and then during ninth and tenth months. The increase was from the initial value of 36.61 to 40.63 per cent and 36.99 to 41.46 per cent in the open and homegarden respectively.

Porosity values in the open and homegarden varied significantly with the corresponding means being 36.61 per cent and 35.54 per cent. Monthly variation was also significant. Although trends of decrease were noticed in between, the final values were significantly greater, indicating improvement in soil porosity with mahogany litter decomposition.

Results on the variation in the physical properties of soil due to litter decomposition reveal that significant decrease in bulk density and increase in particle density, water holding capacity and porosity occurred in the open and homegarden as litter of the different species decomposed. It is obviously due to the incorporation of organic matter to soil by decomposition of overlying leaf litter. It is more pronounced in the homegarden owing to the frequent addition of litter from the trees, thus maintaining a high organic matter status in the soils. This is in accordance with the works of Bronstern (1984); Mittal *et al.* (1992); Mathew *et al.* (1996); Pushkala and Sumam (1996) and John (1997). The effect of organic manures in increasing water holding capacity of the soil has been reported by Biswas and Khosla (1971) and Rajput and Sastry (1987).

4.3.5.2 Soil chemical properties

The changes in soil chemical properties during litter decomposition are discussed below (Table19 a to 24b).

4.3.6.2.1 Mango

The mean values of soil pH in the open and homegarden at 10 cm depth, organic carbon, available nitrogen, phosphorus and potassium in the open and in the homegarden beneath the mango litter bags are given in Table 20 a and b.

There was not much variation in the pH between the open and homegarden soils. The mean monthly variation was, however, significant and the final pH was observed to be higher than initial values in the open and homegarden. All soils were acidic in reaction with decomposition, resulting in a high soil pH in the surface soil of the open area.

The organic carbon content of soils varied significantly between the open and homegarden and within each situation between the months of sampling. The initial carbon value of 0.793 per cent in the open increased

Table 20a. Changes in the soil pH and organic carbon on mango litter decomposition

Month	soil pH			organic carbon (%)		
	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	4.84	5.02	4.93	0.793	0.774	0.754
June'98	5.40	5.44	5.42	0.666	0.55	0.608
July'98	5.36	5.60	5.48	0.679	0.735	0.707
Aug'98	5.52	5.38	5.45	0.628	0.548	0.588
Sept'98	5.46	5.52	5.49	0.704	0.831	0.768
Oct'98	5.64	5.76	5.70	0.461	0.869	0.665
Nov'98	5.74	5.58	5.66	0.641	1.275	0.958
Dec'98	5.86	-	-	0.998	-	-
Jan'99	5.92	-	-	1.363	-	
Feb'99	5.98	-		1.511	-	-
Mean	5.57	5.47	-	0.844	0.797	
CD	C: NS	P: 0.143	CP:NS	C: 0.082	P: 0.165	CP: 0.233

C-Condition (open / homegarden) P-Period CP- Interaction to 1.511 per cent in nine months of decomposition. The increase in the homegarden was from 0.774 to 1.275 per cent in six months.

Significant variation was recorded between the open and homegarden in the available nitrogen status of soil, the mean of the open being 374.63 kg ha^{-1} and that of homegarden being 388.65 kg ha^{-1}. The soil nitrogen did not vary significantly between the different fortnights in the two situations.

Soil phosphorus status was significantly influenced by the condition / location of decomposition study and also by the period of decomposition. Soil phosphorus increased during the first month in the open and homegarden from the initial values, decreased and then finally increased. The mean soil phosphorus was significantly more in the open and the final values recorded were 36.66 kg ha^{-1} in the open (initial 32.70 kg ha^{-1}) and 39.7.0 kg ha^{-1} in the homegarden (initial 29.8 kg ha^{-1}) the percentage increases were 12.1 and 33.2 per cent in the open and homegarden respectively.

Potassium status of the open and homegarden soils varied significantly with mango leaf litter decomposition. The potassium content of the open soil was comparatively lower than the homegarden soils. With decomposition and release, though a slight increase was noted in the early stages, potassium being highly mobile in soil and subjected to leaching losses was not retained in the soil. It was found to decrease as decomposition proceeded and the final values were lower than the initially increased values. In the open though the initial value of 105.40 kg ha^{-1}

Table 20b. Changes in the soil nitrogen, phosphorus and potassium status on mango litter decomposition (kg ha^{-1})

Month	Available N			Phosphorus			Potassium		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	343.08	368.72	355.90	32.70	29.80	31.52	105.40	332.73	219.06
June'98	368.84	382.58	375.71	40.01	32.78	36.40	108.96	329.39	219.17
July'98	388.06	355.42	371.74	37.46	30.22	33.84	109.04	330.25	219.65
Aug'98	408.16	305.34	356.75	37.06	35.08	36.07	107.86	323.25	215.55
Sept'98	341.54	390.54	366.04	34.40	32.78	33.59	105.36	319.40	212.38
Oct'98	256.08	426.80	341.44	35.12	34.20	34.66	101.00	315.85	208.43
Nov'98	288.10	491.14	389.62	38.52	39.70	39.11	98.04	307.69	202.86
Dec'98	435.88	-	-	42.42	-	-	96.45	-	-
Jan'99	445.72	-	-	40.35	-	-	95.66	-	-
Feb'99	470.84	-	-	36.66	-	-	94.32	-	-
Mean	374.63	388.65	-	37.47	33.51	-	102.21	322.65	-
CD	C: 21.87	P: NS	CP: 57.86	C: 2.05	P: 3.84	CP: 5.43	C: 5.36	P: 10.03	CP: NS

C- Condition (open/ homegarden) P- Period CP- Interaction

increased to 109.04 kg ha^{-1}, it finally declined to 94.32 kg ha^{-1} at the time of final sampling. The same pattern of change was noticed in the homegarden also. The initial content of 332.73 kg ha^{-1} decreased to 307.69 kg ha^{-1} at the end of decomposition study.

4.3.6.2.2 Jack

The variation in soil chemical properties beneath the litter bags are depicted in Table 21a and b.

Significant differences were noticed in the soil pH beneath the litter bags during the different months of decomposition and also between the open and homegarden soils. The final pH was comparatively more in the homegarden (5.66) and significantly greater than the initial pH in either situation, confirming that decomposition resulted in lowering soil acidity.

The organic carbon content of open and homegarden soils were not found to vary significantly between them, but differed significantly between the months of sampling. The values ranged from 0.793 per cent (initial) to 0.815 per cent in the open and from 0.795 per cent to 0.966 per cent in the homegarden. In both situations a decline was noticed before the final increase.

The mean available nitrogen status of soil beneath litter bags in the open and homegarden was found to increase from the initial values on jack litter decomposition, the value increasing from 383.09 to 401.66 kg ha^{-1}.

Soil phosphorus increased during the first five months in the open and first four months in the homegarden from the initial values and then decreased. The final values were comparatively more (35.30 kg ha^{-1} and

Table 21a. Changes in the soil pH and organic carbon on jack litter decomposition

Month	soil pH			organic carbon (%)		
	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	4.84	5.28	5.06	0.793	0.795	0.794
June'98	5.60	5.34	5.47	0.788	0.881	0.735
July'98	5.24	5.18	5.21	0.613	0.640	0.627
Aug"98	5.32	5.40	5.36	0.482	0.461	0.472
Sept'98	5.20	5.46	5.33	0.619	0.827	0.723
Oct"98	5.38	5.66	5.52	0.716	0.966	0.946
Nov'98	5.38	-	-	0.800	-	-
Dec'98	5.48	-	-	0.815	-	-
Mean	5.31	5.39	-	0.703	0.762	-
CD	C: 0.188	P: 0.108	CP: 0.26	C: NS	P: 0.180	CP: 0.254

Table 21b. Changes in the soil nitrogen, phosphorus and potassium status on jack litter decomposition (kg ha^{-1})

Month	Available N			Available P			Available K		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	343.08	423.10	383.09	32.70	42.19	37.44	105.40	297.14	201.27
June'98	346.44	430.76	388.60	32.14	46.20	39.17	105.31	295.17	200.64
July'98	315.26	210.26	262.76	36.66	48.18	42.42	107.29	300.55	203.92
Aug'98	299.92	247.38	273.65	37.57	48.06	42.82	108.88	295.41	202.14
Sept'98	325.04	434.20	379.62	39.40	48.37	43.02	102.29	295.81	199.09
Oct'98	354.30	449.02	401.66	37.13	44.60	42.00	100.84	289.33	195.09
Nov'98	468.74	-	-	35.30	-	-	100.62	-	-
Dec'98	421.40	-	-	36.22	-	-	98.38	-	-
Mean	359.27	365.79			46.27	-	103.23	295.71	-
CD	C: 21.05	P: 36.46	CP: 51.56	C: 1.533	P: 2.66	CP: 3.76	C: 5.13	P: NS	CP:NS

C- Condition (open/ homegarden) P- Period CP- Interaction

44.60 kg ha^{-1}in the open and homegarden respectively) than the initial values of 32.70 kg ha^{-1} and 42.19 kg ha^{-1}. The variations were significant between homegarden and open and during the different months.

The available potassium status of the soils was significantly lowered with decomposition. In either situation, variation that occurred during the different months was not significant but the mean soil potassium values in the open and homegarden during the five months of comparative study were significantly different. Slight increases in potassium were noticed during the initial stages, however, it declined in the later stages. The initial value of 105.40 kg ha^{-1} in the open increased to 108.88 kg ha^{-1}in three months and then decreased to 98.38 kg ha^{-1}. In the homegarden the initial increase was from 297.14 to 300.55 kg ha^{-1} and then fell to 289.33 kg ha^{-1}.

4.3.6.2.3 Cashew

Analysis of variance data on soil pH, organic carbon and soil nitrogen, phosphorus and potassium status during the different months are furnished in Table 22a and b. The pH of the soil beneath the cashew litter bags in the open and homegarden showed not much variation between them. The mean values ranged from 5.13 to 5.46 during decomposition. In the open, the value increased from the initial pH of 4.84 to 5.62, whereas, in the homegarden a decrease was noticed as decomposition progressed, with the final pH recorded being 5.43.

The soil organic carbon content did not vary much between the open and homegarden whereas it was found to significantly increase with

Table 22a. Changes in the soil pH and organic carbon on cashew litter decomposition

Month	soil pH			organic C (%)		
	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	4.84	5.42	5.13	0.793	1.030	0.942
June'98	5.26	5.08	5.17	1.921	1.170	1.546
July'98	5.38	5.32	5.35	1.694	1.336	1.515
Aug'98	5.30	5.40	5.35	1.204	1.472	1.338
Sept'98	5.46	5.58	5.52	1.337	1.618	1.477
Oct'98	5.42	5.82	5.62	1.800	1.920	1.860
Nov'98	5.50	5.43	5.46	1.832	2.022	1.927
Dec'98	5.62	-	-	1.974	-	-
Mean	5.35	5.44	-	1.512	1.510	-
CD	C: 0.083	P: 0.155	CP: 0.219	C :NS	P: 0.175	CP: 0.248

decomposition in both conditions. The increase was from 0.793 per cent to 1.974 per cent in the open and from 1.030 per cent to 2.022 per cent in the homegarden. The monthly variation in organic carbon content was significant. The significant increase was noted during the first and fifth months in the open. Cashew litter left for decomposition in the homegarden could significantly increase the carbon content of the soil from 1.030 per cent to 1.336 per cent in two months and finally to 2.022 per cent by the time of 95 per cent decomposition.

The available nitrogen status of the soils varied significantly between the control and homegarden with cashew litter decomposition and also during the different months of sampling. Significant increase was noted during the first month and thereafter, this was not significant in the open. In the homegarden, after a slight drop in the early stage, nitrogen content increased from 505.38 kg ha $^{-1}$ to 614.70 kg ha^{-1}. The increase was significant during the fifth month of decomposition.

The soil phosphorus status increased from the initial value of 32.70 kg ha^{-1} to 35.83 kg ha^{-1} in the open and from 35.42 kg ha^{-1} to 40.28 kg ha^{-1} in the homegarden. The variation was not significant between the open condition and homegarden but monthly variation was observed to be significant.

Potassium status of the open garden and homegarden soils varied significantly with cashew leaf litter decomposition. The potassium contents of the open soils were comparatively lower than the homegarden soils. With decomposition and release, although a slight increase was

Table 22b.Changes in the soil nitrogen, phosphorus and potassium status on cashew litter decomposition (kg ha^{-1})

Month	Available N			Available P			Available K		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	343.08	505.38	424.23	32.70	35.42	34.06	105.40	267.06	186.23
June"98	594.20	502.04	548.12	30.10	31.90	31.00	106.50	267.98	187.24
July'98	535.32	528.52	531.92	33.38	31.92	32.65	108.68	268.52	188.60
Aug'98	518.86	536.82	527.84	35.46	36.30	35.53	107.70	248.95	178.33
Sept'98	532.06	551.08	541.70	39.11	33.22	36.16	105.09	250.18	177.64
5oct'98	533.32	597.22	565.27	37.78	32.12	34.75	100.93	250.53	175.73
Nov'98	473.34	614.70	544.02	35.45	40.28	37.86	97.46	235.76	166.61
Dec'98	501.60	-	-	35.83	-	-	97.02	-	-
Mean	503.97	547.97		34.93	34.45	-	103.60	255.57	-
CD	C: 17.89	P: 33.47	CP: 47.34	C: NS	P: 2.78	CP: 3.93	C: 7.05	P: 13.19	CP: NS

C- Condition (open/ homegarden) P- Period CP- Interaction

noted in the early stages, potassium being highly mobile in soil and subjected to leaching losses, was not retained in the soil. It was found to decrease as decomposition proceeded and the final values were lower than the initially increased values. In the open, though the initial value of 105.40 kg ha^{-1} increased to 108.68 kg ha^{-1}, it finally declined to 97.02 kg ha^{-1} at the time of final sampling. The same pattern of change was noticed in the homegarden also. The initial content of 267.06 kg ha^{-1} increased to 268.52 kg ha^{-1} and then decreased to 235.76 kg ha^{-1} at the end of decomposition study.

4.3.6.2.4 Ailanthus

The data pertaining to the soil pH, available nitrogen, phosphorus and potassium associated with ailanthus litter decomposition in the open and homegarden are furnished in Table 23a and b.

The pH of soils on ailanthus litter decomposition did not vary between the open and homegarden significantly, but the monthly variation was significant. In both situations the pH was found to increase from the initial value. In the open the increase was from 4.84 to 5.76 and the change was significant during all the months. The pH in the homegarden was initially 5.06 and it showed slight fluctuations in between, but attained a final value of 5.72 with complete decomposition. The mean of the two situations improved from 4.95 to 5.74.

Organic carbon content of open and homegarden soils after ailanthus litter decomposition decreased from the initial values of 0.793 to 0.720 per cent in the open and increased from 0.742 to 0.938 per cent in

Table 23a Changes in soil pH and organic carbon on ailanthus litter decomposition

Month	soil pH			organic carbon (%)		
	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	4.84	5.06	4.95	0.793	0.742	0.768
June'98	5.14	5.3	5.22	1.01	1.291	1.151
July'98	5.32	5.32	5.32	0.762	0.846	0.804
Aug'98	5.5	5.54	5.53	0.928	0.674	0.801
Sept'98	5.36	5.36	5.36	0.954	0.639	0.796
Oct'98	5.46	5.56	5.51	0.595	0.546	0.57
Nov'98	5.74	5.44	5.59	0.479	0.667	0.573
Dec'98	5.4	5.6	5.5	0.622	0.747	0.685
Jan'99	5.76	5.72	5.74	0.72	0.938	0.829
Mean	5.39	5.44	-	0.762	0.788	-
CD	C:NS	P:0.066	CP:0.198	C:0.063	P:0.133	CP:0.188

C- Condition (open/ homegarden) P- Period CP- Interaction

the homegarden. The monthly variation and that between the open and home situation were significant. Ailanthus litter decay in the open showed a significant increase in organic carbon status of soil initially and then declined. Although a final increase due to litter decay was noticed, it could not exceed the initial value.

Ailanthus litter decomposition showed significant variation in soil available nitrogen status in the open and homegarden and also during the different months of sampling. Wide fluctuations in soil nitrogen were noticed, increasing initially with nitrogen release followed by a decrease and finally a slight increase. The final status revealed improvement in soil nitrogen over the initial status.

The soil phosphorus analysis revealed that open plot and homegarden soils differed significantly in their soil phosphorus status. The monthly variation was also significant. In either case a decline was noted during the period of decomposition but this was temporary. The final stages of decomposition showed increase in soil phosphorus content. Release of phosphorus from the litter would have finally improved the phosphorus status of the soil.

Soil potassium varied significantly with the condition of decomposition (open and home) and during the months of sampling. The initial potassium content was analyzed as 105.40 kg ha^{-1} in the open and 281.90 kg ha^{-1} in the homegarden. The soil potassium content after 95 per cent decomposition of ailanthus litter was 90.81 kg ha^{-1} and 274.32 kg ha^{-1} in the open and homegarden respectively.

Table 23b. Changes in the soil nitrogen, phosphorus and potassium status on ailanthus litter decomposition (kg ha^{-1})

Month	Available N			Available P			Available K		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	343.08	391.12	367.10	32.70	38.24	35.47	105.40	281.90	193.65
June'98	496.62	489.60	493.11	31.94	39.04	35.49	110.26	271.52	190.82
July'98	484.76	433.20	458.98	31.54	39.58	35.56	111.29	289.12	200.21
Aug'98	468.50	406.64	437.57	30.64	50.22	40.43	108.32	301.75	205.04
Sept'98	492.82	414.66	453.74	30.58	50.40	40.49	106.25	288.21	197.23
Oct'98	299.98	411.88	355.73	34.18	48.44	41.31	99.48	284.07	191.97
Nov'98	297.98	428.12	363.05	34.54	49.22	41.88	93.80	270.20	182.00
Dec'98	369.34	439.76	404.55	5.86	51.18	43.52	95.98	275.44	185.71
Jan'99	389.32	404.78	397.05	38.58	53.48	46.03	90.81	274.32	182.57
Mean	406.89	424.42	-	33.40	46.64	-	102.39	281.37	-
CD	C: 20.25	P: 42.95	CP: 60.7	C: 1.11	P: 2.356	CP: 3.328	C: 4.76	P: 10.10	CP: NS

C- Condition (open/ homegarden) P- Period CP- Interaction

4.3.6.2.5 Wild Jack

The values of soil pH, organic carbon, available nitrogen, phosphorus and potassium are presented in Table 24a and b.

The pH of soil was found to increase significantly in the open and homegarden as a result of wild jack litter decomposition and mean pH was comparatively more in the open compared to that in homegarden. The monthly variation was also significant. Slight fluctuations in the pH values were observed both in the open and homegarden in the early stages. However, the final pH was significantly higher than the initial values.

The mean organic carbon content of homegarden soil was greater than that of the open. The monthly variation was also significant. The organic carbon of the open soil at the time of final sampling was 0.899 per cent, 13.4 per cent more than the initial value of 0.793 per cent. The homegarden soils recorded a significant decline in soil carbon after significant increase to 1.086 per cent from the initial value of 0.763 per cent and then gradually increased to 1.079 per cent at the end of decomposition.

Soil analyses reveal that available nitrogen status of soil in both situations improved significantly from the initial values with wild jack litter addition and decomposition, although the peak was observed during the sixth month (578.46 kg ha^{-1}) in the open and during the third month (538.98 kg ha^{-1}) in the homegarden. There was not much variation in mean soil nitrogen status between open and homegarden soils. However, the monthly variation was significant. The final nitrogen status after 95 per

Table 24a. Changes in the soil pH and organic carbon on wild jack litter decomposition

Month	soil pH			organic carbon (%)		
	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	4.84	4.94	4.89	0.793	0.763	0.778
June'98	5.18	5.14	5.16	0.739	0.871	0.805
July'98	5.26	5.46	5.36	0.649	1.067	0.958
Aug'98	5.04	5.34	5.19	0.564	1.086	0.896
Sept'98	5.22	5.42	5.32	0.482	0.631	0.557
Oct'98	5.14	5.48	5.31	0.900	0.730	0.815
Nov'98	5.46	5.36	5.41	0.885	0.784	0.835
Dec'98	5.24	5.44	5.34	0.875	0.829	0.852
Jan'9	5.44	5.46	5.45	0.852	1.030	0.941
Feb'9	5.52	5.58	5.55	0.971	1.079	1.025
Mar'9	5.60	-	-	0.899	-	-
Mea	5.27	5.36	-	0.783	0.870	-
CD	C: 0.046	P: 0.102	CP: 0.144	C: 0.084	P: 0.189	CP: 0.267

C-Condition (open / homegarden)   P-Period   CP-Interaction

Table 24b. Changes in the soil nitrogen, phosphorus and potassium status on wild jack litter decomposition (kg ha^{-1})

Month	Available N			Available P			Available K		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May '98	343.08	382.39	362.74	32.70	30.98	31.84	105.40	281.87	193.63
June'98	390.42	455.42	422.92	32.64	29.80	31.22	106.18	285.56	195.87
July'98	353.48	453.97	403.72	36.72	33.86	35.29	106.82	285.92	196.37
Aug'98	298.18	538.98	418.58	35.08	35.68	35.38	107.00	281.26	194.13
Sept"98	317.82	288.66	303.24	29.74	31.66	30.70	106.73	279.88	193.31
Oct'98	521.18	386.02	453.60	32.80	33.88	33.34	106.11	276.12	191.12
Nov"98	578.46	373.49	475.94	30.38	32.10	31.24	102.76	275.90	188.83
Dec"98	424.16	417.46	420.81	33.07	35.84	34.56	102.26	273.83	188.05
Jan'99	468.76	486.14	477.45	34.20	48.82	41.51	99.92	272.59	186.26
Feb'99	446.20	504.45	485.32	39.62	52.78	46.20	99.43	270.19	184.81
Mar'99	475.92	-	-	39.92	-	-	98.13	-	-
Mean	419.79	428.70	-	34.26	36.54	-	103.70	278.21	-
CD	C: NS	P: 53.25	CP: 75.3	C: 1.81	P: 4.05	CP: 5.73	C: 1.732	P: NS	CP: NS

C- Condition (open/ homegarden) P- Period CP- Interaction

cent decomposition in the open was 475.92 kg $ha^{-1}$and 504.45 kg ha^{-1} in the homegarden.

The mean soil phosphorus was significantly different in the open and homegarden. The monthly variation was also significant. Fluctuations of increase and decrease were noted during the period of decomposition with the final values being significantly higher than the initial values proving that with 95 per cent complete decomposition of wild jack litter could significantly improve soil phosphorus status. The fluctuations might be due to the same associated with phosphorus immobilization and release during the various stages of decomposition.

The soil potassium status significantly declined as decomposition was completed in both situations. Variation in soil K between the two were not significant. In the open, the decline was from an initial value of 105.40 to 98.13 kg ha^{-1} and from 281.87 to 270.19 kg ha^{-1} in the homegarden.

4.3.6.2.6 Mahogany

The variations in soil chemical properties with mahogany litter decomposition are depicted in Table 25a and b.

The pH of soil beneath the litter bags were found to increase towards neutrality on decomposition. The changes were significant between the soils of the two sites and also between the months of sampling. The mean pH of the open recorded was 5.51 and that of the homegarden, 5.42.

Table 25a. Changes in the soil pH and organic carbon on mahogany litter decomposition

Month	soil pH			organic carbon (%)		
	Open	Home garden	Mean	Open	Home garden	Mean
May'98	4.84	4.94	4.89	0.793	0.538	0.666
June'98	5.40	5.30	5.35	0.755	0.843	0.799
July'98	5.80	5.44	5.62	0.576	1.334	0.955
Aug'98	5.60	5.48	5.54	0.383	0.535	0.459
Sept'98	5.64	5.32	5.48	0.488	0.234	0.361
Oct'98	5.70	5.46	5.58	0.372	0.283	0.327
Nov'98	5.54	5.64	5.59	0.304	0.178	0.241
Dec'98	5.52	5.64	5.58	1.016	0.386	0.178
Jan'99	5.48	5.32	5.40	0.909	0.416	0.663
Feb'99	5.56	5.44	5.50	0.836	0.830	0.833
Mar'99	5.58	5.52	5.55	0.795	0.857	0.826
April'99	5.44	5.54	5.49	0.874	0.900	0.887
May'99	5.58	-	-	0.784	-	-
Mean	5.51	5.42	-	0.683	0.611	-
CD	C: 0.047	P: 0.116	CP: 0.163	C: 0.062	P: 0.151	CP: 0.214

C- Condition(open/ homegarden) P-Period CP- Interaction

The organic carbon status of the soil improved with litter decomposition though fluctuations of decrease were noticed in between. The mean of the two situations revealed significant increase from the initial value of 0.666 per cent to 0.887 per cent.

Analysis of variance of the data on soil nitrogen status established that variation between open and homegarden soils with mahogany litter decomposition was not significant. The fortnightly changes, however, was significant. As in the case of organic carbon, the nitrogen status of the soil declined significantly before increasing in the final stages when nitrogen was released from litter after immobilization. The final increase from the initial values significant in both situations.

The phosphorus status of soils did not vary significantly in the open and homegarden. Monthly variations were significant. The increase was from 32.70 to 39.0 kg ha^{-1} in the open and from 35.22 to 35.40 kg ha^{-1} in the homegarden.

A declining trend in the potassium status of open and homegarden soils were noted after slight increase confirming that potassium is highly susceptible to leaching losses and hence is sparsely retained in the soil.

Trees in managed land use systems frequently cause favourable changes in soil physico-chemical properties. The foregoing results elucidate increase in soil pH and improvement in soil organic carbon and N and phosphorus nutrient pools on litter decomposition. References on better soil physical and chemical properties in tree-based systems are many

Table 25b. Changes in the soil nitrogen, phosphorus and potassium status on mahogany litter decomposition (kg ha^{-1})

Month	Available N			Available P			Available K		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	343.08	339.98	341.53	32.70	35.22	33.96	105.40	226.14	165.77
June'98	374.98	453.92	414.45	30.38	29.54	29.96	108.46	226.84	167.65
July'98	336.12	489.60	412.86	30.30	27.82	29.06	109.43	240.53	174.98
Aug'98	237.88	297.94	267.91	36.12	33.26	34.69	101.04	233.44	167.24
Sept'98	215.04	170.92	192.98	37.50	37.00	37.25	100.37	231.76	166.06
Oct'98	159.86	207.32	183.59	35.04	36.46	35.75	99.53	232.17	165.85
Nov'98	167.12	133.68	150.40	34.66	40.84	37.75	91.15	229.88	160.51
Dec'98	356.48	300.10	328.29	31.78	34.24	33.01	86.15	228.66	157.40
Jan'99	417.00	299.98	358.49	32.06	31.06	31.56	85.42	227.24	156.33
Feb'99	446.82	426.66	436.74	35.18	30.96	33.07	83.84	227.66	155.75
Mar'99	356.32	440.40	398.36	36.66	31.08	33.87	83.81	226.56	155.18
April'99	434.72	449.16	441.94	36.34	35.40	36.37	83.57	222.89	153.23
May'99	434.50	-	-	39.00	-	-	82.17	-	-
Mean	329.23	334.14	-	34.60	33.66	-	93.87	229.48	-
CD	C: NS	P: 40.28	CP: 56.97	C: NS	P: 2.13	CP: 3.01	C: 4.17	P: 10.206	CP: NS

C- Condition(open/ homegarden) P-Period CP- Interaction

(Skerman and Riveros, 1990; Balagopalan *et al.*, 1992; John, 1997; Kumar *et al.*, 1998).

The final increase in pH ascertains that accumulation of basic cations occurred in the surface layer by way of bi-cycling; basic cations like calcium, magnesium and potassium are absorbed from the deeper layers and deposited in the surface by way of litter fall and decomposition (Moosa, 1997).

The increase in nitrogen and phosphorus status of soils associated with litter decomposition may be attributed to the release from litter on decomposition. This is well supported by the decline in the relative and absolute quantity of litter in the litter bags as depicted in Tables 6a and b.

Potassium content increased initially but then declined as this element is highly liable to leaching losses. The findings corroborate with that of Hegde (1995) in acacia litter decomposition.

The organic carbon of the soil was found to increase from the initial value by the time decomposition was complete, however, fluctuations were noticed with a decline midway of decomposition. It is possible that a good portion of the organic carbon was liberated as CO_2 during the decomposition process. Jenkinson (1971) indicated that the degradation of most types of organic material returns 55 to 70 per cent of the bound carbon to the atmosphere as CO_2, 5 to 15 per cent is incorporated into soil biomass and the remaining is partially stabilized in the soil as humus. Substantial increases can occur after a period of decay. The loss of carbon would have resulted in the lowering of carbon content in soil, whereas, the addition paves way for the final increase. Reports on carbon losses by respiration and leaching from soil were given by O'Connell and Sankaran (1997). The organic carbon level of soil under acacia litter on decomposition remained almost static during the one year of study carried out by Mary and Sankaran (1991).

4.3.6.3 Soil biological properties

The population of the macroorganism, earthworms (m^{-3}) and microflora (g^{-1} soil) was monitored during the period of decomposition study. Analysis of variance to compare the open and homegarden site, faunal and floral activity were done only until the month of 95 per cent decomposition in the homegarden for all species and are presented in tables 26 a to 26 f.

4.3.6.3.1 Mango

The earthworm count per cubic metre, fungal, bacterial and actinomycete count per gram soil recorded in the open and homegarden soils as a result of mango litter decomposition at monthly intervals are presented in Table 26 a.

The earthworm count did not vary significantly between open and homegarden soils. However, the monthly variation was significant. The mean values showed maximum population during the fourth month, September, (32.0 m^{-3}) followed by that in August (29.9 m^{-3}). The population then declined during the summer months.

Fungal population varied significantly in the open and homegarden during the different months of decomposition. The mean population of the

Table 26a. Changes in earthworm count (m^{-3}) and micro floral counts (g^{-1} soil) in soil on mango litter decomposition

Month	Earthworm			Fungi ($x10^3$)			Bacteria ($x10^6$)			Actinomycetes (x 10^4)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	10.80	12.20	11.50	10.40	11.20	10.80	11.20	7.20	9.20	1.60	1.40	1.50
June'98	18.20	21.20	19.70	13.20	14.40	13.80	12.80	12.40	12.60	2.20	2.00	2.10
July'98	21.60	23.80	22.70	16.40	15.00	15.70	16.00	19.60	17.80	2.40	3.00	2.70
Aug'98	26.60	33.20	29.90	22.60	21.20	21.90	23.80	28.40	26.10	3.80	3.40	3.60
Sept'98	29.00	35.00	32.00	23.40	25.40	24.40	21.80	25.00	23.40	3.40	7.40	5.40
Oct'98	31.60	22.40	27.00	16.60	21.20	18.90	18.20	19.60	18.90	3.20	8.20	5.70
Nov'98	34.80	18.20	26.50	16.60	17.60	17.10	21.40	15.20	18.30	7.40	9.00	8.20
Dec'98	36.80	-	-	13.00	-	-	17.40	-	-	8.00	-	-
Jan'99	17.20	-	-	10.00	-	-	11.40	-	-	8.40	-	-
Feb'99	11.60	-	-	6.20	-	-	8.60	-	-	6.80	-	-
Mean	23.82	23.74	-	14.84	18.00	-	16.26	18.20	-	4.72	4.91	-
CD	C:NS	P: 1.80	CP : 2.54	C: 0.74	P: 1.39	CP: 1.96	C: NS	P: 2.34	CP: 3.31	C: 0.541	P: 1.012	CP: 1.43

C- Condition (open / homegarden) P-Period CP- Interaction two sites was maximum in September (24.4 x 10^3) and gradually declined towards the end of decomposition. The same trend followed within the open and homegarden soils also. The change in population was significant in the initial two months in the open and during all months compared to the preceding month except during the second month, in the homegarden.

Significant differences in the bacterial population were in open and homegarden soils during the different months of decomposition but that between the two sites was not significant. Bacterial population increased in the early stages with decomposition and was found to decline during the final stages. The peak was recorded during August (23.8 x 10^3).

The actinomycete activity on mango litter decomposition was meagre in the initial months, the population being 1.60 x 10^4 in the open and 1.40 x 10^4 in the homegarden. It gradually increased to 8.4 x in the open in eight months and to 9.0 x 10^4 in six months in the homegarden. The increase was statistically significant. The variation in mean population in the open and homegarden soil was also significant.

4.3.6.3.2 Jack

The data pertaining to the monthly variation in earthworm count, fungal, bacterial and actinomycetes population in the open and homegardens are given in Table 26 b.

The earthworm population in the open and homegarden soils associated with jack litter decomposition was significantly different,with that in the homegarden being significantly more. The population was found to increase until the fourth month (September) and then decreased in

Table 26b. Changes in earthworm count (m^{-3}) and micro floral counts (g^{-1} soil) in soil on jack litter decomposition

Month	Earthworm			Fungi ($x 10^3$)			Bacteria ($x 10^6$)			Actinomycetes ($x 10^4$)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	11.00	17.20	14.10	11.00	15.40	13.20	12.00	11.40	11.70	6.00	7.00	6.50
June'98	17.00	21.20	19.10	14.80	21.60	18.20	16.60	23.80	20.20	6.40	10.40	8.40
July'98	22.20	24.80	23.50	17.80	27.20	22.50	17.20	33.40	25.30	7.80	7.80	9.80
Aug'98	26.40	34.80	30.60	22.80	37.00	29.90	29.00	48.80	38.90	8.80	13.80	11.30
Sept'98	32.20	37.40	34.80	24.00	28.20	26.10	36.00	39.40	37.70	10.20	16.00	13.10
Oct'98	36.80	32.40	34.60	18.20	20.00	19.10	27.60	26.40	27.00	13.20	16.40	14.80
Nov'98	34.20	-	-	17.40	-	-	21.60	-	-	13.80	-	-
Dec'98	29.60	-	-	13.40	-	-	14.40	-	-	15.00	-	-
Mean	26.20	27.97	-	17.43	24.90	-	21.80	30.54	-	10.15	12.57	-
CD	C: 0.746	P: 1.29	CP: 1.83	C: 1.563	P: *2.71	CP: 3.82	C**2.05	P: 3.54	CP: 5.01	C: 0.314	P: 0.545	CP: NS

C- Condition (open/ homegarden) P- Period CP - Interaction both situations. The monthly variation over the preceding month was also significant. The population ranged from 11.0 to 36.8 m^{-3} in the open and from 17.2 to 37.4 m^{-3} in the homegarden.

The difference in fungal population in the open and homegarden soils was significant. The mean population recorded was 17.43 x 10^3 in the former and 24.9 x 10^3 in the latter situation. Monthly variations were also significant. The increase noticed until the third month and the decrease towards the end were significant in the homegarden and that in the open during the first, third and fifth months after start of the study.

The bacterial count taken during the different months of decomposition reveal significant variation in population in the open and homegarden. The activity was more in the homegarden (mean 30.54 x10^6) compared to the open (21.8 x 10^6). Monthly variations were also significant. The mean of the population in open and homegarden was maximum in August. Maximum bacterial activity in the open (36.0 x 10^6) was recorded in the month of September and that in the homegarden (48.8 x 10^6) in the month of August. After this peak, the population was found to decline in both situations.

The open and homegarden soils recorded significant variation in the actinomycete population, with increased number being observed in the homegarden. The population was significantly low (mean 6.5 x 10^4) in the early stages and increased to the maximum value during the final months of decomposition (mean 14.8 x 10^4).

4.3.6.3.3 Cashew

The data on the soil faunal and floral composition during the period of study are furnished in Table 26 c.

The earthworm count associated with cashew leaf litter decomposition in the open and homegarden were significantly different and showed monthly variation within each condition. The maximum mean number of earthworms in the open was 35.60, and 38.80 m^{-3} in the homegarden. Data on monthly variation showed significant increase in the count from 12.4 (May) to 35.6 (October) in the open and this declined to 29.4 in December. In the homegarden the population per square metre increased from the initial value of 17.6 in May to 38.8 in August, which decreased to 32.6 in November.

Fungal population increased in the open up to the end of the second month, declined during the third month and thereafter increased during the fourth, fifth and sixth months. The highest population was observed during November (20.0 x 10^3). The pattern of change remained the same in the homegarden except for the decline in the sixth month, final stage of decomposition. The maximum number was observed in September (31.40 x10^3)

Significant differences in the bacterial population were observed between open and homegarden and also between the different months of decomposition. Bacterial population ranged from 12 x 10^6 to 32.4 x 10^6 in the open and 12.2 x 10^6 to 65.8 x 10^6 in the homegarden. There has been

Table 26c. Changes in earthworm count (m^{-3}) and micro floral counts (g^{-1} soil) in soil on cashew litter decomposition

Month	Earthworm			Fungi ($x10^3$)			Bacteria ($x10^6$)			Actinomycetes($x10^4$)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	12.40	17.60	15.00	10.40	10.20	10.30	12.00	12.20	12.10	5.00	11.80	8.40
Jun'98	17.40	22.80	20.10	17.20	17.40	17.30	13.80	14.20	14.00	5.20	16.20	10.70
July'98	22.20	31.00	26.60	19.20	21.40	20.30	18.00	32.60	25.30	17.40	17.00	12.20
Aug'98	24.80	38.80	26.80	14.20	18.80	16.50	25.00	46.80	35.90	11.20	19.40	15.30
Sept'98	33.80	32.80	33.00	18.20	31.40	24.80	32.40	65.80	49.10	11.40	20.40	15.90
Oct'98	35.60	32.40	34.00	18.40	22.40	20.40	29.00	35.60	32.30	13.60	18.20	15.90
Nov'98	31.20	32.60	31.90	20.00	17.20	18.60	25.00	28.60	26.80	18.40	18.00	18.20
Dec'98	29.40	-	-	16.80	-	-	23.60	-	-	18.60	-	-
Mean	25.76	28.29	-	16.80	19.83	-	22.35	33.69	-	11.35	17.29	-
CD	C: 0.312	P: 0.584	CP: 2.34	C: 1.50	P: 2.81	CP: 3.97	C: 1.61	P: 3.01	CP: 4.26	C: 1.42	P: 2.66	CP:3.77

C- Condition (open/ homegarden) P- Period CP -Interaction significant increase in the population up to the fourth month (September) and thereafter a decline was noted.

The actinomycetes population associated with cashew leaf litter increased significantly as decomposition proceeded, the maximum count being at the final stage of decomposition in the open. However, in the homegarden unlike that of other species actinomycete population was significantly high during the second month itself and the population reached maximum during the fourth month.

4.3.6.3.4 Ailanthus

Data pertaining to the monthly variation in earthworm count, fungal, bacterial and actinomycetes population in the open and homegardens are given in Table 26 d.

The earthworm counts taken at monthly intervals reveal a progressive increase in the population from May to October both in the open and homegarden and thereafter declined. The count was significantly different in the two situations and also varied with the different months. The initial count in the open was 10.2 m^{-3} and reached maximum in October (33.4) and declined during November and December. The same pattern was also observed in the homegarden, the initial count being comparatively lower, 5.6 and the maximum 29.4 m^{-3} during October.

The fungal population varied significantly between open and homegarden plots, the mean population being more in the homegarden (27.56 x 10^3). Monthly variation was also significant. The population in both situations increased in the initial months and declined in the later

Table 26d. Changes in earthworm count (m^{-3}) and micro floral counts (g^{-1} soil) in soil on ailanthus litter decomposition

Month	Earthworm			Fungi ($x10^3$)			Bacteria ($x10^6$)			Actinomycetes($x10^4$)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	10.20	5.60	7.90	11.00	19.40	15.20	10.80	18.40	14.60	5.60	8.80	7.20
June'98	13.80	11.20	12.50	11.60	23.60	17.60	16.80	18.80	17.80	8.40	9.00	8.70
July'98	18.20	14.40	16.30	16.00	31.40	23.70	18.40	22.40	20.40	9.60	11.60	10.60
Aug'98	25.20	21.20	23.20	21.60	34.60	28.10	31.60	41.40	36.50	12.20	14.40	13.30
Sept'98	31.00	27.20	29.10	26.00	33.80	29.90	34.20	39.80	37.00	12.80	14.00	13.40
Oct'98	33.40	29.40	31.40	22.20	37.40	29.80	27.00	29.80	28.40	18.60	12.80	15.70
Nov'98	26.80	22.20	24.50	18.40	27.00	22.70	25.20	23.20	24.20	18.40	14.40	16.40
Dec'98	23.00	19.60	21.30	16.80	24.40	20.60	15.80	19.40	17.60	21.60	19.80	20.70
Jan'99	18.00	13.40	15.70	11.60	16.4	14.00	12.00	16.20	14.10	21.80	19.80	20.80
Mean	22.18	18.24	-	17.24	27.56	-	21.31	25.49	-	14.33	13.84	-
CD	C:0.601	P:1.274	CP:NS	C:1.097	P:2.327	CP:3.288	C :1.095	P: 2.32	CP: 3.28	C: NS	P: 1.873	CP: 2.651

C- Condition (open/ Homegarden) P- Period CP- Interaction

stages (from 11.0 to 26.0 x $10^3$and 11.6 x 10^3 in the open and 19.4 to 37.4 x 10^3 and 16.4 x 10^3). The change was significant over the preceding month's population during the entire period except the first month in the open and fourth month in the homegarden.

The bacterial population varied significantly between open and homegarden and during the different months of decomposition. The count taken per gram of open plot soil increased significantly from 10.8 x 10^6 to 34.2 x 10^6 in four months and then decreased, the final count was 12 x 10^6 at the end of study. The maximum population in the homegarden was 41.4 x 10^6 during the third month and the final count was 16.2 x 10^6.

Actinomycete population was comparatively low in the early stages of ailanthus litter decomposition and increased towards the final stages. Significant increase was noticed during the first, third, fifth and seventh months in the open and during second, third, and sixth and seventh months in the homegarden. The maximum count observed was during the final stages, in the open (21.8 x 10^4) and homegarden (19.8 x 10^4).

4.3.6.3.5 Wild jack

The data on the monthly variation in earthworm count, fungal, bacterial and actinomycetes population in the open and homegardens is depicted in Table 26 e.

The analysis of the earthworm count taken from the open and homegarden at monthly intervals reveal that the population was significantly more in the homegarden, compared to the open and significantly different during the different months. In the open, maximum

Table 26e. Changes in earthworm count (m^{-3}) and micro floral counts (g^{-1} soil) in soil on wild jack litter decomposition

Month	Earthworm			Fungi count ($x10^3$)			Bacteria ($x10^6$)			Actinomycetes ($x 10^4$)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	9.20	11.80	10.50	11.00	19.40	15.20	12.80	15.40	14.10	6.40	8.40	7.40
June'98	10.00	16.80	13.40	11.80	23.40	17.60	18.40	18.00	18.20	6.20	7.00	6.60
July'98	14.40	23.80	19.10	13.20	27.60	20.40	14.80	19.80	17.30	4.80	7.40	6.10
Aug'98	22.40	30.80	26.60	20.00	33.00	26.50	16.80	39.20	28.00	6.60	11.00	8.80
Sept'98	27.80	35.60	31.70	22.20	33.20	27.70	21.60	44.60	33.10	11.80	16.40	14.10
Oct'98	31.80	36.60	34.20	22.80	25.20	24.00	22.00	48.80	35.40	12.40	17.20	14.80
Nov'98	23.20	27.40	25.30	19.40	27.40	23.40	19.00	35.40	27.20	15.80	20.20	18.0
Dec'98	22.80	27.40	25.10	16.80	23.40	20.10	22.00	29.80	25.90	18.80	17.60	18.20
Jan'99	15.20	15.40	15.30	12.80	16.60	14.70	18.20	27.00	22.60	16.20	18.00	17.10
Feb'99	14.60	11.60	13.10	11.80	13.60	12.70	14.80	21.40	18.10	15.40	21.60	18.50
Mar'99	11.00	-	-	10.80	-	-	16.40	-	-	16.40	-	-
Mean	18.40	23.72	-	15.69	24.28	-	17.89	29.94	-	11.89	-	-
CD	C: 0.821	P: 1.836	CP: 2.600	C: 0.943	P: 2.110	CP: 2.980	C: 0.951	P: 2.120	CP: 3.007	C: 0.655	P: 1.465	CP: 2.071

C- Condition (open/ homegarden) P- Period CP- Interaction

population was observed in October (31.80) and least in May (9.20). Homegarden soils recorded maximum earthworm activity during October (36.6) and the least in February (11.60) which was on par with that in May (11.80).

The microbial population associated with the decomposition varied significantly between the open and homegarden and showed significant monthly variations.

The fungal population in the open, increased from the initial mean of 11.0 to 22.8 x 10^3 in 5 months and then declined. In the homegarden also the same trend was noticed, the increase being from 19.4 to 33.2 x 10^3 in four months. The mean population in the homegarden (24.28 x 10^3) was greater than that in the open (15.69 x 10^3).

Maximum population of bacteria was recorded during the fifth month in the open (22.0 x 10^6) and homegarden (48.8 x 10^6) and the activity was lowered towards the completion of the decomposition study.

The actinomycete activity was significantly low in the initial stages in both situations and then increased towards the end of decomposition. The final population in the open was 16.4 x 10^4 compared to the initial 6.4 x 10^4 in the open and 21.6 x 10^4 compared to the observed initial value of 8.4 x 10^4 in the homegarden.

4.3.6.3.6 Mahogany

The earthworm count per cubic metre, fungal, bacterial and actinomycete count recorded in the open and homegarden soils as a

Table 26f. Changes in earthworm count (m^{-3}) and micro floral counts (g^{-1} soil) in soil on mahogany litter decomposition

Month	Earthworm			Fungal count (x 10^3)			Bacteria (x 10^6)			Actinimycetes (x 10^4)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
May'98	11.00	7.20	9.10	11.20	15.40	13.30	10.40	19.00	14.70	4.60	6.00	5.30
June'98	14.20	12.60	13.40	13.00	14.60	13.80	18.20	18.80	18.50	6.00	3.80	4.90
July'98	17.60	17.60	17.60	14.60	16.80	15.70	18.40	24.40	21.40	7.00	6.60	6.80
Aug'98	23.40	26.20	24.80	23.00	30.20	26.60	36.00	47.80	41.90	6.40	11.40	8.90
Sept'98	31.20	31.80	31.50	27.40	34.40	30.90	37.20	37.00	37.10	7.80	11.60	9.70
Oct'98	36.80	34.00	35.40	25.60	26.40	26.00	33.60	39.80	36.70	11.20	13.60	12.50
Nov'98	24.60	25.60	25.10	19.00	30.80	24.90	32.60	35.40	34.00	12.40	19.00	15.70
Dec'98	20.40	18.60	19.50	17.80	19.40	18.60	26.80	21.20	24.00	12.80	21.80	17.30
Jan'99	14.60	14.20	14.40	15.60	15.40	15.50	18.40	22.80	20.60	16.60	24.40	20.50
Feb'99	13.00	11.40	12.20	13.20	11.60	12.40	19.00	19.80	19.40	18.20	21.60	19.90
Mar'99	6.40	10.20	8.30	12.40	10.80	11.60	13.00	15.60	14.30	19.20	25.00	22.10
April'99	10.80	10.80	10.80	14.20	12.60	13.40	13.80	15.00	14.40	22.40	19.00	20.70
May'99	15.60	-	-	13.20	-	-	14.60	-	-	21.80	-	-
Mean	18.43	18.35	-	16.94	-	-	22.46	26.38	-	12.80	15.32	-
CD	C: NS	P: 1.692	CP: 2.39	C: 0.67	P: 1.64	CP: 2.32	C: 1.30	P: 3.18	CP: 4.50	C: 0.742	P: 1.818	CP: 2.575

Condition (open/ homegarden) P- Period CP- Interaction result of decomposition of mahogany litter at monthly intervals are presented in Table 26 f.

The earthworm count did not show any significant variation between the open and homegarden soils. However, the monthly variation was highly significant. The mean of the two situations was maximum in October (35.4 m^{-3}). In the open soil, the population increased to a peak in October (36.8 m^{-3}) and subsequently declined. In the homegarden also the same trend was noticed, the peak being in October 34.0 m^{-3}.

Significant variation in the fungal population was noted between open and homegarden soils and also between the months of sampling. The population increased significantly during the third and fourth months of decomposition and thereafter declined. A slight increase was observed during the last two months, which were on par with the initial values in the open. This is because mahogany litter continued to decay during May of the second year, during which, soil faunal and floral activity increased with higher soil moisture.

Bacterial population associated with mahogany litter decomposition was significantly different in the two situations during the eleven months of comparative study. Significant monthly variations were also noted. The peak population was observed in September (37.2×10^6) and was on par with that in August (36.0×10^6) in the open and the peak in the homegarden was in August (47.8×10^6). The activity was more during the wet months and declined towards the dry period, at the end of decomposition.

Actinomycete population was significantly low in the initial stages but was found to increase during the fifth month in the open and during third month in the homegarden. The peak was recorded in the twelvth month (22.4 x 10^4) and ninth month (25.0 x 10^4) in the open and homegarden respectively, *i.e.* ,during the final stage of decomposition. The variation between the two situations was also significant.

The results revealed that the homegarden soils harboured more earthworms due to the contigous litter fractions present in the soil compared to the open barren land. However, with the addition of organic material their population had increased. A cover of tree litter is generally associated with higher rates of activity of soil fauna (Young, 1997). In each soil the population is decided by the rainfall and temperature. Population was maximum during rainy periods and was lowered with the onset of summer. A note worthy observation in the study was that mango, jack and cashew litter bags in the homegarden were permeated by earthworms during the rainy months. Nearly three to four worms were collected from each bag. They disintegrated the litter making them easily amenable to the microorganisms. The short term activation of decomposition by the earthworms is reported by Lavelle *et al.* (1993). This would have been responsible for the earlier documented faster rates of decomposition in these three species, compared to that of the others. Litter decomposition by earthworms was more rapid in the early and rainy months of decomposition. According to Lepage (1982), earthworm population declines with increasing dryness and during this period termites become dominant.

The initial population of microorganisms in the homestead soils recorded higher values compared to the open plots and is an indication of the intense microbial activity in the homestead. The higher microbial population in the homegarden could be attributed to the larger quantities of organic matter and ideal climatic conditions, the soil moisture and relative humidity beneath the tree canopies favouring microbial proliferation. The population and activity increased with litter addition and decomposition. This is evidently due to the availability of large quantity of nutrients from fresh litter. The macro organisms viz., earthworms and termites initially acted upon the litter, pulverising them to smaller fractions, creating conditions suitable for the microbial activity. Fungi and bacteria were the chief decomposers from the start of the study, while actinomycetes were dominant during the later stages, except in the case of cashew in homegarden soils. The preponderance of fungi and bacteria in litter decomposition noted in this study, is in concurrence with the findings of Moosa (1997).

The maximum fungal and bacterial population and activity were noticed during August to October, in all situations, coinciding with the rainy months. As rains declined, the activity got lowered. The rapid organic matter decomposition in the tropics is mediated by generally high bacterial cell counts and fungal hyphal lengths in the soil compared to those in temperate and boreal forest (Swift *et al.*, 1979).

The increase in fungal counts in litter during high rainfall periods could be attributed to the congenial atmospheric and soil condition and increased moisture content of litter, as suggested by Witkamp (1966) and Sinha and Dayal (1983).

4.3.7 Factors affecting the rate of decomposition

4.3.7.1 Soil Temperature

The mean and monthly soil temperatures in the open and homegarden at 15cm and 30 cm depth during the period of decomposition of the different tree species litter are given in Tables 27 a to 27 f.

In the open plots, the soil temperature was maximum during April 1999 (33.3^{0}C and 35.2^{0}C) at 15 and 30 cm depth respectively followed by that in May 1999 (32.4^{0}C and 34.5^{0}C) at 15 and 30 cm depth respectively. The values recorded for the homegarden varied with the extent of canopy cover, light interception, atmospheric temperature, humidity beneath the respective tree canopy, the biological activity of the soil and organic matter status.

4.3.7.1.1 Mango

The soil temperature data presented in Table 27 a shows significant variation between sites and the different fortnights of observation at both depths. The maximum temperature was recorded during the first fortnight of June 1998 in the homegarden (29.2 ^{0}Cand 30.6 ^{0}C), at 15 cm and 30 cm depth. These were significantly greater than that during the other months and lower than that recorded in the open condition. This is because, the canopy cover lowers the soil temperature in homegardens.

Table 27a. Changes in soil moisture and soil temperature during decomposition of mango litter at fortnightly intervals

Fortnight	Soil moisture (%)			Soil temperature at 15 cm depth (^{0}C)			Soil temperature at 30 cm depth (^{0}C)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	7.34	14.34	10.84	32.24	28.12	30.18	33.90	29.90	31.90
1	14.46	16.88	15.67	31.30	27.72	29.51	32.90	28.82	30.86
2	'8.47	11.82	10.15	30.86	29.24	30.05	32.70	30.62	31.66
3	14.77	16.86	15.81	29.00	27.16	28.08	31.50	28.40	29.95
4	16.68	17.76	17.22	28.50	27.20	27.85	31.00	28.68	29.84
5	18.94	18.29	18.61	28.60	26.44	27.52	30.30	27.70	29.00
6	16.06	20.61	18.33	28.10	27.02	27.56	29.70	28.60	29.15
7	15.13	20.94	18.04	28.82	27.10	27.96	30.40	28.78	29.59
8	20.69	19.62	20.16	31.80	27.20	29.50	33.60	29.50	31.55
9	20.55	20.46	20.50	31.70	26.60	29.15	33.20	28.00	30.60
10	20.02	22.28	21.15	28.70	25.04	26.87	31.40	27.24	29.32
11	21.06	22.79	21.92	26.58	25.10	25.84	28.40	27.08	27.74
12	14.56	19.99	17.28	26.90	25.10	26.00	29.10	27.00	28.05
13	15.51	-	-	26.70	-	-	29.20	-	-
14	8.77	-	-	27.80	-	-	30.40	-	-
15	14.16	-	-	26.70	-	-	28.90	-	-
16	12.65	-	-	29.34	-	-	31.20	-	-
17	8.83	-	-	31.10	-	-	32.90	-	-
Mean	14.93	18.66	-	29.15	26.85	-	31.15	28.49	-
CD	C: 0.449	P: 1.14	CP: 1.62	C: 0.166	P: 0.423	CP: 0.598	C: 0.177	P: 0.451	CP: 0.637

C- Condition (open / homegarden) P- Period CP - Interaction

4.3.7.1.2 Jack

The soil temperature data taken at 15 and 30 cm depth in the open and homegarden where jack litter was kept for decomposition are given in Table 27 b. The data elucidate the significant variations noticed between the sites and the fortnights of sampling during the period of study.

The temperature recorded at 30 cm depth were more than that at 15 cm depth. Comparing that recorded in the open and homegarden, soil temperature in the homegarden was lower owing to the canopy cover provided by the trees. The highest temperature was observed during the first fortnight of September, ie., 28.3 ^{0}C and 30.2^{0}C at 15 and 30 cm soil depth in the homegarden respectively.

4.3.7.1.3 Cashew

Soil temperature associated with cashew litter decomposition varied significantly between the two conditions and also during the fortnights of decomposition (Table 27 c). The values were found to be more in the open compared to that in the homegarden. Homegarden soil recorded maximum temperature at 15 cm and 30 cm depths during the June (28.8^{0}C and 30.4^{0}C respectively-) and (27.8^{0}C and 30.0^{0}C respectively during second fortnight).

4.3.7.1.4 Ailanthus

The soil temperature associated with ailanthus litter decomposition is given in Table 27d. Significant variations were recorded between the two sites. The fortnightly variations were also significant in the two conditions. The values were found to be more in the open, compared to

Table 27b. Changes in soil moisture and soil temperature during decomposition of jack litter at fortnightly intervals

Fortnight	Soil moisture (%)			Soil temperature at 15 cm depth (^0C)			Soil temperature at 30 cm depth(^0C)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	7.36	14.82	11.09	32.24	27.00	29.62	33.90	29.10	31.50
1	12.91	17.22	15.07	31.30	27.32	29.31	32.90	28.80	30.85
2	11.28	13.00	12.14	30.86	28.08	29.47	32.70	29.70	31.20
3	14.76	19.01	16.89	29.00	26.78	27.89	31.50	28.50	30.00
4	15.04	22.15	18.60	28.50	26.46	27.48	31.00	27.70	29.35
5	15.50	24.70	20.10	28.60	26.62	27.61	30.30	28.50	29.40
6	15.69	22.34	19.01	28.10	26.36	27.23	29.70	27.76	28.73
7	14.62	22.37	18.50	28.82	26.50	27.66	30.40	28.12	29.26
8	18.99	21.38	20.19	31.80	28.28	30.04	33.60	30.18	31.89
9	19.73	21.76	20.75	31.70	25.50	28.60	33.20	27.06	30.13
10	19.29	21.27	20.28	28.70	25.00	26.80	31.40	26.60	29.00
11	20.53	-	-	26.58	-	-	28.40	-	-
12	18.93	-	-	26.90	-	-	29.10	-	-
13	19.18	-	-	26.70	-	-	29.20	-	-
14	18.04	-	-	27.80	-	-	30.40	-	-
Mean	16.12	20.00	-	29.17	26.72	-	31.18	28.37	-
CD	C: 0.376	P: 0.882	CP: 1.25	C: 0.482	P: 0.189	CP: 0.626	C: 205	P: 0.48	CP: 0.679

C-Condition (open / homegarden) P- Period CP - Interaction that in the homegarden. The homegarden soil recorded maximum temperature during the , first fortnight of May, followed by second fortnight in June at 15 cm (29.70^{0}C and 29.2^{0}C) and at 30cm depth (31.8^{0}C and 30.7^{0}C).

4.3.7.1.5 Wild jack

Table 27e. gives the soil temperature value recorded at 15 and 30 cm depth as wild jack litter decomposed in the open and homegarden. The highest soil temperature was recorded during the first fortnight of June (28.72 ^{0}C) in the homegarden at 15 cm depth and during second fortnight of January at 30 cm depth (30.22 ^{0}C).

4.3.7.1.6 Mahogany

Perusal of the data on soil temperature under mahogany litter at two depths in the open and homegarden in Table 27 f. reveal significant differences in the values recorded between the two sites and also with the fortnights. The maximum temperature were recorded in February (30.10 and 32.20^{0}C at 15 cm and 30 cm respectively). These were significantly lower than the maximum values recorded in the open, during the first fortnight of April, at 15 cm and 30 cm depth (33.30^{0}C and 35.20 ^{0}C respectively).

The maximum soil temperatures were recorded in the open, and during the drier periods at both sites. The soil temperature in the homegarden was lower than that in the open at all times. This could be attributed to the intense canopy cover provided by the tree- crop components existing in the homegardens. Consequently, the reduced

Table 27c. Changes in soil moisture and soil temperature during decomposition of cashew litter at fortnightly intervals

Fortnight	Soil moisture (%)			Soil temperature at 15cm (^0C)			Soil temperature at 30cm (^0C)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	7.78	12.04	9.91	32.24	27.60	29.92	33.90	29.10	31.50
1	14.22	17.09	15.65	31.30	27.70	29.50	32.90	29.30	31.10
2	10.94	11.87	11.41	30.86	28.80	29.83	32.70	30.40	31.55
3	14.75	19.14	16.95	29.00	27.80	28.40	31.50	30.00	30.75
4	14.97	20.27	17.62	28.50	27.10	27.80	31.00	29.20	30.10
5	16.95	20.88	18.91	28.60	26.10	27.35	30.30	27.60	28.95
6	16.94	23.92	20.43	28.10	27.00	27.55	29.70	28.80	29.25
7	15.55	24.01	19.78	28.82	27.30	28.06	30.40	29.10	29.75
8	19.62	24.93	22.28	31.80	26.90	29.35	33.60	28.80	31.20
9	19.52	23.38	21.45	31.70	26.80	29.25	33.20	28.40	30.80
10	19.31	20.86	20.08	28.70	26.60	27.65	31.40	27.80	29.60
11	19.85	20.26	20.05	26.58	25.50	26.04	28.40	27.20	27.80
12	17.88	-	-	26.90	-	-	29.10	-	-
13	18.98	-	-	26.70	-	-	29.20	-	-
Mean	16.23	17.05	-	29.27	23.23	-	31.24	24.69	-
CD	C: 0.54	P: 1.31	CP: 1.86	C: 0.173	P: 0.423	CP: 0.599	C: 0.210	P: 0.515	CP: 0.729

C- Condition (open/ homegarden) P- Period CP- Interaction

exposure of soil to solar radiation results in reduced soil temperatures. Similar findings were reported by Nair and Balakrishnan (1977), Nair (1983 and 1984), and Mathew *et al.* (1996) under various situations in homegardens.

The mean temperature recorded beneath ailanthus canopy were comparatively lower than that of other species owing to the poor canopy spread.

Correlation studies explicate positive correlations between the residual mass of mango, jack, cashew, ailanthus and wild jack litter and soil temperature at 15 and 30 cm depth both in the open and homegarden (Table 28a and b). Mahogany litter showed positive correlation between the mass remaining and soil temperature at 15 cm in the homegarden and at 30 cm depth at both sites. Negative and significant correlation was noticed between residual mass of mahogany litter and soil temperature recorded at 15 cm depth.

4.3.7.2 Soil moisture

4.3.6.2.1 Mango

The soil moisture data associated with mango litter decomposition in the open and homgarden are furnished in Table 27 a. The fortnightly variations and that between the two sites were significant. The mean values during the period of comparative study ranged from 10.15 per cent during the first fortnight of June to 21.92 per cent in October. The moisture status of soil in the open in the final months of decomposition are also given in the table.

Table 27d. Changes in soil moisture and soil temperature during decomposition of ailanthus litter at fortnightly intervals

Fortnight	Soil moisture (%)			Soil temperature at 15cm (^0C)			Soil temperature at 30cm (^0C)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	7.36	13.01	10.19	32.24	29.70	30.97	33.90	31.80	32.85
1	14.31	15.57	14.94	31.30	27.20	29.25	32.90	29.10	31.00
2	8.12	11.84	9.98	30.86	28.00	29.43	32.70	29.90	31.30
3	14.02	17.35	15.68	29.00	29.20	29.10	31.50	30.70	31.10
4	15.80	18.89	17.35	28.50	26.60	27.55	31.00	28.10	29.55
5	15.01	21.65	18.33	28.60	25.90	27.25	30.30	27.40	28.85
6	15.20	22.49	18.85	28.10	26.60	27.35	29.70	28.60	29.15
7	16.89	21.76	19.32	28.82	26.30	27.56	30.40	27.80	29.10
8	16.53	21.91	19.22	31.80	27.80	29.80	33.60	30.10	31.85
9	19.69	18.29	18.97	31.70	27.00	29.35	33.20	28.40	30.80
10	17.25	19.92	18.59	28.70	25.90	27.30	31.40	27.20	29.30
11	20.63	19.00	19.81	26.58	25.70	26.14	28.40	27.50	27.95
12	18.37	19.62	18.99	26.90	26.20	26.55	29.10	27.70	28.40
13	16.92	18.94	17.93	26.70	28.50	27.60	29.20	29.90	29.55
14	14.98	18.67	16.83	27.80	26.80	27.30	30.40	28.30	29.35
15	18.48	19.71	19.09	26.70	26.76	26.73	28.90	27.66	28.28
16	12.78	-	-	29.34	-	-	31.20	-	-
Mean	15.43	18.66	-	29.04	27.14	-	31.05	28.76	-
CD	C: 0.505	P: 1.428	CP: 2.02	C: 0.163	P: 0.462	CP: 0.653	C: 0.158	P: 0.447	CP: 0.063

C- Condition (open/ homegarden) P- Period CP - Interaction

4.3.7.2.2 Jack

The relevant data are furnished in Table 27 b. The mean moisture content of the soil associated with jack litter decomposition during the study period ranged from 11.09 per cent to 20.28 per cent with relatively higher contents during the rainy months. The mean moisture content of the homegarden soils was greater (20.0 per cent) than the open soil (16.12 per cent).

4.3.7.2.3 Cashew

The mean moisture content of the soil, in the open plot of cashew litter decomposition was significantly lower, compared to that recorded in the homegarden. The fortnightly variations were also significant with highest moisture contents being recorded during the months of August and September (Table 27 c.). The mean moisture content in the open was 16.23 per cent and 17.05 per cent in the homegarden.

4.3.7.2.4 Ailanthus

The data on soil moisture changes associated with ailanthus litter decomposition are presented in Table 27 d, reveal significant variations between the sites and the fortnights of sampling. The mean values were significantly high during the months of August, September and October. The mean moisture status was significantly greater in the homegarden (18.66 per cent) compared to the open (15.43 per cent).

4.3.7.2.5 Wild jack

Table 27 e. divulges the significant differences in soil moisture content associated with wild jack litter decomposition. The mean moisture

Table 27e. Changes in soil moisture and soil temperature during decomposition of wild jack litter at fortnightly intervals

Fortnight	Soil moisture (%)			Soil temperature at 15cm depth (^{0}C)			Soil temperature at 30cm depth(^{0}C)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	7.36	13.51	10.44	32.24	27.26	29.75	33.90	28.74	31.32
1	14.62	17.46	16.04	31.30	27.16	29.23	32.90	28.70	30.80
2	12.03	10.88	11.46	30.86	28.72	29.79	32.70	29.80	31.25
3	15.57	17.86	16.71	29.00	27.30	28.15	31.50	29.36	30.43
4	16.53	18.82	17.68	28.50	26.70	27.60	31.00	28.16	29.58
5	19.12	22.28	20.70	28.60	27.20	27.90	30.30	28.74	29.52
6	20.95	21.82	21.38	28.10	27.38	27.74	29.70	28.42	29.06
7	17.15	23.06	20.11	28.82	27.48	28.15	30.40	28.30	29.35
8	18.64	24.12	21.38	31.80	28.20	30.00	33.60	29.74	31.67
9	16.29	20.05	18.17	31.70	27.30	29.50	33.20	28.66	30.93
10	18.08	23.51	20.79	28.70	25.62	27.16	31.40	26.86	29.13
11	19.09	18.98	19.03	26.58	25.92	26.25	28.40	27.70	28.05
12	16.99	18.82	17.91	26.90	25.62	26.26	29.10	27.06	28.08
13	18.59	20.65	19.62	26.70	25.80	27.35	29.20	28.54	28.87
14	17.23	17.91	17.57	27.80	26.84	27.32	30.40	28.40	29.40
15	18.52	20.73	19.63	26.70	26.20	26.45	28.90	28.18	28.54
16	14.56	22.02	18.29	29.34	26.84	28.09	31.20	28.76	29.98
17	8.40	14.78	11.59	31.10	28.22	29.66	32.90	30.22	31.56
18	8.41	-	-	27.90	-	-	29.70	-	-
19	11.95	-	-	32.20	-	-	33.70	-	-
Mean	15.50	19.29	-	29.24	26.99	-	31.21	28.57	-
CD	C: 0.363	P: 1.09	CP: 1.54	C: 0.13	P: 0.39	CP: 0.55	C: 0.138	P: 0.413	CP: 0.585

C- Condition (open/ homegarden) P- Period CP- Interaction

of open soil was 15.50 per cent and homegarden soils was 19.29 per cent. The means of the two situations during the different fortnights of comparative study ranged from 10.44 to 21.38per cent, higher contents being observed during the rainy periods.

4.3.7.2.6 Mahogany

The moisture content of the soil associated with mahogany litter decomposition was significantly higher in the homegarden (mean-18.36 per cent) compared to that of the open (15.29 per cent). The fortnightly variations were also significant (Table 27 f). The mean value of the two situations was observed to vary between 7.96 per cent (first fortnight of March) and 21.59 per cent (second fortnight of September).

The existing data summarises significant variation in the moisture status associated with litter decomposition in the open and homegarden. The soil moisture status in the open soils did not vary much between them (14.93 to 16.23 per cent). The moisture content in the homegarden soils varied between 17.05 per cent (cashew) to 20.0 per cent (jack), which could possibly be due to litter decomposition. In all species studied, the moisture content of the soil was significantly higher in the homegarden. This is in concurrence with the reports of John (1997) and Abraham (1998), who recorded significantly higher moisture contents in homegarden soils compared to that of barren plots. The positive effect of moisture conservation by trees in homegardens is proved true in the study. The canopy spread of the tree and litter cover would have paved way for the higher retention of soil moisture in the homegarden. The fortnightly

Table 27f. Changes in soil moisture and soil temperature during the decomposition of mahogany litter at fortnightly intervals

Fortnight	Soil moisture (%)			Soil temperature at 15 cm depth (^0C)			Soil temperature at 30 cm depth (^0C)		
	Open	Homegarden	Mean	Open	Homegarden	Mean	Open	Homegarden	Mean
0	7.36	13.05	10.21	32.24	27.80	30.02	33.90	29.60	31.75
1	14.54	17.65	16.10	31.30	26.80	29.05	32.90	28.70	30.80
2	11.79	14.51	13.15	30.86	28.70	29.78	32.70	30.60	31.65
3	15.56	18.87	17.21	29.00	28.10	28.55	31.50	29.50	30.50
4	16.36	20.51	18.43	28.50	27.20	27.85	31.00	29.00	30.00
5	18.92	21.11	20.01	28.60	27.60	28.10	30.30	29.60	29.40
6	18.29	23.04	20.66	28.10	27.20	27.65	29.70	29.10	29.40
7	16.93	21.16	19.05	28.82	26.70	27.76	30.40	28.50	29.45
8	18.45	24.34	21.40	31.80	28.10	29.95	33.60	30.00	31.80
9	19.52	23.65	21.59	31.70	27.30	29.50	33.20	29.60	31.40
10	18.45	21.36	19.91	28.70	25.80	27.25	31.40	28.20	29.80
11	19.91	19.53	19.72	26.58	26.50	26.54	28.40	28.10	28.25
12	18.14	17.86	18.00	26.90	26.00	26.45	29.10	28.40	28.75
13	20.06	21.58	20.82	26.70	29.30	28.00	29.20	30.70	29.95
14	18.58	21.21	19.90	27.80	27.20	27.50	30.40	28.70	29.55
15	20.98	21.60	21.29	26.70	26.20	26.45	28.90	28.20	28.55
16	15.64	18.26	16.95	29.34	27.00	28.17	31.20	28.50	29.85
17	11.13	13.64	12.39	31.10	28.50	29.80	32.90	30.20	31.55
18	8.41	16.20	12.30	27.90	30.10	29.00	29.70	32.20	30.95
19	8.13	11.40	9.77	32.20	28.30	30.25	33.70	30.20	31.95
20	6.94	8.99	7.96	31.30	29.40	30.35	33.40	31.00	32.20
21	14.38	14.50	14.44	29.00	27.60	28.30	30.90	29.70	30.30
22	12.74	-	-	33.30	-	-	35.20	-	-
23	13.06	-	-	32.30	-	-	34.40	-	-
24	18.05	-	-	32.40	-	-	34.50	-	-
Mean	15.29	18.36	-	29.73	27.60	-	31.70	29.46	-
CD	C: 0.335	P: 1.112	CP: 1.57	C: 0.118	P: 0.393	CP: 0.556	C: 0.128	P: 0.425	CP: 0.601

C- Condition (open/ homegarden) P- Period CP- Interaction

differences were in accordance with the climatic variations recorded during the period of study. The soil moisture content was higher during the rainy days compared to non rainy days. During the dry season, soils of the open area recorded low moisture contents compared to that of the homegardens.

The residual mass at fortnightly intervals in this experiment gave significant negative correlations with soil moisture in mango, jack cashew, ailanthus and mahogany litter decomposition, whereas, that of wild jack was positively correlated, but non significant (Table 28a and b). Hence, it could be inferred that soil moisture influenced the rate of decomposition in mango, jack, cashew and ailanthus due to its influence on the microbial population and proliferation. Significant and negative correlations between soil moisture underneath litter bags and litter decomposition rates were reported by Okeke and Omaliko (1991) and Hegde (1995). According to Donnelly *et al.* (1990), soil moisture exerts a greater influence on microbial mass than soil temperature and pH. Faster rates of decomposition in all the homegardens could thus be attributed to the higher soil moisture status. Lavelle *et al.* (1993) added that under favourable soil water regimes, the association between earthworms and bacteria predominate, leading to breakdown of organic materials. The above noticed moisture dependent decomposition in four species and the absence of such a relation for wild jack and mahogany is probably due to the differences in substrate quality.

4.3.7.3 Litter quality

The initial litter nitrogen, lignin and lignin: N and C: N ratios are presented in Table 2. The time taken for complete (95 per cent) disappearance of litter were related to the initial litter nitrogen, lignin and lignin: N and C: N ratios of litter samples. Correlation studies between initial litter quality and decay rate constants revealed a significant influence of lignin and lignin: N ratio on litter decay coefficients while the others showed non significant correlations (Table 28c). High lignin contents are expected to retard the decomposition process (low k values). Melillo *et al.* (1982) opined that plant materials with high lignin concentrations decompose more slowly than those with lower concentrations. According to Fogel and Cromack (1977) and Meentemeyer (1978), lignin is the primary variable controlling decomposition. The data in Table 2 showed that wild jack and mahogany had the highest lignin contents (28.86 and 32.10 per cent respectively) and their k values were -1.161 and -1.228.

4.3.8 Prediction models

The data for the weight loss of litter on decomposition and the nutrient contents of residual litter were subjected to curve fit analysis in order to arrive at the best-suited prediction model of decomposition for each tree species. Twenty-four equations were tried and of these, the best ideal for each species and parameter were selected based on R^2 value. The multiple correlation coefficients of more than eighty percent were generally selected. However, in some cases very low values were obtained but had to be selected as these were the best of the equations tried. The selected equations for each parameter are given in Appendix III.

Table 28 a. Correlation studies

Parameter	Mango (r)		Jack (r)		Cashew (r)	
	open	home	open	home	open	home
soil moisture x residual mass	-0.081	-0.795*	-0.860*	-0.730*	-0.783*	-0.757*
soil temperature at 15 cm depth x residual mass	0.469*	0.763*	0.562*	0.470*	0.504*	0.725*
soil temperature at 30 cm depth x residual mass	0.441*	0.616*	0.026*	0.439*	0.476*	0.659*

Table 28 b.Correlation studies

Parameter	Ailanthus (r)		Wild jack (r)		Mahogany (r)	
	open	home	open	home	open	home
soil moisture x residual mass	-0.504*	-0.466*	0.112	-0.324*	-0.374	-0.517*
soil temperature at 15 cm depth x residual mass	0.599*	0.393*	0.224*	0.349*	-0.477	0.043*
soil temperature at 30 cm depth x residual mass	0.567*	0.495*	0.229*	0.157	0.473*	0.344*

Table 28 c. Correlation of initial litter chemistry with decay constants over all trees

Parameter	r	
	calculated	predicted
initial nitrogen and decay constant	0.326	0.246
initial C:N and decay constant	0.124	0.154
initial lignin and decay constant	0.803 *	0.665 *
initial lignin: N and decay constant	0.627 *	0.546 *

A critical review of the results has helped in drawing the following conclusions.

The residual mass related to the time elapsed on decomposition gave the best fit for the straight-line equation. The decomposition model for the six species studied can be made based on this equation. The decrease in mass on litter decomposition was linear. The exponential function normally used to predict decomposition pattern of litter gave poor fit in this study.

Most of the nutrients remaining in the residual mass (potassium, calcium, magnesium, zinc, manganese and iron) related to the time elapsed followed the parabolic function, quadratic equation (equation 8 in Appendix II).

Nitrogen followed the cauchy function in most species (equation 24 in Appendix II)

However, the phosphorus dynamics in most situations gave very poor fits for the equations tried, revealing this to be highly variable. It did not show a specific pattern so as to fit an equation common for all the 6 species studied. The R^2 values were comparatively low also. The one with maximum R^2 value is given in the table.

Phosphorus in mango, ailanthus, wild jack and mahogany litter agreed to the cauchy function, jack to the second order hyperbolic function (equation 7), and cashew to the parabolic function.

Copper in the litter could be best predicted with the Hoerl function (equation 19) in all litter.

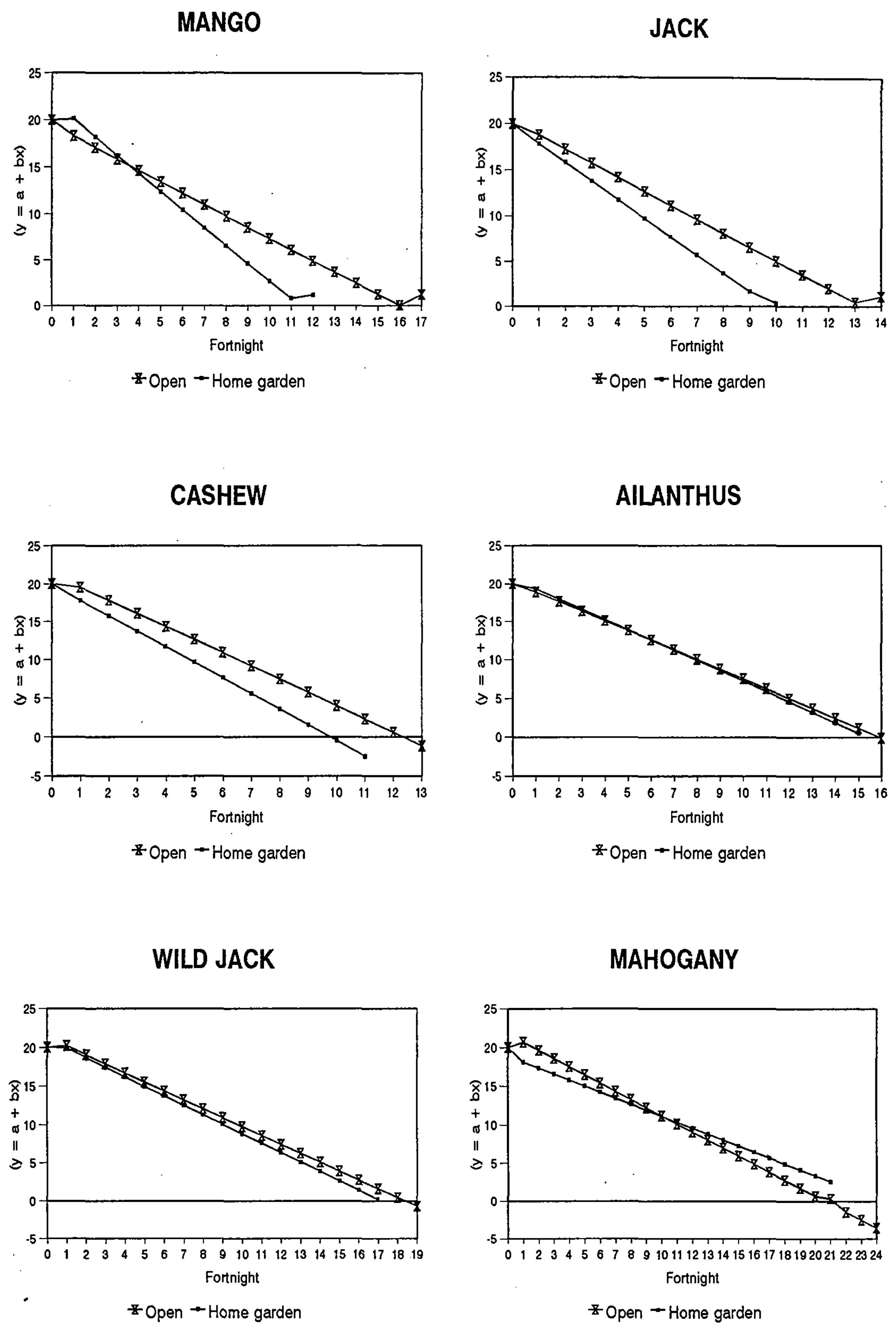

Fig. 15 Decomposition models for the litter of different tree species (y = a + bx)

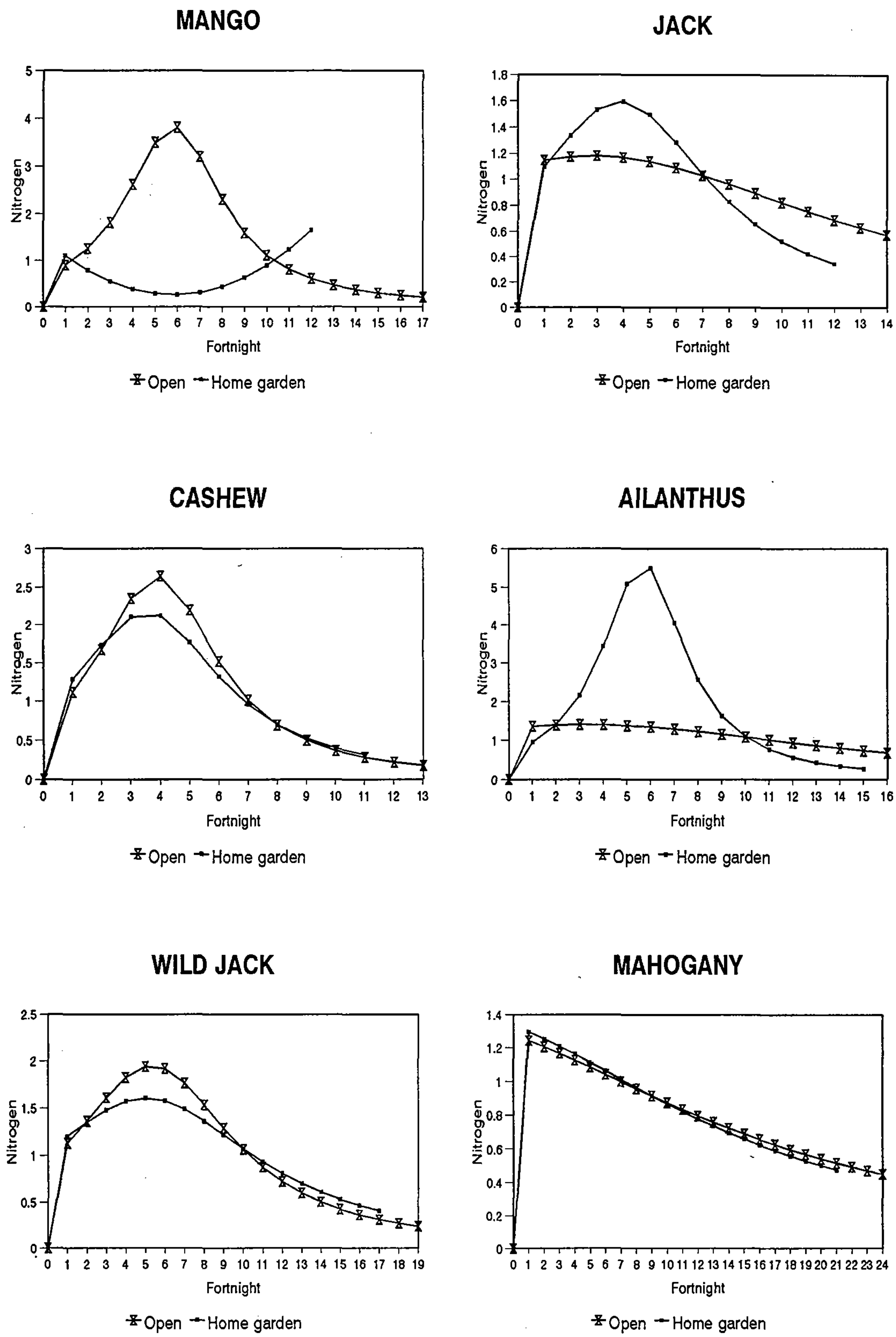

Fig. 16 Nitrogen dynamics model for the litter of different tree species (y = 1/[a.{ x+ b}^2+c]

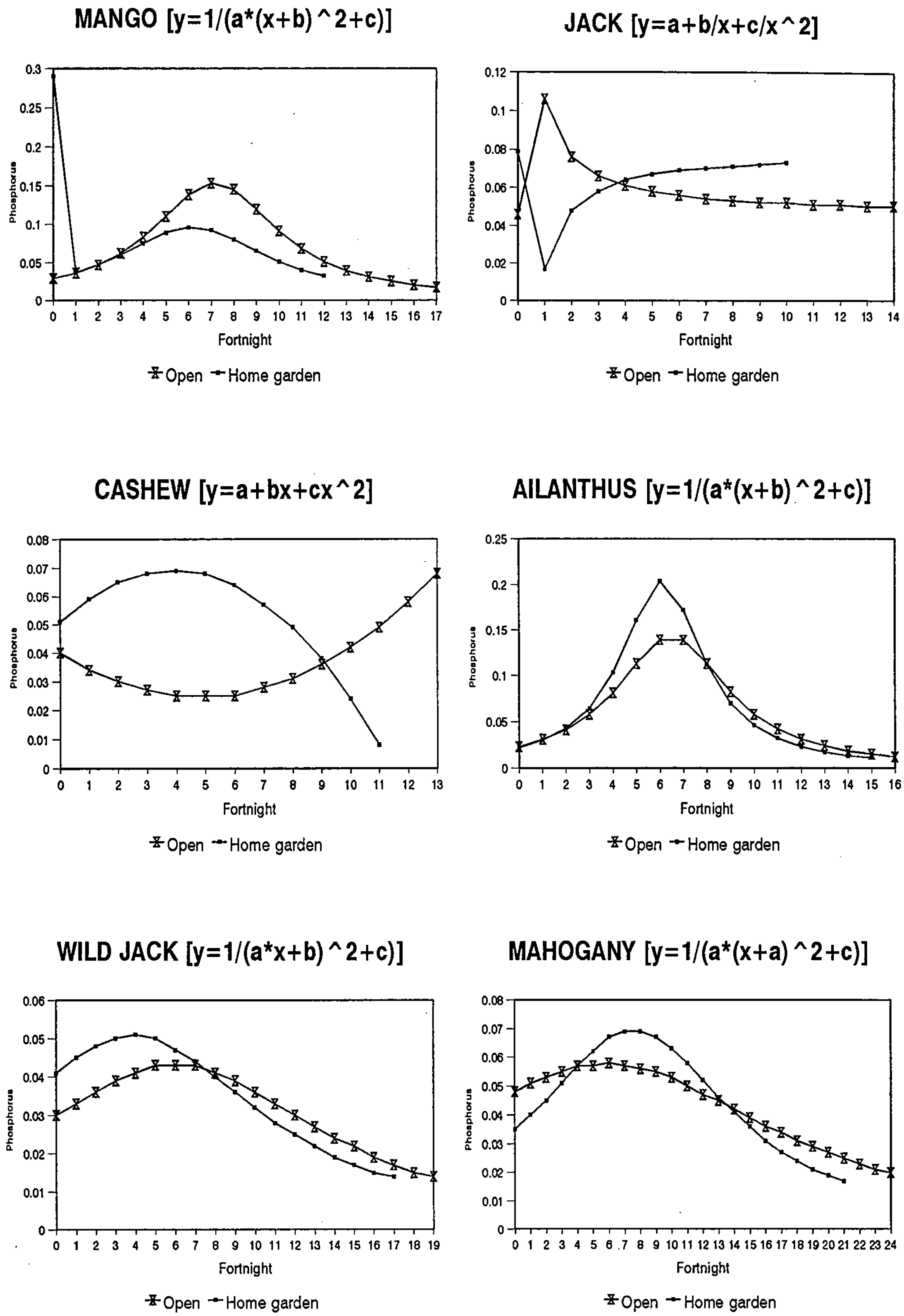

Fig. 17 Phosphorus dynamics model for the litter of different tree species

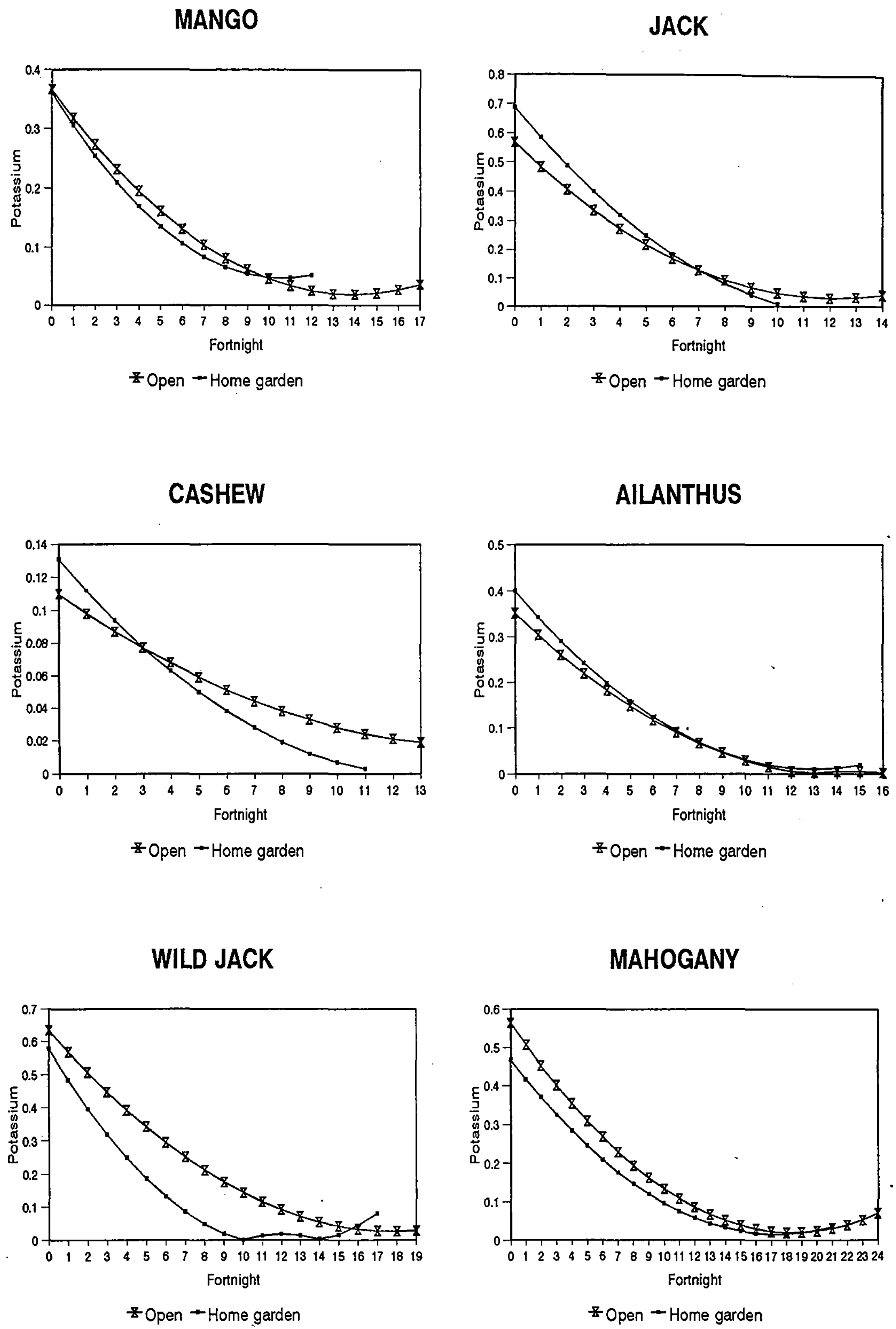

Fig. 18 Potassium dynamics model for the litter of different tree species (y = a+ bx+cx^2)

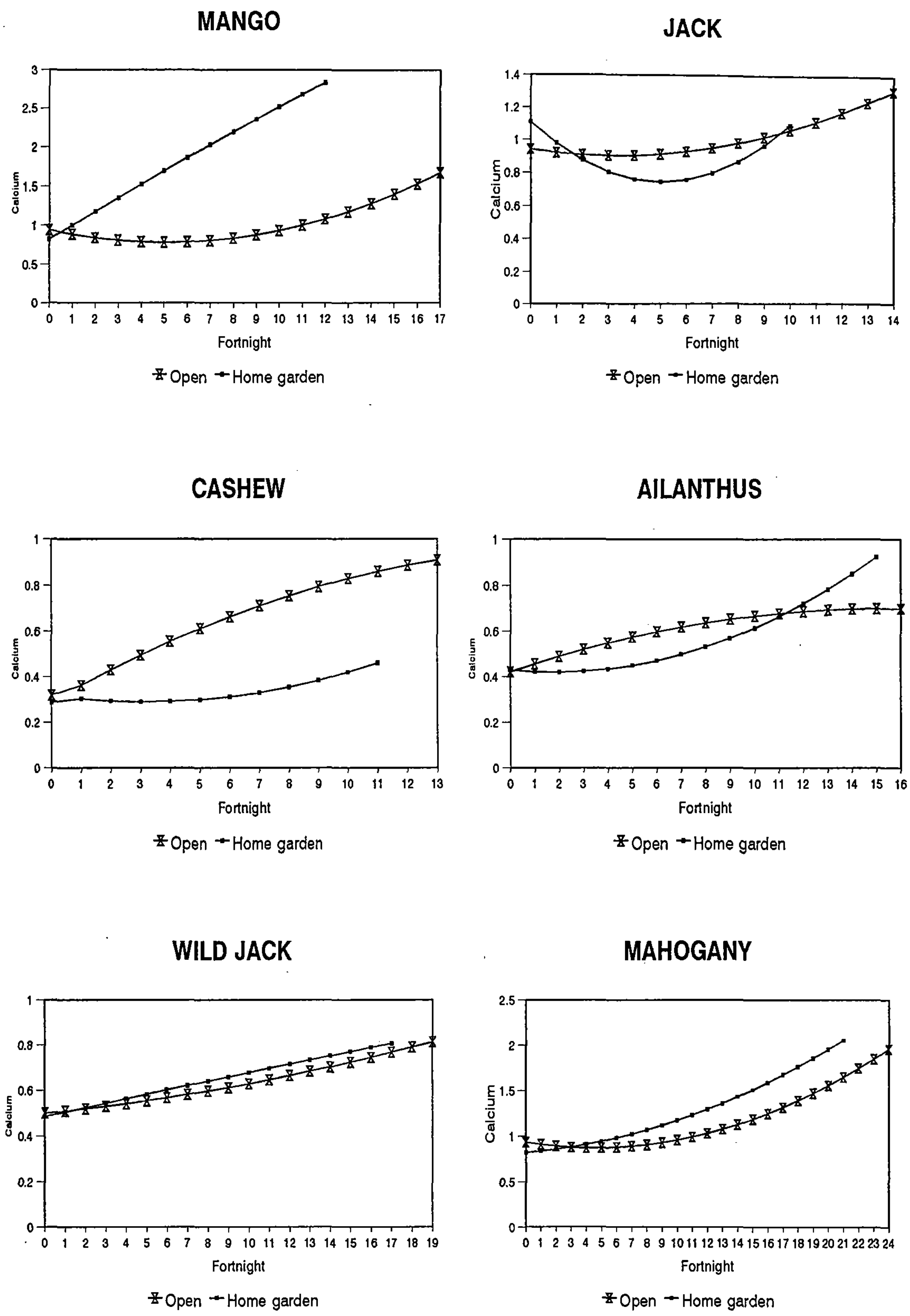

Fig. 19 Calcium dynamics model for the litter of different tree species (y = a+ bx+cx^2)

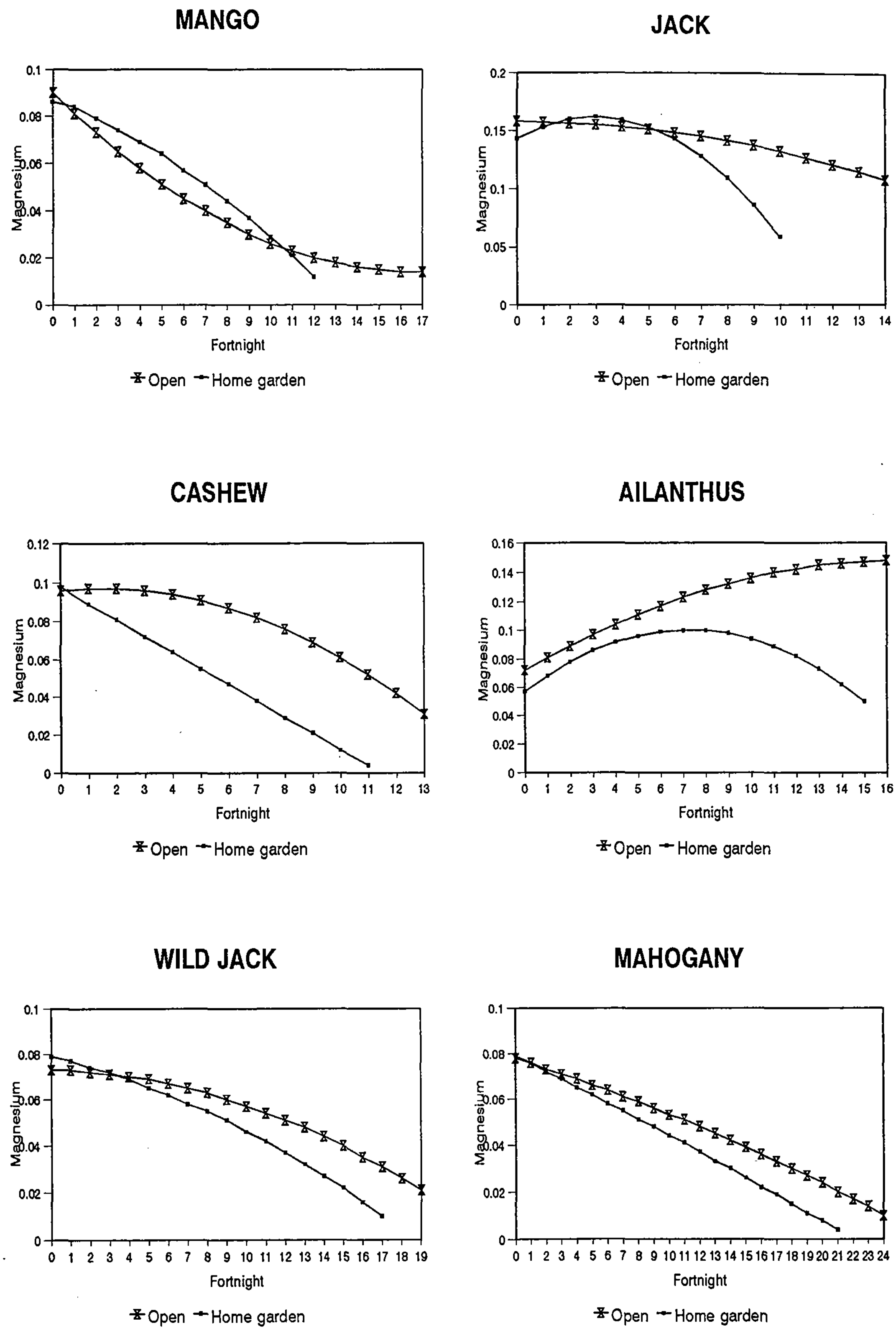

Fig. 20 Magnesium dynamics model for the litter of different tree species (y = a+ bx+cx^2)

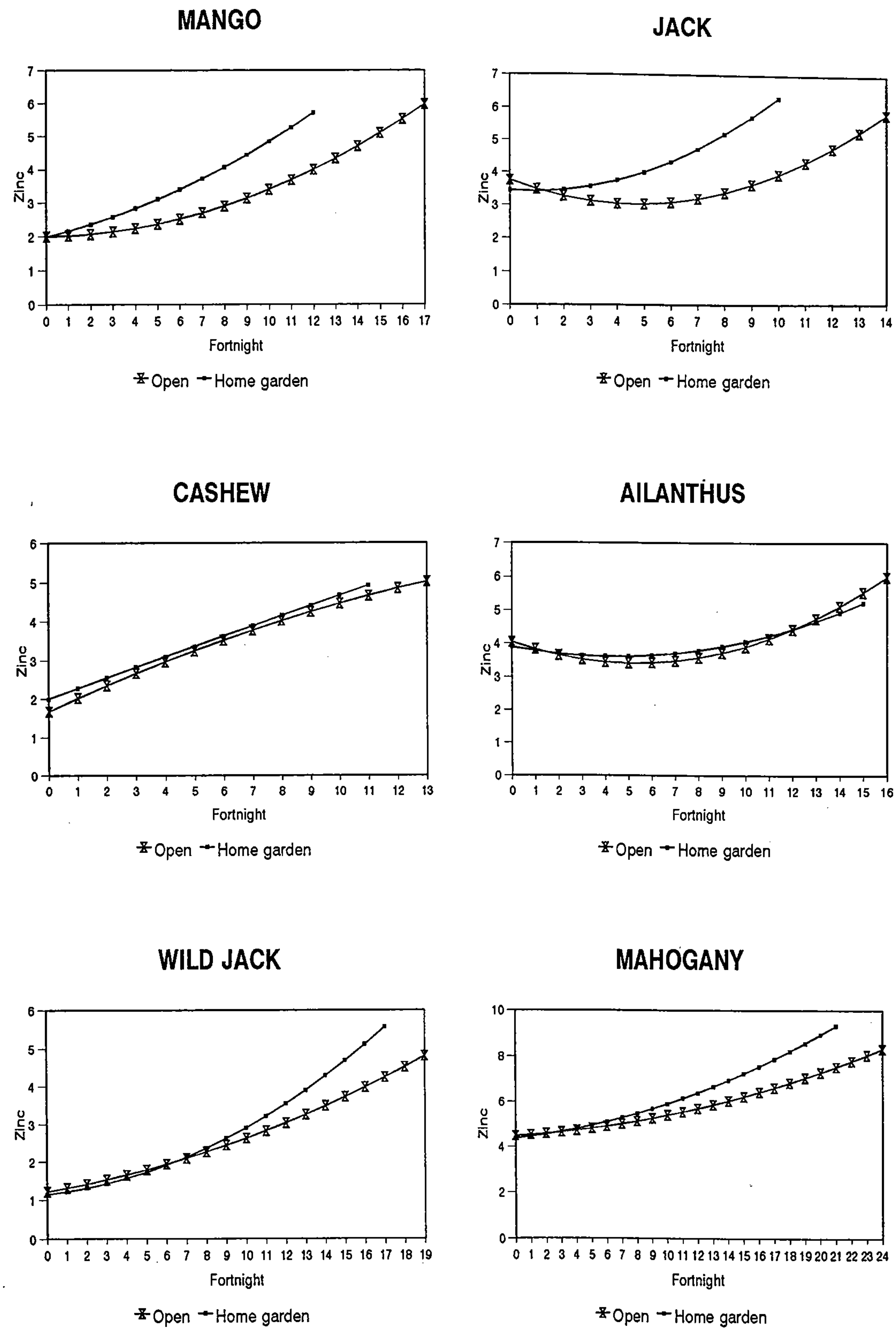

Fig. 21 Zinc dynamics model for the litter of different tree species (y = a+ bx+cx^2)

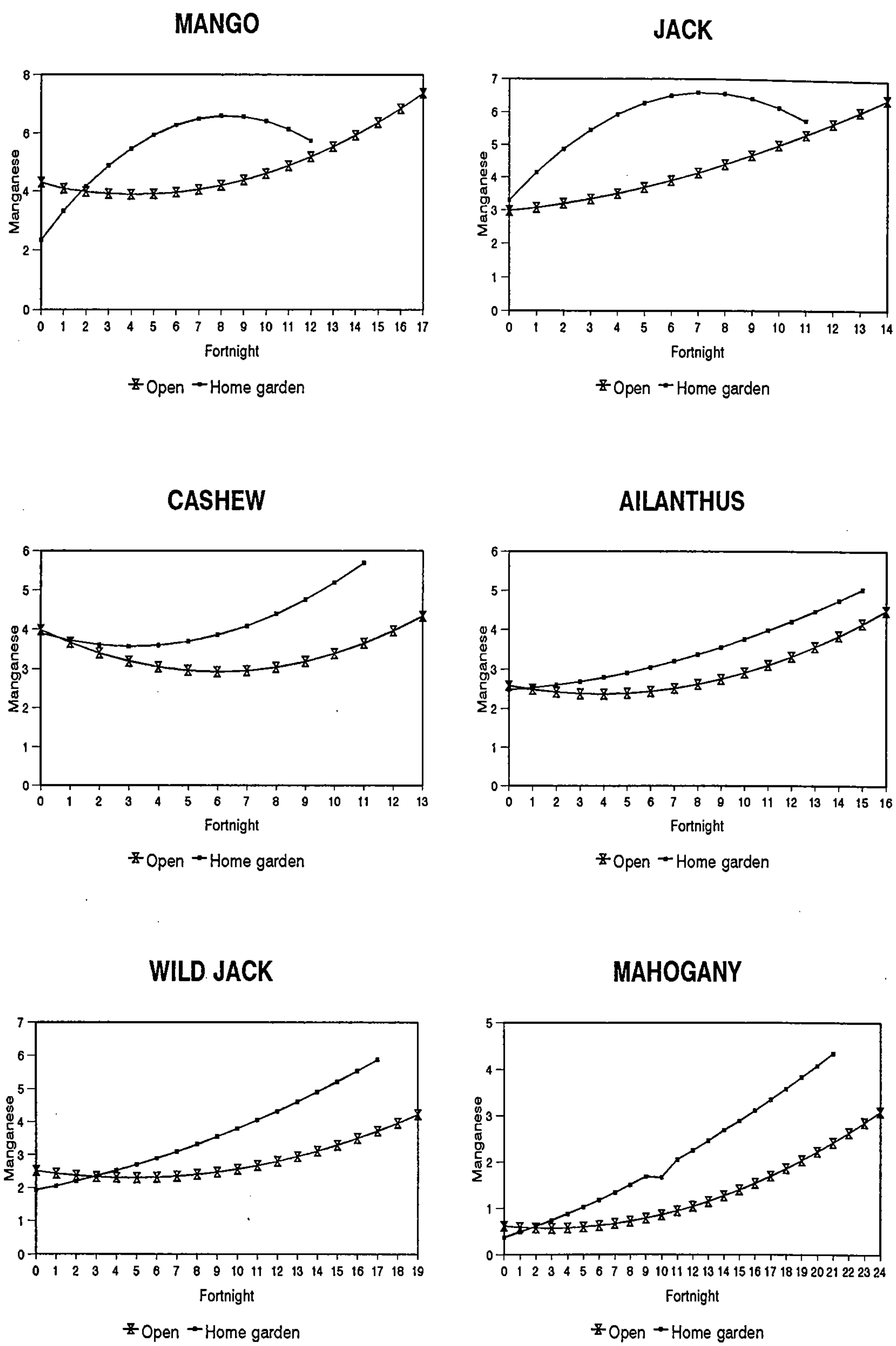

Fig. 22 Manganese dynamics model for the litter of different tree species (y = a+ bx+cx^2)

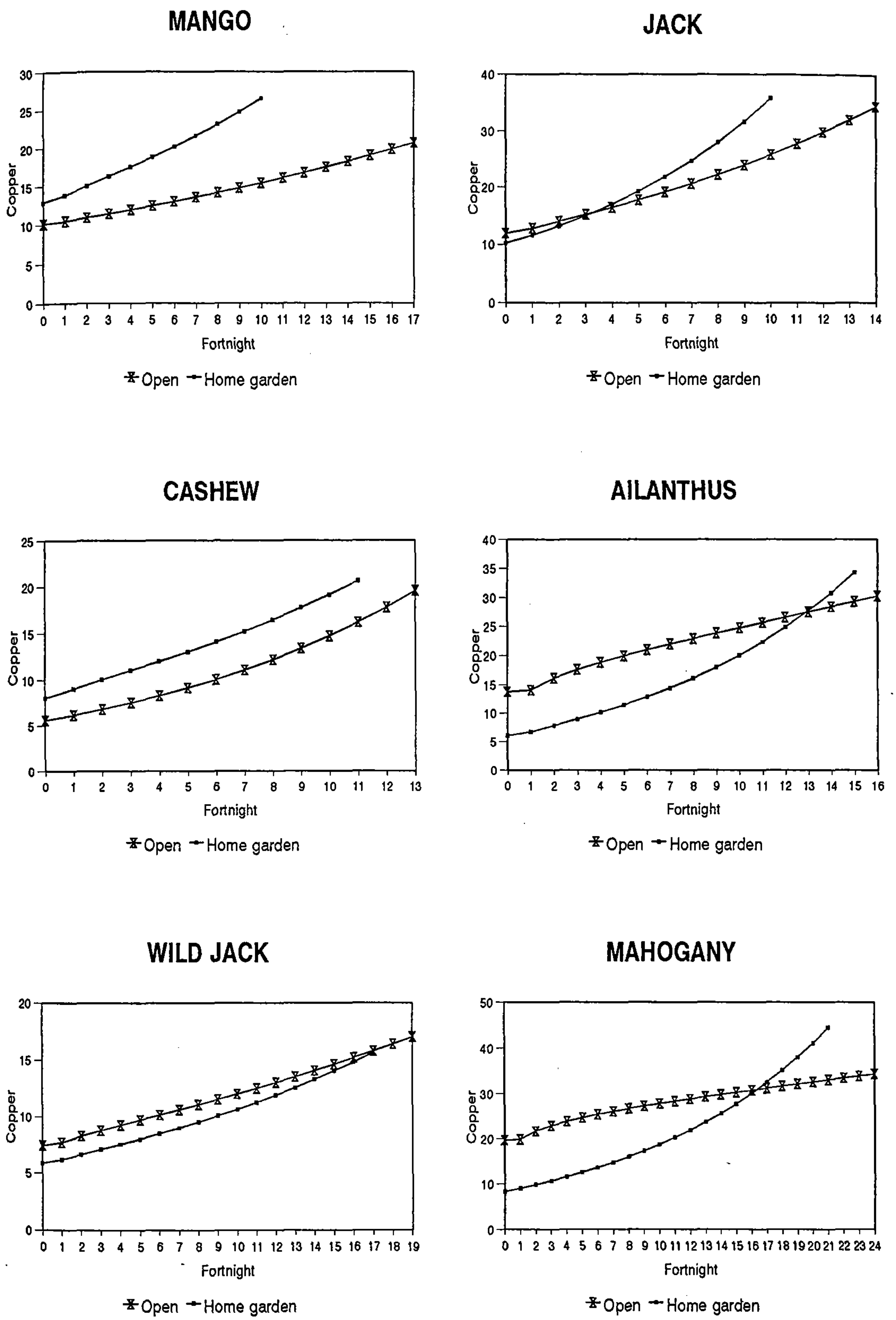

Fig. 23 Copper dynamics model for the litter of different tree species (y = ab^x.x^c)

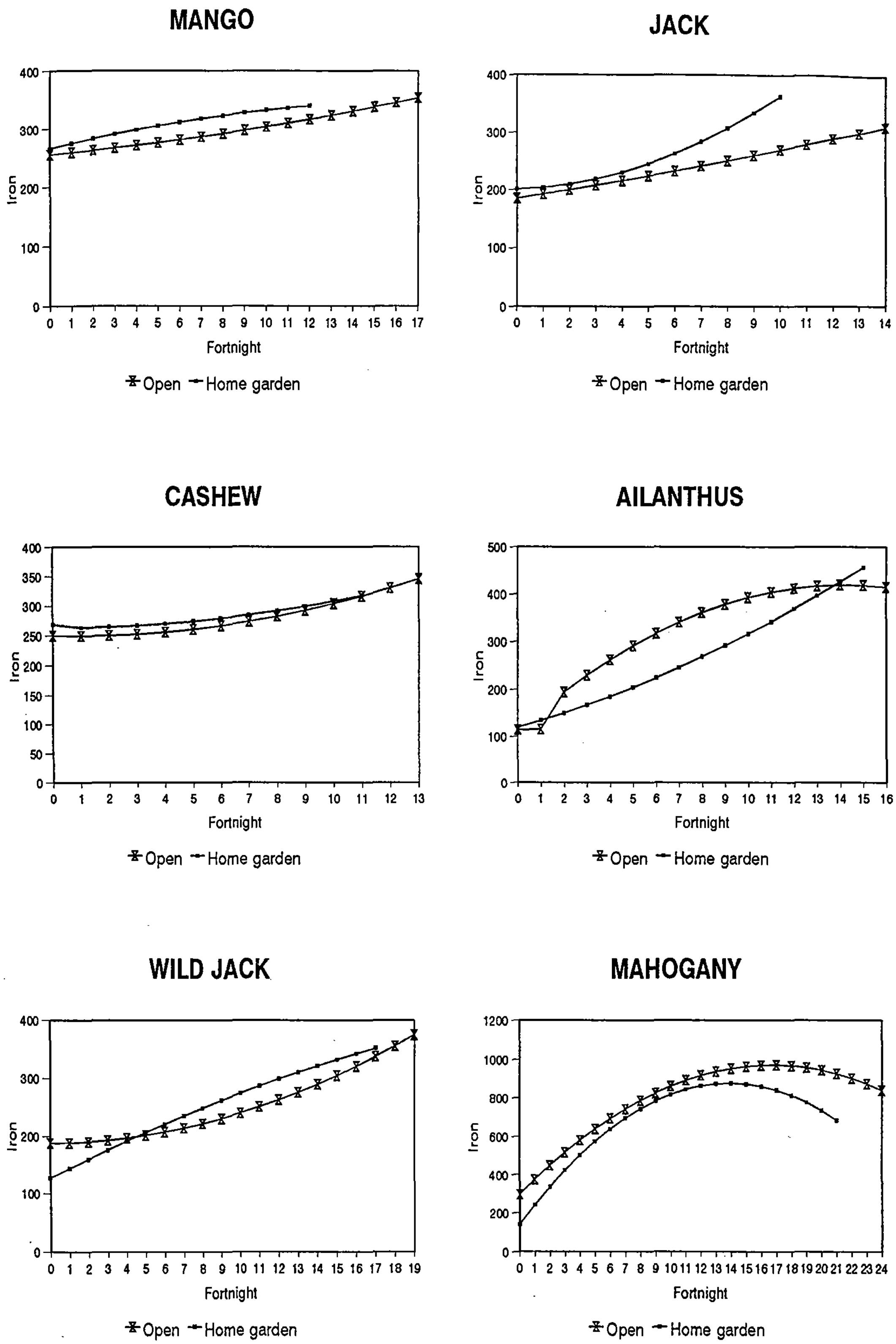

Fig. 24 Iron dynamics model for the litter of different tree species (y = a+bx+cx^2)

Considering litter decomposition species wise, all parameters barring phosphorus showed comparatively good values of R^2 for equation No.8 and litter decomposition model for each species could developed based on the parabolic function, $y=a+bx+cx^2$.

The litter dynamics of the different tree species reveal that leaf litter serves as a potential source of organic matter and nutrients.

The differential nutrient composition of the fallen litter is responsible for the differential pattern of nutrient addition through litter. Nitrogen was the major nutrient added through litter followed by potassium and phosphorus.

Mango is a multipurpose tree commonly found in homesteads. The annual litterfall of the species in the present study averaged 0.770 kg m^{-2} and amount of nutrients to the tune of 8.3 g nitrogen, 0.40 g phosphorus and 2.65 g potassium per square metre. Decomposition of leaf litter in an exposed area as in the open plot occurred in 17 fortnights, whereas the same took only 12 fortnights in the homegarden where the litter was placed beneath the tree canopy. The presence of the tree cover made rapid decomposition possible in the homegarden compared to the open site. A more favourable microclimate probably enhanced microbial activity. This prolific growth and activity of soil organisms in the homegarden would have ultimately been responsible for this difference in the rate of decomposition. The decay constants worked out was -1.09 in the open and –1.63 in the homegarden. The half-life value (years) of mango leaf litter was 0.321 and 0.256 in the open.

The overall nutrient release from mango litter was in the order K> Mg >N/P >Fe > Mn >Ca > Zn > Cu and was found to be more complete in the open than in the homegarden. However, nearly 95 per cent of the initial nutrient concentration was released in both situations. The accumulation of micronutrients was mostly from exogenous sources and that of nitrogen, phosphorus and calcium were due to microbial immobilization. The major amount of nitrogen release occurred during the last six fortnights after the initial release by leaching and accumulation. Phosphorus in mango litter also showed similar trends of accumulation but this was a temporary phenomenon. In the open, the release occurred from the eleventh fortnight and in the homegarden, from the eighth fortnight. Potassium and magnesium concentrations in litter showed decreasing trends ensuring release during decomposition. Lignin content was found to increase as decay of litter progressed and the influence was positive. As lignin: N content of mango litter increased decay rate declined. Favourable influence of mango litter decay on soil properties were also recorded. The use of mango litter as an organic manure is possible as nutrient dynamics reveal more than 95 per cent release and this occur in nine months in an open field and in six months in a shaded area as that beneath the mango canopy.

Jack litter also finds use as an organic source of nutrients in agriculture as the nutrient release patterns reveal that only less than 5 per cent of the initial nutrient contents remaining in the final litter and this was less than 10 per cent in the case of the micronutrients. The difference shown in nutrient release is mainly because micronutrients were significantly accumulated during decay. Nitrogen release in jack occurred from the third month after litter was kept for decomposition and phosphorus during the sixth month in the open and eighth month in the homegarden. Potassium and magnesium in general showed declining trends throughout whereas the micronutrients got accumulated. The order of release was K>P>N/ Mg> Ca> Zn/Fe> Mn> Cu in both situations. The time taken for 95 per cent decay differed in the open and homegarden conditions, that in the former being 14 fortnights and the latter being only 10 fortnights. The decay rate constants and half-lives (years) were -1.529 and 0.277 respectively in the open and –2.024 and 0.201 respectively in the homegarden. The decrease in weight of litter followed a linear pattern with soil moisture having a more regulatory role than soil temperature. The average amount of jack litter in the homegardens is 0.69 kgm^{-2} $year^{-1}$and which accrued to the soil 8.04 g nitrogen, 0.36 g phosphorus and 2.09 g potassium m^{-2}.

Cashew litter disappeared more rapidly in the homegarden (11 fortnights- half-life -0.269) compared to that in the open (13 fortnights- half-life -0.207) ensuring decay constants of –2.022 in the former and -1.721 in the homegarden. Soil moisture was found to have positive correlation with the weight loss of cashew litter. The nutrient release followed the order K> Mg> N>P/Mn/ Fe> Ca/Zn>Cu. The higher rate of decay in the homegarden can be attributed to the soil organisms especially the earthworms that were found in the litter bags.

The amount of most nutrients remaining in the litter was less than 5 per cent of the original content ensuring nutrient release. Micronutrients increased in contents and showed least mobility and the decrease in their absolute concentrations is relative to the initial content and mass remaining. The nitrogen dynamics of cashew litter revealed release, starting from the second (homegarden) and third (open) months after being kept for decay. Phosphorus dynamics in the open appear distorted as the data reveal accumulations even in the final month. In the homegarden, the release of phosphorus occurred from the fourth month onwards. Potassium and magnesium contents were found to decrease in the litter as time elapsed while calcium, as in the case of micronutrients, increased.

The litter addition by ailanthus trees is comparatively low 0.442 kg m^{-2} $year^{-1}$, with 7.37 g nitrogen, 0.2 g phosphorus and 1.46 g potassium per unit area. This is due to the low canopy spread of the trees. The litter decay took 16 fortnights in the open and 15 fortnights in the homegarden. The nutrient release from ailanthus litter were in the order K> P/N/ Mg>Zn>Mn>Ca>Fe>Cu. By the time 95 per cent decomposition of ailanthus litter was completed, nearly 98 per cent of nitrogen, phosphorus and magnesium were released; calcium, zinc, manganese, copper and iron owing to the accumulation showed higher values of absolute contents. The linear model holds good for the weight loss pattern in ailanthus litter and the decay constants computed were –1.267 and –1.347 in the open and homegarden respectively. The decomposition time for disappearance of the initial litter in the open and beneath ailanthus canopy did not vary much owing to nature of ailanthus canopy. The canopy spread was not extent and dense as in mango and jack and so the pattern remained almost same.

The litter addition by wild jack in the three homegarden averaged 0.672 $kg m^{-2}$ $year^{-1}$ and nutrients, 6.94 g nitrogen, 0.373 g phosphorus and 1.7 g potassium per square metre annually. In mahogany, the nutrients added were to the tune of 7.98 g nitrogen, 0.187 g phosphorus and 2.903 g potassium from 0.747 kg m^{-2} litter annually.

Wild jack and mahogany leaf litter were characterized by high lignin and nitrogen contents and as earlier documented, higher these values lower the lignin: N ratio and hence lower the value of k. These were found to take comparatively longer periods for 95 per cent decomposition (19 and 17 fortnights for wild jack litter in the open and homegarden respectively and 24 and 21 fortnights respectively for mahogany litter).

The wild jack litter decay constants worked out from the linear equations, which gave the best fit, were –1.061 and –1.228 for the open and homegarden sites. The half lives were 0.402 and 0.373 years respectively. The regulatory role of soil moisture and soil temperature could not be well correlated with the weight loss in the open while that in the homegarden the residual mass decreased as soil moisture increased.

The pattern of nutrient release according to the mobility was K>N/P>Mg> Ca> Fe> Mn>Cu>Zn reflecting the release of the primary nutrients and accumulation of the micronutrients. Wild jack leaf litter initially accumulated nitrogen and thereafter released nearly 99 per cent of the initial amount in the open. In the homegarden, this was 98 per cent as the nutrient remaining in the final sample was less than 2 per cent. The release was gradual starting from the second month onwards. The phosphorus dynamics revealed an initial release, followed by accumulation and release in the final stages. Potassium and magnesium contents showed decreasing trends in the litter while calcium and the four micronutrients increased as time elapsed. The increase in zinc, manganese, copper and iron was probably from exogenous sources and calcium mostly due to microbial immobilization. Monitoring the changes in the soil properties, litter decomposition had a general favourable influence on the soil physical and chemical properties though a decline in the organic carbon and soil nitrogen status were noticed in between. The comparatively high lignin content and the thick, rough and leathery texture of the fallen leaves would have reduced the soil faunal and floral activity leading to a gradual decay of the litter.

Mahogany litter in the open took the longest period for 95 per cent decay (one year). The leaf texture and high lignin contents along with the microclimatic conditions would have been responsible for this slow decomposition. The decay rate constants were also low, -0.776 in the open and –1.052 in the homegarden. The time for 50per cent decay were computed as 0.623 and 0.349 years respectively. The influence of soil moisture and whereas soil temperature at 15 cm depth showed significant regulatory effects on decomposition in the open. The influence of soil temperature on litter beneath the tree canopy could not be correlated.

Nutrient release pattern from mahogany leaf litter was K>Mg>N/P>Zn >Ca>Fe> Cu>Mn. The per cent of micronutrients and calcium remaining in the litter mass at the time of final sampling were comparatively higher than that of the other species. The primary and secondary nutrients (magnesium) remaining were less than 4 per cent, in the open and homegarden, as these were finally released even though accumulations due to microbial immobilization occurred in between. Release of nitrogen and phosphorus from litter were slow. Mahogany litter on decomposition could improve the soil physical and chemical properties but fluctuations were recorded during the process. The favourable influence was noticed only with the disappearance of 95 per cent of the initial litter kept for decomposition. This has to be borne in mind while recommending mahogany litter as a source of nutrient inputs in agriculture. Owing to the high lignin content and glazy texture, the leaves take a longer period for complete decomposition.

The above study examining the decomposition and nutrient release dynamics of six species litter in open plots and homegardens indicate that significant amounts of nitrogen, phosphorus, potassium and magnesium are released during decay showing potential for use as a source of major nutrients, while calcium and micronutrients accumulated in the litter. The selected trees differ widely in their rates of decomposition. Jack and cashew showed faster rate of decomposition among the six species and the k values in the homegarden were higher compared to the corresponding values in the open. Wild jack and mahogany took the longest period for decay and recorded lowest k values. The soil physical and chemical properties were favourably affected and hence leaf litter can be used as manures for crop production provided the allelopathic potential of the litter is negligible. This aspect needs to be further investigated.

SUMMARY

5. SUMMARY AND CONCLUSION

The investigation entitled "Litter decomposition and nutrient dynamics of selected multipurpose trees in homesteads" was carried out in three homegardens at Kalliyur Panchayat, Thiruvanthapuram District, during May 1998 to May1999 to assess the quantity of litter production and litter decomposition and nutrient dynamics of six tree species - mango, jack, cashew, ailanthus, wild jack and mahogany. The litter fall of the mature trees in the homegardens was quantified. Litter bag technique was adopted to assess the decomposition and nutrient release characteristics of the leaf litters of mango, jack, cashew, ailanthus, wild jack and mahogany, The changes in the physico-chemical and biological properties of the soil were monitored. Attempts were made to work out a relationship between soil moisture and temperature with the mass loss in the different tree species and evolve mathematical models for the decomposition pattern shown by the litter.

The salient findings of the present study are summarised below.

The homegardens studied resembled multi-storied cropping systems with trees and agricultural crops occupying different layers of the atmosphere. Coconut was the predominant tree component species in all three homegardens and the other components varied with the needs and interests of the farm family. There was no specific pattern of arrangement, but an intense mix of a variety of tree species and agricultural components.

The intense cropping pattern resulted in high cropping intensities, which is unique to homegardens alone. The cropping intensity of the three homegadens was 187, 186.7 and 177 per cent respectively.

The quantity of litter fall by the different tree species varied with the species, phenology, stand age, density and climatic conditions. The annual litter fall in the three homegardens were 473.6 kg, 425.37 kg and 345.11kg respectively.

Nitrogen and potassium additions to the soil through litter were substantial but phosphorus was comparatively low.

The litter chemistry of fresh leaves and leaf litter were determined and green leaves revealed higher contents of nitrogen, phosphorus, potassium and magnesium and lower amounts of lignin. Zinc, manganese, copper and iron contents were more in the litter. Nutrient contents were significantly different in the different species litter.

The weight loss of the litter was more rapid in the homegarden compared to the litters kept in the open (exposed) area in all species examined. The time taken for 95 per cent decomposition was comparatively greater for mahogany and the others followed the order wild jack >ailanthus > mango > cashew > jack in the homegardens.

The loss in weight of litter as time elapsed was found to follow a linear pattern in all the six species litter at the two sites.

The nutrient release characteristics of decomposing litter showed that nitrogen and phosphorus exhibited trends of initial leaching losses followed by accumulation due to microbial immobilisation but were mostly released during the final stages. Potassium and magnesium contents in the decomposing litter were found to decrease as decay progressed, while the calcium and various micronutrient contents in the final samples were higher than the initial concentrations. The absolute amount of the nutrients in the litter bags decreased in the litter of all species relative to the decline in weight of remaining litter after decomposition.

The cellulose and hemicellulose fractions decreased with the time of decomposition whereas that of lignin increased.

The soil physical properties, bulk density, particle density, porosity and water holding capacity were favourably influenced by the litter decomposition after 95 per cent weight loss.

The pH and organic carbon content of the soil below the litter layer increased with decomposition of the leaf litter in the open and homegarden.

The decomposition of the litters of different tree species had brought about an increase in the available nitrogen and phosphorus status of soil, whereas the potassium content increased initially and thereafter declined.

The earthworm activity in soils was significantly greater during the rainy months and was found to decrease with the onset of summer. The highest population was found associated with jack and cashew litter decomposition and the least with ailanthus in the open and mahogany.

The microbial population was significantly high in the homegarden. The activity of fungi and bacteria was high in the early stages and actinomycetes dominated towards the later stages of decomposition in the open and homegarden situations.

Correlation studies between the residual weight of litter and soil temperature revealed significant regulatory role of temperature on decomposition of mahogany litter alone whereas soil moisture showed better influence on the decomposition of litter of the different species.

The litter quality had a significant influence on the rate of decomposition. The initial nitrogen, lignin, C: N and lignin: N ratio showed negative correlations with the decay constants but was significant only in the case of initial lignin and lignin: N ratio.

The decomposition model ideal developed for the mass loss of the study was the linear model. Among the nutrients, potassium, magnesium, calcium, zinc, manganese and iron content in the six species litter gave the best fit for the parabolic (quadratic) function. Phosphorus in litter showed highly variable trends. The cauchy function suited the phosphorus changes in mango, ailanthus, wild jack and mahogany litter while phosphorus in jack, the second order hyperbolic function, and cashew to the parabolic function. The cauchy function was the best fit for nitrogen dynamics in all species litter. Copper in all species showed best fit for the Hoerl function.

Future line of work

The quality and decomposition rates of green foliage and fallen leaves (litter) of the same plant are markedly different. In agroforestry systems green leaves and litter serve as inputs materials and hence decomposition studies on green leaves should be taken up.

Often mixed species litter are used as organic materials for agricultural crops. Evaluating the decomposition characteristics of such litter would be of immense use in agroforestry especially homegardens.

Litter decomposition and nutrient release from decomposing leaf litter may be studied under widely differing climatic and soil conditions to understand their influence on litter decomposition and nutrient cycling.

The regulatory role of other compounds such as polyphenols and tannins on decomposition needs to be investigated.

The proximate composition of soil organic matter on litter decomposition in homegardens should be taken up.

A comparitive study on the nutrient release from surface applied and incorporated litter needs to be made.

Litter, in addition to the nutrients may contain in them allelochemicals, and field evaluation of their allelopathic effects on commonly raised homestead agricultural crops should be initiated. *In vivo* studies on allelopathy along with the *in vitro* studies need be undertaken.

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APPENDICES

APPENDIX – I

Weather data for the experiment period-weekly averages (May 1998-June 1999)

Period	Maximum temperature (^0C)	Minimum temperature (^0C)	Relative humidity (%)	Rainfall (mm)	Evaporation (mm)
1998					
April 29-May 5	33.91	25.45	74.29	1.34	4.64
May 6- May 12	33.36	25.84	80.86	1.91	3.66
May 13- May 19	30.83	25.16	85.79	15.91	3.66
May 20- May 26	33.24	26.94	81.64	0.14	4.66
May 27- June 2	37.50	26.91	82.21	9.00	4.79
June 3- June 9	31.70	25.67	81.43	5.84	3.56
June 10 – June 16	30.26	24.83	87.07	3.23	3.56
June 17- June 23	30.54	27.74	84.00	8.74	3.79
June 24 – June 30	29.76	23.04	88.50	16.14	3.46
July 1 – July 7	30.30	23.63	80.21	0.03	1.81
July 8 – July 14	30.39	28.41	82.79	2.77	6.80
July 15 – July 21	28.83	23.89	85.79	4.00	2.71
July 22 – July 28	29.19	23.91	86.07	1.57	3.46
July 29 – Aug. 4	29.59	24.84	85.71	0.70	3.13
Aug. 5 – Aug. 11	30.07	24.24	83.00	2.77	3.56
Aug. 12 – Aug. 18	30.74	24.83	81.93	0.31	3.80
Aug. 19 – Aug. 25	29.01	26.80	87.50	16.74	2.21
Aug. 26 – Sep. 1	30.19	24.17	82.29	0.04	3.59
Sep. 2 – Sep. 8	29.96	24.13	83.14	8.69	3.80
Sep. 9 – Sep. 15	29.75	23.97	85.29	13.46	3.06
Sep. 16 – Sep. 22	25.97	24.03	88.21	7.54	3.73
Sep. 23 – Sep. 29	28.71	23.50	84.93	15.00	2.61
Sep. 30 – Oct. 6	29.60	24.16	86.57	0.94	2.96
Oct. 7 – Oct. 13	28.24	23.21	94.29	51.91	1.94
Oct. 14 – Oct. 20	30.20	23.70	83.50	5.69	3.60
Oct. 21 – Oct. 27	30.54	23.70	81.64	-	4.01

Appendix – I Contd…

Period	Max. temp. (^{0}C)	Min. temp. (^{0}C)	Relative humidity (%)	Rainfall (mm)	Evaporation (mm)
Oct. 28 – Nov. 3	30.07	23.04	81.86	41.57	2.20
Nov. 4 – Nov. 10	28.77	23.39	89.14	41.57	2.20
Nov. 11 – Nov. 17	30.07	23.10	82.71	7.43	3.30
Nov. 18 – Nov. 24	30.57	23.07	78.36	-	3.57
Nov. 25 – Dec. 1	30.74	23.76	84.36	1.51	2.94
Dec. 2 – Dec. 8	30.9	23.43	83.07	16.77	2.60
Dec. 9 – Dec. 15	29.20	23.11	87.09	5.54	1.90
Dec. 16 – Dec. 22	30.79	23.08	85.00	6.86	2.87
Dec. 23 – Dec. 29	31.34	21.14	85.50	0.86	2.79
Dec. 30 – Jan. 5	30.93	22.63	92.93	0.46	2.11
1999					
Jan. 6 – Jan. 12	31.34	22.27	94.71	-	6.14
Jan. 13 – Jan. 19	31.34	22.53	92.50	-	3.59
Jan. 20 – Jan. 26	31.36	21.27	77.43	-	2.27
Jan. 27 – Feb. 2	30.63	21.37	76.29	0.29	3.53
Feb. 3 – Feb. 9	30.94	22.27	83.00	11.23	3.97
Feb. 10 – Feb. 16	31.40	23.06	81.64	-	3.77
Feb. 17 – Feb. 23	31.80	23.14	84.39	-	3.77
Feb. 24 – Mar. 2	31.93	23.11	80.00	-	3.96
Mar. 3 – Mar. 9	32.20	23.09	78.79	-	4.31
Mar. 10 – Mar. 16	32.70	24.31	80.71	0.26	4.34
Mar. 17 – Mar. 23	32.53	25.23	81.21	7.74	4.51
Mar. 24 – Mar. 30	32.73	25.34	82.00	0.31	4.03
Mar. 31 – Apr. 6	32.44	24.90	80.71	-	4.23
Apr. 7 – Apr. 13	32.30	25.06	81.14	4.15	4.44
Apr. 14 – Apr. 20	32.04	25.41	82.57	0.14	4.06
Apr. 21 – Apr. 27	29.1	24.00	87.64	15.83	2.73
Apr. 28 – May 4	31.69	25.51	87.64	0.89	4.03
May 5 – May 11	30.97	24.40	83.07	6.11	2.99

Appendix – I Contd…

Period	Max. temp. (°C)	Min. temp. (°C)	Relative humidity (%)	Rainfall (mm)	Evaporation (mm)
May 12 – May 18	31.03	24.00	85.43	21.14	2.93
May 19 – May 25	29.54	23.16	88.07	15.91	2.61
May 26 – June 1	29.43	23.69	88.87	15.41	2.71
June 2 – June 8	28.01	23.51	89.71	36.63	2.47
June 9 – June 15	28.21	23.09	91.43	14.77	1.74
June 16 – June 22	30.24	24.79	82.86	5.14	3.49
June 23 – June 29	31.10	24.17	78.79	-	3.94

APPENDIX II

Details of the mathematical models used to represent the decomposition pattern and changes in nutrient contents with litter decay.

Sl. no.	Equation	Explanation
1	y=a+bx	straight line model (linear)
2	y=bx	line through origin
3	y=1/(a+bx)	reciprocal straight line model
4	y=a+bx+c/x	line and reciprocal
5	y=a+b/x	hyberbolic function
6	y=x/(ax+b)	reciprocal hyberbolic function
7	$y=a+b/x+c/x^2$	second order hyberbolic function
8	$y=a+bx+cx^2$	parabolic function (quadratic)
9	$y=ax+bx^2$	par at origin function
10	y=ax^b	power function
11	y=ab^x	modified power function
12	y=b^(1/x)	root function
13	y=ax^(bx)	super geometric function
14	y=ax^(b/x)	modified geometric function
15	y=ae^(bx)	exponential function
16	y=ae^(b/x)	modified exponential function
17	y=a+b lnx	logarithimic function
18	y=1/(a+b^x.x ^c)	reciprocal log function
19	y=ab^x·x^c	Hoerl function
20	y=ab^(1/x)x^c	modified hoerl function
21	y=ae^[(x-b)/2]	normal function
22	y=ae^[(lnx-b)^2/c]	log normal function
23	y=a(x/b)^c.e^(x/b)	gamma function
24	y=1/[a (x+b)^2+c]	Cauchy function

APPENDIX I

Mathematical models that gave best fit for the different characters for each tree species in the open and homegarden

Tree species&site	character	Decomposition model	Coefficient A	Coefficient B	R^2
Mango					
open	residual mass	y=a+bx	19.51	-1.218	0.9768
home		y=a+bx	22.06	-1.935	0.9453
Jack					
open		y=a+bx	20.32	-1.529	0.9812
home		y=a+bx	19.88	-2.024	0.9726
Cashew					
open		y=a+bx	21.25	-1.721	0.9554
home		y=a+bx	19.79	-2.022	0.8845
Ailanthus					
open		y=a+bx	20.18	-1.267	0.9916
home		y=a+bx	20.66	-1.343	0.9966
Wild jack					
open		y=a+bx	21.36	-1.16	0.9787
home		y=a+bx	21.15	-1.23	0.9843
Mahogany					
open		y=a+bx	21.74	-1.052	0.9788
home		y=a+bx	18.92	-0.7763	0.9546

Tree species&site	character	Nutrient equation	Coefficient A	Coefficient B	Coefficient C	R^2
Mango						
open		Y=1/{a*(x+b)^2 +c}	0.03064	-5.822	0.2615	0.784
home		Y=1/{a*(x+b)^2 +c}	0.023	-3.66	0.511	0.921
Jack						
open		Y=1/{a*(x+b)^2 +c}	0.00724	-2.864	0.8464	0.347
home		Y=1/{a*(x+b)^2 +c}	0.0343	-3.89	0.6266	0.946
Cashew						
open		Y=1/{a*(x+b)^2 +c}	0.06243	-3.878	0.3779	0.911
home	**nitrogen**	Y=1/{a*(x+b)^2 +c}	0.0487	-3.545	0.4616	0.779
Ailanthus						
open		Y=1/{a*(x+b)^2 +c}	0.00468	-3.267	0.711	0.771
home		Y=1/{a*(x+b)^2 +c}	0.03968	-5.684	0.178	0.406
Wild jack						
open		Y=1/{a*(x+b)^2 +c}	0.0197	-5.345	0.513	0.93
home		Y=1/{a*(x+b)^2 +c}	0.0127	-5.0471	0.6231	0.963
Mahogany						
open		Y=1/{a*(x+b)^2 +c}	0.00278	-6.732	-0.6996	0.816
home		Y=1/{a*(x+b)^2 +c}	-0.000421	-40.18	1.273	0.887

Tree species&site	**character**	Nutrient equation	Coefficient A	Coefficient B	Coefficient C	R^2
Mango						
open		Y=1/{a*(x+b)^2 +c}	0.557	-7.153	6.504	0.861
home		Y=1/{a*(x+b)^2 +c}	0.622	-6.178	10.4	0.894
Jack						
open		$y=a+b/x+c/x^2$	0.0455	0.0602	-0.000005	0.534
home		$y=a+b/x+c/x^2$	0.0789	-0.0616	0.000006	0.597
Cashew						
open		$Y=a+bx+cx^2$	0.0398	-0.0063	0.00065	0.522
home	**phosphorus**	$Y=a+bx+cx^2$	0.051	0.0093	-0.0012	0.352
Ailanthus						
open		y=1/[a(x+b)^2+c]	0.8435	-6.508	6.97	0.43
home		y=1/[a(x+b)^2+c]	1.113	-6.09	4.889	0.603
Wild jack						
open		y=1/[a(x+b)^2+c]	0.29	-6.03	23.17	0.19
home		y=1/[a(x+b)^2+c]	0.314	-3.9	19.68	0.39
Mahogany						
open		y=1/[a(x+b)^2+c]	0.1006	-5.897	17.33	0.694
home		y=1/[a(x+b)^2+c]	0.2513	-7.589	14.35	0.734

Tree species&site	**character**	Nutrient equation	Coefficient A	Coefficient B	Coefficient C	R^2
Mango						
open		$Y=a+bx+cx^2$	0.366	-0.05	0.0018	0.9694
home		$Y=a+bx+cx^2$	0.362	-0.0594	0.0028	0.9385
Jack						
open		$Y=a+bx+cx^2$	0.568	-0.0884	0.00362	0.935
home		$Y=a+bx+cx^2$	0.688	-0.108	0.004	0.9034
Cashew						
open		$Y=a+bx+cx^2$	0.11	-0.0122	0.0004	0.8775
home		$Y=a+bx+cx^2$	0.131	-0.0202	0.00078	0.9753
Ailanthus	**potassium**					
open		$Y=a+bx+cx^2$	0.352	-0.0493	0.0017	0.9301
home		$Y=a+bx+cx^2$	0.401	-0.06	0.0023	0.9825
Wild jack						
open		$Y=a+bx+cx^2$	0.635	-0.068	0.0019	0.9803
home		$Y=a+bx+cx^2$	0.579	-0.099	0.0041	0.9133
Mahogany						
open		$Y=a+bx+cx^2$	0.564	-0.059	0.0016	0.9682
home		$Y=a+bx+cx^2$	0.468	-0.0521	0.0015	0.6733

Tree species&site	**character**	Nutrient equation	Coefficient A	Coefficient B	Coefficient C	R^2
Mango						
open		$Y=a+bx+cx^2$	0.942	-0.0636	0.00626	0.8089
home		$Y=a+bx+cx^2$	0.822	0.179	-0.00695	0.9181
Jack						
open		$Y=a+bx+cx^2$	0.942	-0.0243	0.0036	0.769
home		$Y=a+bx+cx^2$	1.11	-0.145	0.0143	0.5657
Cashew						
open		$Y=a+bx+cx^2$	0.3189	-0.0184	0.00284	0.9548
home		$Y=a+bx+cx^2$	0.288	0.0751	-0.0021	0.8878
Ailanthus	**calcium**					
open		$Y=a+bx+cx^2$	0.421	0.0366	-0.0012	0.6718
home		$Y=a+bx+cx^2$	0.429	-0.0105	0.0029	0.9109
Wild jack						
open		$Y=a+bx+cx^2$	0.499	0.009	0.0004	0.8984
home		$Y=a+bx+cx^2$	0.484	0.02	-0.00006	0.9331
Mahogany						
open		$Y=a+bx+cx^2$	0.932	-0.0265	0.00288	0.9678
home		$Y=a+bx+cx^2$	0.821	0.0131	0.00217	0.943

Tree species&site	**character**	Nutrient equation	Coefficient A	Coefficient B	Coefficient C	R^2
Mango						
open		$Y=a+bx+cx^2$	0.0897	-0.009031	0.000269	0.85
home		$Y=a+bx+cx^2$	0.0875	-0.00373	-0.000214	0.9482
Jack						
open		$Y=a+bx+cx^2$	0.1576	-0.00007729	-0.000254	0.577
home		$Y=a+bx+cx^2$	0.1429	0.01247	0.002084	0.873
Cashew						
open		$Y=a+bx+cx^2$	0.0958	0.00164	-0.0005076	0.878
home		$Y=a+bx+cx^2$	0.09755	-0.008418	-0.00001133	0.989
Ailanthus	**magnesium**					
open		$Y=a+bx+cx^2$	0.07151	0.009342	-0.0002866	0.916
home		$Y=a+bx+cx^2$	0.0571	0.012	-0.00083	0.733
Wild jack						
open		$Y=a+bx+cx^2$	0.07315	-0.0002612	-0.000131	0.946
home		$Y=a+bx+cx^2$	0.07898	-0.002149	-0.000112	0.974
Mahogany						
open		$Y=a+bx+cx^2$	0.07788	-0.002186	-0.0000265	0.976
home		$Y=a+bx+cx^2$	0.07907	-0.003379	-0.00000994	0.945

Tree species&site	**character**	Nutrient equation	Coefficient A	Coefficient B	Coefficient C	R^2
Mango						
open		$Y=a+bx+cx^2$	1.999	0.00456	0.0135	0.9155
home		$Y=a+bx+cx^2$	1.984	0.158	0.0128	0.9773
Jack						
open		$Y=a+bx+cx^2$	3.758	-0.3099	0.0326	0.8411
home		$Y=a+bx+cx^2$	3.439	-0.0625	0.0348	0.9265
Cashew						
open		$Y=a+bx+cx^2$	1.68	0.349	-0.0071	0.8959
home	**zinc**	$Y=a+bx+cx^2$	2.004	0.277	-0.0011	0.8696
Ailanthus						
open		$Y=a+bx+cx^2$	4.045	-0.24	0.0226	0.7709
home		$Y=a+bx+cx^2$	3.895	-0.128	0.0144	0.3919
Wild jack						
open		$Y=a+bx+cx^2$	1.218	0.088	0.0053	0.9584
home		$Y=a+bx+cx^2$	1.148	0.056	0.012	0.9811
Mahogany						
open		$Y=a+bx+cx^2$	4.486	0.0423	0.0049	0.9623
home		$Y=a+bx+cx^2$	4.371	0.0772	0.0076	0.9785

Tree species&site	**character**	**Nutrient equation**	**Coefficient A**	**Coefficient B**	**Coefficient C**	R^2
Mango						
open		$Y=a+bx+cx^2$	4.288	-0.173	0.021	0.9466
home		$Y=a+bx+cx^2$	2.339	1.027	-0.062	0.1598
Jack						
open		$Y=a+bx+cx^2$	2.976	0.08538	0.0114	0.9331
home		$Y=a+bx+cx^2$	2.612	0.7204	-0.017	0.9626
Cashew						
open		$Y=a+bx+cx^2$	3.984	-0.351	0.0291	0.6987
home		$Y=a+bx+cx^2$	3.898	-0.213	0.0342	0.9215
Ailanthus	**manganese**					
open		$Y=a+bx+cx^2$	2.58	-0.1101	0.0143	0.9618
home		$Y=a+bx+cx^2$	2.478	0.0451	0.0083	0.9733
Wild jack						
open		$Y=a+bx+cx^2$	2.511	-0.0884	0.0094	0.6577
home		$Y=a+bx+cx^2$	1.928	0.122	0.0065	0.9452
Mahogany						
open		$Y=a+bx+cx^2$	0.611	-0.0314	0.0056	0.8919
home		$Y=a+bx+cx^2$	0.3673	0.1137	0.0036	0.94

Tree species&site	character	Nutrient equation	Coefficient A	Coefficient B	Coefficient C	R^2
Mango						
open	**copper**	y=ab^x.x^c	10.01	1.043	0.0033	0.8257
home		y=ab^x.x^c	12.9	1.066	0.0347	0.902
Jack						
open		y=ab^x.x^c	11.9	1.073	0.0288	0.8418
home		y=ab^x.x^c	10.24	1.131	0.0091	0.9709
Cashew						
open		y=ab^x.x^c	5.608	1.099	0.0084	0.9733
home		y=ab^x.x^c	8.402	1.072	0.0552	0.8946
Ailanthus						
open		y=ab^x.x^c	13.77	1.02	0.169	0.9448
home		y=ab^x.x^c	6.096	1.106	0.0793	0.9816
Wild jack						
open		y=ab^x^2 ^c	7.447	1.035	0.0592	0.7735
home		y=ab^x^2 ^c	5.878	1.054	0.0306	0.8724
Mahogany						
open		y=ab^x.x^c	19.64	1.008	0.116	0.6715
home		y=ab^x.x^c	8.304	1.081	0.0142	0.9703

Tree species&site	character	Nutrient equation	Coefficient A	Coefficient B	Coefficient C	R^2
Mango						
open		$Y=a+bx+cx^2$	255.4	3.442	0.1365	0.9677
home		$Y=a+bx+cx^2$	265.6	8.998	-0.235	0.7598
Jack						
open		$Y=a+bx+cx^2$	184.6	7.247	0.117	0.6676
home		$Y=a+bx+cx^2$	200.5	1.498	1.473	0.9182
Cashew						
open		$Y=a+bx+cx^2$	249.7	-1.103	0.652	0.8866
home		$Y=a+bx+cx^2$	262.8	-0.165	0.467	0.8346
Ailanthus	**iron**					
open		$Y=a+bx+cx^2$	113.7	42.96	-1.51	0.9146
home		$Y=a+bx+cx^2$	119.1	14.14	0.554	0.902
Wild jack						
open		$Y=a+bx+cx^2$	188.1	0.211	0.508	0.9426
home		$Y=a+bx+cx^2$	127.5	16.93	-0.2155	0.7738
Mahogany						
open		$Y=a+bx+cx^2$	295.9	80.82	-2.42	0.3277
home		$Y=a+bx+cx^2$	139.7	106.1	-3.814	0.8151

APPENDIX IV

Appendix IV a - MANGO

1. Nitrogen release on mango litter decomposition

Fortnight	Open			Homegarden		
	N%	Relative concentration (%)	Absolute concentration (%)	N%	Relative concentration (%)	Absolute concentration (%)
0	1.320	100.00	100.00	1.320	100.00	100.00
1	1.368	110.21	103.25	1.490	104.26	101.13
2	1.538	141.70	125.00	1.596	126.81	119.82
3	1.528	171.92	138.50	1.688	154.89	141.48
4	1.294	147.66	107.35	1.798	216.60	182.98
5	1.490	172.34	117.64	1.898	242.13	168.62
6	1.628	167.66	105.36	1.926	265.11	143.66
7	1.510	248.94	138.04	1.366	214.47	61.87
8	1.184	232.77	117.52	1.056	190.21	43.71
9	1.656	352.34	128.50	0.680	172.34	24.51
10	1.150	244.68	66.72	0.834	177.45	23.85
11	1.186	252.34	58.77	0.626	133.19	7.97
12	0.992	211.06	41.14	0.442	94.04	2.10
13	0.866	184.26	30.29			
14	0.746	158.72	15.63			
16	0.240	51.06	5.02			

2. Phosphorus release on mango litter decomposition

Fortnight	Open			Homegarden		
	P%	Relative concentration (%)	Absolute concentration (%)	P%	Relative concentration (%)	Absolute concentration (%)
0	0.030	100.00	100.00	0.030	100.00	100.00
1	0.039	130.00	121.78	0.042	140.00	135.80
2	0.051	170.00	149.96	0.048	160.00	151.18
3	0.056	186.67	150.38	0.055	183.33	167.46
4	0.098	326.67	237.49	0.062	206.67	174.59
5	0.110	366.67	250.29	0.072	240.00	167.14
6	0.094	313.33	196.90	0.091	303.33	164.38
7	0.059	196.67	109.05	0.122	406.67	117.32
8	0.100	333.33	168.30	0.091	303.33	69.71
9	0.106	353.33	128.86	0.080	266.67	37.92
10	0.129	430.00	117.26	0.062	206.67	27.78
11	0.081	270.00	62.88	0.043	143.33	8.57
12	0.052	173.33	33.78	0.028	93.93	2.08
13	0.047	156.67	25.76	na	na	na
15	0.036	120.00	8.48	na	na	na
16	0.016	53.33	5.24	na	na	na
17	0.015	50.00	0.96	na	na	na

3. Potassium release on mango litter decomposition

Fortnight	Open			Homegarden		
	K%	Relative concentration (%)	Absolute concentration (%)	K%	Relative concentration (%)	Absolute concentration (%)
0	0.362	100.00	100.00	0.362	100.00	100.00
1	0.337	93.09	87.21	0.312	86.19	83.60
2	0.278	76.80	67.74	0.245	67.68	63.95
3	0.261	72.10	58.08	0.230	63.54	58.03
4	0.166	45.86	33.34	0.157	43.37	36.64
5	0.154	42.54	29.04	0.130	35.91	25.01
6	0.100	27.62	17.36	0.108	29.83	16.17
7	0.101	27.90	15.47	0.075	20.72	5.98
8	0.063	17.40	8.79	0.063	17.40	4.00
9	0.056	15.47	5.64	0.046	12.71	1.81
10	0.049	13.54	3.69	0.076	20.99	2.82
11	0.050	13.81	3.22	0.109	30.11	1.80
12	0.049	13.54	2.64	0.010	2.76	0.06
13	0.044	12.16	2.00	na	na	na
14	0.036	9.95	0.98	na	na	na
15	0.013	3.59	0.25	na	na	na
16	0.027	7.46	0.73	na	na	na
17	0.008	2.21	0.04	na	na	na

4. Calcium release on mango litter decomposition

Fortnight	Open			Homegarden		
	Ca%	Relative concentration (%)	Absolute concentration (%)	Ca%	Relative concentration (%)	Absolute concentration (%)
0	0.836	100.00	100.00	0.836	100.00	100.00
1	0.838	100.24	93.90	0.970	116.03	112.55
2	0.904	108.13	95.39	1.282	153.35	144.90
3	0.962	115.07	92.70	1.164	139.23	127.18
4	0.822	98.33	71.48	1.306	156.22	131.98
5	0.790	94.50	64.50	1.552	185.65	129.28
6	0.746	89.23	56.08	1.848	221.05	119.79
7	0.832	99.52	55.19	1.638	195.93	56.53
8	0.634	75.84	38.29	1.874	224.16	51.51
9	0.930	111.24	40.57	1.930	230.86	32.83
10	0.984	117.70	32.10	1.846	220.81	29.68
11	1.272	152.15	35.44	1.848	221.05	13.22
12	0.958	114.59	22.33	2.048	244.98	5.46
13	1.054	126.08	20.73	na	na	na
14	1.156	138.28	13.62	na	na	na
15	1.250	149.52	10.57	na	na	na
16	1.690	202.15	19.87	na	na	na
17	1.740	208.13	4.00	na	na	na

5 . Magnesium release on mango litter decomposition

Fortnight	Open			Homegarden		
	Mg%	Relative concentration (%)	Absolute concentration (%)	Mg%	Relative concentration (%)	Absolute concentration (%)
0	0.086	100.00	100.00	0.086	100.00	100.00
1	0.086	100.00	93.68	0.089	103.49	100.38
2	0.056	65.12	57.44	0.083	96.51	91.19
3	0.073	84.88	68.38	0.073	84.88	77.53
4	0.065	75.58	54.95	0.061	70.93	59.92
5	0.054	62.79	42.86	0.054	62.79	43.73
6	0.037	43.02	27.04	0.058	67.44	36.55
7	0.063	73.26	40.62	0.054	62.79	18.12
8	0.044	51.16	25.83	0.049	56.98	13.09
9	0.015	17.44	6.36	0.044	51.16	7.28
10	0.016	18.60	4.00	0.031	36.05	4.85
11	0.017	19.77	4.60	0.016	18.61	1.11
12	0.015	17.44	3.40	0.009	10.47	0.23
13	0.017	19.77	3.25	na	na	na
14	0.019	22.09	2.18	na	na	na
15	0.020	23.26	1.64	na	na	na
16	0.017	19.77	1.94	na	na	na
17	0.013	15.12	0.29	na	na	na

6. Zinc release on mango litter decomposition (ppm)

Fortnight	Open			Homegarden		
	Zn ppm	Relative concentration(%)	Absolute concentration	Zn ppm	Relative concentration (%)	Absolute concentration
0	2.138	100.00	100.00	2.138	100.00	100.00
1	1.674	78.30	73.35	2.218	103.74	100.63
2	2.056	96.17	84.83	2.158	100.94	95.37
3	2.154	100.75	81.16	2.66	124.42	113.64
4	2.86	133.77	97.25	2.892	135.27	114.27
5	2.42	113.19	77.26	3.172	148.36	103.32
6	2.324	108.70	68.31	3.626	169.60	91.91
7	2.65	123.95	68.73	3.818	178.58	51.52
8	2.734	127.88	64.57	4.288	200.56	46.09
9	2.818	131.81	48.07	4.886	228.53	32.50
10	3.124	146.12	39.85	5.466	255.66	34.36
11	3.286	153.70	35.80	5.192	242.84	14.52
12	4.062	189.99	37.03	6.044	282.69	6.30
13	4.98	232.93	38.29	na	na	na
14	5.01	234.33	23.08	na	na	na
15	5.458	255.29	18.05	na	na	na
16	5.526	258.47	25.41	na	na	na
17	5.424	253.70	4.87	na	na	na

7.Manganese release on mango litter decomposition (p

Fortnight	Open			Homegarden		
	Mn ppm	Relative concentration (%)	Absolute concentration (%)	Mn ppm	Relative concentration (%)	Absolute concentration (%)
0	4.052	100.00	100.00	4.052	100.00	100.00
1	4.452	109.87	102.93	3.510	86.62	84.03
2	3.882	95.81	84.51	3.798	93.73	88.57
3	3.738	92.25	74.32	3.984	98.32	89.81
4	4.476	110.46	80.31	4.112	101.48	85.73
5	3.652	90.13	61.52	4.862	119.99	83.56
6	4.170	102.91	64.67	5.090	125.62	68.07
7	3.952	97.53	54.08	6.504	160.51	46.31
8	4.062	100.25	50.62	7.040	173.74	39.93
9	4.572	112.83	41.15	7.134	176.06	25.04
10	4.876	120.34	32.82	7.962	196.50	26.41
11	4.870	120.19	27.99	8.260	203.85	12.19
12	5.084	125.47	24.45	9.270	228.78	5.10
13	5.352	132.08	21.71	na	na	na
14	6.000	148.08	14.59	na	na	na
15	6.052	149.36	10.56	na	na	na
16	6.792	167.62	16.48	na	na	na
17	7.586	187.22	3.60	na	na	na

8. Iron release on mango litter decomposition (ppm)

Fortnight	Open			Homegarden		
	Fe ppm	Relative concentration (%)	Absolute concentration (%)	Fe ppm	Relative concentration (%)	Absolute concentration (%)
0	261.40	100.00	100.00	261.40	100.00	100.00
1	260.20	99.54	93.25	261.80	100.15	97.15
2	250.40	95.79	84.50	286.80	109.72	103.67
3	265.00	101.38	81.67	306.20	117.14	106.99
4	275.40	105.36	76.59	295.00	112.85	95.34
5	278.40	106.50	72.70	322.80	123.49	86.00
6	285.40	109.18	68.61	311.40	119.13	64.56
7	283.80	108.57	60.20	314.40	120.28	34.70
8	288.40	110.33	55.71	317.20	121.35	27.89
9	303.00	115.91	42.27	319.40	122.19	17.38
10	302.40	115.68	31.55	312.20	119.43	16.05
11	299.40	114.54	26.68	331.20	126.70	7.58
12	317.80	121.58	23.70	361.40	138.26	3.08
13	326.40	124.87	20.53	na	na	na
14	335.00	128.16	12.62	na	na	na
15	339.60	129.92	9.19	na	na	na
16	348.20	133.21	13.09	na	na	na
17	349.20	133.59	2.56	na	na	na

9. Copper release on mango litter decomposition (ppm)

Fortnight	Open			Homegarden		
	Cu ppm	Relative concentration (%)	Absolute concentration (%)	Cu ppm	Relative concentration (%)	Absolute concentration (%)
0	9.60	100.00	100.00	9.60	100.00	100.00
1	10.20	106.25	99.54	10.60	110.42	107.10
2	11.60	120.83	106.59	15.50	161.46	152.56
3	11.90	123.96	99.86	17.80	185.42	169.36
4	12.70	132.29	96.18	18.20	189.58	160.16
5	13.20	137.50	93.86	20.60	214.58	149.44
6	13.80	143.75	90.33	21.10	219.79	119.11
7	13.50	140.63	77.98	22.80	237.50	68.52
8	13.40	139.58	70.48	24.50	255.21	58.65
9	14.50	151.04	55.08	23.00	239.58	34.07
10	14.30	148.96	40.62	27.80	289.58	38.92
11	14.20	147.92	34.45	25.40	264.58	15.82
12	14.40	150.00	29.24	29.70	309.38	6.90
13	15.80	164.58	27.06	na	na	na
14	16.30	169.79	16.72	na	na	na
15	20.30	211.46	14.95	na	na	na
16	20.60	214.58	21.09	na	na	na
17	27.10	282.29	5.42	na	na	na

Appendix IV a - JACK

1.Nitrogen release on jack litter decomposition

Fortnight	Open			Homegarden		
	N%	Relative concentration (%)	Absolute concentration (%)	N%	Relative concentration (%)	Absolute concentration (%)
0	0.908	100.00	100.00	0.908	100.00	100.00
1	1.052	115.86	111.24	1.064	117.18	107.42
2	1.358	149.56	128.83	1.338	147.36	118.99
3	1.438	158.37	126.19	1.402	154.41	113.63
4	1.670	183.92	139.41	1.634	179.96	111.27
5	1.326	146.04	96.00	1.526	168.06	63.39
6	1.464	161.23	91.69	1.272	140.09	44.00
7	0.888	97.14	49.52	1.006	110.79	29.40
8	0.692	76.21	24.62	0.820	90.31	14.30
9	0.618	68.06	17.80	0.764	84.14	12.19
10	0.734	80.84	16.34	0.488	53.74	1.59
11	0.774	85.24	10.72	na	na	na
12	1.160	127.75	12.60	na	na	na
13	0.918	101.10	5.38	na	na	na
14	0.442	48.68	1.62	na	na	na

2 . Phosphorus release on jack litter decomposition

Fortnight	Open			Homegarden		
	P%	Relative concentration (%)	Absolute concentration (%)	P%	Relative concentration (%)	Absolute concentration (%)
0	0.126	100.00	100.00	0.126	100.00	100.00
1	0.104	82.54	79.25	0.010	7.94	7.28
2	0.098	77.78	67.00	0.064	50.79	41.02
3	0.062	49.21	39.21	0.046	36.51	26.87
4	0.029	23.02	17.45	0.066	52.38	32.39
5	0.029	23.02	15.13	0.078	61.90	23.35
6	0.048	38.10	21.66	0.077	61.11	19.20
7	0.058	46.03	23.47	0.105	83.33	22.12
8	0.065	51.59	16.67	0.066	52.38	8.30
9	0.072	57.14	14.94	0.052	41.27	5.98
10	0.073	57.94	11.71	0.045	35.71	1.06
11	0.077	61.11	7.69	na	na	na
12	0.051	40.48	3.99	na	na	na
13	0.041	32.54	1.73	na	na	na
14	0.026	20.63	0.69	na	na	na

3. Potassium release on jack litter decomposition

Fortnight	Open			Homegarden		
	K%	Relative concentration (%)	Absolute concentration (%)	K%	Relative concentration (%)	Absolute concentration (%)
0	0.601	100.00	100.00	0.601	100.00	100.00
1	0.486	80.87	77.64	0.596	99.17	90.91
2	0.397	66.06	56.90	0.564	93.84	75.78
3	0.346	57.57	45.87	0.516	85.86	63.18
4	0.231	38.44	29.13	0.331	55.07	34.05
5	0.172	28.62	18.81	0.175	29.12	10.98
6	0.113	18.80	10.69	0.092	15.31	4.81
7	0.102	16.97	8.65	0.089	14.81	3.93
8	0.223	37.10	11.99	0.108	17.97	2.85
9	0.066	10.98	2.87	0.062	10.32	1.49
10	0.054	8.99	1.82	0.023	3.83	0.11
11	0.043	7.15	0.90	na	na	na
12	0.034	5.66	0.56	na	na	na
13	0.021	3.49	0.19	na	na	na
14	0.010	1.66	0.06	na	na	na

4. Calcium release on jack litter decomposition

Fortnight	Open			Homegarden		
	Ca%	Relative concentration (%)	Absolute concentration (%)	Ca%	Relative concentration (%)	Absolute concentration (%)
0	0.962	100.00	100.00	0.962	100.00	100.00
1	0.968	100.62	96.61	1.022	106.24	97.39
2	0.994	103.33	89.01	1.054	109.56	88.47
3	0.758	78.79	62.78	0.916	95.22	70.07
4	0.782	81.29	61.62	0.646	67.15	41.52
5	0.858	89.19	58.63	0.744	77.34	29.17
6	0.970	100.83	57.34	0.666	69.23	21.75
7	1.004	104.37	53.21	0.740	76.92	20.42
8	1.026	106.65	34.46	0.846	87.94	13.93
9	1.018	105.82	27.67	1.002	104.16	15.09
10	1.128	117.26	23.70	1.120	116.42	3.45
11	1.084	112.68	14.18	na	na	na
12	1.198	124.53	12.28	na	na	na
13	1.204	125.16	6.66	na	na	na
14	1.292	134.30	4.47	na	na	na

5. Magnesium release on jack litter decomposition

Fortnight	Open			Homegarden		
	Mg%	Relative concentration (%)	Absolute concentration	Mg%	Relative concentration (%)	Absolute concentration
0	0.147	100.00	100.00	0.147	100.00	100.00
1	0.161	109.52	105.15	0.160	108.84	99.78
2	0.158	107.48	92.59	0.165	112.24	90.64
3	0.155	105.44	84.02	0.154	104.76	77.09
4	0.158	107.48	81.47	0.144	97.96	60.57
5	0.163	110.88	72.90	0.136	92.52	34.90
6	0.151	102.72	58.42	0.138	93.88	29.49
7	0.144	97.96	49.94	0.134	91.16	24.19
8	0.134	91.16	29.45	0.126	85.71	13.58
9	0.137	93.20	24.37	0.111	75.51	10.94
10	0.129	87.76	17.74	0.068	46.26	1.37
11	0.122	82.99	10.44	na	na	na
12	0.089	60.54	5.97	na	na	na
13	0.143	97.28	5.18	na	na	na
14	0.109	74.15	2.47	na	na	na

6. Zinc release on jack litter decomposition (ppm)

Fortnight	Open			Homegarden		
	Zn ppm	Relative concentration (%)	Absolute concentration (%)	Zn ppm	Relative concentration (%)	Absolute concentration (%)
0	3.750	100.00	100.00	3.750	100.00	100.00
1	2.918	77.81	74.71	3.056	81.49	74.70
2	3.318	88.48	76.22	3.488	93.01	75.11
3	3.570	95.20	75.86	3.292	87.79	64.60
4	3.570	95.20	72.16	3.710	98.93	61.17
5	3.104	82.77	54.42	4.366	116.43	43.92
6	3.160	84.27	47.92	4.568	121.81	38.26
7	3.136	83.63	42.63	4.392	117.12	31.08
8	2.896	77.23	24.95	5.142	137.12	21.72
9	2.960	78.93	20.64	5.836	155.63	22.55
10	4.118	109.81	22.19	6.210	165.60	4.90
11	4.606	122.83	15.45	na	na	na
12	4.732	126.19	12.44	na	na	na
13	5.112	136.32	7.25	na	na	na
14	5.972	159.25	5.30	na	na	na

7 .Manganese release on jack litter decomposition (ppm)

Fortnight	Open			Homegarden		
	Mn ppm	Relative concentration (%)	Absolute concentration (%)	Mn ppm	Relative concentration (%)	Absolute concentration (%)
0	2.704	100.00	100.00	2.704	100.00	100.00
1	3.108	114.94	110.35	3.126	115.61	105.98
2	3.594	132.91	114.49	4.064	150.30	121.36
3	3.420	126.48	100.78	4.552	168.34	123.88
4	3.400	125.74	95.31	4.964	183.58	113.51
5	3.874	143.27	94.19	6.150	227.44	85.79
6	3.900	144.23	82.02	6.778	250.67	78.73
7	3.676	135.95	69.31	6.828	252.51	67.02
8	4.042	149.48	48.30	6.686	247.26	39.17
9	4.772	176.48	46.15	7.462	275.96	39.99
10	5.048	186.69	37.73	8.504	314.50	9.31
11	5.750	212.65	26.75	na	na	na
12	5.796	214.35	21.13	na	na	na
13	5.586	206.58	10.99	na	na	na
14	6.482	239.72	7.98	na	na	na

8. Iron release on jack litter decomposition (ppm)

Fortnight	Open			Homegarden		
	Fe ppm	Relative concentration (%)	Absolute concentration (%)	Fe ppm	Relative concentration (%)	Absolute concentration (%)
0	202.80	100.00	100.00	202.80	100.00	100.00
1	209.80	103.45	99.32	207.40	102.27	93.75
2	131.80	64.99	55.98	189.20	93.29	75.33
3	183.80	90.63	72.21	219.40	108.19	79.61
4	242.40	119.53	90.60	247.60	122.09	75.49
5	247.80	122.19	80.33	253.40	124.95	47.13
6	253.80	125.15	71.17	259.80	128.11	40.24
7	248.20	122.39	62.39	274.00	135.11	35.86
8	257.20	126.82	40.98	274.60	135.40	21.45
9	250.40	123.47	32.29	291.80	143.89	20.85
10	256.20	126.33	25.53	346.40	170.81	5.06
11	266.60	131.46	16.54	na	na	na
12	266.60	131.46	12.96	na	na	na
13	306.20	150.99	8.03	na	na	na
14	324.80	160.16	5.33	na	na	na

9. Copper release on jack litter decomposition (ppm)

Fortnight	Open			Homegarden		
	Cu ppm	Relative concentration	Absolute concentration	Cu ppm	Relative concentration (%)	Absolute concentration
0	9.50	100.00	100.00	9.50	100.00	100.00
1	9.20	96.84	92.98	10.00	105.26	96.49
2	12.90	135.79	116.97	14.90	156.84	126.65
3	15.70	165.26	131.68	15.10	158.95	116.97
4	23.00	242.11	183.52	17.90	188.42	116.50
5	17.80	187.37	123.18	20.80	218.95	82.59
6	17.40	183.16	104.16	22.20	233.68	73.40
7	21.80	229.47	116.99	24.90	262.11	69.56
8	23.60	248.42	80.26	28.10	295.79	46.85
9	25.90	272.63	71.29	30.30	318.95	46.22
10	29.50	310.53	62.76	36.30	382.11	11.31
11	28.90	304.21	38.27	na	na	na
12	27.50	289.47	28.54	na	na	na
13	28.30	297.89	15.85	na	na	na
14	30.90	325.26	10.83	na	na	na

1. Nitrogen release on cashew litter decomposition

Fortnight	Open			Homegarden		
	N%	Relative concentration(%)	Absolute concentration(%)	N%	Relative concentration(%)	Absolute concentration(%)
0	1.278	100.000	100.000	1.278	100.000	100.000
1	1.314	102.817	95.661	1.314	102.817	96.144
2	1.256	98.279	85.247	1.386	138.871	120.429
3	1.268	99.218	81.001	1.444	140.752	107.746
4	1.516	118.623	90.225	1.502	157.053	113.110
5	1.054	82.473	60.931	1.526	185.893	41.807
6	1.102	86.228	54.850	1.234	162.069	31.733
7	0.976	76.369	43.004	0.840	109.718	20.539
8	0.726	56.808	20.326	0.822	128.840	20.176
9	0.682	53.365	9.211	0.724	113.480	8.885
10	0.480	37.559	3.264	0.558	87.461	4.224
11	0.336	26.291	1.735	0.246	38.558	0.937
12	0.230	17.997	0.664	na	na	na
13	0.152	11.894	0.128	na	na	na

2.Phosphorus release on cashew litter decomposition (%)

Fortnight	Open			Homegarden		
	P%	Relative concentration(%)	Absolute concentration(%)	P%	Relative concentration(%)	Absolute concentration(%)
0	0.040	100.00	100.00	0.040	100.00	100.00
1	0.035	87.50	81.41	0.038	95.00	88.83
2	0.028	70.00	60.72	0.075	187.50	162.60
3	0.020	50.00	40.82	0.101	252.50	193.29
4	0.036	90.00	68.45	0.090	225.00	162.05
5	0.038	95.00	70.19	0.075	187.50	42.17
6	0.018	45.00	28.62	0.056	140.00	27.41
7	0.017	42.50	23.93	0.047	117.50	22.00
8	0.018	45.00	16.10	0.025	62.50	9.79
9	0.034	85.00	14.67	0.020	50.00	3.92
10	0.045	112.50	9.78	0.032	80.00	3.86
11	0.066	165.00	10.89	0.036	90.00	2.19
12	0.074	185.00	6.83	na	na	na
13	0.049	122.50	1.32	na	na	na

3. Potassium release on cashew litter decomposition (%)

Fortnight	Open			Homegarden		
	K%	Relative concentration (%)	Absolute concentration (%)	K%	Relative concentration (%)	Absolute concentration (%)
0	0.125	100.00	100.00	0.125	100.00	100.00
1	0.082	65.60	61.03	0.110	88.00	82.29
2	0.088	70.40	61.06	0.100	80.00	69.38
3	0.084	67.20	54.86	0.081	64.80	49.60
4	0.070	56.00	42.59	0.072	57.60	41.48
5	0.052	41.60	30.73	0.046	36.80	8.28
6	0.044	35.20	22.39	0.024	19.20	3.76
7	0.043	34.40	19.37	0.025	20.00	3.74
8	0.045	36.00	12.88	0.021	16.80	2.63
9	0.043	34.40	5.94	0.016	12.80	1.00
10	0.040	32.00	2.78	0.009	7.20	0.35
11	0.040	32.00	2.11	0.003	2.40	0.06
12	0.032	25.60	0.94	na	na	na
13	0.012	9.60	0.10	na	na	na

4. Calcium release on cashew litter decomposition (%)

Fortnight	Open			Homegarden		
	Ca %	Relative concentration(%)	Absolute concentration(%)	Ca%	Relative concentration(%)	Absolute concentration(%)
0	0.298	100.00	100.00	0.298	100.00	100.00
1	0.312	104.70	97.41	0.314	105.37	98.53
2	0.304	102.01	88.49	0.478	160.40	139.10
3	0.312	104.70	85.48	0.452	151.68	116.11
4	0.310	104.03	79.12	0.664	222.82	160.47
5	0.288	96.64	71.40	0.594	199.33	44.83
6	0.290	97.32	61.90	0.528	177.18	34.69
7	0.318	106.71	60.09	0.752	252.35	47.24
8	0.334	112.08	40.10	0.780	261.74	40.99
9	0.414	138.93	23.98	0.826	277.18	21.70
10	0.432	144.97	12.60	0.834	279.87	13.52
11	0.484	162.42	10.72	0.848	284.56	6.91
12	0.538	180.54	6.66	na	na	na
13	0.554	185.91	2.01	na	na	na

5. Magnesium release on cashew litter decomposition (%)

Fortnight	Open			Homegarden		
	Mg %	Relative concentration (%)	Absolute concentration (%)	Mg%	Relative concentration (%)	Absolute concentration (%)
0	0.096	100.00	100.00	0.096	100.00	100.00
1	0.097	101.04	94.01	0.089	92.71	86.69
2	0.105	109.38	94.87	0.084	87.50	75.88
3	0.085	88.54	72.29	0.068	70.83	54.22
4	0.099	103.13	78.44	0.064	66.67	48.01
5	0.094	97.92	72.34	0.060	62.50	14.06
6	0.084	87.50	55.66	0.046	47.92	9.38
7	0.074	77.08	43.41	0.041	42.71	8.00
8	0.080	83.33	29.82	0.029	30.21	4.73
9	0.064	66.67	5.70	0.016	16.67	1.31
10	0.065	67.78	14.85	0.011	11.46	0.55
11	0.069	71.88	4.74	0.011	11.46	0.28
12	0.044	45.83	1.69	na	na	na
13	0.021	21.88	0.24	na	na	na

6. Zinc release on cashew litter decomposition (ppm)

Fortnight	Open			Homegarden		
	Zn ppm	Relative concentration (%)	Absolute concentration (%)	Zn ppm	Relative concentration (%)	Absolute concentration (%)
0	2.042	100.00	100.00	2.042	100.00	100.00
1	1.786	87.46	81.38	2.000	97.94	91.59
2	2.524	123.60	107.21	2.768	135.55	117.55
3	2.460	120.47	98.35	2.816	137.90	105.57
4	2.676	131.05	99.68	3.182	155.83	112.23
5	2.916	142.80	105.50	3.414	167.19	37.60
6	3.558	174.24	110.83	3.442	168.56	33.00
7	3.724	182.37	102.69	4.266	208.91	39.11
8	4.326	211.85	75.80	4.384	214.69	33.62
9	4.714	230.85	39.85	3.598	176.20	13.80
10	4.624	226.44	19.68	4.528	221.74	10.71
11	4.888	239.37	15.80	5.308	259.94	6.32
12	4.076	199.61	7.37	na	na	na
13	5.180	253.67	2.74	na	na	na

7. Manganese release on cashew litter decomposition (ppm)

Fortnight	Open			Homegarden		
	Mn ppm	Relative concentration(%)	Absolute concentration(%)	Mn ppm	Relative concentration(%)	Absolute concentration(%)
0	3.886	100.00	100.00	3.886	100.00	100.00
1	3.544	91.20	84.85	3.580	92.13	86.15
2	3.580	92.13	79.91	3.504	90.17	78.20
3	3.072	79.05	64.54	3.750	96.50	73.87
4	3.234	83.22	63.30	3.820	98.30	70.80
7	2.546	65.52	36.89	3.916	100.77	18.86
8	2.564	65.98	23.61	4.296	110.55	17.31
9	3.020	77.71	13.41	4.588	118.06	9.24
10	3.676	94.60	8.22	4.960	127.64	6.16
11	3.880	99.85	6.59	6.034	155.28	3.77
12	3.966	102.06	3.77	na	na	na
13	4.256	109.52	1.18	na	na	na

8. Copper dynamics in cashew litter during decomposition

Fortnight	Open			Homegarden		
	Cu ppm	Relative concentration (%)	Absolute concentration (%)	Cu ppm	Relative concentration(%)	Absolute concentration (%)
0	5.20	100.00	100.00	5.20	100.00	100.00
1	5.80	111.54	103.78	7.10	136.54	127.68
2	7.30	140.38	121.77	8.90	171.15	148.42
3	7.50	144.23	117.75	12.50	240.38	184.01
4	9.20	176.92	134.57	13.00	250.00	180.05
5	8.60	165.38	122.19	14.70	282.69	63.58
6	9.90	190.38	121.10	16.00	307.69	60.25
7	10.30	198.08	111.54	16.10	309.62	57.96
8	11.20	215.38	77.06	16.30	313.46	49.09
9	13.00	250.00	43.15	18.80	361.54	28.31
10	16.10	309.62	26.91	17.90	344.23	16.63
11	17.00	326.92	21.58	17.80	342.31	8.32
12	18.30	351.92	12.99	na	na	na
13	18.40	353.85	3.82	na	na	na

9. Iron release on cashew litter decomposition (ppm)

Fortnight	Open			Homegarden		
	Fe ppm	Relative concentration (%)	Absolute concentration (%)	Fe ppm	Relative concentration (%)	Absolute concentration(%)
0	269.20	100.00	100.00	269.20	100.00	100.00
1	234.40	87.07	81.01	268.00	99.55	93.09
2	240.60	89.38	77.52	253.00	93.98	81.50
3	245.00	91.01	74.30	255.60	94.95	72.68
4	251.00	93.24	70.92	269.00	99.93	71.97
5	267.80	99.48	73.50	275.20	102.23	22.99
6	267.00	99.18	63.09	286.20	106.32	20.82
7	283.80	105.42	59.36	288.60	107.21	20.07
8	297.00	110.33	39.47	300.20	111.52	17.46
9	295.40	109.73	18.94	295.20	109.66	8.59
10	289.40	107.50	9.34	297.60	110.55	5.34
11	309.60	115.01	7.59	320.80	119.17	2.90
12	327.00	121.47	4.48	na	na	na
13	352.40	130.91	1.41	na	na	na

Appendix IV d.- AILANTHUS

1. Nitrogen release on ailanthus litter decomposition (%)

Fortnight	Open			Homegarden		
	N%	Relative concentration(%)	Absolute concentration(%)	N%	Relative concentration(%)	Absolute concentration(%)
0	1.458	100.00	100.00	1.458	100.00	100.00
1	1.480	101.51	98.61	1.454	99.73	93.66
2	1.200	82.30	71.31	1.252	85.87	78.93
3	1.216	83.40	68.37	1.316	90.26	75.73
4	1.452	99.59	76.29	1.188	81.48	63.67
5	1.520	104.25	77.13	1.212	83.13	60.92
6	1.250	85.73	51.83	1.326	90.95	56.52
7	1.496	102.61	59.37	1.244	85.32	48.40
8	1.042	71.47	35.31	1.536	105.35	53.42
9	0.940	64.47	29.28	1.600	109.74	45.88
10	1.482	101.65	30.96	1.752	120.16	42.51
11	1.272	87.24	23.44	1.726	118.38	36.75
12	0.864	59.26	14.37	1.336	91.63	19.66
13	0.886	60.77	12.48	1.046	71.74	11.74
14	0.728	49.93	6.54	0.676	46.36	3.61
15	0.754	51.71	3.22	0.150	10.29	0.23
16	0.676	46.36	1.31	na	na	na

2. Phosphorus release on ailanthus litter decomposition (%)

Fortnight	Open			Homegarden		
	P%	Relative concentration(%)	Absolute concentration(%)	P%	Relative concentration(%)	Absolute concentration (%)
0	0.052	100.00	100.00	0.052	100.00	100.00
1	0.041	78.85	76.59	0.033	63.46	59.60
2	0.044	76.92	66.65	0.034	65.38	60.10
3	0.040	76.92	63.06	0.032	61.54	51.63
4	0.041	78.85	60.40	0.039	75.00	58.61
5	0.033	63.46	46.95	0.055	105.77	77.52
6	0.038	73.08	44.18	0.062	119.23	74.10
7	0.050	96.15	55.63	0.087	167.31	94.91
8	0.061	117.31	57.96	0.099	190.38	96.54
9	0.094	180.77	82.10	0.116	223.08	93.27
10	0.088	169.23	51.55	0.087	188.46	66.68
11	0.098	188.46	50.64	0.065	123.08	38.20
12	0.101	196.15	47.57	0.048	92.31	19.81
13	0.078	150.00	30.80	0.022	42.31	6.93
14	0.043	82.69	10.83	0.018	34.62	2.69
15	0.016	30.77	1.92	0.007	13.46	0.29
16	0.007	13.46	0.38	na	na	na

Fortnight	Open			Homegarden		
	K%	Relative concentration(%)	Absolute concentration(%)	K%	Relative concentration(%)	Absolute concentration(%)
0	0.372	100.000	100.000	0.372	100.000	100.000
1	0.292	78.495	76.250	0.360	96.774	90.890
2	0.262	70.430	61.021	0.319	85.753	78.824
3	0.280	75.269	61.705	0.266	71.505	59.993
4	0.158	42.473	32.539	0.187	50.269	39.280
5	0.145	38.978	28.836	0.137	36.828	26.991
6	0.056	15.054	9.100	0.128	34.409	21.385
7	0.052	13.978	8.088	0.081	21.774	12.353
8	0.058	15.591	7.704	0.061	16.398	8.315
9	0.049	13.172	5.983	0.050	13.441	5.620
10	0.042	11.290	3.439	0.035	9.409	3.329
11	0.043	11.559	3.106	0.027	7.258	2.253
12	0.037	9.946	2.412	0.024	6.452	1.385
13	0.025	6.720	1.380	0.023	6.183	1.012
14	0.017	4.570	0.599	0.013	3.495	0.272
15	0.012	3.226	0.201	0.007	1.882	0.041
16	0.012	3.226	0.091	na	na	na

4. Calcium release on ailanthus litter decomposition (%)

Fortnight	Open			Homegarden		
	Ca %	Relative concentration(%)	Absolute concentration(%)	Ca%	Relative concentration(%)	Absolute concentration(%)
0	0.384	100.00	100.00	0.384	100.00	100.00
1	0.410	106.77	103.72	0.422	109.90	103.21
2	0.522	135.94	117.78	0.478	124.48	114.42
3	0.538	140.10	114.86	0.530	138.02	115.80
4	0.658	171.35	131.27	0.422	109.90	85.87
5	0.612	159.38	117.91	0.378	98.44	72.14
6	0.568	147.92	89.42	0.386	100.52	62.47
7	0.584	152.08	88.00	0.462	120.31	68.25
8	0.604	157.29	77.72	0.528	137.50	69.73
9	0.668	173.96	79.01	0.606	157.81	65.98
10	0.598	155.73	47.44	0.644	167.71	59.34
11	0.638	166.15	44.64	0.694	180.73	56.10
12	0.660	171.88	41.68	0.736	191.67	41.13
13	0.688	179.17	36.78	0.810	210.94	34.53
14	0.784	204.17	26.75	0.856	222.92	17.34
15	0.788	205.21	12.78	0.888	231.25	5.06
16	0.782	42.19	1.19	na	na	na

5. Magnesium release on ailanthus litter decomposition (%)

Fortnight	Open			Homegarden		
	Mg %	Relative concentration (%)	Absolute concentration(%)	Mg%	Relative concentration (%)	Absolute concentration (%)
0	0.066	100.00	100.00	0.066	100.00	100.00
1	0.065	98.48	95.67	0.068	103.90	94.00
2	0.085	128.79	111.58	0.079	119.70	110.03
3	0.077	116.67	95.64	0.087	131.82	110.60
4	0.069	104.55	80.09	0.079	119.70	93.53
5	0.066	100.00	73.98	0.080	121.21	88.84
6	0.067	101.52	61.37	0.086	130.30	80.98
7	0.066	100.00	57.86	0.119	180.30	102.29
8	0.070	106.06	52.40	0.107	162.12	82.21
9	0.053	80.30	36.47	0.104	157.58	65.88
10	0.047	71.21	21.69	0.098	148.48	52.53
11	0.042	63.64	17.10	0.094	142.42	44.21
12	0.039	59.09	14.33	0.083	125.76	26.99
13	0.033	50.00	10.27	0.068	103.03	16.87
14	0.032	48.48	6.35	0.061	92.42	7.19
15	0.020	30.30	1.89	0.048	72.73	1.59
16	0.017	25.76	0.73	na	na	na

6. Zinc release on ailanthus litter decomposition (ppm)

Fortnight	Open			Homegarden		
	Zn ppm	Relative concentration (%)	Absolute concentration (%)	Zn ppm	Relative concentration (%)	Absolute concentration (%)
0	2.042	100.00	100.00	2.042	100.00	100.00
1	1.786	87.46	81.38	2.000	97.94	91.59
2	2.524	123.60	107.21	2.768	135.55	117.55
3	2.460	120.47	98.35	2.816	137.90	105.57
4	2.676	131.05	99.68	3.182	155.83	112.23
5	2.916	142.80	105.50	3.414	167.19	37.60
6	3.558	174.24	110.83	3.442	168.56	33.00
7	3.724	182.37	102.69	4.266	208.91	39.11
8	4.326	211.85	75.80	4.384	214.69	33.62
9	4.714	230.85	39.85	3.598	176.20	13.80
10	4.624	226.44	19.68	4.528	221.74	10.71
11	4.888	239.37	15.80	5.308	259.94	6.32
12	4.076	199.61	7.37	na	na	na
13	5.180	253.67	2.74	na	na	na

7. Manganese release on ailanthus litter decomposition (ppm)

Fortnight	Open			Homegarden		
	Mn ppm	Relative concentration(%)	Absolute concentration(%)	Mn ppm	Relative concentration(%)	Absolute concentration(%)
0	2.608	100.00	100.00	2.608	100.00	100.00
1	2.478	95.02	92.30	2.428	93.10	87.44
2	2.448	93.87	81.32	2.640	101.23	93.05
3	2.362	90.57	74.25	2.670	102.38	85.89
4	2.360	90.49	69.33	2.748	105.37	82.33
5	2.430	93.17	68.93	2.910	111.58	81.78
6	2.488	95.40	57.67	2.952	113.19	70.35
7	2.246	86.12	49.83	3.086	118.33	67.13
8	2.540	97.39	48.12	3.242	124.31	63.04
9	2.888	110.74	50.30	3.870	148.39	62.04
10	2.884	110.58	33.68	3.834	147.01	52.01
11	3.164	121.32	32.60	3.996	153.22	47.56
12	3.212	123.16	29.87	4.294	164.65	35.33
13	3.658	140.26	28.80	4.300	164.88	26.99
14	4.152	159.20	20.86	4.874	186.89	14.54
15	4.050	155.29	9.67	4.906	188.11	4.12
16	4.324	165.80	4.68	na	na	na

8. Copper dynamics in ailanthus litter during decomposition

Fortnight	Open			Homegarden		
	Cu ppm	Relative concentration(%)	Absolute concentration(%)	Cu ppm	Relative concentration (%)	Absolute concentration (%)
0	3.00	100.00	100.00	3.00	100.00	100.00
1	9.70	323.33	314.09	6.30	210.00	197.23
2	19.80	660.00	571.82	6.50	216.67	199.16
3	17.30	576.67	472.75	9.00	300.00	251.70
4	17.70	590.00	452.00	10.50	350.00	273.49
5	20.50	683.33	505.53	11.70	390.00	285.83
6	23.30	776.67	469.50	13.90	463.33	287.96
7	23.70	790.00	457.09	16.50	550.00	312.02
8	23.80	793.33	391.99	18.20	606.67	307.64
9	26.30	876.67	398.18	17.80	593.33	248.07
10	28.00	933.33	284.29	19.30	643.33	227.61
11	25.70	856.67	230.19	22.90	763.33	236.94
12	25.20	840.00	203.70	25.50	850.00	182.41
13	28.40	946.67	194.35	27.10	903.33	147.88
14	26.30	876.67	114.84	30.10	1003.33	78.06
15	28.61	953.67	59.41	30.30	1010.00	22.12
16	28.50	950.00	26.79	na		

9. Iron release on ailanthus litter decomposition (ppm)

Fortnight	Open			Homegarden		
	Fe ppm	Relative concentration (%)	Absolute concentration (%)	Fe ppm	Relative concentration (%)	Absolute concentration (%)
0	133.80	100.00	100.00	133.80	100.00	100.00
1	134.80	100.75	97.87	120.40	89.99	84.51
2	187.60	140.21	121.48	162.40	121.38	111.57
3	241.60	180.57	148.03	191.20	142.90	119.89
4	264.80	197.91	151.62	192.20	143.65	112.25
5	280.60	209.72	155.15	187.60	140.21	102.76
6	311.20	232.59	140.60	173.60	129.75	80.64
7	318.80	238.27	137.86	207.60	155.16	88.02
8	355.40	265.62	131.24	237.60	177.58	90.05
9	358.40	267.86	121.66	280.60	209.72	87.68
10	493.40	368.76	112.32	375.80	280.87	99.37
11	393.80	294.32	79.08	384.00	287.00	89.08
12	401.00	299.70	72.68	410.20	306.58	65.79
13	396.40	296.26	60.82	409.40	305.98	50.09
14	409.80	306.28	40.12	412.00	307.92	23.96
15	414.20	309.57	19.29	410.60	306.88	6.72
16	427.00	319.13	9.00	na		

Appendix IV e- WILD JACK

1 . Nitrogen dynamics of decomposing wild jack litter (%)

fortnight	Open			Homegarden		
	N%	Relative concentration (%)	Absolute concentration(%)	N%	Relative concentration (%)	Absolute concentration(%)
0	1.102	100.00	100.00	1.102	100.00	100.00
1	1.244	102.12	100.70	1.262	101.18	99.77
2	1.412	100.12	96.86	1.412	102.94	99.59
3	1.632	106.46	98.60	1.492	92.36	85.54
4	1.606	96.71	87.97	1.612	94.71	86.15
5	1.482	87.07	74.70	1.410	82.84	71.07
6	1.504	88.37	68.40	1.436	84.37	65.30
7	1.418	83.31	59.28	1.138	66.86	47.57
8	1.384	81.32	44.98	1.128	66.27	36.66
9	1.134	66.63	30.68	1.298	76.26	35.12
10	1.042	61.22	25.38	1.386	81.43	33.76
11	0.956	56.17	20.91	1.026	60.28	22.44
12	0.790	46.42	16.28	0.874	51.35	18.01
13	0.568	33.37	10.58	0.734	43.13	13.67
14	0.540	31.73	8.43	0.632	37.13	9.86
15	0.388	22.80	4.32	0.514	30.20	5.73
16	0.494	29.02	3.64	0.436	25.62	3.21
17	0.322	18.92	1.56	0.412	24.21	2.00
18	0.310	18.21	0.76	na	na	na
19	0.198	11.63	0.21	na	na	na

2. Phosphorus dynamics of decomposing wild jack litter (%)

fortnight	Open			Homegarden		
	P%	Relative concentration(%)	Absolute concentration(%)	P%	Relative concentration(%)	Absolute concentration(%)
0	0.049	100.000	100.000	0.049	100.00	100.00
1	0.040	81.633	80.498	0.046	93.88	93.44
2	0.047	95.918	92.801	0.051	104.08	102.05
3	0.066	134.694	124.740	0.054	110.20	101.54
4	0.048	97.959	89.104	0.053	108.16	98.53
5	0.040	81.633	70.033	0.055	112.24	79.42
6	0.031	63.265	48.967	0.045	91.84	57.85
7	0.014	28.571	20.329	0.040	81.63	49.64
8	0.016	32.653	18.060	0.036	73.47	40.44
9	0.021	42.857	19.736	0.021	42.86	22.05
10	0.030	61.224	25.384	0.023	46.94	19.41
11	0.076	155.102	57.729	0.019	38.78	13.82
12	0.109	222.449	78.013	0.026	53.06	17.30
13	0.060	122.449	38.804	0.040	81.63	23.29
14	0.052	106.122	28.186	0.052	106.12	24.27
15	0.048	97.959	18.573	0.031	63.27	7.25
16	0.034	69.388	8.708	0.020	40.82	3.22
17	0.023	46.939	3.872	0.008	16.33	0.41
18	0.014	28.571	1.186	na	na	na
19	0.008	16.327	0.300	na	na	na

3. Potassium dynamics of decomposing wild jack litter (%)

fortnight	Open			Homegarden		
	K%	Relative concentration(%)	Absolute concentration(%)	K%	Relative concentration(%)	Absolute concentration(%)
0	0.593	100.00	100.00	0.593	100.000	100.000
1	0.533	89.88	88.63	0.516	87.015	86.606
2	0.531	89.54	86.63	0.446	75.211	73.744
3	0.494	83.31	77.15	0.386	65.093	59.976
4	0.414	69.81	63.50	0.141	23.777	21.659
5	0.405	68.30	58.59	0.079	13.322	9.427
6	0.283	47.72	36.94	0.059	9.949	6.267
7	0.232	39.12	27.84	0.058	9.781	5.948
8	0.194	32.72	18.09	0.056	9.444	5.199
9	0.171	28.84	13.28	0.049	8.263	4.252
10	0.111	18.72	7.76	0.031	5.228	2.162
11	0.100	16.86	6.28	0.042	7.083	2.524
12	0.062	10.46	3.67	0.024	4.047	1.320
13	0.054	9.11	2.89	0.023	3.879	1.107
14	0.052	8.77	2.33	0.023	3.879	0.887
15	0.050	8.43	1.60	0.023	3.879	0.444
16	0.042	7.08	0.89	0.010	1.686	0.133
17	0.036	6.07	0.50	0.008	1.349	0.034
18	0.022	3.71	0.15	na	na	na
19	0.012	2.02	0.04	na	na	na

4. Calcium dynamics of decomposing wild jack litter (%)

fortnight	Open			Homegarden		
	Ca%	Relative concentration(%)	Absolute concentration(%)	Ca%	Relative concentration(%)	Absolute concentration(%)
0	0.486	100.00	100.00	0.486	100.00	100.00
1	0.494	101.65	100.23	0.484	99.59	99.12
2	0.506	104.12	100.73	0.500	102.88	100.87
3	0.540	111.11	102.90	0.566	116.46	107.31
4	0.548	112.76	102.56	0.598	123.05	112.08
5	0.604	124.28	106.62	0.632	130.04	92.02
6	0.584	120.16	93.01	0.578	118.93	74.91
7	0.630	129.63	92.23	0.584	120.16	73.07
8	0.574	118.11	65.32	0.596	122.63	67.51
9	0.532	109.47	50.41	0.682	140.33	72.21
10	0.614	126.34	52.38	0.692	142.39	58.89
11	0.614	126.34	47.02	0.706	145.27	51.77
12	0.634	130.45	45.75	0.716	147.33	48.04
13	0.676	139.09	44.08	0.736	151.44	43.21
14	0.726	149.38	39.68	0.734	151.03	34.54
15	0.756	155.56	29.49	0.750	154.32	17.69
16	0.740	152.26	19.11	0.804	165.43	13.05
17	0.756	155.56	12.83	0.812	167.08	4.21
18	0.766	157.61	6.54	na	na	na
19	0.794	163.37	3.01	na	na	na

5. Magnesium dynamics of decomposing wild jack litter (%)

fortnight	Open			Homegarden		
	Mg%	Relative concentration(%)	Absolute concentration(%)	Mg%	Relative concentration(%)	Absolute concentration(%)
0	0.075	100.00	100.00	0.075	100.00	100.00
1	0.073	97.33	95.98	0.074	98.67	98.20
2	0.071	94.67	91.59	0.075	100.00	98.05
3	0.068	90.67	83.97	0.073	97.33	89.68
4	0.070	93.33	84.90	0.072	96.00	87.45
5	0.066	88.00	75.50	0.072	96.00	67.93
6	0.074	98.67	76.37	0.062	82.67	52.07
7	0.067	89.33	63.56	0.059	78.67	47.84
8	0.061	81.33	44.99	0.058	77.33	42.57
9	0.060	80.00	36.84	0.048	64.00	32.93
10	0.057	76.00	31.51	0.044	58.67	24.27
11	0.050	66.67	24.81	0.042	56.00	19.96
12	0.045	60.00	21.04	0.034	45.33	14.78
13	0.046	61.33	19.44	0.026	34.67	9.89
14	0.054	72.00	19.12	0.026	34.67	7.93
15	0.044	58.67	11.12	0.021	28.00	3.21
16	0.036	48.00	6.02	0.016	21.33	1.68
17	0.030	40.00	3.30	0.016	21.33	0.54
18	0.024	32.00	1.33	na	na	na
19	0.020	26.67	0.49	na	na	na

6. Zinc dynamics of decomposing wild jack litter (ppm)

fortnight	Open			Homegarden		
	Zn ppm	Relative concentration(%)	Absolute concentration(%)	Zn ppm	Relative concentration(%)	Absolute concentration(%)
0	1.484	100.000	100.000	1.484	100.000	100.000
1	1.486	100.135	98.743	1.456	98.113	97.652
2	1.498	100.943	97.663	1.530	103.100	101.089
3	1.504	101.348	93.858	1.846	124.394	114.616
4	1.372	92.453	84.095	1.876	126.415	115.152
5	1.354	91.240	78.275	2.254	151.887	107.475
6	1.702	114.690	88.770	2.344	157.951	99.494
7	1.664	112.129	79.780	2.426	163.477	99.410
8	2.362	159.164	88.034	2.706	182.345	100.381
9	2.616	176.280	81.177	3.038	204.717	105.347
10	2.768	186.523	77.332	2.912	196.226	81.159
11	3.114	209.838	78.102	3.382	227.898	81.223
12	3.256	219.407	76.946	3.422	230.593	75.196
13	3.360	226.415	71.751	4.352	293.261	83.667
14	3.620	243.935	64.789	4.742	319.542	73.079
15	3.722	250.809	47.553	5.256	354.178	40.589
16	4.024	271.159	34.030	5.232	352.561	27.817
17	4.214	283.962	23.427	5.714	385.040	9.703
18	4.224	284.636	11.812	na	na	na
19	4.756	320.485	5.897	na	na	na

7. Manganese release from decomposing wild jack litter (ppm)

fortnight	Open			Homegarden		
	Mn ppm	Relative concentration(%)	Absolute concentration(%)	Mn ppm	Relative concentration(%)	Absolute concentration(%)
0	2.164	100.00	100.00	2.164	100.00	100.00
1	2.086	96.40	95.06	2.174	100.46	99.99
2	2.220	102.59	99.25	2.140	98.89	96.96
3	2.260	104.44	96.72	2.300	106.28	97.93
4	2.470	114.14	103.82	2.356	108.87	99.17
5	2.800	129.39	111.00	2.342	108.23	76.58
6	3.260	150.65	116.60	3.224	148.98	93.84
7	2.930	135.40	96.34	2.972	137.34	83.52
8	2.496	115.34	63.80	2.672	123.48	67.97
9	2.412	111.46	51.33	3.470	160.35	82.52
10	2.358	108.96	45.18	3.926	181.42	75.04
11	2.368	109.43	40.73	4.438	205.08	73.09
12	2.596	119.96	42.07	4.760	219.96	71.73
13	2.574	118.95	37.69	4.912	226.99	64.76
14	2.630	121.53	32.28	5.304	245.10	56.05
15	2.894	133.73	25.36	5.130	237.06	27.17
16	3.332	153.97	19.32	5.234	241.87	19.08
17	3.966	183.27	15.12	5.754	265.90	6.70
18	3.928	181.52	7.53	na	na	na
19	4.936	228.10	4.20	na	na	na

9. Iron release from decomposing wild jack litter (ppm)

fortnight	Open			Homegarden		
	Fe ppm	Relative concentration(%)	Absolute concentration(%)	Fe ppm	Relative concentration(%)	Absolute concentration(%)
0	160.20	100.00	100.00	160.20	100.00	100.00
1	188.20	117.48	115.85	189.40	118.23	117.67
2	198.60	123.97	119.94	202.40	126.34	123.88
3	202.20	126.22	116.89	206.20	128.71	118.60
4	200.80	125.34	114.01	201.20	125.59	114.40
5	206.40	128.84	110.53	215.60	134.58	95.23
6	220.60	137.70	106.58	213.80	133.46	84.07
7	221.60	138.33	98.42	234.60	146.44	89.05
8	235.20	146.82	81.20	262.00	163.55	90.03
9	236.60	147.69	68.01	258.00	161.05	82.88
10	246.40	153.81	63.77	266.80	166.54	68.88
11	250.60	156.43	58.22	272.80	170.29	60.69
12	254.00	158.55	55.60	275.00	171.66	55.98
13	260.80	162.80	51.59	279.40	174.41	49.76
14	273.60	170.79	45.36	328.20	204.87	46.85
15	290.60	181.40	34.39	327.80	204.62	23.45
16	315.20	196.75	24.69	362.20	226.09	17.84
17	324.80	202.75	16.73	372.60	232.58	5.86
18	359.00	224.09	9.30	na	na	na
19	410.80	256.43	4.72	na	na	na

8 . Copper dynamics of decomposing wild jack litter (ppm)

fortnight	Open			Homegarden		
	Cu pm	Relative concentration(%)	Absolute concentration(%)	Cu ppm	Relative concentration(%)	Absolute concentration(%)
0	4.64	100.00	100.00	4.64	100.00	100.00
1	5.92	127.59	125.81	5.00	107.76	107.25
2	6.40	137.93	133.45	5.50	118.53	116.22
3	7.30	157.33	145.70	7.10	153.02	140.99
4	8.30	178.88	162.71	7.60	163.79	149.20
5	11.00	237.07	203.38	7.90	170.26	120.48
6	12.00	258.62	200.17	8.80	189.66	119.46
7	12.70	273.71	194.74	10.50	226.29	137.61
8	13.50	290.95	160.92	11.40	245.69	135.25
9	14.90	321.12	147.88	11.60	250.00	128.65
10	13.30	286.64	118.84	12.30	265.09	109.64
11	12.10	260.78	97.06	12.60	271.55	96.78
12	14.50	312.50	109.59	12.40	267.24	87.15
13	14.30	308.19	97.67	11.30	243.53	69.48
14	15.90	342.67	91.01	11.50	247.84	56.68
15	16.20	349.14	66.20	13.50	290.95	33.34
16	14.30	308.19	38.68	13.80	297.41	23.47
17	14.30	308.19	25.43	14.10	303.88	7.66
18	13.20	284.48	11.81	na	na	na
19	14.20	306.03	5.63	na	na	na
Mean	11.95			10.90		

Appendix IV f.- MAHOGANY

1. Nitrogen release from mahogany litter on decay (%)

	Open			Homegarden		
Fortnight	N%	Relative concentration (%)	Absolute concentration(%)	N%	Relative concentration (%)	Absolute concentration(%)
0	1.300	100.00	100.00	1.300	100.00	100.00
1	1.296	99.69	96.61	1.280	98.46	97.54
2	1.272	97.85	88.50	1.258	96.77	93.08
3	1.230	94.62	84.10	1.282	98.62	91.31
4	1.360	104.62	89.29	1.478	113.69	103.87
5	1.362	104.77	86.23	1.688	129.85	111.50
6	1.304	100.31	70.74	1.738	133.69	104.24
7	1.616	124.31	80.79	1.382	106.31	77.87
8	1.690	130.00	74.00	1.320	101.54	69.08
9	1.494	114.92	59.63	1.296	99.69	65.90
10	1.376	105.85	47.85	1.248	96.00	61.71
11	1.236	95.08	38.21	1.242	95.54	54.46
12	1.166	89.69	34.88	1.232	94.77	50.28
13	1.192	91.69	32.52	1.160	89.23	39.88
14	1.372	105.54	37.41	1.070	82.31	23.83
15	1.162	89.38	29.09	0.936	72.00	17.43
16	0.934	71.85	23.13	0.890	68.46	10.91
17	1.028	79.08	24.09	0.858	66.00	9.95
18	0.944	72.62	21.09	0.846	65.08	7.00
19	0.902	69.38	18.30	0.840	64.62	4.78
20	0.856	65.85	15.55	0.832	64.00	3.33
21	0.097	7.46	1.52	0.806	62.00	1.15
22	0.980	75.38	8.78	na	na	na
23	0.806	62.00	4.31	na	na	na
24	0.768	59.08	1.98	na	na	na

2. Phosphorus release from mahogany litter on decay (%)

	Open			Homegarden		
Fortnight	P%	Relative concentration (%)	Absolute concentration (%)	P%	Relative concentration (%)	Absolute concentration (%)
0	0.051	100.00	100.00	0.051	100.00	100.00
1	0.048	94.12	91.21	0.046	90.20	89.35
2	0.047	92.16	83.36	0.047	92.16	88.65
3	0.046	90.20	80.18	0.049	96.08	88.96
4	0.044	86.27	73.64	0.045	88.24	80.61
5	0.049	96.07	79.07	0.042	82.35	70.72
6	0.055	107.84	76.05	0.053	103.92	81.03
7	0.058	113.73	73.91	0.054	105.88	
8	0.066	129.41	73.66	0.064	125.49	85.37
9	0.056	109.80	56.98	0.054	105.88	69.99
10	0.056	109.80	49.64	0.052	101.96	65.54
11	0.059	115.69	46.49	0.047	92.16	52.53
12	0.044	86.27	33.55	0.055	107.84	57.22
13	0.060	117.65	41.73	0.050	98.04	43.81
14	0.047	92.16	32.67	0.051	100.00	28.95
15	0.037	72.55	23.61	0.040	78.43	18.99
16	0.041	80.39	25.88	0.042	82.35	13.13
17	0.029	56.86	17.32	0.033	64.71	9.76
18	0.034	66.67	19.36	0.035	68.63	7.38
19	0.020	39.22	10.35	0.021	41.18	3.04
20	0.024	47.06	11.11	0.021	41.18	2.15
21	0.018	35.29	7.20	0.012	23.53	0.44
22	0.032	62.75	13.02	na	na	na
23	0.028	54.90	7.36	na	na	na
24	0.020	39.22	3.88	na	na	na

3. Potassium release from mahogany litter on decay (%)

	Open			Homegarden		
Fortnight	K%	Relative concentration (%)	Absolute concentration (%)	K%	Relative concentration (%)	Absolute concentration (%)
0	0.578	100.00	100.00	0.578	100.00	100.00
1	0.542	93.77	90.87	0.482	83.39	82.61
2	0.471	81.49	73.71	0.427	73.88	71.06
3	0.424	73.36	65.21	0.440	76.12	70.48
4	0.306	52.94	45.19	0.386	66.78	61.01
5	0.291	50.35	41.43	0.283	48.96	42.04
6	0.258	44.64	31.48	0.188	32.53	25.36
7	0.207	35.81	23.27	0.150	25.95	19.01
8	0.190	32.87	18.71	0.104	17.99	12.24
9	0.150	25.95	13.47	0.100	17.30	11.44
10	0.073	12.63	5.71	0.081	14.01	9.01
11	0.064	11.07	4.45	0.083	14.36	8.19
12	0.065	11.25	4.37	0.067	11.59	6.15
13	0.055	9.52	3.38	0.053	9.17	4.10
14	0.064	11.07	3.93	0.051	8.82	2.55
15	0.059	10.21	3.32	0.050	8.65	2.09
16	0.054	9.34	3.01	0.036	6.23	0.99
17	0.068	11.76	3.58	0.035	6.06	0.91
18	0.046	7.96	2.31	0.019	3.29	0.35
19	0.034	5.88	1.55	0.019	3.29	0.24
20	0.043	7.44	1.76	0.011	1.90	0.10
21	0.036	6.23	1.27	0.007	1.21	0.02
22	0.024	4.15	0.48	na	na	na
23	0.014	2.42	0.17	na	na	na
24	0.006	1.04	0.03	na	na	na

4. Calcium release from mahogany litter on decay (%)

	Open			Homegarden		
Fortnight	Ca%	Relative concentration(%	Absolute concentration.	Ca%	Relative concentration(%	Absolute concentration.
0	0.904	100.00	100.00	0.904	100.00	100.00
1	0.876	96.90	93.91	0.948	104.87	103.88
2	1.020	112.83	102.06	1.000	110.62	106.40
3	0.864	95.58	84.96	0.750	82.96	76.82
4	0.838	92.70	79.12	0.780	86.28	78.83
5	0.802	88.72	73.01	0.736	81.42	69.91
6	0.854	94.47	66.62	0.892	98.67	76.94
7	0.892	98.67	64.13	1.044	115.49	84.59
8	0.916	101.33	57.68	1.124	124.34	84.59
9	0.950	105.09	54.53	1.080	119.47	78.97
10	1.042	115.27	52.11	1.200	132.74	85.33
11	1.060	117.26	47.13	1.246	137.83	78.56
12	0.944	104.42	40.61	1.280	141.59	75.13
13	0.944	104.42	37.04	1.374	151.99	67.92
14	1.092	120.80	42.82	1.466	162.17	46.95
15	1.138	125.88	40.98	1.530	169.25	40.97
16	1.286	142.26	45.79	1.568	173.45	27.65
17	1.416	156.64	47.71	1.724	190.71	28.76
18	1.386	153.32	44.52	1.920	212.39	22.85
19	1.510	167.04	44.06	1.928	213.27	19.00
20	1.526	168.81	39.85	1.978	218.81	11.40
21	1.580	174.78	35.65	2.024	223.89	4.14
22	1.732	191.59	22.32	na	na	na
23	1.838	203.32	14.13	na	na	na
24	1.966	217.48	7.29	na	na	na

5. Magnesium release from mahogany litter on decay (%)

	Open			Homegarden		
Fortnight	Mg%	Relative concentration (%)	Absolute concentration(%)	Mg%	Relative concentration (%)	Absolute concentration(%)
0	0.070	100.00	100.00	0.070	100.00	100.00
1	0.080	113.96	110.44	0.072	101.99	101.04
2	0.076	108.26	97.92	0.074	105.41	101.40
3	0.073	103.99	92.44	0.073	104.27	96.55
4	0.064	91.74	78.30	0.068	96.58	88.24
5	0.069	98.01	80.66	0.063	90.03	77.31
6	0.066	94.59	66.70	0.065	92.02	71.75
7	0.060	85.19	55.36	0.067	95.73	70.12
8	0.058	82.05	46.70	0.053	75.50	51.36
9	0.056	80.34	41.69	0.048	67.81	44.82
10	0.053	75.78	34.26	0.046	64.96	41.75
11	0.053	74.93	30.11	0.034	47.86	27.28
12	0.056	80.34	31.24	0.031	44.44	23.58
13	0.045	64.39	22.84	0.031	44.16	19.73
14	0.040	57.26	20.30	0.027	38.46	11.13
15	0.036	51.00	16.60	0.024	34.47	8.35
16	0.032	45.87	14.77	0.022	31.62	5.04
17	0.032	46.15	14.06	0.013	17.95	2.71
18	0.027	38.75	11.25	0.013	18.52	1.99
19	0.024	34.76	9.17	0.014	20.23	1.49
20	0.023	32.19	7.60	0.011	15.95	0.83
21	0.022	31.05	6.34	0.008	11.97	0.22
22	0.017	24.22	2.82	na	na	na
23	0.016	22.79	1.58	na	na	na
24	0.012	17.09	0.57	na	na	na

6. Zinc release from mahogany litter on decay (ppm)

	Open			Homegarden		
Fortnight	Zn ppm	Relative concentration (%)	Absolute concentration (%)	Zn ppm	Relative concentration (%)	Absolute concentration (%)
0	4.748	100.00	100.00	4.748	100.00	100.00
1	4.618	97.26	94.26	4.018	84.63	83.83
2	4.868	102.53	92.74	4.214	88.75	85.37
3	4.476	94.27	83.80	4.646	97.85	90.60
4	4.744	99.92	85.28	4.946	104.17	95.17
5	4.304	90.65	74.60	5.262	110.83	95.17
6	4.604	96.97	68.38	5.040	106.15	82.77
7	4.816	101.43	65.92	5.514	116.13	85.07
8	5.124	107.92	61.43	5.814	122.45	83.30
9	5.266	110.91	57.55	5.566	117.23	77.49
10	5.270	110.99	50.18	5.650	119.00	76.49
11	5.850	123.21	49.52	5.896	124.18	70.78
12	5.990	126.16	49.06	6.464	136.14	72.24
13	6.304	132.77	47.09	6.598	138.96	62.10
14	5.842	123.04	43.62	6.888	145.07	42.00
15	5.940	125.11	40.72	7.254	152.78	36.99
16	6.508	137.07	44.12	7.344	154.68	24.66
17	6.716	141.45	43.09	8.046	169.46	25.55
18	6.708	141.28	41.03	8.314	175.11	18.84
19	7.210	151.85	40.06	8.700	183.24	13.54
20	7.416	156.19	36.88	8.792	185.17	9.65
21	7.576	159.56	32.55	9.362	197.18	3.65
22	7.850	165.33	19.26	na	na	na
23	7.950	167.44	11.64	na	na	na
24	8.106	170.72	5.72	na	na	na

7. Manganese release from mahogany litter on decay (ppm)

	Open			Homegarden		
Fortnight	Mn ppm	Relative concentration (%)	Absolute concentration (%)	Mn ppm	Relative concentration (%)	Absolute concentration (%)
0	0.366	100.00	100.00	0.366	100.00	100.00
1	0.460	125.68	121.80	0.432	118.03	116.92
2	0.630	172.13	155.69	0.662	180.87	173.98
3	0.598	163.39	145.24	0.756	206.56	191.25
4	0.522	142.62	121.73	0.852	232.79	212.67
5	0.626	171.04	140.76	0.840	229.51	197.08
6	0.644	175.96	124.08	0.930	254.10	198.12
7	0.758	207.10	134.60	0.982	268.31	196.53
8	0.944	257.92	146.81	1.282	350.27	238.29
9	0.964	263.39	136.67	1.532	418.58	276.68
10	1.240	338.80	153.17	1.802	492.35	316.48
11	1.150	314.21	126.28	1.684	460.11	262.26
12	1.104	301.64	117.31	2.188	597.81	317.20
13	1.228	335.52	119.01	2.146	586.34	262.03
14	1.140	311.48	110.42	1.910	521.86	151.08
15	1.210	330.60	107.61	1.886	515.30	124.75
16	0.996	272.13	87.60	2.170	592.90	94.51
17	0.938	256.28	78.06	2.138	584.15	88.09
18	1.976	539.89	156.78	2.354	643.17	69.21
19	1.902	519.67	137.09	2.590	707.65	52.30
20	1.966	537.16	126.82	2.722	743.72	38.75
21	2.888	789.07	160.97	3.312	904.92	16.74
22	2.796	763.93	89.00	na	na	na
23	2.786	761.20	88.68	na	na	na
24	3.232	883.06	61.37	na	na	na

8 .Copper release from mahogany litter on decay (ppm)

	Open			Homegarden		
Fortnight	Cu ppm	Relative concentration (%)	Absolute concentration (%)	Cu ppm	Relative concentration (%)	Absolute concentration (%)
0	7.40	100.00	100.00	7.40	100.00	100.00
1	15.30	206.76	200.37	7.90	106.76	105.75
2	17.90	241.89	218.79	10.00	135.14	129.99
3	20.10	271.62	241.44	9.90	133.78	123.87
4	23.50	317.57	271.04	13.40	181.08	165.44
5	30.00	405.41	333.65	12.70	171.62	147.37
6	30.80	416.22	293.52	15.70	212.16	165.42
7	31.80	429.73	279.28	12.30	166.22	121.75
8	29.20	394.59	224.60	15.40	208.11	141.58
9	41.70	563.51	292.41	17.10	231.08	152.74
10	23.50	317.57	143.57	19.70	266.22	171.12
11	28.50	385.14	154.79	22.90	309.46	176.39
12	32.80	443.24	172.38	20.70	279.73	148.42
13	28.10	379.73	134.69	23.30	314.86	140.71
14	26.30	355.41	125.99	28.90	390.54	113.06
15	23.80	321.62	104.69	27.80	375.68	90.95
16	25.80	348.65	112.23	28.00	378.38	60.31
17	26.40	356.76	108.67	34.20	462.16	69.69
18	23.70	320.27	93.01	30.90	417.57	44.93
19	21.60	291.89	77.00	37.00	500.00	36.95
20	30.60	413.51	97.63	43.50	587.84	30.63
21	41.70	563.51	114.96	44.30	598.65	11.08
22	37.90	512.16	59.67	na	na	na
23	32.60	440.54	30.62	na	na	na
24	43.60	589.19	19.74	na	na	na

9.Iron release from mahogany litter on decay (ppm)

	Open			Homegarden		
Fortnight	Fe ppm	Relative concentration (%)	Absolute concentration (%)	Fe ppm	Relative concentration (%)	Absolute concentration(%)
0	196.40	100.00	100.00	196.40	100.00	100.00
1	217.40	110.69	107.27	267.60	136.25	134.97
2	404.60	206.01	186.33	286.60	145.93	140.37
3	490.80	249.90	222.13	357.80	182.18	168.68
4	512.00	260.69	222.50	434.50	221.23	202.12
5	510.20	259.78	213.80	555.00	282.59	242.66
6	818.80	416.90	294.00	651.40	331.67	258.60
7	875.60	445.82	289.74	714.40	363.75	266.45
8	760.80	387.37	220.49	845.40	430.45	292.83
9	1195.20	608.55	315.78	805.60	410.18	271.13
10	1871.40	952.85	430.78	910.80	463.75	298.10
11	662.60	337.37	135.59	919.20	468.02	266.77
12	633.80	322.71	125.50	710.80	361.91	192.03
13	771.00	392.57	139.24	809.00	411.91	184.08
14	657.00	334.52	118.59	839.00	427.19	123.67
15	820.60	417.82	136.00	880.00	448.07	108.48
16	851.40	433.50	139.54	877.00	446.54	71.18
17	881.80	448.98	136.76	1024.60	521.69	78.67
18	835.80	425.56	123.58	823.40	419.25	45.11
19	831.40	423.32	111.67	596.00	303.46	22.43
20	1023.40	521.08	123.03	570.60	290.53	15.14
21	1052.60	535.95	109.33	882.00	449.08	8.31
22	917.80	467.31	54.44	na	na	na
23	948.00	482.69	33.55	na	na	na
24	955.80	486.66	16.30	na	na	na

LITTER DECOMPOSITION AND NUTRIENT DYNAMICS OF SELECTED MULTIPURPOSE TREES IN HOMESTEADS

By

SHEEBA REBECCA ISAAC

ABSTRACT OF A THESIS

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ABSTRACT

An investigation was undertaken in three homegardens at Kalliyur Panchayat, Thiruvananthapuram District during the period 1998 – 1999, to analyse the structure, quantify the litter production and to assess the decomposition characteristics of leaf litter of commonly grown multipurpose trees. The six tree species selected for the study were mango, jack, cashew, ailanthus, wild jack and mahogany. Decomposition studies were carried out in the homegardens, beneath the respective tree species canopy and in an exposed area, which served as the control plot. The standard litter bag technique was adopted for the purpose. The changes in the soil properties associated with the decomposition were monitored at both sites

The homegardens studied represented a multi-storied tree based cropping system with coconut palms being the most dominant species. The other tree species common to the three homegardens were mango, jack, cashew, wild jack, morinda and mahogany. The farmers effectively utilized the interspaces and they mostly relied on tuber, fodder and spice crops for income. There was no definite pattern of arrangement but the cropping intensities worked out for the homegardens were high.

The amount of litter accumulated in the homegardens annually by the different tree components varied with the species, its density and prevailing climatic conditions. Homegarden I recorded the highest amount of litter addition followed by the homegardens II and III studied. The litter added

considerable amount of nutrients with nitrogen and potassium accretions being comparatively more than that of phosphorus. The total amount of nutrients added depended on the quantity of the litter produced and its nutrient contents.

The fresh leaf and litter chemistry revealed comparatively lower contents of nutrients in leaf litter in all the six species. Lignin content was more in the litter than in fresh leaves.

Leaf litter decomposition was more rapid in the homegarden compared to that in the open plots. The dry matter loss in the leaf litter in the homegarden followed the order jack > cashew > mango > ailanthus > wild jack > mahogany. The linear equations best described the pattern of mass loss from the decomposing litter. Mahogany litter exhibited the slowest decay and recorded the lowest value for decay coefficient.

The nutrient release pattern for the different species was also worked out. The rate of release of nutrients during decomposition differed markedly between the different elements and most of the mobile nutrients revealed more than 90 per cent release by the time decomposition was complete. Nitrogen, phosphorus, potassium and magnesium were released from the litter on decay, whereas, calcium and the micronutrients showed trends of accumulation. The release pattern of the nutrients remained almost similar for each species at both sites.

Significant improvements in the soil physical and chemical properties were noticed due to the leaf litter decay at both sites. The soil faunal and floral counts recorded higher populations during the rainy months and were comparatively more in the homegardens.

The weight loss was found to be more soil moisture dependent than soil temperature as the decay was mediated by the soil microbial biomass, which was significantly more under the moist situations.

The initial litter quality was correlated with the rate of decomposition and of the different chemical constituents, the lignin and lignin: N ratio had significant influence on the rate of decomposition.

The decomposition models relating the residual mass and time elapsed for the different species litter and nutrient equations for the different elements at both sites were also worked out. The quadratic equation described best most of the nutrient dynamics in the litter.