Structural diversity and nutrient recycling potentials of three selected agroforestry homegardens in southern Kerala

Sheeba Rebecca Isaac

Farming Systems Research Station, Sadanandapuram PO, Kottarakkara, Kollam, Kerala Agricultural University

Abstract— *Homegardens in Kerala mimic forest ecosystems on account of the tree components included and are agroforestry systems that integrate different agricultural crops and enterprises as per the needs and interests of the farm family. Analysis of the structural diversity and nutrient recycling potentials of three agroforestry homegardens in southern Kerala revealed multi-tier cropping patterns with cropping intensities ranging from 177.18 to 187.04%. Two of the homegardens included livestock components adding to the nutritional security of the family. Diversity indices were in the order 0.92, 1.53 and 0.86. The quantum of litter fall varied with the tree canopies and species, amounting to 473.6, 425.37 and 345.11 kg adding 7.02, 7.517 and 5.165 kg NPK annually in the three homegardens. Maximum nutrient additions were recorded for nitrogen and potassium and least for phosphorus.*

Keywords: agroforestry, diversity, homegarden, litter, nutrient

I. INTRODUCTION

Agroforestry systems offer immense potential for sustainable agriculture as the tree based systems are rich in biodiversity and organic matter production that can be suitably recycled in the system. Trees are characterized by a continuous litterfall, the quantity varying with age, species, canopy spread and season. Litter contributes significantly to the nutrient pool of the agroforestry system. In Kerala, homestead agroforestry predominates among the agroforestry systems practiced in the state. These systems refer to the intimate associations of multipurpose trees and shrubs with annual and perennial crops and invariably livestock, within the compounds of individual houses, with the whole tree- crop- animal unit being managed by family labour (Ferenandes and Nair, 1986). The present study explored the diversity of three selected agroforestry homegardens in Thiruvananthapuram, southern Kerala and the nutrient accretions via litter fall from the perennial components.

II. MATERIALS & METHODS

A preliminary survey was conducted in Kalliyur Panchayat, Thiruvananthapuram district, southern Kerala to identify the agroforestry gardens for the study. The selected gardens comprised of an intense mix of a variety of multipurpose trees and agricultural crops. The sites, located at an altitude of 40m 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 1619mm. The soil type of the area was oxisol with a sandy clay loam texture.

The diversity and evenness of the homegardens were assessed using the Simpson and Shannon –Weiner indices. Nutrient accretions were computed based on the quantum of litterfall and nutrient contents in the litter. Litter traps of 0.75 m diameter fabricated from plaited coconut leaves were used for the purpose. Sufficient number of traps were set below the trees in a random number, secured on tripods at a height of 1m above the ground to collect the falling litter. The amount of litter collected at monthly intervals per unit area were quantified separately for each species and annual litterfall computed using the formula

$$Annual\ litter\ fall(kg\ tree\ area^{-1}year^{-1}) = \frac{Canopy\ area(m^2) \times Monthly\ litter\ in\ trap(kg)}{Total\ Area\ of\ the\ litter\ trap(m^2)}$$

The litter samples were powdered and analyzed for N, P and K contents as per standard procedures. The nutrient addition by litter fall to the system was calculated by multiplying the total quantity of the litter added with nutrient content and expressed as kg year $^{-1}$ tree area $^{-1}$ for each species.

III. RESULTS AND DISCUSSION

The details on the inventory, cropping intensity, diversity index in the three agroforestry gardens are presented in Table 1. The three gardens studied represented coconut based multi tier based cropping systems with the different species occupying different strata ensuring annidation in space. 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. Agricultural crops comprised mostly of banana, tuber crops (Amorphophallus, cassava, Colocasia, Dioscorea), fodder grasses (guinea grasses) and spices (ginger, turmeric and black pepper). Livestock and poultry were maintained in the agroforestry homegardens I and II. Cropping intensities of the three gardens were 187.04, 186.7 and 177.2 % respectively.

TABLE 1
INVENTORY AND LITTER ADDITIONS IN THE SELECTED AGROFORESTRY SYSTEMS

Particulars	Agroforestry garden I	Agroforestry garden II	Agroforestry garden III
Total area (m^2)	5400	5000	7600
Net area available for cultivation(m^2)	4000	3000	6600
Gross cropped area (m^2)	7481.65	5600.17	11694.09
Cropping intensity %	187.04	186.67	177.18
No. of perennial species	13	17	13
No. of annual species	3	7	5
Species richness (S)	16	24	18
Diversity index (H)	0.928	1.353	0.862
Simpson index (D)	0.652	0.473	0.692
Effective Number Species	2.53	3.87	2.37
Evenness	0.375	0.488	0.360
Litter fall (kg tree area^{-1}year^{-1})	473.60	425.37	345.11
Nutrient additions (kg tree area^{-1}year^{-1})			
N	5.414	5.892	3.759
P	0.249	0.267	0.182
K	1.359	1.358	1.224

The major perennial tree crop in homegarden I was coconut (*Cocos nucifera*), which constituted 56.6 per cent of the gross cropped area and the second important species was wild jack (*Artocarpus hirsuta*). In this homegarden, the perennials, coconut, mango (*Mangifera indica*) and wild jack formed the uppermost layer of the canopy (>25m). Jack (*A. heterophyllus*), tamarind (*Tamarindus indica*), mahogany (*Swietenia mahoganii*) and black pepper (*Piper nigrum*) formed the second layer; Morinda (*Morinda tinctoria*), cashew (*Anacardium occidentale*) and Ailanthus (*Ailanthus triphysa*) the third layer, papaya (*Carica papaya*), curry leaf (*Murraya koenigii*), Moringa (*Moringa oleifera*), tapioca (*Manihot esculenta*) and banana (*Musa sp*.) the fourth layer. Fodder grasses grown in the inter spaces of the perennials along with and pineapple (*Ananas comosus*) constituted the lowermost layer. Coconut seed nuts were planted in an area of 120 m^2. The farmer also maintained two cows, five hens and two goats in his farm to cater to the food and manure needs of the homestead.

Wild jack and coconut were the major perennial species in the homegarden II also, these occupying the uppermost layer of the canopy. Tamarind, mahogany, jack and black pepper formed the second layer. Mango, Erythrina (*Erythrina indica)*, cashew and Morinda constituted the third layer. Coffee (*Coffea arabica*), sapota (*Manilkhara zapota*), nutmeg (*Myristica fragrans*), curry leaf, bilimbi *(Averrhoia bilimbi)*, papaya, cherry (*Malpighia glabra)*, Dioscorea, tapioca and banana formed the fourth layer. The fifth layer included annual agricultural crops viz., ginger, turmeric, Amorphophallus and Colocasia. The livestock component in the garden included three hens, 10 chicks and one cow to meet the protein diet of the homestead family.

Adult coconut palms occupied an area of 3532.50 m^2 and young palms 1360.25 m^2 in homegarden III. 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 (*Macarenga peltata*) and Ailanthus. Clove (*Syzygium aromaticum*) breadfruit (*Artocarpus altilis)*, tapioca and banana formed the fourth layer; guinea grass, ginger and Colocasia, the fifth layer and floor crops of this homegarden.

The cropping pattern adopted by the farmers reveals the structural complexity and species diversity of homegardens, which is unique to tropical homegardens. Rather than the presence of more number of trees per species, homestead farms are characterized by species diversity. The design of the gardens has been based on the preference of the individual farmer. The component selection is generally based on the farm family requirements of food, fuel, fodder and income. 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 data in Table 1 revealed the species richness and abundance relevant to the diversity of agroforestry gardens and the quantum of litter and nutrient additions that occur annually in these gardens.

The species richness (S) and diversity indices (H) showed maximum values in homegarden II. Values of evenness indicate how similar the abundance of the different species are in each homegarden. The lower value of Simpson index indicates higher diversity, which, as it approaches 1, indicates monoculture.

It is evident that recycling of litter has immense potential in contributing to the soil nutrient pool. The additions varied with the tree species, density and / stage of stand development. In the agroforestry garden I, maximum litter production and nutrient accretions were due to wild jack (*Artocarpus hirsuta*), while in the second garden, mango predominated litter additions. In the third garden, jack was most important (Fig 1).

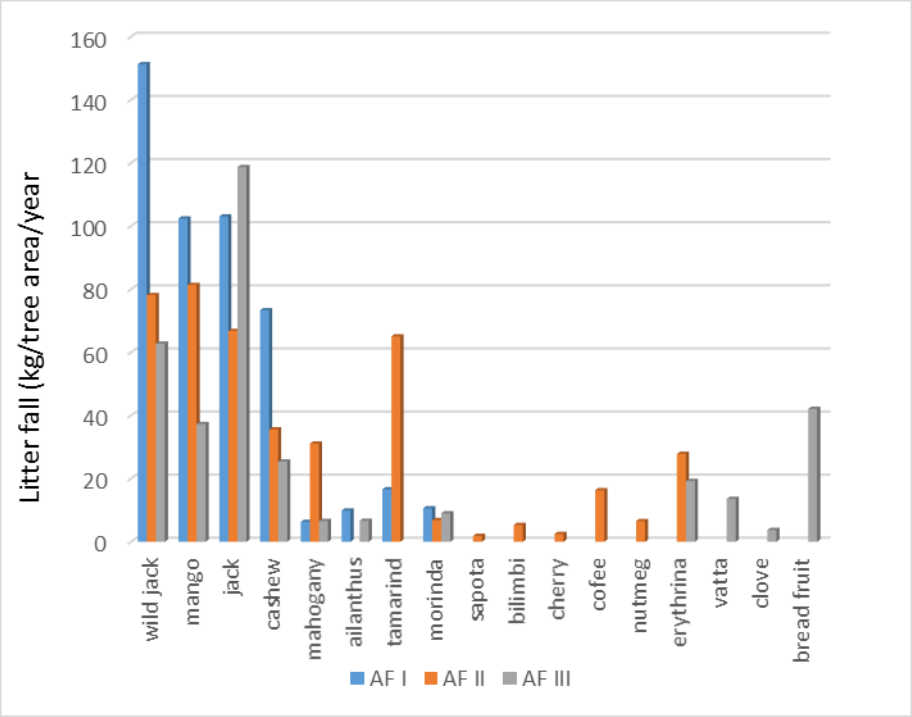

FIG.1 LITTER FALL FROM THE DIFFERENT TREE SPECIES IN THE THREE AF HOMEGARDENS

Nutrient additions from the different trees in the homegardens are depicted in Fig. 2. 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 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.

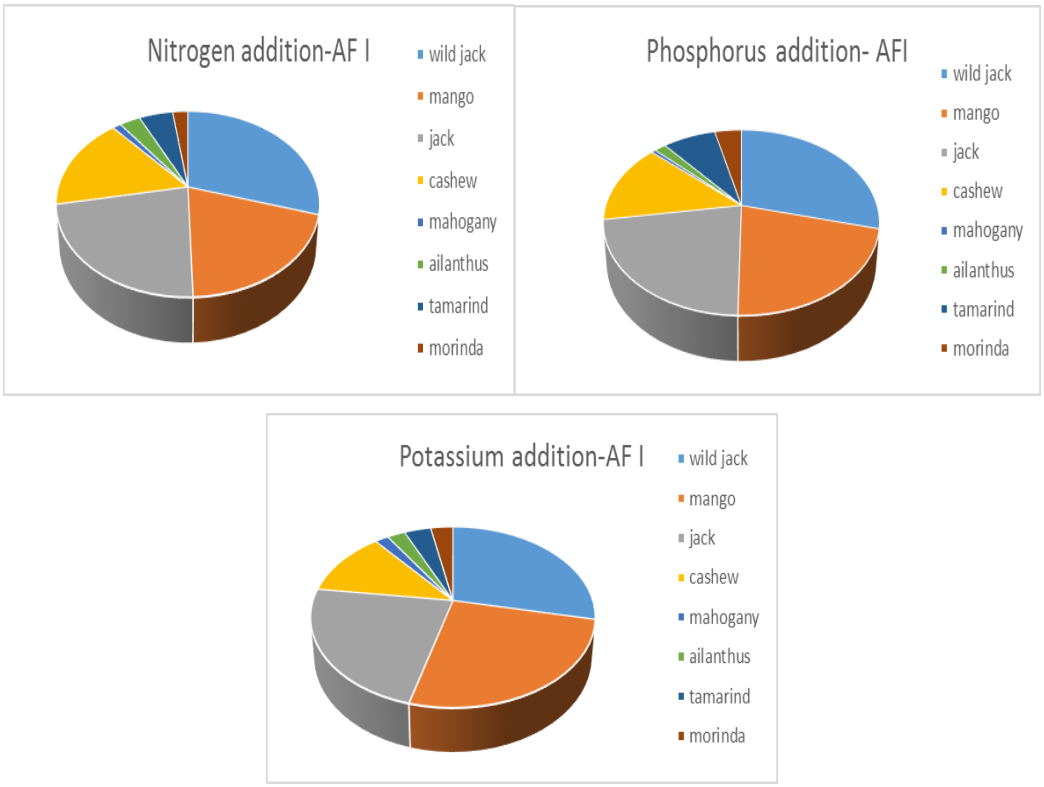

FIG.2A NUTRIENT ADDITIONS FROM THE DIFFERENT TREE SPECIES IN AF HOMEGARDEN I

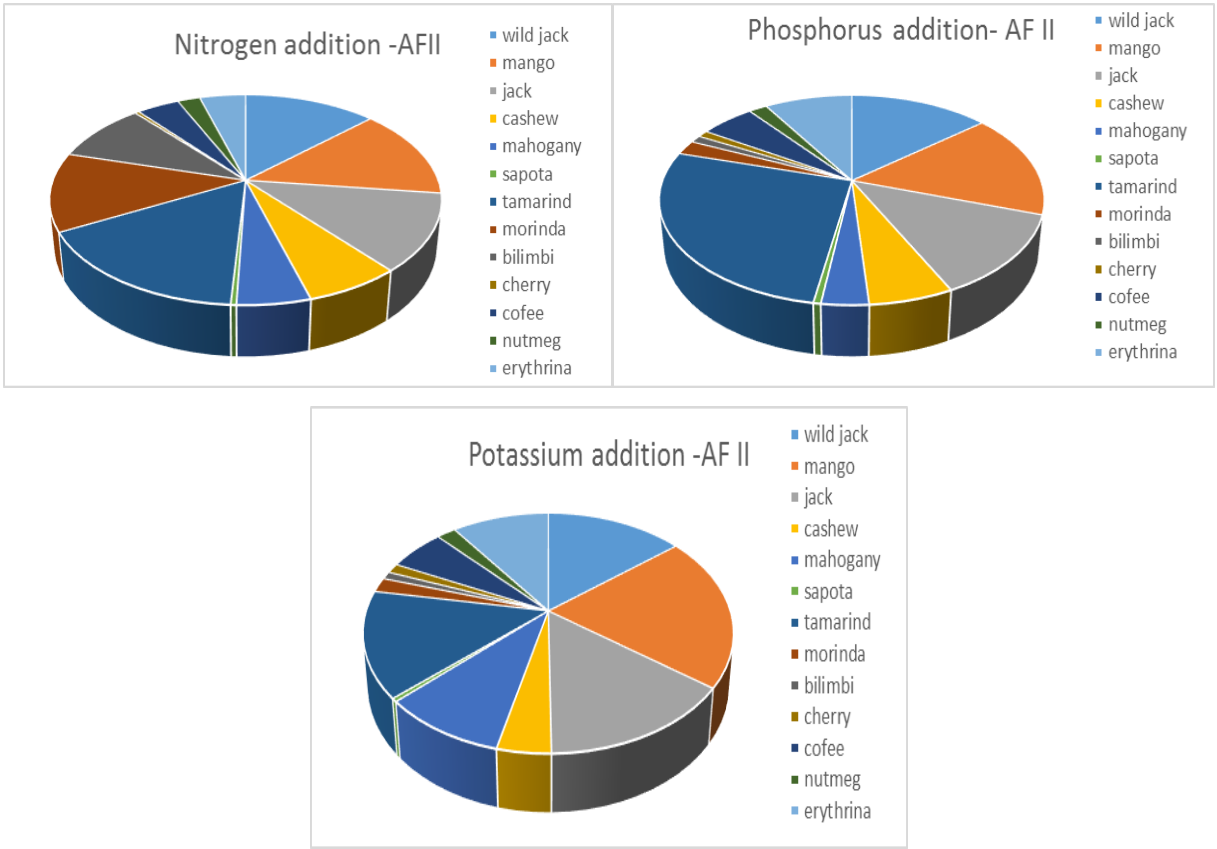

FIG.2B NUTRIENT ADDITIONS FROM THE DIFFERENT TREE SPECIES IN AF HOMEGARDEN II

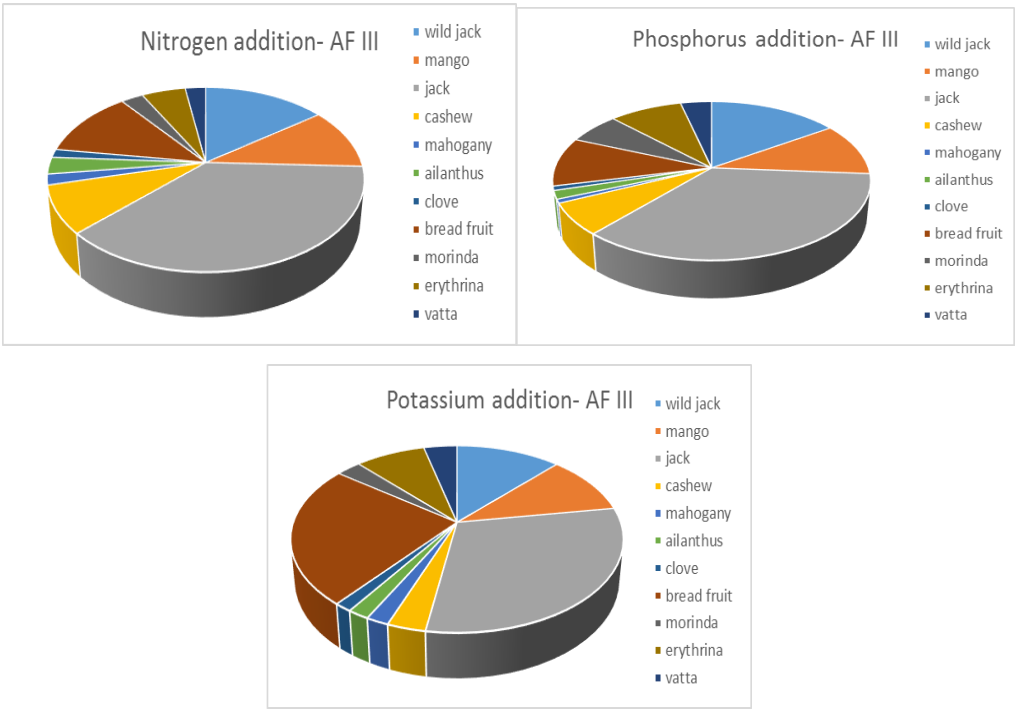

FIG.2C NUTRIENT ADDITIONS FROM THE DIFFERENT TREE SPECIES IN AF HOMEGARDEN III

The annual nutrient inputs from 11 tree species in homegarden III were 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 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.

The nutrient accretions through litter were highest in nitrogen followed by potassium and least, phosphorus. This conforms the litter nutrient additions reported by Das and Ramakrishnan (1985) and Saravanan *et al.* (1995). Potassium in the above ground mass is known to be stored in tree stems contributing to lower input in the litter compared to nitrogen. The quantum of phosphorus added was the least and it could be deduced as due to the comparatively lower phosphorus content in the leaves. Total nutrient additions followed the same trend as litter in the first and third homegardens, while in the second garden, despite maximum litter addition by mango, nutrient additions were comparatively more in tamarind. This amounted to 1.22 kg in the mango and 1.31 kg in tamarind, emphasizing that nutrient contents also have a significant role in deciding nutrient turn over (Shajikumar, 1991). It is reported that on decomposition nutrients are released by mineralization and the order was primarily K> N> P in leaf litters. The variation is attributed to the differential mobility and leachability of the elements in the species litter (Isaac and Nair, 2005).

IV. CONCLUSION

The study provides an insight to the diversity and nutrient recycling potentials of agroforestry homegardens in southern Kerala. The homegardens studied represented multi- storied tree based systems with high cropping intensities, however, the diversity and evenness indices worked out were low. The tree species add substantial amounts of litter and nutrients contributing to the soil fertility status and thus sustaining the soil productivity in the tree crop systems. The litter accrued 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.

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REFERENCES

[1] Abdulsalam, M., Sathees Babu, R. and Mohankumaran, N. 1992. Homegarden agroforestry in Kerala will prove more profitable with planning. Indian Farming. 42 (5): 22-24

[2] Das, A. K and Ramakrishnan,P.S. 1985. Litter dynamics in khasi pine North East India. Forest Ecology Management 10: 130-153

[3] Ferenandes, E.C.M. and Nair, P.K.R. 1986.An evaluation of the structure and function of the tropical homegardens. Agricultural Systems 21: 279-310

[4] Isaac, S.R and Nair, M.A.2005. Biodegradation of leaf litter in the warm humid tropics of Kerala, India. Soil Biology and Biochemistry 37: 1656-1664

[5] Nair, M.A. and Sreedharan, C. 1986. Agroforestry farming systems in the homesteads of Kerala, Southern India. Agroforestry Systems 4: 339-363

[6] Saravanan, A., Kalieswari,R.K., Nambeesan,K.M.K and Sankaralingam,P. 1995. Leaf litter accumulation and mineralisation pattern of hilly soils. Madras Agricultural Journal 82(3) 184-187

[7] Shajikumar,V.M. 1991. Nutrient cycling in coconut based agroforestry system- contribution from litter fall of multipurpose trees. Project Report BSc. (Forestry) Kerala Agricultural University, Thrissur