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# Structural diversity, leaf litter recycling and allelopathic influences of leaf litter in an agroforestry homegarden of southern Kerala

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## ABSTRACT

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 systems. The present study explored the diversity of a selected tropical agroforestry homegarden in southern Kerala. It assessed the organic additions via litter fall from the perennial components, recycling through vermicomposting and allelopathic influence of litter on sprouting and early growth of tannia (*Xanthosoma sagittifolium*). The homegarden represented a multispecies cropping system with diversity index of 2.03 and annual litter additions of 1782.89 kg from the 28 perennial tree components. The amount of litter added by the different trees varied with the species, number and age. Recycling of the litter using earthworms was attempted and vermicomposting of litter could accrue nutrients to the tune of 10.67 kg N, 3.82 kg P and 1.71 kg K per year in the homegarden emphasizing the importance litter has on sustaining soil productivity. The allelopathic influence of selected eight species litter revealed that litter leachates at 2 per cent did not exert any significant allelopathic effects but when applied as mulch, mango, nutmeg and *Ailanthus* litter exhibited significant allelopathy on sprouting and seedling growth of tannia.

**Keyword:** Agroforestry; allelopathy; homegarden; litter; recycling

## INTRODUCTION

Agroforestry, the practice of growing trees in combination with agricultural crops with or without livestock is an integral component of the agriculture systems in Kerala. The state with many woody perennial-based land use practices is often regarded as the 'Mecca of agroforestry' (Kumar 2011). Agroforestry practiced in and around the farmer dwelling is characterized by the disparate and intricate species mix which is responsible for its uniqueness and ecological importance. The multiple functions performed by the system include the potential to provide food, fuel, green manure and timber resources, conservation of biodiversity, carbon sequestration, regulation of physical and chemical fluxes in ecosystems and mitigation of environmental pollution (Nair 2008). Analysis of the structure of the systems and the recycling potentials are important for further sustainable and eco-friendly interventions. In this background an investigation was undertaken in an agroforestry homegarden in Kollam, southern Kerala to assess the diversity, biomass additions from the different components, possible recycling of litter through vermicomposting and use as nutrient source in tuber crops and also to examine the allelopathic influences of selected species litter on sprouting and early growth of tannia (*Xanthosoma sagittifolium*), a popularly grown tuber inter-crop in homegardens.

## MATERIAL and METHODS

The field experiment on the structural analysis and organic recycling was carried out in a selected agroforestry homegarden in the western Ghat tract of Ummanur Panchayat, Kollam district, southern Kerala during 2013-14. The garden falls in the agro-ecological unit, 12 southcentral foothills of Kerala, (latitude 9°16'N, longitude 76°37'E, altitude 91.44 m amsl) and enjoys a warm humid tropical climate with mean maximum temperature of 35.13°C and minimum of 23.13°C. Data on tree-crop-livestock components in the system were collected during field visits and interactions with the farmer and litter additions quantified by collection of litter fall at monthly intervals in litter traps. Circular traps prepared using wire mesh nets each of 1 m diameter were placed beneath the tree canopies, the number per tree varying with the canopy spread. The annual litter fall was computed from the monthly litter collection as per formula:

$$\text{Annual litter fall (kg/year/tree area)} = \frac{\text{Canopy area (m}^2\text{) x } \Sigma\text{Monthly litter in traps (kg)}}{\text{Total area of the litter traps (m}^2\text{)}}$$

Mixed species litter samples from the system were subjected to composting using *Eisenia foetida* earthworms in tanks of 2 x 1 x 0.70 m, the time taken for the complete decay was recorded and nutrient contents in the composted litter were analysed as per the procedure to ascertain the possible nutrient accretions when used as nutrient source for crop production.

The allelopathic experiment was conducted using litter leachates and litter as mulch materials in tannia (*Xanthosoma sagittifolium*). Freshly-fallen litter of eight tree species commonly found in the agroforestry garden were collected and 2 per cent concentrations of the leachates were prepared by soaking 20 g of the samples in one liter of water overnight. Cut mini-corm pieces of tannia each of twenty five gram weight were planted in trays in soil medium and replicated thrice. The corms were irrigated with 10 ml of the leachate daily for three weeks and observations were taken. In the second study of allelopathy twenty five gram of the leaf litter was used for mulching tannia corms planted in grow bags (40 x 24 x 24 cm) filled with soil-FYM medium. The bags were irrigated as and when rains failed and observations on days to sprouting, sprouting percentage and root and shoot characters were taken in both the cases. The percentage inhibition on the seedling characters were computed from the recorded data.

## RESULTS and DISCUSSION

**Structural diversity:** The agroforestry garden of 0.8 ha included perennials (29 species including rubber) and annuals (12 cultivated species) in addition to the ornamental plants, livestock and poultry maintained by the farmer. The detailed inventory is presented in Table 1. Unlike monocropping the garden had an intimate mix of different species and this combination reflected the uniqueness of the homestead system compared to other agroforestry systems.

Coconut was the mainstay of the selected homegardens, a characteristic feature of homesteads in Kerala (Nair and Sreedharan 1986). Fruit trees predominated among the perennial species, rubber and nutmeg ensured financial security, green manure and fodder addressed the soil fertility and feed requirements of livestock components respectively. Food and nutritional security in the family was guaranteed by the fruit, vegetable and tuber crops grown in the homestead along with the cattle and poultry maintained in the system. Paddy crop was grown in an adjacent field (0.08 ha) and this catered to the staple food requirement of the family and straw formed the bulk feed of the animals. Organic recycling of the cow dung and poultry excreta reduced the need for external nutrient inputs for crop production by nearly 61 per cent. The Shannon-Weiner diversity index (H) and evenness computed revealed values of 2.03 and 0.61 respectively in the agroforestry homegarden. The index values of more than zero indicated the diversity and multi-layered canopy of the agroforestry system which could be the result of selection of species by the farmer with utility of the specific products as the main criterion (Krishnal and Weeraheva 2014). The mean evenness value of 0.61 in the garden indicated that evenness in abundance of the species is 61 per cent of what would have been under uniform or even distribution.

**Litter production and nutrient accretions:** The annual bio-wastes from the system amounted to 4.65 ton of which the litter output from perennials was to the tune of 1782.89 kg (38.6%) and the remaining were contributed by the crop residues, poultry and livestock wastes. The species-wise contribution of the trees to the annual litter fall is presented in Fig 1. Coconut and arecanut contributed nearly 62.39 per cent of the litter addition followed by mango (23%). The predominance of these species in the litter contribution can be attributed the higher number of trees of the species in the system. The quantum of litter fall per m$^2$ was different for the different species. O'Connell and

Sankaran (1997) reported that the amount of litter fall from different tree species varied with species, stand age, growth rate, climatic condition and soil properties which would explain the variations in the litter production among the different species in the present study. Studies on the litter dynamics in agroforestry systems have revealed similar variations and these are attributed to the intrinsic properties of the species and systems (Abraham 1998, Mathew 1993).

**Litter recycling:** Decomposition of litter (excluding palm and rubber litter) with earthworms (*Eisenia foetida)* illustrated that vermicompost production from mixed species leaf litter took six months, the turnover being 23 per cent of the litter material added, while other crop wastes decomposed in two months. The latter could be attributed to the succulent nature of the biowastes such as in banana and green leaves. Litter is a dry material with wide C-N ratio and high lignin contents (Isaac and Nair 2005) and this extends the decay time. Earlier studies on in situ decomposition of leaf litters in agroforestry systems by the same authors have revealed that natural decomposition of leaf litter took six to twelve months, the period varying with species litter chemistry.

Nutrient contents of litter compost were 1.586, 0.569 and 0.253 per cent N, P and K respectively indicating nutrient accretions to the tune of 10.67, 3.82 and 1.71 kg N, P and K per year respectively in the homegarden, the annual accretions being higher on account of litter fall occurring almost throughout the year although the quantum would vary. Nitrogen and phosphorus contents were found to be higher in composted litter while potassium was lower. Potassium being highly mobile (Tisdale et al 1997) would have been subjected to leaching losses via vermin-leachate that gets collected through the pipe fitted to remove excess water draining from the compost tank.

**Allelopathic effects:** The data on the allelopathic influence of the litter leachate and mulch on the sprouting and early growth in tannia (*Xanthomonas sagittifolium*) are presented in Table 2.

The results showed that the leaf litter leachates at 2 per cent concentration did not exert any significant allelopathic effects on the germination and early growth in tannia however litter as mulch significantly affected the sprouting and seedling growth. Among litter leachates although non-significant tamarind and jack leachates imparted maximum negative allelopathy. Mango and nutmeg leachates showed allelopathic effects on seedling growth rather than on sprouting.

Fig 2 illustrates the variation in the days to sprouting in tannia with litter application. The days to sprouting were between 36 and 40 in control but were significantly greater in nutmeg, *Ailanthus*, tamarind, mango and jack litter mulch. Cashew and rubber mulch were found to encourage early sprouting.Similarly leachates of the cashew, wild jack, jack and *Ailanthus* could bring about this positive allelopathic effect.

Perusal of the data on the effect of litter mulches (Fig 3) revealed that the inhibition of litter mulch recorded was to varying degrees in all species compared to control. Maximum inhibition in sprouting and seedling growth was observed with nutmeg, *Ailanthus* and mango. Contrary to the general concept rubber litter was found to have least allelopathic effect thus encouraging its use as mulch material. The peak period of litterfall in rubber coincides with planting time of tubers and hence can be suitably used for conserving moisture and preventing build up of soil temperature.

Species specific allelopathic influences have been attributed to the fact that plants vary in the amount of indigenous secondary metabolites synthesized and released in them (Melkania 1983) and release different amounts of the phytotoxins. Putnam and Duke (1978) reported that secondary compounds released from litter or formed during microbes decomposing are influenced by the type of crop being leached or decomposed. Singh et al (2009 ) based on their investigations concluded that allelopathic influences were species specific, had different effects on germination, radicle and plumule growth and the toxicity also depended on the concentration of allelochemicals in the medium.

Allelopathic effects of mango leachates have been reported in agricultural crops (Sahoo et al 2010) and it has been documented that release of allelochemicals and inhibition occur at the time of germination or at the early developmental stage, the stage at which the plantlets are more susceptible. In the present study seedling growth was affected with mango litter compared to sprouting. The maximum allelopathic effects observed in the soil mulched with crushed leaves compared to leachates in the experiment are similar to that reported by Divya and Yassin (2003). It was also noted that the inhibition observed with litter

Table 1. Inventory of the selected agroforestry homegardens (area: 0.8 ha)

| Component | Scientific names | Family | Growth habit | Number/area |
|---|---|---|---|---|
| Coconut | *Cocos nucifera* | Arecaceae | P | 36 |
| Jackfruit | *Artrocarpus heterophyllus* | Moraceae | P | 4 |
| Mango | *Mangifera indica* | Anacardiaceae | P | 5 |
| Wild jack | *Artocarpus hirsutus* | Moraceaea | P | 4 |
| Mahagony | *Swietenia macrophylla* | Meliaceae | P | 1 |
| Subabul | *Leucaena leucocephala* | Fabaceae | P | 1 |
| Cashew | *Anacardium occidentale* | Anacardiaceae | P | 1 |
| Bilimbi | *Averrhoia bilimbi* | Oxalidaceae | P | 1 |
| Breadfruit | *Artocarpus altilis* | Moraceae | P | 1 |
| Guava | *Psidum guajava* | Myrtaceae | P | 2 |
| Sapota | *Manilkhara zapota* | Sapotaceae | P | 1 |
| Rambuttan | *Nephelium lappaceum* | Sapindaceae | P | 3 |
| Nutmeg | *Myristica fragrans* | Myristicaceae | P | 24 |
| Wild trumphet tree | *Pajanelia longifolia* | Biogonaceae | P | 1 |
| Coffee | *Coffea arabica* | Rubiaceae | P | 2 |
| All spice | *Pimenta diocia* | Myrtaceae | P | 1 |
| Cherry | *Malpighia glabra* | Malpighiaceae | P | 2 |
| Flame of forest | *Butea monosperma* | Fabaceae | P | 1 |
| Indian hog plum | *Spondias purpurea* | Anacardiaceae | P | 1 |
| Luvlovi | *Flacourtia inermis* | Salicaceae | P | 1 |
| Amla | *Phyllanthus emblica* | Euphorbiaceae | P | 2 |
| Rose apple | *Syzigium samarangense* | Myrtaceae | P | 1 |
| Cassia | *Cassia fistula* | Fabaceae | P | 2 |
| Water rose apple | *Syzigium aquem* | Myrtaceae | P | 1 |
| Monkey puzzle | *Aruacaria araucana* | Araucariaceae | P | 1 |
| Arecanut | *Areca catechu* | Arecacaeae | P | 8 |
| Moringa | *Moringa oleifera* | Moringaceae | P | 1 |
| Papaya | *Carica papaya* | Caricaceae | P | 1 |
| Rubber | *Hevea brasililiensis* | Euphobiaceae | P | 80 |
| Banana | *Musa* spp | Musaceae | A | 25 |
| Elephant foot yam | *Amorphophallus paeniifolius* | Araceae | A | 70 |
| Tannia | *Xanthosoma sagittifolium* | Araceae | A | 40 |
| **Vegetables** | | | A | 0.04 ha |
| Bhindi | *Abelmoschus esculentus* | Malvaceae | | |
| Cow pea | *Vigna sesquipedalis* | Fabaceae | | |
| Chilli | *Capsicum annum* | Solanaceae | | |
| Brinjal | *Solanum melongena* | Solanaceae | | |
| Amaranthus | *Amaranthus* sp | Amaranthaceae | | |
| Foliage and ornamental plants | - | - | A&P | 25 nos |
| **Fodder grass** | | | | 0.15 ha |
| Guinea grass | *Panicum maximum* | Poaceae | P | |
| Hybrid napier | *Pennisetum* sp | Poaceae | P | |
| Turmeric | *Curcuma longa* | Zingiberaceae | A | 0.01 ha |
| Ginger | *Zingiber officinale* | Zingiberaceae | A | 0.02 ha |
| Arrow root | *Maranta arundinacea* | Maranataceae | A | 0.008 ha |
| **Livestock** | | | | |
| cows | *Bos taurus* | Bovidae | | 2 nos |
| Poultry | *Gallus domesticus* | Anatidae | | 10 nos |

Diversity index: 2.03, Evenness: 8.41

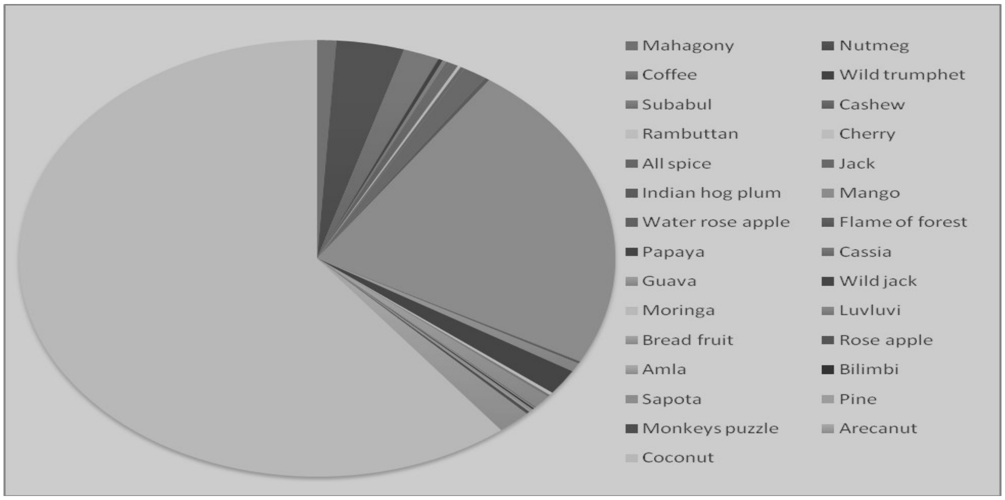


**Fig 1. Species contribution to the annual litter fall in the agroforestry homegarden**

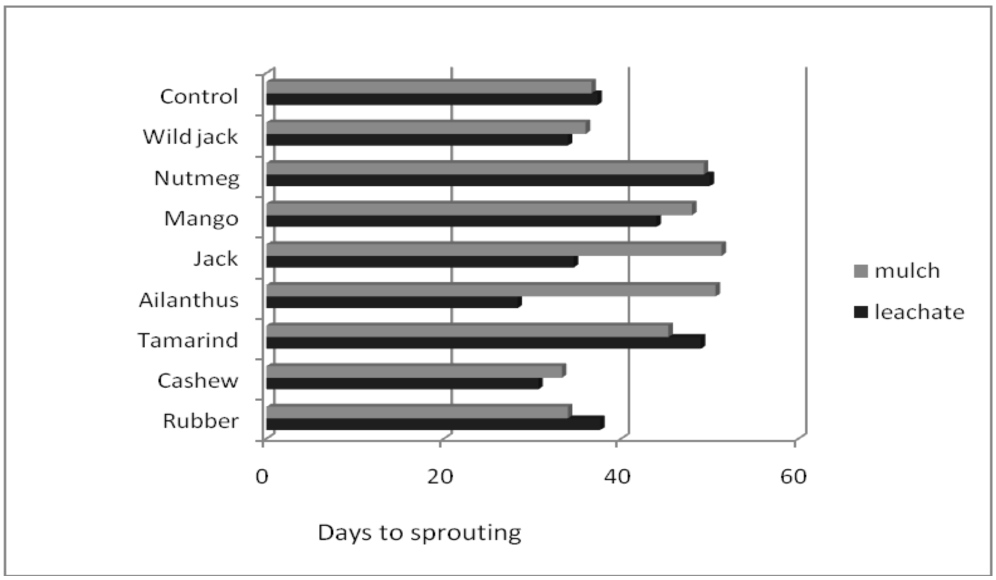


**Fig 2. Influence of litter leachates and mulch on sprouting in tannia**

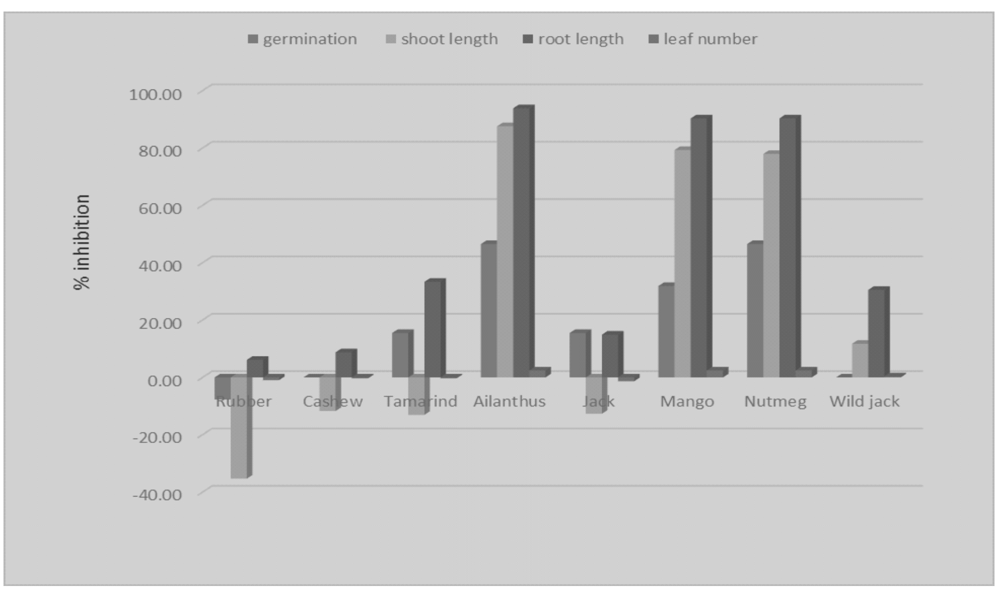


**Fig 3. Inhibition of sprouting and seedling growth of tannia corms with litter mulch**

Table 2. Influence of litter leachates (2%) and mulch on the sprouting and early growth in tannia

| Treatment | Sprouting (%) | | Shoot length (cm) | | Root length (cm) | | Leaf number | |
|---|---|---|---|---|---|---|---|---|
| | Leachate | Mulch | Leachate | Mulch | Leachate | Mulch | Leachate | Mulch |
| Mango | 100.00 | 58.86 | 11.33 | 5.00 | 17.67 | 3.67 | 3.67 | 1.58 |
| Ailanthus | 79.16 | 46.21 | 14.00 | 3.00 | 21.67 | 2.33 | 3.33 | 1.58 |
| Cashew | 80.00 | 86.42 | 13.33 | 27.00 | 23.67 | 34.67 | 2.67 | 4.31 |
| Tamarind | 64.38 | 73.02 | 10.33 | 27.33 | 21.33 | 25.33 | 1.00 | 4.31 |
| Jack | 65.14 | 73.02 | 15.67 | 27.23 | 24.33 | 32.33 | 2.67 | 5.31 |
| Wild jack | 93.08 | 86.42 | 12.67 | 21.33 | 23.00 | 26.40 | 2.33 | 3.63 |
| Rubber | 79.16 | 93.08 | 11.67 | 32.70 | 24.33 | 35.67 | 2.33 | 4.93 |
| Nutmeg | 100.00 | 46.21 | 10.67 | 5.33 | 21.33 | 3.67 | 2.33 | 1.59 |
| Control | 100.00 | 86.42 | 13.33 | 24.17 | 29.00 | 38.00 | 3.00 | 3.99 |
| $CD_{0.05}$ | ns | 1.34 | ns | 7.90 | ns | 8.74 | ns | 1.91 |

mulch was more on root growth. Ahmed et al (2008) working on *Leucaena* litter also documented similar inhibitory effects on root growth than on shoot growth. This would have a greater bearing on further growth as the roots are the anchor and absorbing organs of the plants.

## CONCLUSION

The agroforestry homegarden studied exemplified multispecies cropping pattern with a high biodiversity and litter production revealing the in situ organic resource potential existing in the garden. Vermicomposting took a longer period for complete decomposition of litter however nutrient contents were appreciable indicating that litter compost could be used in integration with other sources for crop production. The allelopathic effects examined in tannia revealed non-significant effects of litter leachates at 2 per cent concentration while mulches of mango, nutmeg and *Ailanthus* recorded significant inhibitions bringing to focus the non-suitability of these species litter as mulch materials in tannia.

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