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The diversity profile of pepper and banana based high range home gardens in Kerala

Nithish Babu M[a,*], Allan Thomas[b,!] & Lenin Venu[c]

[a]Department of Agricultural Extension, College of Agriculture, Agricultural University, Vellayani 695 522, Kerala
[b]Communication Center, Kerala Agricultural University, Mannuthy, Thrissur 680 651
[c]Department of Agricultural Extension, Indian Agricultural Research Institute, New Delhi 110 012

[*]E-mail: nithishkau@gmail.com; [!]t.allan@kau.in

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Kerala, renowned for its rich biodiversity, is endowed with home garden based agroecosystems which act as a reservoir to satisfy the escalating food, nutritional and economic demands of the people. The home gardens on the high range area are of typical, with complex biodiversity profile, peculiar ecological and edaphic factors. In this context, the overriding objective of the present study was to identify and analyze the diversity profile of the high range home gardens and also to compare the species diversity of different crop based home gardens in the high range area. The results of diversity index using Shannon and Weaners diversity index revealed that the total diversity (H't) of the home garden was high (H't=4.443 and H't=5.907) in 'pepper and banana'-based home gardens respectively, however the mean total biodiversity index (H'm) that could be considered as the real measure of biodiversity was (H'm=1.481 and H'm=1.969) which indicated that high range home gardens that was once considered to mimic the forest ecosystems with high biodiversity, is now attributing declining trends in diversity profile. However, the crop abundance profile disclosed that the high-value crops *viz*., spices and plantation crops dominated the home gardens of high range areas which subjugated the diversity of vegetables and tubers which act as the pillars of food security.

Keywords: Biodiversity, Food security, High range, Homesteads, Livelihood, Nutritional security, Shannon–Weiner index

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Home gardens are considered as the oldest known land-use systems in the world, which act as hotspots of biodiversity and also as 'epitome of sustainability'. Home gardens are traditional farming systems that provide a base for the sociocultural and economic well-being of the people, especially in the rural area. Home gardens are defined as the multi-storied combination of various crop plants in association with livestock that functions as a supplementary source of food and income for the family[1]. These are considered as miniature models of the natural ecosystem, which play a vital role in nutrient recycling and also ensure environmental resilience[2]. Home gardens are time tested experimental beds for implementation of sustainable and ecologically safe technologies, wherein, it acts as the gene banks that conserve plant genetic resources such as landraces, cultivars, wild varieties and endangered species[3]. Besides, it ensures rural employment, risk reduction due to diversification of crops, uplifting the status of women, and preserving the indigenous knowledge[4]. Home gardens are known as the reservoir of culture, traditions, management techniques and symbols of heritage[5].

Kerala is often consecrated as the 'Mecca of home gardens', owing to its rich species diversity, sustainability and ethnic values[1]. Home garden systems are the major source of nutrition and income for many households of Kerala, thus contributing to the food, nutritional and biodiversity security of the state fulfilling the different pillars of socio-economic and environmental stability[6,7]. The biodiversity in the home gardens varies depend on factors *viz.,* cultural aspects, climatic conditions, interest, domestic needs and economic factors[8,9]. Traditional home gardens ensure food security without relying on high energy inputs and recognized as ecologically safe and sustainable agroecosystems by using indigenous knowledge and resources[10].

*Corresponding author

With the dawn of commercialization, the traditional diverse cropping pattern was in the verge of extinction and the introduction of cash crops led to homogenization which threatens the rich biodiversity of home gardens[11]. The homogenization was more overtly observed for the mid regions than that of court yard or outer regions[6]. So there is an urgent need for better understanding of the home gardens to revive and conserve the existing biodiversity for the enhanced productivity and sustainability. Detailed investigations on the structural and functional characteristics of home gardens will facilitate the formulation of need-based technologies and policies for the upliftment of traditional home gardens. In this context, the present study is envisaged with an objective to assess the trends in high range home garden biodiversity of Kerala.

Materials and Methods

Study area

Idukki, the second largest district in Kerala with lowest population density, comprised of more than half of the area under forest cover was the study area. This land-locked district of Kerala contains rich biodiversity as it lies amidst the Western Ghats, one of the globally recognized hotspot of biodiversity. The region experiences an average annual rainfall of about 3677 mm a year with four major soil types *viz.,* forest loam, lateritic, brown hydromorphic soil and alluvial soil. Owing to its undulating topographical features such as hills and perilous terrains, most of the regions were not appropriate for crop-husbandry though the major economy of the district is based on agriculture. The present study was conducted in the high range home gardens of two panchayaths, Adimaly (10.01150 N, 76.95280 E) and Konnathady (9.94950 N, 77.04490 E) in the Idduki district of Kerala during the year 2018 to 2020. These panchayaths were purposively selected because of the dominance of banana and pepper-based home gardens.

Sampling

A total of fifteen home gardens were selected from each panchayat and the plant components were recorded for the assessment of biodiversity. Each home garden was divided into the courtyard (CY), mid-region (MR) and outer region (OR) for the comparison of biodiversity with reference to the different regions in a home garden. The crops were categorized into different groups based on their use as vegetables, spices, plantation crops, beverages, fruits, tubers, medicinal plants, ornamentals and multipurpose trees and the total count of plants were recorded. The identification of plant species was done with the help of scientists in the relevant fields.

In order to compare the biodiversity of different home gardens, Shannon-Weiner index of diversity was used. $H = -\Sigma Pi \log (Pi)$, where, $Pi = ni/N$ (ni = number of individuals of a species, N = total number of individuals of all species). "Variation in biodiversity" among and between groups was measured using ANOVA to analyze the differences among group means in a sample. The obtained data were analyzed statistically using WASP version 2.0 software.

Results and Discussion

The present study revealed that significant variability existed in the crop diversity in high range home gardens even though the region wise difference in biodiversity was varying and was less. A total of 154 plant species belongs to 58 families were recorded in banana-based home gardens whereas a total of 146 plant species under 54 families were documented from pepper-based home gardens.

In pepper based home gardens of Idukki, the predominant crop family observed was Fabaceae followed by Malvaceae, Cucurbitaceae, Moraceae, Myrtaceae, Zingiberaceae etc (Fig. 1). The banana based home gardens recorded highest diversity of Fabaceae followed by Myrtaceae and Aracaceae (Fig. 2). The present study revealed the rich diversity profile of home gardens in high range areas of Idukki district where the crop cafeteria showed a total of 154 plant species in banana-based home gardens and 146 plant species in pepper-based home gardens from

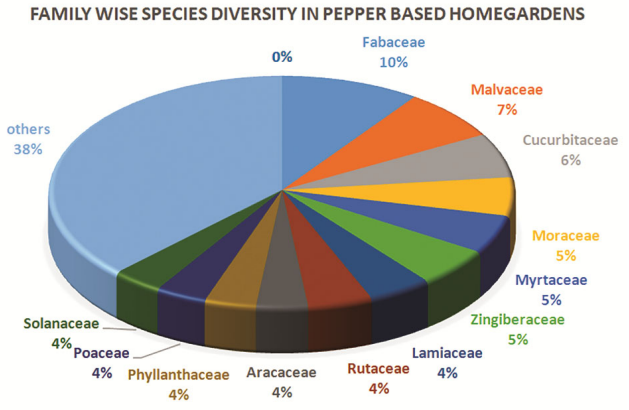

Fig. 1 — Family wise species diversity present in pepper based home gardens

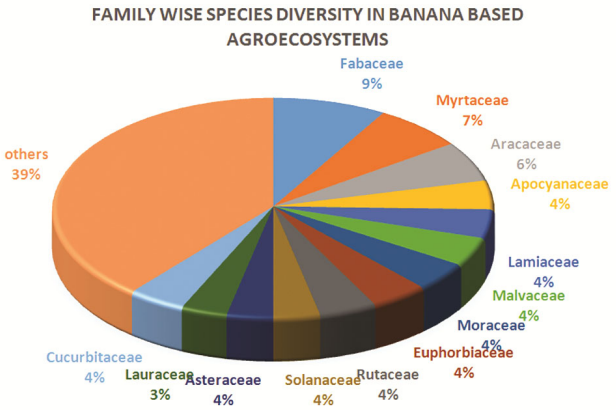

Fig. 2 — Family wise species diversity present in banana based home gardens

the surveyed lot of 15 home gardens each from both the cropping systems. This was higher than the previous findings as a total of 106 species of plants from the home gardens of Thrissur and the urban homesteads of Thrissur district exhibited lower diversity with 76 plant species[12,13]. A higher diversity exhibited by the homesteads of the select regions may be due to the ecological factors, as the place is a part of the Western Ghats, which is distinguished as a hotspot of biodiversity[13].

There were studies which recorded a total of 463 species of plants from home gardens of Central Kerala that indicated the high biodiversity[14]. Likewise, a total of 182 plants in 160 genera under 67 families were documented from the tribal home gardens of Attappady in Palakkad district[15]. This high species richness reported from home gardens of Central Kerala and Attappady regions of Palakkad district could be due to more number of homegardens included in the survey.

The predominant crop family documented from homesteads of Idukki district was Fabaceae followed by Malvaceae, Cucurbitaceae, Myrtaceae Arecaecea etc. Similar results were also recorded in the home gardens of Karantaka[16] whereas the present findings were contradictory to the study conducted in home gardens of Tamil Nadu which reported Euphorbiaceae as the dominant family followed by Acanthaceae, Asteraceae and Fabaceae[10]. This is quite natural that the decision making of the farmer is based on their choices considering the different physiological and eco-edaphic factors that exist in the respective areas of study.

The crop cafeteria with a total of 154 plant species in banana-based home gardens and 146 plant species

Table 1 — The crop diversity index in different regions of pepper and banana based high range home gardens

Type of home garden (H) Region (R)	Pepper H’	Banana H’
Court yard	0.907	1.370
Mid region	1.776	2.656
Outer region	1.760	1.881
Total biodiversity	4.443	5.907
Total mean biodiversity	1.481	1.969
F value	F_R 14.449**	F_R 8.708**
	F_H 8.898**	
CD (0.01)	CD_R 0.507	CD_R 0.837
	1.351	
SE	SE_R 0.157	SE_R 0.374
	0.731	
Individual home garden		
Highest	1.91	2.83
Lowest	0.91	0.96

** Significant at 1% levels

in pepper-based home gardens seems quite favourable in terms of species richness for high range home gardens, however to understand the diversity of crops with reference to different regions in high range home gardens, diversity index is to be measured that will give a clear picture of the crop structural configurations in home gardens and varying diversity that contributes to the change in structural configuration.

The crop diversity index in different regions (courtyard, mid-region and outer region) of pepper and banana-based high range home gardens are given in Table 1. The maximum crop diversity was observed in the mid regions (H=1.776) and it was found to be on par with that of outer regions (H=1.760). However, the courtyard recorded a significantly lower value (H=0.907) of biodiversity compared to the mid and outer region.

A similar trend in crop diversity was observed in banana-based home gardens with a higher value of biodiversity compared to that of pepper based high range home gardens and the recorded values for mid-region, outer region and courtyard were 2.656, 1.881 and 1.370, respectively. The findings of study on diversity index of crops in pepper and banana - based high range home gardens revealed the rich diversity profile of banana based home gardens (H’mean=1.968) than that of pepper based home gardens (H’mean=1.489) in high range areas of Idukki district. The results show that biodiversity is on the decline side if compared to the works in home gardens of Thailand which recorded a similar

Shannon-Weiner diversity index that ranged from 1.9 to 2.7 which was comparable to the diversity index of a dipterocarp forest in Thailand[17]. However, from Table 1, the research undoubtedly proves that certain home gardens from the total sample of both the cropping systems showed high biodiversity (max H'=2.83) and this index can be compared to the findings that recorded a comparable Shannon-Weiner diversity index of tropical homegardens that ranged from 1.12 - 3 which was similar to the diversity index of a forest ecosystem[18]. Individual cases of reported high biodiversity even though are encouraging; conceivably, the mean biodiversity index of home gardens reveals the lowering of biodiversity in high ranges.

The significantly lower biodiversity in the courtyards of both pepper and banana based home gardens is a matter of concern. This can be attributed due to the indiscriminate utilization of the land surface immediately near to the house in the front region for aesthetic derivation. Many households have their courtyards plastered or interlocked with concrete blocks and transformed their gardens to pot culture that has adversely affected vegetation, its composition and its regeneration capacity. Intensively cultivated areas have lost all natural vegetation except a few roses, crotons, ixoras, hibiscus jasmine, orchids, anthuriums and like in small proportions that too in pot culture. This has resulted in loss of diversity of natural fauna and flora that faces local extinction. Kala home garden courtyards are a spectacular buildup of associated biodiversity with butterflies, dragonflies, ladybugs, grasshoppers and beetles. All of these had an important role in crop pollination that we trust upon for food in natural ecosystems. When human converts this biodiversity into mere concrete structures or interlocks for artificial aesthetic or easy maintenance, it may lead to the disappearance of pollinators and would eventually impact crop production.

Also, the highest crop diversity was observed in the mid regions of both pepper and banana-based home garden systems. The results of the study are in conformity with the previous findings that reported a higher biodiversity index in the mid-regions of home gardens of Kerala irrespective of the size of holding and district[19]. This was attributed due to the easiness of gardener to adopt better management practices with reference to spatial planning, incorporate more crop components in the existing crop cafeteria especially in home gardens with more area and also provide better care of the crops at mid-region compared to outer regions.

In contrary to this, a higher biodiversity index in the outer regions of the home gardens in different districts of South Kerala were reported[20]. They attributed this due to the planting of perennial multipurpose tree crops that were both commodity and non-commodity in nature. Household entity behavior of dumping of organic waste, seeds of consumed fruits and natural regeneration was another reason for high biodiversity in the outer regions. Even though the mean diversity index does not reflect on highest biodiversity in the outer regions there were instances of high biodiversity index reported for some individual home gardens in the study area.

An attempt was further made to assess and infer the diversity index of crops domesticated in high range home gardens with reference to pepper and banana based cropping system. The diversity index of crops in pepper and banana based high range home gardens is presented in Table 2.

In pepper-based home gardens, the highest diversity was recorded in spices (H=1.318) compared to all other crops and the range of diversity index values for different crops varied from H= 0.181 (medicinal plants) to H= 1.318 (spices). The diversity index of different crops in the decreasing order for spices based high range home gardens was for spices (H=1.318) followed by MPTS-Multi Purpose Tree Species (0.824), plantation (0.652), fruits (0.495), tubers (0.468), ornamentals (0.262), vegetables (0.244) and medicinal plants (0.181).

In banana-based home gardens, the highest diversity was recorded in spices (H=1.253) and was

Table 2 — The diversity index of crops in pepper and banana - based high range home gardens.

Type of home garden (H) Crop (C)	Pepper	Banana
Vegetables	0.244	0.327
Tubers	0.468	0.412
Fruits	0.495	1.031
Plantation	0.652	1.156
Spices	1.318	1.253
Medicinal plants	0.181	0.121
Ornamentals	0.262	0.303
MPTS	0.824	0.765
Forage	0	0.046
F value	**25.336****	**21.117****
CD (0.01)	**0.273**	**0.364**
SE	**0.133**	**0.153**

** Significant at both 1% levels

on par with the plantation crops (H=1.156) and fruit crops (H=1.031). The diversity index of all other crops was significantly lower than that of spices, plantation and fruit crops. The range of diversity index values for different crops varied from H= 0.046 (fodder) to H= 1.253 (spices). The diversity index of different crops in the decreasing order for banana-based high range home gardens was for spices (H=1.253) followed by plantation (1.156), fruits (1.031), MPTS (0.765), tubers (0.412), vegetables (0.327), ornamentals (0.303), medicinal plants (0.121) and fodder crops (0.046).

In both banana and pepper-based home gardens, the highest diversity of spice crops may be due to the ecological peculiarities of the region which favour the cultivation of spices along with the assurance of high economic returns. Furthermore, the dominance of spices in the home garden reduced the soil temperature and soil evaporation rate, thus maintained the soil microclimate which favours the diversity of crops in the spice based cropping systems[21]. The higher vegetative cover provided by the plantation crops mitigate the soil erosion problems, improves soil health and upgrade the species composition in the area[22]. The home gardens of Kerala were not only focusing on the food security, rather concentrated on economic aspects especially in Idukki and Kottayam districts as they introduce more cash crops in the crop cafeteria[23].

The higher diversity index of MPTS in the pepper-based home garden was due to the necessity of shade for the cultivation of pepper and the farmer's habit of retaining all type of tree species for trailing pepper. This may be also due to high market value of the multipurpose tree species and these species does not require additional management practices. The tree species grown around the gardens enhance both the productivity and also resource use efficiency[24].

On comparison with pepper-based home gardens, diversity of vegetables and fruits were higher in banana-based home gardens and the reason behind this can be explained with the geographical difference between the regions. Besides, frequent intercropping of vegetables in the early growth stages of banana may assure an additional income for the home garden farmer. In general, diversity of vegetable crops and tubers were comparatively less in the high range home gardens. The lower diversity index exhibited by vegetable crops was due to the peculiar climatic conditions prevailing in the area were not in support of cultivation of vegetables except cool-season vegetable crops during the tenure of study. Moreover, the farmers in Idukki district were more focused on the cultivation of cash crops which may create downstream effects on the food security of the region. Many of the traditional homegardens were in a shift from subsistence-oriented agriculture to market economy through incorporation of high value vegetables, which resulted in unforeseen consequences in the ecosystem that could have impacted in lowering the overall biodiversity[25].

The diversity index of medicinal plants and ornamentals were also found to be lower in high range home gardens of Idukki. A study conducted on the home gardens of Idukki district revealed that cultivation of medicinal plants was diminishing in the region owing to the increased reliance on the allopathic medicines[26]. In contrary to this, previous findings pointed out that ornamentals were dominated in home gardens of Tamil Nadu followed by medicinal and edible crops[10]. The variability in the crop diversity of different home gardens relies upon preferences of the family, socio-economic and ecological factors[27]. The homestead gardens exhibited a great diversity in floral compositions as influenced by climatic and geographic uniqueness of the region[28,29].

Conclusions

The good floristic diversity exists in high range home gardens in isolation is an indication of the capability of home gardens to function as a reservoir of genetic diversity despite the menace of modernization. However, the low mean diversity index is also an indication of the importance to device extension strategies and programmes to ensure conservation of existing biodiversity and further to augment biodiversity through spatial planning of crop cafeteria by considering the peculiar ecographic and climatic conditions of high ranges. The vast diversity of cash crops in the region ensures the income generation potential of the home gardens. The lower diversity of vegetables and tuber crops shows the feeble role of home gardens food and nutritional security were not attained in the high range home gardens.

People should be encouraged to cultivate medicinal plants, ornamentals and kitchen garden at least on a small scale on the available lands focusing either the courtyard region, backyards or outer region.

The neighborhood system of People's Planning, Kudumbasree Programme, youth clubs may be strengthened to take up cultivation in home gardens as micro enterprises. If organized micro markets and value addition centers can be linked to the production catchment, many more home garden farmers will be motivated to venture in farming and it will not only help in achieving additional profit but also will augment the biodiversity of the high range home gardens. In this scenario, proper planning and implementation of site-specific technologies for crops which ensure the food and nutritional security of the people is the need of the hour.

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Conflict of Interest

The authors declare that they have no conflict of interest in the study undertaken.

Authors' Contributions

NBM- Field trips, data generation, data analysis, writing the manuscript; AT- editing/correcting manuscript; LV- editing/correcting manuscript.

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