BIODIVERSITY ANALYSIS REPORT

ATHIRA S KRISHNAN

Thanal

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COMPARATIVE BIODIVERSITY ANALYSIS OF ORGANIC FARMS, CONVENTIONAL FARMS AND FARMS UNDER THE PERIOD OF CONVERSION TO ORGANIC

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December 2024

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Athira S Krishnan
Programme Officer, Thanal Trust

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OBJECTIVE

The objective of this Systematic Monitoring is to do a comparative analysis of the biodiversity in organically maintained farms in Wayanad with conventional fields over a period of specific time.

PRINCIPLE

Biodiversity is the variety of life on the planet. Natural biological diversity in ecosystems provides direct benefits and products to people, such as medicines, shelter, food, fuel, and clothing as well as cultural, aesthetic and recreational values. Biodiversity monitoring – the systematic observation and recording of various life forms and ecological processes in an environment – is vital for assessing the impact of pressures on the natural environment, such as human activities, climate change, and other environmental factors; and in making informed decisions for nature conservation and sustainable management of natural resources.

METHODOLOGY

1. Select one meter square spaces at 10 different locations in a field and analyze what all diverse flora is present in the selected area.
2. Collect topsoil samples up to one inch below the surface during early morning and late evening from the selected 2 spots. Mark location, Date and time of collection.
3. Then the next day early in the morning, visit the selected farm and study all fauna which are seen on the soil surface, one inch below the soil and on the flora. The findings are to be recorded with a picture and its numbers in that selected area.
4. Take the average of the population found in 10 different spots in the field.
5. Field visits have to be made 3 times a day in 3 weather conditions (Rainy weather, Dry weather, Hot weather, cold weather). That is early morning 6 am to 7 am, Day time 11Am to 12 noon ,evening 6 Pm to 7 Pm .

SAMPLE POPULATION

We have decided to study randomly selected organic farms (15 nos) and conventional farms (5 nos) in Wayanad District. Among organic farms, those under 1st, 2nd and 3rd year of conversion were also selected (5 nos each).

DISCUSSIONS

Organic agriculture is normally defined as any farming system where the use of pesticides, herbicides and synthetic fertilizers is prohibited or strictly limited. Organic farms often have other differences, for example they tend to use more complex crop rotations as a weed- and pest-control strategy and use animal manure, green manure or compost in place of synthetic fertilizers. Conventional systems, however, use pesticides and inorganic fertilizers to various degrees and often use simplified crop rotations and fewer crops. For the comparative study of biodiversity, the following parameters are used for comparing organic farms, conventional farms and farms under organic conversion:

1. **Invasive plants**
2. **Pest- Defender dynamics (P:D Ratio)**
3. **Farming system**
4. **Crop diversity and field management practices**
5. **Biological indicators and Ecological Interactions**
6. **Wild edible and medicinal plants (uncultivated)**
7. **Plant species showing wild growth that are beneficial**

Findings from recently collected data -Rainy season

1.Invasive plants

The invasive plants identified in selected farm lands include Lantana camara, Mikania micrantha, Mimosa diplotricha, Parthenium hysterophorus and Sphagneticola trilobata. Among these, Mikania micrantha (Mile-a-minute) and Sphagneticola trilobata are the most challenging to manage. According to the Global Invasive Species Database, Singapore daisies are one among 100 of the "World's Worst" invaders (*Invasives, n.d.*). These invasive species disrupt natural ecosystems by altering soil structure and microenvironments to their advantage through the production of allelochemicals, which lead to the decline of native species and local biodiversity. They also affect the food chain *Lone PA, (2019)*. Once established, they are costly to control and also affect the crop yield by limiting soil nutrients. Parthenium hysterophorus is particularly problematic, releasing allelopathic chemicals that inhibit the growth of crops and pasture plants, as well as allergens that can harm humans and livestock. This weed is considered to cause some allergic respiratory , contact dermatitis and mutagenicity in livestock and humans *(Patel, 2011)*. Mimosa diplotricha forms impenetrable thickets that invade, especially agricultural systems. It's difficult to control using mechanical or chemical means disrupting the natural ecosystem, biodiversity and livestock rearing. Controlling these weeds is an additional expense for farmers every season. The roots or propagating structures overwinter in soils during the summer season and will flourish in rainy seasons creating a smothering effect on crops. The growth of crops is thus suppressed affecting the overall profit.

The invasive plant population was found to be lowest in conventional fields compared to organic fields. The reasons for this are assumed as: regular application of weedicides, poor soil microbiome resulting due to excessive tilling and irrational application of chemical fertilizers may destroy the propagating structures of the plants. In conventional fields, farmers are spraying Round up once in 2 months as a solution for controlling these invasive weeds.

Recommendations

Adopting soil conservation measures like mulching and cover cropping was found effective. Maximum utilization of land area without leaving it barren can have a smothering effect on weed growth. Planting cover crops like Bush cowpea, brazilian groundnut, sesame and black gram in vacant spaces along with main crops shows multiple benefits for farmers like additional income, soil fertility maintenance and weed management. In paddy fields, after the harvesting period, cultivating low maintenance short duration crops like bush cowpea, millets and dhaincha adds soil fertility and controls wild growing weeds. State government is now supporting farmers by providing these seeds for crop rotation in paddy fields. Using dried leaves and green leaf manures as mulches also smothers the weeds by limiting the oxygen availability for their overwintering structures to flourish during favourable climate. It is also a cost effective method to control weeds. Spraying concentrated cow urine directly to weeds is successful in controlling the weeds in small scale farming areas but this will dry up crops too. So applications with utmost care can be employed.

Studies show that the presence of beneficial fungi in the soil has been shown to significantly inhibit the growth of weeds. This is because beneficial fungi secrete acidic enzymes which lower soil pH. The reduced pH levels inhibit the ability of nitrifying bacteria to transform ammonia into nitrates that is vital for weeds to flourish. So maintaining a better soil microbiome can suppress the weed growth too without any

Some invasive plant species

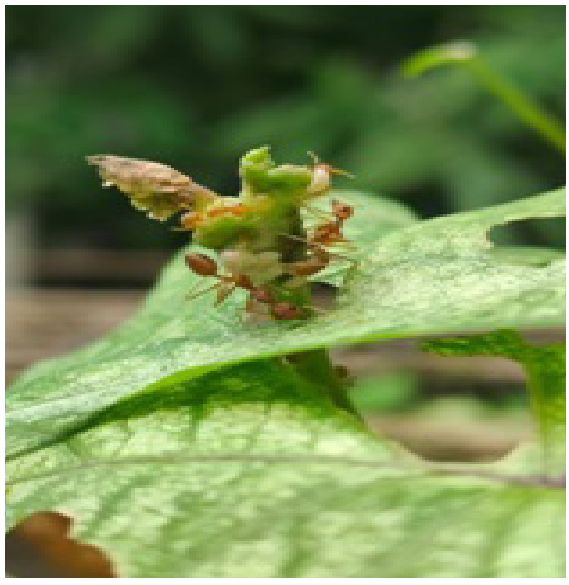
additional management costs. For that, organic formulations like Jeevamrutham, Amruthapani, farm yard manure etc can be used to generate a healthy and sustainable soil microbiome. Instead of using fungicides and insecticides that affect soil beneficial organisms, applying manures enriched with entomopathogenic fungal and bacterial cultures like Trichoderma viride and Pseudomonas fluorescens can control soil borne pathogens as well as maintain soil biomes.

2.Agroecosystem analysis - PD Ratio

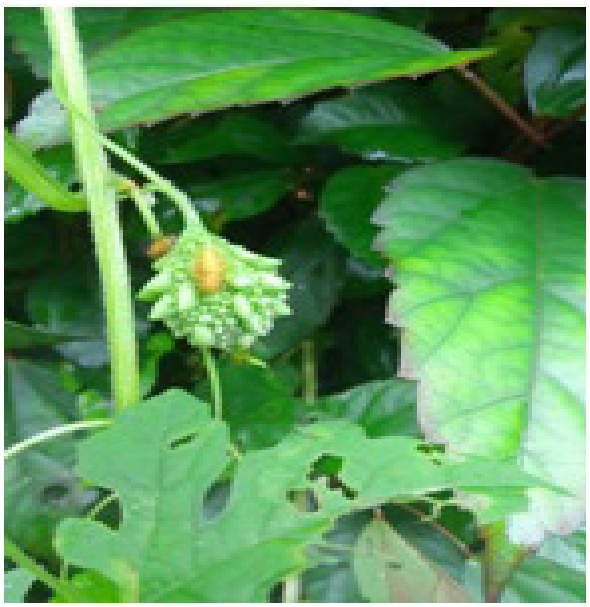
Identifying the number of pests and beneficial insects helps the farmers to make appropriate pest management decisions at proper time. The general rule to be adopted for management decisions relying on the P: D (Pest -Defender ratio) ratio is 2: 1, ie, when analysing a single plant in a selected area, for two pests there should be one defender. This is a common method used in farm schools, where extension agents along with farmers identify the pests and diseases in the selected fields. This was a successful approach that helped farmers in distinguishing pests and predators and also aids in early management.

Biodiversity monitoring data of the months September- October showed that disease incidence was severe due to heavy rain in Organic fields. Diseases like Sigatoka leaf spot in Banana, powdery and downy mildew in Vegetables and damping off of seedlings was severe in some regions. Presence of Banana leaf roller, which is an invasive pest, also surged in Nendran variety in one of the 3rd year organic fields. This may have reached Kerala through infected planting materials imported from

Pests and defenders spotted in fields



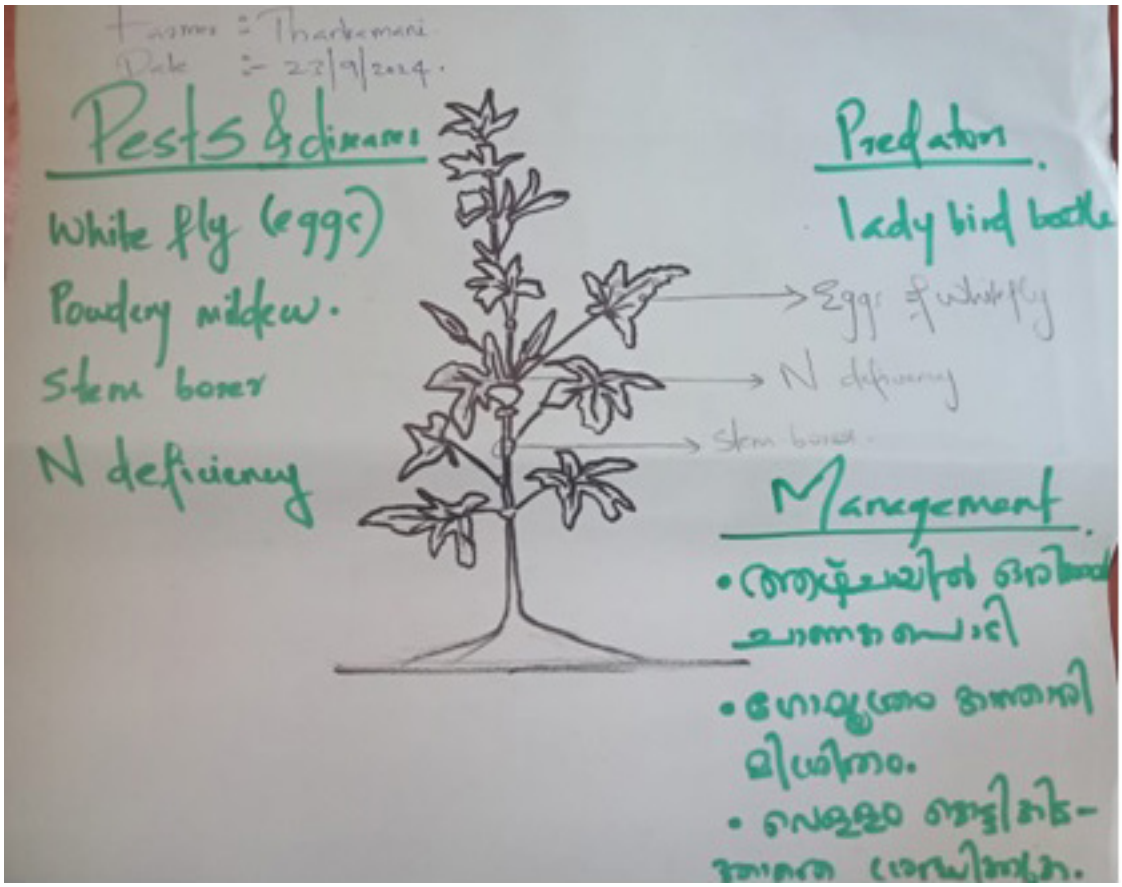
other states in India. Most common predators observed in fields are red ants, reduviid bugs, praying mantis, lady bird beetles, spiders and wasps. In 3rd year pepper fields, the armyworm attack was found to be severe which attacked both the nursery and adult vines, which was found to be very difficult in managing. But in November- December data, the attack of sucking pests like white flies, thrips and aphids became severe in vegetable crops due to intermittent rain and hot weather conditions.



Organic fields under 1st and 2nd year of conversion showed more pest attacks and the defenders population was low. So application of pest repellents like neem oil garlic emulsion, diluted cow urine, 5 leaf extracts and biocontrol agents were recommended and the infestation were controlled. Also inoculative release of natural predators and parasites was found very effective. For example, in cowpea fields, when the aphid infestation became severe, release of red ant population to the pandal along with routine spray of entomopathogenic fungal culture of Verticillium lecanii helped in management. In paddy fields, installation of egg cards of Trichogramma chilonis and Trichogramma japonicum- egg parasitoids, was very effective in controlling the stem borer attack. So the biological control method of augmentation can be adopted But in 3rd year fields, the pest and defender ratio was almost equal.

In the case of conventional fields, the predator three categories. Monocropping system harbors more pests (those with similar feeding habits and mode of propagation) on host plants and also irrational application of chemicals in the

farm poses a great risk on the reproduction of predators and parasites. Predators and parasitoids are frequently misidentified as pests, leading farmers to use chemical pesticides against these beneficial organisms. Through regular monitoring, farmers learned how to differentiate between pests and beneficial predators, helping in conserving these beneficial insects and reducing frequency of pesticide sprays.



Agro-ecosystem analysis at selected fields

Soil sample collection for soil analysis

Plot division for biodiversity monitoring

Farming systems

Agriculture is not only about food production and livelihood generation. It is multifaceted. The contribution of agricultural landscapes to society goes beyond provisioning ecosystem services (e.g. production of food, forage and fiber). Farmlands can contribute with a wide range of other key ecosystem services to society such as regulating (e.g. climate regulation, pollination) and cultural (e.g. aesthetic and/or touristic values), while providing habitat for biodiversity.

Agricultural intensification has been pinpointed as a major driver of land use change, causing landscape homogenization, habitat degradation and loss, and the decline of species of conservation interest. From the field data collected, those managed under intensive farming systems (monocropping, excessive tillage, excessive application of chemical fertilizers and pesticides etc) contribute mainly to food and fiber production, but at high costs for the natural environment. Conversely, farmlands managed under low intensive farming systems,

Different intercropping systems observed in selected fields

have been highlighted in showing a wide range of ecosystem services. Characterized by low usage of agrochemicals, minimal mechanization and rotational land use, this farming system utilizes more natural resources thus promoting heterogeneity. Especially, the agroforestry farming system and homestead integrated farming system fields showed the highest degree of diversity of birds, uncultivated edible leafy vegetables, uncultivated medicinal plants, pollinators and predators and better yield.

All the selected samples are practicing the Intercropping system. Majority of the selected samples followed coffee based and arecanut based integrated farming systems. Coffee intercropped with fruit trees, green manure trees, arecanut, pepper and livestock/poultry was the common system followed in most of the fields. In conventional fields, where large quantities of cow manure is usually used along with other chemical fertilizers like urea, factamfos etc also showed considerably good diversity of flora and fauna and the soil carbon was also found medium. Among the sample population, the fields under 3rd year of organic conversion showed significantly high degree of diversity in terms of production as well as other ecosystem services. The soil organic carbon content in those fields were also medium which was concluded on the basis of soil testing as well as soil biodiversity. Some research studies also point out that coffee plantations with enough shade (intercropping of coffee with fruit trees) showed higher degrees of pollination (improved nectar quality) and increased caffeine content than those grown in full sun. *Prado (2019).*

In the integrated farming system, it was noted that a balanced food chain was established. For example, termite populations are controlled by poultry, larvae of pests are eaten by birds, ants are predatory on aphids and whiteflies etc. One of the 3rd year organic fields practiced an agroforestry system, where fruit crops are planted along with pepper, turmeric, ginger and herbs. This field was rich in pollinators, birds and beneficial insects and also the soil quality was very high. Also any yield loss from the main crop pepper is compensated from the tubers and fruit crops.

3.Crop diversity and Field Management practices

Increased crop diversity over both space and time is associated with improved soil health, pest control, decreased erosion, and increased nutrient cycling. There are several reasons that diverse plantings experience fewer pest problems. First, it can be more difficult for specialized herbivores to find their host plant against a background of one or more non-host species. Second, diverse plantings may provide a broader base of resources for natural enemies to exploit, both in terms of non-pest prey species and resources such as pollen and nectar provided by the plants themselves, building natural enemy communities and strengthening their impacts on pests.

Monocropped fields showed an increased population of one or two species (flora and fauna). For example, tapioca fields were having high levels of whitefly infestation which are the major vectors of yellow vein mosaic seen in tapioca. Some weed plants were found to be the host for some of the common pests. It was noted that Chromolaena odorata is a preferred host plant of aphids, which in turn is attracted by many lady bird beetles (predators). In case of crop rotation, high manure requiring crops followed by low manure requiring crops, rotating crops from different families etc can control pests and diseases and maintain soil quality. For intercropping, deep rooted plants intercropped with shallow rooted plants were found effective in soil nutrient absorption and water utilization. Deep rooted plants absorb water and nutrients from the deeper layers of soil, which is returned back to the top layers through fallen leaves and debris making it available for shallow rooted crops.

Field sanitation (crop residue management, removing plants that are heavily infested with disease or pest) , ensuring proper drainage and proper composting are the important steps to be followed for maintaining a healthy crop. Improper field management can increase the incidence of pests and diseases. Majority of the organic fields were not properly maintained. Crop residue remains serves as a medium for pest outbreak especially in summer season. For instance, in some fields, many banana plants were found to be affected by pseudostem weevils. The dried and diseased leaves often hide the early signs of infestation, making it difficult to detect. During the rainy season, fungal leaf spots spread through spores dispersed by water splashes. Removing and destroying infected plants can help prevent the disease from spreading to healthy plants

while maintaining overall yield. Poor sanitation practices are a significant cause of crop yield losses.

Adopting ecological engineering practices—such as planting pollinator-friendly and defender-attracting plants as border crops, incorporating trap crops in strips, and utilizing companion planting—can effectively boost the population of helpful insects on farmlands. For instance, in wetland paddy fields, planting nitrogen-fixing legume plants like cowpeas and red grams on the bunds significantly increased the number of predator and pollinator species, such as honey bees,Reduviid bugs and green lacewing bugs. Flying sounds of the bees add an advantage of keeping away the herbivores from attacking crops. Promoting a live ecosystem for natural enemies is a more cost-effective pest control strategy compared to the inundative release of biological agents in large numbers.

Reluctance in timely harvesting was also a major issue found in organic fields. Harvesting is a crucial step in farming as the method and time of harvesting affects the further yield of the crop. Fruit or vegetable remains on plants serve as egg laying sites for pests. Some pests like fruit flies pupate in soil, pumpkin beetles lay eggs in the soil. So, Improper disposal of pest infected produce can cause pest outbreaks in the next cropping seasons.

Poorly managed fields

4.Biological Indicators and Ecological Interactions

Bioindicators are species that show a response to problems in an ecosystem such as chemicals, pesticides, and pollution. Bioindicators may display deformities or die due to the changes in their environment, alerting scientists that action needs to be taken.

In 5 out of 15 organic fields, different species of frogs were spotted. Eggs of frogs were also spotted on leaves as a frothy excretion. Frogs are an excellent bioindicator of water quality. They have semi permeable skin that needs to stay moist in order to breathe. This means that they easily absorb pollutants, hormones and chemicals that run into water. When this happens the normal body development is altered. So in a polluted aquatic environment, the frog population will be less or nil. Many frogs have life cycles that use both terrestrial and freshwater habitats, making them vulnerable to environmental stressors including temperature changes and UV radiation. Apart from this, frogs are an important component of the food web. They keep check on mosquito breeding.

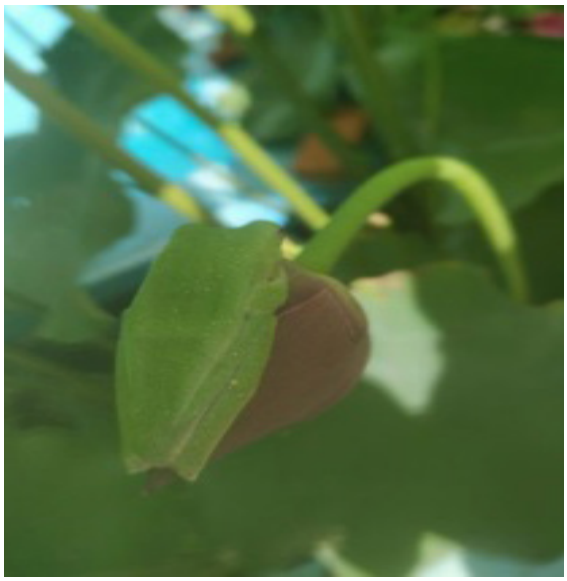
The other important plant bioindicators observed are lichens and mosses. Lichens are an association of fungi and algae. They respond to environmental changes very fastly including air quality and climate. Research studies show that the disappearance of lichen population in a forest may indicate environmental stresses, such as high levels of sulfur dioxide, sulfur based pollutants and nitrogen. In fields under 2nd and 3rd year of conversion, the population of lichen was very high. Different forms of lichen like foliose, fruticose and crustose were noticed in fields. Conventional fields showed

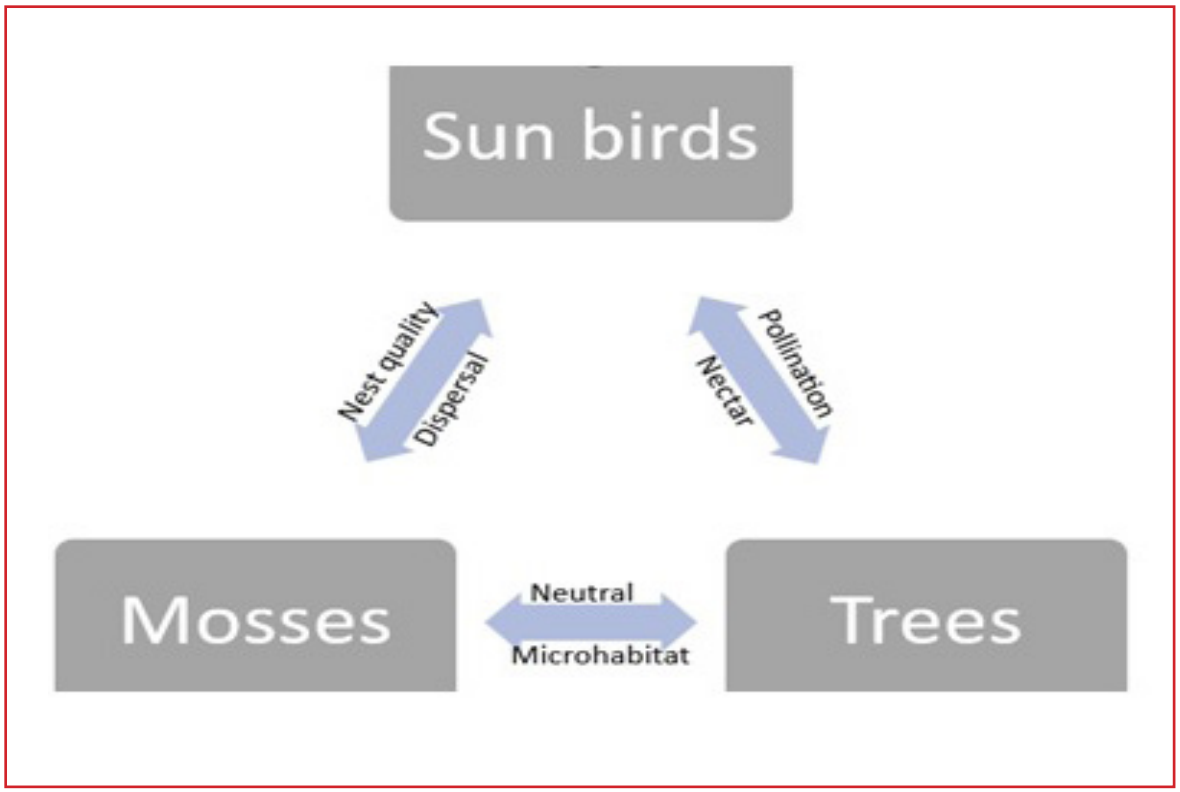
Different species of frogs observed in organic fields

a low population of lichens. This may be due to the overuse of pesticides and chemicals in agricultural land.

Different types of ecological interactions were noticed in fields during monitoring. Irrespective of conventional or organic, interspecific and intraspecific interactions like commensalism, mutualism, competition, predation and parasitism were spotted. For example, ants on coffee trees was a common observation found in all coffee plantations. This ant- plant interaction is in one way considered as mutualism. Because trees provide ants with shelter and in return ants feed on parasitic fungi on trees and aids in seed dispersal. But some research studies focusing on aggressive ants and altered microbial community in coffee flowers suggests that, the presence of aggressive ants on coffee plants reduced the visitation of pollinators and floral visitors on coffee flowers by altering the microbial diversity and species composition within flowers. *(Vannette, R. (2017).*

Algae and mosses growing on tree trunks are another example of ecological interaction- commensalism. This interaction was observed in all the coffee plantations. But there exists some unknown relations among mosses and trees. Moss helps control the flow of water in a forest ecosystem. By slowing the passage of rain down tree trunks, moss colonies hold water in their leaves, allowing the roots of other plants to be nourished for longer. Mosses also absorbs water from mist, their 'hair-like leaf points aiding in the condensation of fog droplets'. Mosses allow the forests to stay rich and damp, even in drier seasons. So there exists mutualism too. Various studies on cryptic interaction of mosses- trees- sun birds are also going on. Below is a flow chart showing this interaction *(Fontúrbel, F. E. (2020)*.

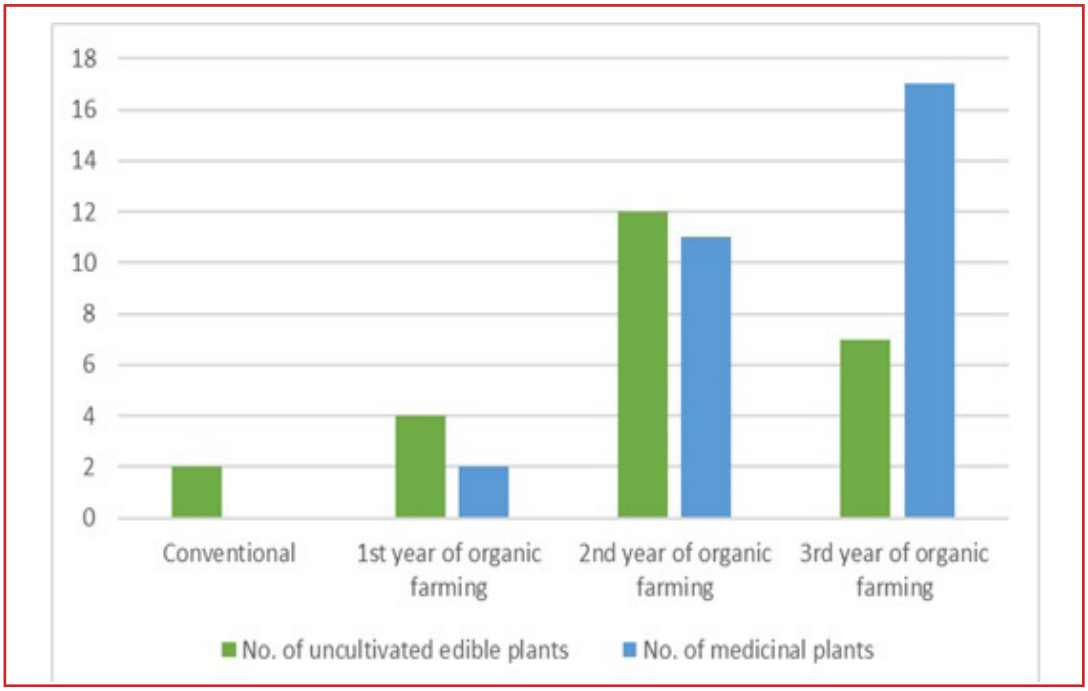


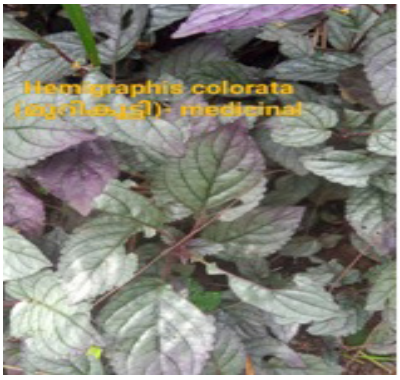


Various Ecological Interactions

5. Diversity of uncultivated medicinal and edible leafy plants

Western ghats are one of the world's biodiversity hotspots, harboring a vast floral diversity. This includes a large number of wild edible leafy vegetables and medicinal plants. The indigenous community here has a thorough knowledge about the medicinal properties and nutritional quality of these plants that are considered as weeds by modern man. From 20 selected fields, more than 20 plant species were identified having high medicinal value. The count was high in organic fields under the 3rd year of conversion and the diversity was very less in conventional fields. 3rd year organic fields showed high soil organic carbon, optimum soil temperature, minimum tillage, improved water holding capacity of soil and proper shade management creates an ideal condition for the propagation of these plants. Some of the common medicinal plants found where kaempferia galanga,Breynia androgyna, wild bitter gourd, Caesalpinia mimosoides, Hemigraphis colorata, Scorpia dulcis, Justicia gendarussa, Nilgirianthus ciliatus, Physalis angulata, Cyanthillium cinereum, Centella asiatica, Solanum nigrum, Cyathula prostrata, Ayapana triplinervis, Phyllanthus niruri and Leucas aspera. Apart from having good medicinal value, these plants possess high nutritional quality too. Increase in monoculture plantations affects the diversity of these indigenous plants and reduces the natural stability of agricultural land. The below graph shows the population of wild and uncultivated edible plants and medicinal plants found in sampling areas.




Hemigraphis colorata
(തുരുകുട്ടി): medicinal


hekkurmanis


അരൂത


Hemidesmus indicus: Indian
sarsaparilla(നന്നാറി)


cherukadaladi


തഴുതാമ


കല്ലോന്നി


ചെറുള

6. Plants showing wild nature but beneficial

Some of those weeds which are not indigenous have significant medicinal value. For instance, Cardiospermum grandiflorum has antibacterial properties, while Euphorbia hirta has shown anti-inflammatory and antipyretic effects. Chromolaena odorata is a common plant used for its antimicrobial, antiinflammatory properties as well as contains 2.65% Nitrogen, 0.53% Phosphate, and 1.9% Potassium, shows that it can be used as alternative green manure (leaves used for mulching, preparing foliar sprays like pathila kashayam for pest control etc). Indigenous communities use these plants for various treatments, and Urtica dioica (stinging nettle) is even consumed as a nutritious leafy vegetable by some indigenous groups.

Chromolaena odorata, Cyperus rotundus, Commelina benghalensis, Commelina diffusa, Tridax procumbens, Calopogonium mucunoides are some other weeds that are used by farmers as manure alternatives, ayurvedic treatments and for mulching purposes. Less managed and least disturbed fields showed the highest population of these wild plants. Even though some of these plants are used by the indigenous communities as food and medicine, some among them showed negative effects on soil and human health.



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