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Full Length Research Paper

Role of agro-forestry on organic and conventional farmers' livelihood in Bahour, Puducherry- India

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Agroforestry is highly adaptable and applicable among a wide range of physical and social conditions as it enhances stability and productivity of agro-ecosystems and alleviate environmental stresses. Hence this practice plays substantial ecological and socioeconomic roles in farmer's livelihood. This paper is an attempt to elucidate the relationships between biodiversity and income generation from agro-forestry systems, in order to identify the optimum sustainable agricultural practices that are ecologically sustainable and socioeconomic feasible in local context. This study was conducted in Kuruvinatham and Soriankuppam villages of Bahour commune, Puducherry during September 2008 to December of 2009; present study investigated 30 farms - 15 organic and 15 inorganic/conventional agricultural fields with varying agro forestry species composition and degree of commercialization. Data were gathered through interviews among selected farmers and 20 utilized species were identified. Species retention is governed by species relative importance. Conventional fields were found to be less diverse with reduced density resulting in low annual gross income. Thus it has less ecological and socioeconomic advantages, as compared to organic fields. Coverage on the field edges and boundaries, shading effects and beautiful natural scenery are the main causes for the adoption of agroforestry among organic farmers, whereas undermining agroforestry importance, ignorance, lack of awareness as well as land shortage are the major factors of non-adoption of agro forestry among conventional farmers. There is a critical need to raise recognition and awareness at the rural grassroots level to instill knowledge about the values of agroforstry and assist in appropriate tree management techniques and inter-cropping regimes as well as ensuring accessibility to markets among the farmers in order to enhance the ecological and socioeconomic sustainability of agro-ecosystems.

Key words: Agroforestry, biodiversity, income, inorganic agriculture, organic agriculture, sustainability.

INTRODUCTION

In the past decades there was a rapid transition in agricultural sector to intensify production for achieving food security by hybridization and chemicalisation. This culminated in the loss of on farm biodiversity, environmental deterioration, leading to detrimental consequences for human welfare. Hence, it triggered the research on the role of biological diversity in agro ecosystems or agricultural landscapes (Matson et al., 1997; Millennium Ecosystem Assessment, 2005; Mooney et al., 2005; Okubo et al., 2010; Nair, 2011).

Agroforestry systems are found to be one of the most appropriate models for achieving sustainable production without causing any environmental destruction. Conserving soil and adopting biodiversity-based Agro-forestry cultivation practices sustains the biological production, through their intricate linkages to ecosystem goods and services (Jackson et al., 2007; Millennium Ecosystem Assessment, 2005; Jose, 2009). In this context, ecologically sound agro forestry practices which are characterized by diversity of plant functional groups on the same piece of land either in a spatial or temporal sequence through intercropping and mixed arable-livestock systems, leads to sustainable agriculture and stable production by reducing on-site and off-site

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consequences (Rasmussen et al., 1998). Agroforestry helps to maintain heterogeneity at the habitat and landscape scales in plot or farm scale (Bhagwat et al., 2008).

A wider adoption of agroforestry encompasses a variety of practices with multifunctional value, including trees on farm boundaries, trees grown in close association with village rainwater collection ponds, crop-fallow rotations and a variety of agroforestr systems like Agri-silvi system, Agri-Horti system, Agri-Pastoral system, Agri-Silvi pastoral system, Agri –Horti- Silvi-pastoral system, Agri –Horti- pastoral system, Agri- Silvi-Horti system (Bawa, 2004; Pandey, 2007; Islam and Sato, 2010). All these alternative land-use agro forestry systems has the potential to enhance soil fertility, reduce erosion, improve water quality, enhance biodiversity, increase aesthetics and sequester carbon (Williams-Guille´n et al., 2008; Nair et al., 2009; Jose, 2009; Padmavathy and Poyyamoli, 2011). By integrating local indigenous trees and fruit varieties that are adapted to the local environment, the crops can be easily cultivated with few external input requirements. This leads to agroforestry based integrated sustainable farming systems to alleviate poverty, to improve human nutrition and to provide cash to farmers for facilitating sustainable livelihoods and livelihood diversification (Jaenicke et al., 2000; Ndoye et al., 2004; Schreckenberg et al., 2006; Nair, 2011). Considering all such benefits of long-standing local practices of tree domestication in Agroforestry practices by farmers, there is a recent shift in different parts of the world towards integrating indigenous tree species in general and fruit bearing species in particular with a potential to generate cash for farmers (Leakey and Simons, 1997; Fentahun and Hager, 2010).

India has a long historical tradition of tree-growing on farms and around homes. This traditional and indigenous ethics had and continue to have an impact on implementing tree-growing in agricultural fields for the ecological, economic and social well-being of the people. Agroforestry systems in India include trees in farms, community forestry, variety of local forest management and ethno-forestry practices (Pandey, 1998). During the late 1970s efforts were initiated to bring the traditional practices into the realm of modern agricultural science called Green Revolution Agriculture (Bene et al., 1977; LaSalle et al., 2008). This was aimed at stimulating agriculture production primarily by monoculture in continued expansion of farming areas, double-cropping in existing farmland, using hybrid seeds by replacing traditional varieties of crops and using wide varieties of chemicals for achieving the desired yield. All these factors ultimately led to the gradual destruction of agroforestry systems. Subsequently, the hybrid/monoculture based Green Revolution Agriculture systems have produced adverse impacts on environment and human health (Evenson and Gollin, 2003; FAO, 2007). In order to benefit the poor farmers and those who are in less-productive agro ecological environments, such alternative agroforestry sustainable farming practices plays a vital role in maintaining biodiversity, regulating climate change and energy use, conserving ecosystem services, optimizing productivity and ensuring food security. Agroforestry systems were established and practiced successfully by organic farmers than the inorganic/conventional farmers.

Therefore, our objective in this study was to elucidate the direct benefits obtained from crop-based agroforestry systems, in this case organic and inorganic agricultural fields of Kuruvinatham and Soriyankuppam village in Bahour, Puducherry. The selected farms had various levels of tree/crop diversity in terms of species compositions. Private profitability of farmers that is, organic and inorganic farmers were taken into account. Private profitability is from the landowners' perspective, as gross income derived from the direct products of the fields and a comparison between on-farm biodiversity and its income generation was calculated for both types of farms. After this, we investigated the relationships between profitability and plant diversity, assessed the outlooks for improving economic functions while maintaining biodiversity in farms and explored the possibilities for popularizing these agroforestry strategies among the farmers, especially to inorganic farmers.

MATERIALS AND METHODS

Study site

The Union Territory of Puducherry is spread across an area of 492 Km^2 consisting of four regions, Puducherry, Karaikal, Mahe and Yanam situated at different geographical locations isolated from one another. Puducherry region is the largest of all the four, and lies on the East-coast, between 11 42' 12 30' N, and between 76 36' and 79 53' E. An area of 25,600 and 13,300 ha land lies in the coastal region of Puducherry and Karaikal, respectively (Soil Survey Report, 2012). The climate is tropical dissymmetric with maximum rains during the North-east monsoon in October to December. The climate data available for 20 years (1991 to 2010) reveal a mean annual temperature of 29.5°C and a mean annual rainfall of 1,141 mm. The mean annual number of rainy days in the annual cycle is 55.4. The mean monthly temperature ranges from 25 to 34°C in a year (Directorate of Economics and Statistics, Puducherry, 2010).

Sampling and data collection

Kuruvinatham and Soriankuppam (Figure 1) (under Bahour commune and revenue village Kuruvinatham)

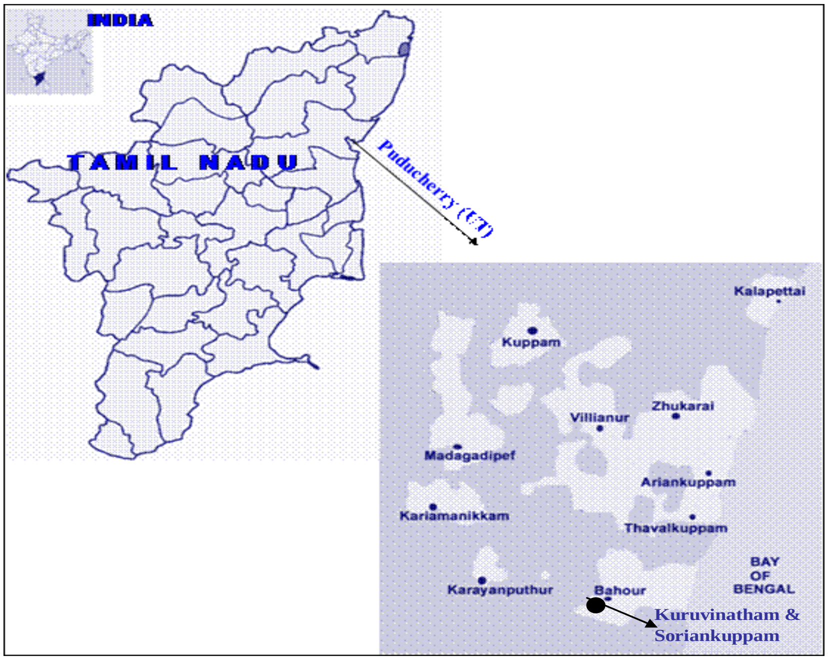

Figure 1. Location of the Study area (black dot indicates the study sites).

are the selected villages for the present study because the village farmers were highly motivated to do organic farming and agricultures fields are thoroughly monitored by Kalanjiyam. The Department of Economics and statistics 2008to 2012, Puducherry, estimated the areas of the two chosen villages as 13.6 and 19.4 km^2, with population densities of 206 and 153 individuals per km^2, with a total population 2812 and 2975 respectively. They live in small-scattered settlements. Majority of the inhabitants (70%) are marginal farmers (> 0.5 to 1 ha), who overwhelmingly rely on agriculture and the dominant cultivatable crops are groundnut (26.5%) and vegetables (25%). Animal husbandry (35%) was the next preferred livelihood after agriculture. The study area is inhabited predominantly by Hindus (85%), there are also a few Christians (10%) and Muslims (5%). The language is Tamil which is the regional as well as the state official language. The main objective of this study is find the role of agro-forestry in farmers livelihood by analyzing and comparing the income generated from agro-forestry species in agro ecosystems under organic and conventional management.

Depending on the perceived variability, stratified random sampling method 125 informants from farming households' in Bahour were chosen, followed by semi-structured interviews. There were only 50 organic farmers who were purely organic in Bahour (personal communication - Kalanjiyam NGO) and so 50 conventional farmers with similar characteristics in field location, soil quality, irrigation pattern and crop sequence pattern were selected to know about the reasons for adoption nd non-adoption of agroforestry. Among them, finally we ended up with a total of 30 informants with agro-forestry fields (15 organic and 15 inorganic farmers). The organic farmers practicing organic farming since 2004 with agro-forestry were selected from both villages for an in-depth comparison income generated by agro-forestry species in conventional and organic farming fields. Similarly, 15 conventional farmers were purposively selected from the chosen villages considered located between 500 m to 1.5 km with that of organic farming fields. Thus, totally 15 organic and 15 conventional agricultural fields were investigated for their agro-forestry production rate and yields/income, comparisons on the impacts of the contrasting agricultural practices (GRA vs. OF). The selected respondents were interviewed individually in local Tamil language, using both open- and close-ended questionnaires. Following this and depending on the answers, a series of specific questions were asked on the subjects of interest, including expansions or clarifications upon as needed. In addition, in-depth interviews were administered to the heads of household using pre-tested structured questionnaires. Focus Group Discussions (FGDs) with 5 to 8 key /knowledgeable innovative farmers as well as GRA farmers using open-ended discussion guidelines were conducted, information was captured on the utilities, constraints, interests and perceptions of people on agro-forestry. Additionally, household socio-economic attributes and site diversity characteristics were documented. The density and diversity of indigenous fruit bearing species and trees were estimated by census survey on accompanied field excursions with agricultural development experts and farmers.

For each species encountered in each farm, its abundance, product type, purpose and its annual production rate was recorded along with its specific agricultural niches/ land use type. Only those plants that reached a height of 150 cm or more at time of the field visit were considered in the census (Beentje, 1994; Fentahun and Hager, 2010). Each species has a different yield cycle, so it is difficult to determine a standard/fixed system cycle (Rasul and Thapa, 2006; Okubo et al., 2010). Particularly of fruit or food tree species and older individuals are commonly replaced with new ones of the same or different species each year. Therefore, we estimated incomes as potential annual gross income assuming that timber species generate a steady income each year and treating a typical yield of other species (for example, fruit trees) as a constant. We did not account for the initial stage of garden development for non-timber species, assuming that all individuals are mature and able to produce. We averaged the data on yield, farm-gate price and harvesting period for each species for all the plots and then determined a typical yield per individual, a typical harvesting period, and a typical sale price per unit for each product. Typical values were selected mainly as mode values, but adjusted by judgment based on interviews with local farmers (Okubo et al., 2010).

Data analysis

Data on species richness, abundance and density was summarized using the following descriptive statistical analysis procedures (Fentahun and Hager, 2010).

Total species richness was calculated by counting the number of species in a given sampling unit (farm and site).

Relative species abundance which is the abundance of a species as percentage of the total abundance of all species was used to judge the pattern of species diversity.

Relative species frequency was calculated as the number of occurrences of a species as a percentage of the total occurrences of all species.

Species and tree density, respectively the number of species and trees per unit area (farm or site), was calculated at individual farm level (where the total number of species or trees were divided by the size of that particular farm).

Species diversity Shannon diversity index was used as diversity indicator in agricultural landscapes. This index takes a value of zero when there is only one species in a community and a maximum value when all species are present in equal abundance. Shannon diversity index (H) was calculated as (Magurran, 1988).

$$H' = -\sum P_i * \ln P_i$$

where H' = Shannon diversity index; Pi = proportion of individuals found in the species; ln = is the natural logarithm of this proportion.

Simpson's index (D) Simpson's diversity index is a measure of diversity which takes into accounts both richness and evenness. Simpson (1949) gave the probability of any two individuals drawn at random from an infinitely large community belonging to different species as;

$$D = ni\ (ni-1)/n\ (n-1)$$

n is the total number of species and *ni* is the number of individuals of a species. As D increases, diversity decreases. Simpson’s index is heavily weighted towards the most abundant species in the sample while being less sensitive to species richness.

The differences between the organic and inorganic farms were compared by Shannon’s species diversity and Simpson's diversity index, statistically analyzed using ANOVA and confirmed by t-test.

Estimation of benefits and costs

Cost-Benefit Ratio (Levin and McEwan, 2001) measures the returns or benefits per unit cost of investment. Benefit-cost ratio is the ratio between total cost of production and total receipts realized by the farmer.

BCR = Value of crop produce - cost of inputs/cost of inputs

Pearson’s correlation between the diversity/density and potential annual gross income for organic and inorganic farms were calculated in order to show the cost–benefit relationship of respective farms (Okubo et al., 2010).

RESULTS

Species richness, abundance and frequency

Over the total study area, 75% (N = 30) of the informants were found to possess one or more tree and fruit tree species in their plots. Altogether 20 species (Table 1), that included 15 fruit bearing species and 5 Timber tree species were recorded during the study (Table 2). In organic farming *Cocos nucifera* and *M. paradisiaca* were the dominant species with a density of 45 (16.5%) and 42(15%) fallowed by *M. indica* and *B. flabellier* species with 20 (7.3%) individuals, while in Inorganic farming *C. nucifera* (36.4%) and *B. flabellier* (14%) are the dominant species with a density of 12 and 10 fallowed by *Musaparadisiaca* (9.4%) with 8 individuals. All the

Table 1 Relative species abundance and frequency of species in Organic and Inorganic agricultural landscapes

Species name	Relative frequency (%)	Organic farming		Inorganic farming	
		Abundance	Proportion (%)	Abundance	Proportion (%)
A. lebbek	2.7	6	2.3	4	5.8
A. indica	3.8	12	3.4	2	3.3
Bambusa vulgaris	5.4	18	6.6	—	—
Borassus flabellifer	8.7	20	7.3	12	14
M. oleifera	7	18	6.6	—	—
Tamarindus indicus	2.2	8	3	—	—
T. grandis	2	8	3	3	4.1
T. populnea	2.9	6	2.3	—	—
C. nucifera	20.4	45	16.5	30	36.4
A. comosus	1.6	6	2.3	—	—
Artocarpus heterophyllus	3.8	8	3	6	7.2
Carica papaya	4	15	5.5	—	—
Citrus limon	1.6	6	2.3	—	—
M. indica	8	20	7.3	10	12.6
Manilkara zapota	1.6	6	2.3	—	—
P. guajava	3.8	8	3	6	7.2
Punica granatum	3.8	8	3	—	—
Phyllanthus emblica	1.6	6	2.3	—	—
Annona squamosa	3.8	8	3	—	—
M. paradisiacal	11.3	42	15	8	9.4
Total		274		81	

Table 2. Species name, typical yield, price of the main product of each plant species and cost benefit ratio in organic and inorganic agricultural fields.

Species name	Common name	Purpose	Organic farming			Inorganic farming		
			Yield and price (Rs) /individual/yr	Cost spent (Rs)	B:C ratio	Yield and price (Rs) / individual /yr	Cost spent (Rs)	B:C ratio
Albizzia lebbek	Lebbek tree	Timber	2 m^3@2500/10yr	500	5	2 m^3/2500/10yr	900	2.7
B. vulgaris	Bamboo	Timber	10 culm@1,500/5 yr	300	5	—	—	—
Azadirachta indica	Neem	Timber	2 m^3@3,000/10yr	400	7.5	2 m^3@3,000/5yr	800	3.7
B. flabellifer	Palmyrah	Fruit leaves	45kg @ 500/yr	100	5	30kg @ 225/yr	100	2.2
Moringa oleifera	Drum stick tree	Fruit	75 nos@375/yr	50	7.5	—	—	—
		Leaves	8kg @240/yr	40	6	—	—	—
T. indicus	Tamarind	Fruit	175kg@10,500/yr	1500	7	—	—	—
T. grandis	Teak	Timber	2 m^3@12,500/10yr	1200	10	—	—	—
T. populnea	Portia Tree	Timber	2 m^3@4200/5yr	420	10	2 m^3@3,000/5yr	550	5.4
Cocos nucifera	Coconut	Fruit	345nos@2070/yr	600	3.45	225@1350/yr	800	1.7
A. comosus	Pine apple	Fruit	3 nos@ 125/yr	25	5	—		

Table 2 Contd.

A. heterophyllus	Jack Fruit	Fruit	37 nos@ 1850/yr	350	5.2	22 nos@1100	600	1.8
C. papaya	Papaya	Fruit	135 nos @ 4050/yr	500	9	—	—	—
C. limon	Lemon	Fruit	600 nos @1800/yr	600	3	—	—	—
Mangifera indica	Mango	Fruit	110 nos @ 1600/yr	600	2.6	85 nos @ 800/yr	300	2.2
M. zapota	Sapodilla	Fruit	10 kg @200/yr	50	4	—		
P. guajava	Guava	Fruit	35 kg@ 400/yr	50	8	20 kg@ 175/yr	50	3.2
P. granatum	Pomegranate	Fruit	15 nos @ 200/yr	50	4	—	—	—
P. emblica	Indian gooseberry	Fruit	35 kg@ 550/yr	75	7.3	—	—	—
A. squamosa	Custard apple	Fruit	25 nos @ 200/yr	50	4	—	—	—
M. paradisiaca	Banana	Whole plant	1 nos@3000/yr	600	5	1 nos@3000/yr	1000	3

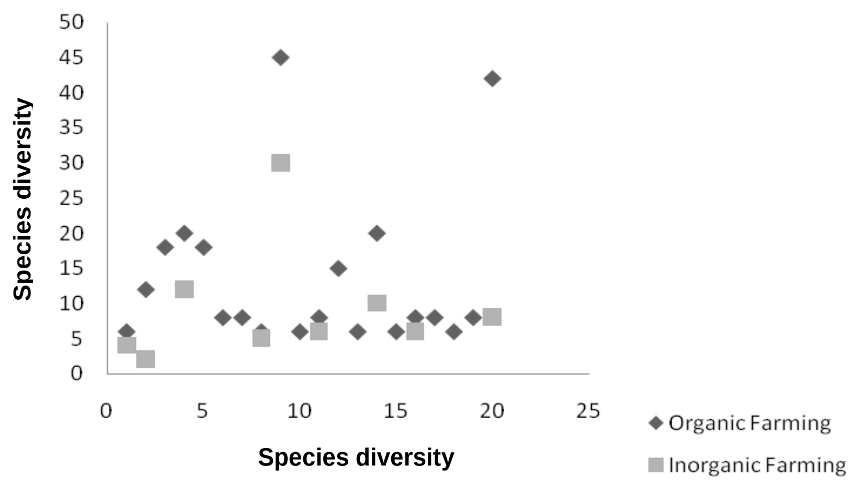

Figure 2 Diversity profile for Organic and Inorganic agricultural study sites.

sites C. nucifera, Musa paradisiaca, M. indica and B. flabellier were the dominant species in both farming systems. All these species were found only on the field edges and boundaries.

Species richness and abundance was so low in Inorganic farming fields (9 and 81) as compared to organic farming sites (20 and 274) (Figure 2), the mean number of species and mean density per farm in organic fields were 1.5 ± 0.5 and 18.2 ± 3 and inorganic farms were 0.6 ± 0.3 and 5.4 ± 1 respectively (Table 3).

Inorganic farming sites are found to be very low in its diversity and density. Pertaining species abundance, the total number of trees of all species at the two sites were (N = 30), in organic fields 274 trees with an average of 18.2 ± 3 trees per field and in inorganic fields 81 trees with an average of 5.4 ± 1 tree per field (Table 3). Shannon and Simpson diversity index values for organic fields were 2.74 and 0.07 and for

Table 3. Mean species abundance and diversity per field in organic and Inorganic study sites.

Farming type	Mean number of species/field	Mean number of trees/field	Diversity and density Indices	
			Shannon	Simpson
Organic farming	1.5 ±.5	18.2 ± 3	2.74	0.07
Inorganic farming	0.6 ± 0.3	5.4 ± 1	1.47	0.21

Table 4. Factors accounted for non-adoption and adoption of integrating Tree and fruit species in agricultural landscapes

Reasons for non adopting	Respondents (%)	Reasons for adopting	Respondents (%)
Undermining their value	25.2	Shading effects	24.1
Ignorance	18.5	Income	5.2
Establishment problems	10.2	Soil and Water management	14.5
Site requirement differences	5.3	Increases pollinators and seed dispersal agents	12.8
Land shortage	11.2	Beautiful natural scenery	16.1
Lack of awareness	20.1	Planting to serve as shelter belt and wind breaks	3.2
No reason accounted	9.5	Coverage on the field edges and boundaries	24.1

inorganic farming was 1.47 and 0.21 respectively (Table 3).
These diversity and density index clearly states that organic farms are significantly highly diverse and dense, as compared to inorganic farms by ANOVA with an F= 3.37 ($P < 0.005$) and one tailed t valve = 6.3 ($P < 0.005$).

Factors affecting propensity of domestication, species richness and abundance

For some 60% (N = 60) of the informants, growing trees and fruit bearing species in their farms does not appeal them. For this, the most frequent responses were undermining agroforestry importance (25.2%), lack of awareness (20.1%) and ignorance (18.5%) (Table 4). In addition, land and labor shortage, disgraces on their use, climatic limitations and failure to establish them due to ecological niche differences between their natural growing environment and farms as well as comparative advantage of staple crops were reported. About 40% (N=60) of agroforstery adopted farmers that organic farmers 15 (25%) and inorganic farmers 9 (15%) informed that the shading effect (24.1%), strengthening the field edges and boundaries (24.1%) and its aesthetic appeal (16.1%) were found to be the major reasons for its adoption (Table 4).

Estimation of benefits and costs

The benefit-cost ratio worked out for organic and inorganic management was given in Table 2. It could be observed that B: C ratio was higher in organic farms. Thus because the organic farmers replaced the external inputs by farm derived resources normally leads to reduction in variable input costs under sustainable management. Expenditure on fertilizers and pesticides were substantially lower than inorganic management in almost all the cases. Costs of inputs were reduced in organic farming because of adoption of indigenous techniques like composting, bio-pesticides, use of natural predators and parasites, growth promoters like effective microorganisms and Panchakavya (fermented solution of 5 ingredients derived from cow products, as a consequence crop growth and yield were enhanced and increased, resulting in increased farm income (Padmavathy and Poyyamoli, 2011).

In organic farming manure was made from green manuring/ green leaf manuring using locally available materials like dried grass, leaves, straw, cow dung and cow urine at no extra cost to the farmer. Organic manure enriches soil without causing any side effects and the biofertilizers like *Rhizobium*, *Azospirillum*, *Azolla etc*., are cheap alternatives, which increase nutrient status of soil. Further, bio pesticides were prepared using decoctions/ extracts from plants with repellent qualities. This method was ideal and safe alternative to high cost, toxic chemical; pesticides. Farmers felt that the bio-pesticide method has controlled pest more effectively and the cost was also cheaper. This considerably improved yield of crops, increases net return and finally high benefit- cost ratio compared to crops grown under inorganic management. The organic farmers perceived chemical fertilizers, pesticides and growth regulators as costly inputs without substantial increase in the profits. In organic farms the highest B:C ratio 10 is found in *Tectona grandis* and *Thespesia populnea*, followed by *Carica papaya* (9) and P*sidium guajava* (8) and lowest B:C ratio is *Citrus limon* (3) and *M. indica* (2.6). For inorganic farms the highest B:C ratio was 5.4 found in *Thespesia populnea* and *A. indica* (3.4) and the lowest was for *Artocarpus heterophyllus* (1.8) and *C. nucifera* (1.7).

Organic farms with higher diversity and density resulted an annual gross income from timber and fruit is approximately Rs. 51,360 ha^{-1} (US$ 1116; US$1 = 46 in 2009) can be generated and in Inorganic farms with low diversity and density resulted annual gross income approximately Rs.15, 150 ha^{-1} (US$329). Income and Diversity/density were significantly positively correlated in Organic farming (n = 15, Pearson's correlation coefficient 0.081, P< 0.01) than in inorganic farms (n = 15, Pearson's correlation coefficient 0.041, P< 0.01) as they lack sufficient density and diversity. When both organic and inorganic farms were compared in terms of annual gross income from agroforestry systems, they showed a significant difference ANOVA, P = 0.02, P< 0.01 and in t-test 0.1, P< 0.01.

DISCUSSION

Purpose of farm inclusion of trees and fruit bearing species

The total number of trees of all species in organic fields 274 trees with an average of 18.2 ± 3 trees per field and in inorganic fields 81 trees with an average of 5.4 ± 1 tree per field (Table 3).

It clearly denotes that inorganic fields have a low level of agroforesty integration that is, tree and fruit bearing species, in the study areas. This is accomplished by retaining natural regenerators at different land use types in the realm of anthropogenic ecosystems than through deliberate planting.

Planting the trees and fruit bearing species will be useful for sustaining socioeconomic and ecological benefits and through agroforestry can reduce pressure on dwindling natural forests and simultaneously enhance biodiversity in the agricultural landscapes (Agea et al., 2007; Fentahun and Hager, 2010).

Frequency of occurrence

The study has generally revealed that only a few of the species occur at higher frequencies (Table 1) in the agricultural settings *C. nucifera* and *M. paradisiaca* were the dominant species with a density of 45 (16.5%) and 42(15%) fallowed by *M. indica* and *Borassus flabellier* species with 20 (7.3%) individuals This is primarily explained by the greater income and utilities sought from certain species, thus could result in low frequencies of the other species in a landscape (Kindt et al., 2003). It is necessary to convey and demonstrate the multiple uses and importance of the species to local farmers (Shrestha and Dhillion, 2006), in order to endure their establishment and conservation (Etkin, 2002; Fentahun and Hager, 2010).

Propensity of domestication

Undermining agroforestry importance (25.2%), lack of awareness (20.1%) and ignorance (18.5%) were found to be major reasons for non-adopting agro-forestry among organic farmers, whereas as in case of adopting among organic farmers shading effect (24.1%), strengthening the field edges and boundaries (24.1%) and its aesthetic appeal (16.1%) were found to be the major reasons. The study revealed that several biological, socio-economic and cultural impediments needed to be tackled for integrating agroforestry trend on agricultural landscapes. Inorganic farmers are more concerned and aimed about the cash crops income, than those of non-cash crops cultivation and income obtained from it. So farmers must be educated about the various uses of agroforesty concepts in terms of environment and socio-economic production status, which in turn help them in improving their livelihood standards (Fentahun and Hager, 2010).

The major reasons for the failure to grow trees/fruit trees in agricultural landscapes among the farmers are the free availability of those resources in the natural environment and they do not want to invest meager resources in tree planting (Kindt et al., 2006). The life style of the local farmers were moderate, so they just think of urgent general scarcity of daily necessities other than planting trees for future use (Food and Agriculture Organization of the United Nations FAO, 1985; Akinnifesi et al., 2005). But growing tree is perceived as the third activity for income generation after agriculture and livestock rearing (Krause and Uibrig, 2006) and it is not known to the all farmers, as majority of the farmers (69%) were illiterate and do not have knowledge about the multiple benefits of agroforestry. There is an urgent need to educate the local farmers about various uses of trees and fruit tree integration in their farms and they should know that farms with higher diversity of tree/crop species tend to support higher income than other mono-crop dominated farms. Popularizing agroforestry systems among farmers can be done through group discussions, field demonstrations and video presentations among the community (Pattanayak, 2003; LaSalle et al., 2008; Fentahun and Hager, 2010).

Species diversity and abundance, their contribution in agricultural lands and farmers livelihood

The site differences in farm species diversity might be argued to have arisen from sample size differences. Nevertheless, as shown in Figure 3, by accounting for sample size differences; it has been possible to compare

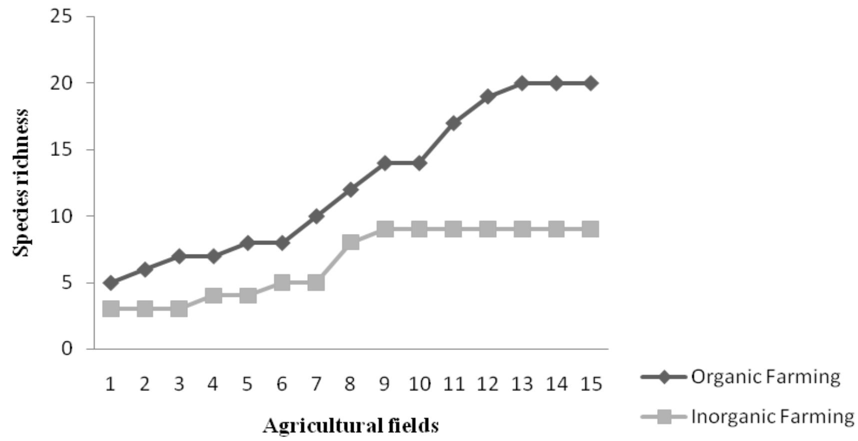

Figure 3. Species richness comparison between Organic and Inorganic agricultural sites.

species richness of sites of unequal sample sizes through species accumulation curves. For instance, at a sample size of 15 where the organic farm sites recorded average species richness 1.5 with average density18.2 and in inorganic farm sites with an average species richness 0.6 and average density 5.4. This again confirms that organic farms were relatively most species rich and dense (LaSalle et al., 2008). Farm edges were usually allocated for border demarcation and fencing through planting trees and fruits bearing species (Kindt et al., 2006).

Tress and fruit species in agroforestry systems played various significant roles in terms of environmental and socio-economic improvements, besides farmer's livelihoods. The simplification of agro-ecosystems to monoculture production and the removal of non-crop vegetation that is agroforestry species from the farm unit has contributed to the homogeneity of agricultural landscapes by reducing botanical and structural variation, resulting in both a reduced capacity of agricultural areas to serve as habitat for wild species as well as to effectively internally regulate populations of pests and disease causing organisms which affect crop productivity (Defra, 2003). This has resulted in a widespread decline in farm species abundance and diversity across many taxonomic groupings, wildlife mortality, reduced reproductive success of many species and reduced the essential agro-ecosystem functions such as purification of water, internal regulation of pests and diseases, carbon sequestration and degradation of toxic compounds (Altieri, 1999; Bugg and Trenham, 2003; Benton et al., 2003; Fentahun and Hager, 2010; Padmavathy and Poyyamoli, 2011).

Recent studies on multiple species use such as *Bambusa nutans* have the potential to help in soil nutrient binding and controls soil erosion in agricultural lands (Arunachalam et al., 2002). Agroforestry systems can also be useful for utilization of sewage-contaminated wastewater from urban systems (Bradford et al., 2003). A diverse multipurpose tree community likes *Albizzia lebbek Tectona grandis*, *Ficus glomerata* provides not only diverse products, but also render stable nutrient cycling (Semwal et al., 2003). Trees in agroecosystems in Rajasthan and Uttaranchal have been found to support threatened cavity-nesting birds, and offer forage and habitat to many species of birds (Pandey and Mohan, 1993). Agroforestry also leads to a more diversified and sustainable rural production system than many treeless farming alternatives and provides increased social, economic and environmental benefits for land users at all levels (Pandey, 2007).

In small-scale, subsistence agriculture in the tropics, traditional farming practices have evolved that provide a sustainable means of reducing the incidence and damage caused by pests, including nematodes. The biodiversity inherent in multiple cropping and multiple cultivar traditional farming systems increases the available resistance or tolerance to nematodes (Bridge, 1996). In structurally complex landscapes, parasitism is higher and crop damage lower than in simple landscapes with a high percentage of agricultural use. Viswanath et al. (2000) found that combination of Acacia and rice traditional agroforestry system has a benefit/cost (B/C) ratio of 1.47 and an internal rate of return (IRR) of 33 at 12% annual discount rate during a ten- year period. In the northeast Indian State of Meghalaya, guava and Assam lemon-based agroforestry systems (that is, farming systems that combine domesticated fruit trees and forest trees) the yields were 2.96 and 1.98-fold higher net return respectively, in comparison to farmlands without trees (Bhatt and Misra, 2003; Pandey, 2007). Average net monetary benefit to guava-based agroforestry systems in Meghalaya was Rs 20,610/ha (US$ 448.00) and for Assam lemon-based agroforestry systems, Rs 13,787.60/ha (US$ 300.00) (Kumar et al., 2004; Pandey, 2007). Agroforestry has not only uplifted the socio-economic status of farmers, but also contributed towards the overall development of the region (Kumar et al., 2004); besides it offers significant opportunity for livelihood improvement through nutritional and economic security of the poor in the tropics (Milne, 2006). For instance, a five-year field experiment of tree mixtures for agroforestry system in tropical southern India involving mango (*Mangifera indica*), sapota (*Achrus sapota*), eucalyptus (*Eucalyptus tereticornis*), casuarina (*Casuarina equisetifolia*) and leucaena (*Leucaena leucocephala*) found that it can exchange the growth of the crops by 17% (Pandey, 2007). Pandey et al. (2010) studies on *Tecomella undulata* L. (Rohida) intercropped with *Cyamopsis tetragonoloba* (L.) Taub Neem (*Azadirachta indica* A. Juss) and understorey crop black gram (*Phaseolus mungo*) experiments suggest that crop yield under the tree canopy decrease but are compensated by increase in wood volume and fruit yield of neem and thus giving higher economic returns.

Present study results coincides with above mentioned findings and proves it once again that organic farms with higher diversity and density will result in increased annual gross income than the inorganic farms with low diversity and density (organic farms Rs.51, 360 ha^{-1} and inorganic farms Rs. 15, 150 ha^{-1}), thus ultimately improves the livelihood standard of the local small farmers.

Conclusion

Organic farming practices are sustainable agricultural practices which are ecologically and socio-economically feasible. Agroforestry on-farm biodiversity extend is comparatively higher in organic farms than inorganic agricultural farms, it is necessary to popularize such unique systems among the farmers and it is an important option for livelihood improvement, climate change mitigation and sustainable development. Present study concludes that there is a need of policy and practice progress towards: (i) effective communication with farmers in order to enhance agroforestry practices by educating them about the primary to multifunctional values of agroforestry; (ii) maintenance of the traditional agroforestry systems (iii) enhancing the size and diversity of agroforestry systems by growing species and participatory domestication of useful fruit tree species which are more useful for livelihood improvement; (iv) designing context-specific farming systems to optimize food production, carbon sequestration, biodiversity conservation; (v) maintaining a continuous cycle of regeneration-harvest–regeneration and (vi) strengthening the markets for the agroforestry products. Practice of traditional agroforestry systems plays significant roles in terms of carbon sequestration, livelihood improvement, biodiversity conservation, soil fertility enhancement and poverty reduction. Therefore it is important to conserve and promote multi-plant agroecosystems to achieve sustainable agricultural landscapes.

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