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*Full Length Research Paper*

# Productivity assessment of agricultural crops in existing agrihortisilvicultural system of mid hills of Central Western Himalaya, India

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**The paper summarizes the productivity of various agricultural crops under existing agrihortisilviculture (AHS) system in northern and southern aspects of mid hills of Central Western Garhwal Himalaya (Narendra Nagar block of district Tehri Garhwal, Uttarakhand), India between 1000 to 2000 m asl during Rabi (winter) and Kharif (summer) seasons. The northern aspect was more diverse and formed good vegetation composition, both in terms of forest crops and in agricultural productivity. The tree diversity and richness was recorded to be higher in northern aspect. A total of 18 tree species were reported in the northern aspect and 13 in the southern aspect of AHS systems. The *Grewia optiva* was observed as dominant tree species and *Citrus sinensis* as co-dominant species in the northern and southern aspects. The northern aspect observed with higher grain productivity under tree (1326 kg/ha/year) and sole cropping (2471 kg/ha/year) compared to southern aspect; similarly, the northern aspect proved to be higher in straw productivity under trees (3587 kg/ha/year) and treeless (4510 kg/ha/year) situation for both Rabi (winter) and Kharif (summer) crops. Overall, there is an average reduction of 45.05% in gain yield and 29.53% in biological yield compared to sole agricultural cropping in northern aspect. The average reduction in the grain yield (29.08%) and biological yield (28.77%) was lower in the southern aspect. It was summarized that the reduction in the agricultural produce under agrihortisilviculture system is supplemented by multiferous benefits of woody perennials which is life supporting to the rural community of this hilly landscape.**

**Key words:** Agrihortisilviculture (AHS) system, grain productivity, biological productivity, northern aspect, southern aspect, IVI (importance value index).

## INTRODUCTION

Agroforestry is a unique and very common practice in the Central Western Himalayan region of Uttarakhand, India. Trees have always been associated in the different places on agricultural fields of this region. These trees are deliberately enhanced by the farmers in order to fulfill their multifarious need namely fodder, fuel, fiber, fruits, small timber, agricultural implements etc along with the agricultural produce. The agrihortisilviculture is very common practice by the farmers of this region which includes the cultivation of agricultural crops in association of forest and horticultural trees present in the fields. The tremendous pressure on forest for the fuel and fodder purposes, the presence of these trees on the agricultural fields become more significant. The arrangement of agrihortisilviculture (agricultural crops + horticulture tree + forest tree) systems on the same piece of land provides the stable and better output to the farmers. It is worthwhile, that in hilly regions the existence without agroforestry is difficult because trees not only supplement the fodder, fuel, fiber, fruits etc but also reduces the pace of land sliding in the fields, protect crops to adverse wind and climatic condition, conserve the moisture, improve the soil quality through nitrogen fixing and organic matter in terms of leaf fall etc.

The storey does not finish here with profits; there are some harmful aspect of the presence of trees like antagonism for the light, water and nutrients between trees and crop which generally lower down the productivity of the agricultural crops. The cultivation of fruit-forest trees with agricultural crops is a common fashion in the Himalayan region for twofold benefits under the practices of the agrihortisilviculture (AHS) system. Considering the profit for the marginal family members, these existing agroforestry systems are more compassionate and sustainable than the single agricultural system, even there is more crop production in pure agricultural operations. The presence of trees, their structure, compositions and effect on crop is an important area to study in this region. In the Himalayan region, a number of indigenous agroforestry systems have been familiar from Himachal Pradesh and Uttarakhand (Atul et al., 1990) out of which agrihortisilviculture, agrisilviculture and agrihorticulture are very frequent. On the other hand, Singh et al. (1980), Dadhwal et al. (1989) and Toky et al. (1989) have recognized these three agroforestry systems with their multifarious benefits.

The assortment of trees on the edges of the agricultural field is farmer friendly and compatible. Selection of intercrops depends mainly on edapho-climatic conditions of the area, farmer's need/traditions and resource availability (Saroj and Dadhwal, 1997). The effect of aspect (the direction a slope is facing) on plant species distribution and growth pattern play a significant role. It has been reported that, even northern and southern facing slopes are at the same elevation, there are a number of environmental differences which form the variant microclimatic situation for the growth and development of the vegetation. Bearing this in mind, the present investigation is an effort to examine the aspect-wise study on productivity of agricultural crops in the existing agrihortisilvicultural system in the Garhwal region of the Central Western Himalaya of Uttarakhand, India.

## MATERIALS AND METHODS

The study was carried out in the existing agroforestry systems of four selected sites (two each in the northern and southern aspect) in Narendra Nagar block of district Tehri Garhwal in Uttarakhand, India; between 1000 to 2000m asl elevation during Rabi (winter) and Kharif (summer) seasons in the year 2004 to 2006. The study area lies between 77° 51' 30" to 80° 30" E longitudes and 29° 40' to 31° 28" N latitudes. Geographically, the area falls between sub-tropical to temperate zone, with the luxuriant and green lush natural vegetation. The area receives an average annual rainfall of 1240 mm, with most of the rain occuring during July to September (monsoon period) with the mean annual temperature of the study area ranging from 9 to 33°C. In the present study, 20 quadrats were laid in each site with 4 replications having sample size of 10 x 10 m for trees and 0.5 x 0.5 m for agricultural crops. The productivity of different existing agriculture crops were calculated and compared with the sole agricultural productivity (control).

The existing agrihortisilviculture (AHS) system was selected for the study. The impact of existing trees and aspect (northern and southern aspects) on the vegetation was analyzed in the existing system. The frequency, density, abundance, A/F ratio, Total Basal Cover (TBC), and Importance Value Index (IVI) of existing trees were computed in different aspects following Curtis and Mc Intosh (1950); Phillips (1959). The diversity parameters of trees were analyzed following (Shannon and Wiener, 1963), concentration of dominance (Simpson, 1949), equitability (Pielou, 1975), species richness (Margalef, 1958), Beta diversity (Whittaker, 1972, 1977). The assessment of productivity status of agricultural crops under AHS system was estimated to understand the feasibility of the systems. The random selection of samples of agriculture crops were taken from farmers' fields. The agriculture crops from the quadrats were harvested at the maturity stage from the agroforestry systems, as well as in sole agriculture system (controlled) to estimate the reduction in yield under agroforestry system, as compared to pure agriculture system. The mature agriculture crop was harvested and separated into grain (seeds) and straw (vegetative portion including shoots and leaves). Further, grain and straw were dried in natural conditions, so as to obtain the net yield (kg/ha) on crop and season basis. The Harvest Index (HI) is used to denote the fraction of economically useful products of a plant, in relation to its total productivity (grain to straw ratio) and calculated using the following formula as given by Khandakar (1985):

$$HI = (EY/BY) \times 100$$

where; HI = Harvest Index, EY = Economic Yield (grain yield), BY = Biological Yield (grain + straw)

## RESULTS AND DISCUSSION

### Phytosociology of tree crops

Agroforestry systems in the Garhwal Himalayan region are practiced by the farmers in order to meet their basic needs from the same piece of land. Agrihortisilviculture (AHS) system is one of the predominant systems in this region and the results of trees and agricultural crops recorded in AHS system are presented and discussed hereafter. Results on tree structure of agrihortisilviculture system on northern aspect of Narendranagar block (site-N) have shown that, the *Grewia optiva* was present with highest frequency, density, Total Basal Cover (TBC) and IVI (30%, 0.65 plants/100 $m^2$, 359.69 $cm^2$/100 $m^2$ and 46.89 respectively), while lowest IVI values were recorded for *Prunus amygdalus* as 7.15 (Table 1). A total of 18 tree species were recorded in the northern aspect.

Data on structural parameters of agrihortisilviculture system on the southern aspect of Narendranagar block (site-S) showed that, the frequency, density, TBC and IVI values were again found to be highest for *G. optiva* as 70%, 1.20 plants/100 $m^2$, 513.33 $cm^2$/100 $m^2$ and 73.53, while the lowest values were recorded for *Citrus aurantifolia* (Table 1). The *Musa paradisiaca*, *Mangifera indica* and *Melia azedarach* were identified as co-dominant plant species due to their higher IVI values, while *Toona ciliata, Ficus palmata*, *Emblica officinalis,* and *Citrus limon* were considered to be the suppressed plant species. There were a total of 13 tree species on this site under agrihortisilviculture system. The analytical characters of woody vegetation of traditional agroforestry systems have made it clear that *G. optiva, Celtis australis, M. azedarach* and *Malus domestica* have

**Table 1.** Phytosociology of tree layer in the northern and southern aspect of Agrihortisilviculture (AHS) system

| Species | % Frequency (F) | Density (Trees/ 100 $m^2$) | Abundance (A) | A/F Ratio | TBC ($cm^2$/100 $m^2$) | IVI |
|---|---|---|---|---|---|---|
| **Northern aspect (site-N)** | | | | | | |
| ***Fodder trees*** | | | | | | |
| *Grewia optiva* | 30 | 0.65 | 2.17 | 0.072 | 359.69 | 46.89 |
| *Celtis australis* | 25 | 0.35 | 1.40 | 0.056 | 213.41 | 30.24 |
| *Quercus leucotrichophora* | 5 | 0.20 | 4.00 | 0.800 | 98.21 | 11.89 |
| *Ficus roxburghii* | 10 | 0.15 | 1.50 | 0.150 | 73.66 | 11.76 |
| *Alnus nepalensis* | 10 | 0.10 | 1.00 | 0.100 | 96.26 | 11.68 |
| ***Timber and fuelwood trees*** | | | | | | |
| *Melia azedarach* | 10 | 0.15 | 1.50 | 0.150 | 73.66 | 11.76 |
| *Prunus cerasoides* | 10 | 0.25 | 2.50 | 0.250 | 103.91 | 15.63 |
| *Pyrus pashia* | 15 | 0.25 | 1.67 | 0.111 | 23.77 | 13.95 |
| *Myrica esculenta* | 5 | 0.10 | 2.00 | 0.400 | 96.25 | 9.41 |
| *Lyonia ovalifolia* | 10 | 0.15 | 1.50 | 0.150 | 8.18 | 8.52 |
| *Pinus roxburghii* | 5 | 0.10 | 2.00 | 0.400 | 70.71 | 8.15 |
| ***Temperate fruit plants*** | | | | | | |
| *Juglans regia* | 15 | 0.20 | 1.33 | 0.089 | 165.98 | 19.78 |
| *Prunus armeniaca* | 15 | 0.25 | 1.67 | 0.111 | 103.91 | 17.91 |
| *Malus domestica* | 10 | 0.25 | 2.50 | 0.250 | 143.20 | 17.57 |
| *Prunus amygdalus* | 5 | 0.15 | 3.00 | 0.600 | 26.52 | 7.15 |
| ***Subtropical fruit plants*** | | | | | | |
| *Citrus sinensis* | 20 | 0.45 | 2.25 | 0.113 | 306.54 | 34.95 |
| *Citrus aurantifolia* | 15 | 0.25 | 1.67 | 0.111 | 44.20 | 14.95 |
| *Citrus limon* | 5 | 0.20 | 4.00 | 0.800 | 15.71 | 7.81 |
| Total (18) | | 4.20 | | | 2023.77 | |
| **Southern aspect (site-S)** | | | | | | |
| ***Fodder trees*** | | | | | | |
| *Grewia optiva* | 70 | 1.20 | 1.71 | 0.024 | 513.33 | 73.53 |
| *Ficus roxburghii* | 15 | 0.35 | 2.33 | 0.156 | 213.41 | 22.18 |
| *Celtis australis* | 20 | 0.30 | 1.50 | 0.075 | 189.23 | 21.98 |
| ***Timber and fuelwood trees*** | | | | | | |
| *Melia azedarach* | 20 | 0.40 | 2.00 | 0.100 | 177.28 | 23.52 |
| *Ficus palmata* | 10 | 0.15 | 1.50 | 0.150 | 73.66 | 10.08 |
| *Toona ciliata* | 10 | 0.10 | 1.00 | 0.100 | 49.11 | 7.98 |
| ***Temperate fruit plants*** | | | | | | |
| *Prunus armeniaca* | 25 | 0.30 | 1.20 | 0.048 | 167.62 | 22.93 |
| ***Subtropical fruit plants*** | | | | | | |
| *Citrus sinensis* | 30 | 0.60 | 2.00 | 0.067 | 314.61 | 37.40 |
| *Musa paradisiaca* | 15 | 0.60 | 4.00 | 0.267 | 204.61 | 26.95 |
| *Mangifera indica* | 20 | 0.25 | 1.25 | 0.063 | 268.91 | 24.42 |
| *Citrus limon* | 15 | 0.25 | 1.67 | 0.111 | 33.20 | 12.26 |
| *Emblica officinalis* | 10 | 0.15 | 1.50 | 0.150 | 73.66 | 10.08 |
| *Citrus aurantifolia* | 5 | 0.20 | 4.00 | 0.800 | 15.71 | 6.70 |
| Total (13) | | 4.85 | | | 2294.34 | |

contributed more than 50% of the total IVI values (Table 1). The IVI values of present investigation were in concurrence with the studies conducted in the traditional agroforestry systems in the Bilaspur and Raipur districts of Chhattisgarh region (Sharma et al., 2006). The results also showed that, the aspect significantly influenced the concentration of dominance, species richness and beta diversity in different agroforestry systems. The earlier studies have also demonstrated that, the aspect had a marked effect on the structure and diversity of forest ecosystems (Kusumlata and Bisht, 1991; Bijalwan, 2002; Dhanai and Panwar, 1999; Sharma and Baduni, 2000; Kusumlata and Bisht (1991) had reported that, phytosociological characters differ among aspects and position even in the same vegetation type.

**Diversity indices of trees**

The data presented in Table 2 reveals that, Shannon index (diversity) values was higher (1.118) on northern aspect (site-N), while it was lower (0.994) on the southern aspect (site-S) of AHS system. Contrary to this, the Simpson index values were found to be highest (0.120) in the southern aspect (site-S). The higher species richness value (2.233) was recorded in northern aspect. The higher equitability (0.388) was observed in the southern aspect of AHS systems. Beta diversity was higher (2.154) on the southern aspect while it was lower (1.556) on the northern aspect of the AHS system. The diversity parameters of these agroforestry systems are comparable with the diversity indices reported by different workers for other regions in agroforestry and non-agroforestry systems (Toky et al., 1989; Sharma et al., 2006; Ralhan et al., 1982; Singh and Sigh, 1991). Tewari et al. (1999) reported the Shannon-Weaver index values from 0.41 to 2.31, concentration of dominance from 0.38 to 1.00 in the Thar desert, under natural silvipastoral system which are higher than the present study. The Simpson Index for the home garden of Kerala varied from 0.44 to 0.86 (Mohan et al., 1994; Jose, 1992) which is quite higher than the present study. In the present study, the higher diversity values on the northern aspects, may be due to the higher moisture content and low insolation rates, as compared to the southern aspects, which receive Sun rays in the later part of the day, when the atmosphere is sufficiently warmed. The effect of aspect on structure and diversity of vegetation was also quantified by several workers (Joshi and Tiwari, 1990; Singh et al., 1991; Jha, 2001).

**Productivity of agricultural crops**

The annual agriculture productivity under agrihorti-silviculture system (summer + winter season), when compared with control/sole agriculture system, a significant difference in the productivity of agricultural crops was observed. The productivity of agricultural crops includes the productivity of grain or seeds (also referred to as economic productivity), straw productivity (includes other than the grain that is shoot and leaves) and biological productivity or total productivity (includes both grain and straw). In an agroforestry system, the agricultural crop production is generally lower due to competition with trees, but the biomass production is adequately compensated due to overall productivity (tree + crop), which is generally greater than sole agriculture system (Newaj et al., 2003).

**Biological productivity (grain and straw)**

Table 3 shows that under AHS systems, the biological yield of agriculture crops is 4913 kg/ha/year on site-N with a reduction of 29.53% as compared to the sole agriculture crops (6981 kg/ha/year). In the site-S, the biological yield was recorded to be 3413 kg/ha/year as compared to 4833 kg/ha/year in the control condition (sole cropping) with a reduction of 28.77% from sole cropping. It was observed that the biological yield was reduced under trees, as compared to the sole cropping. The reduction in crop yield under agroforestry systems was mainly due to competition for the light, water, nutrients and allelopathic effect etc. The competition may be interspecific or intraspecific (Carnell, 1990).

Shading was found to be more important than below ground competition in an intercropping study of pearl millet and groundnut in India (Willey and Reddy, 1981). The nutrient status in agroforestry systems was shared by agriculture and forestry components; hence, the resource sharing resulted into the retardation of growth of the agriculture crops. Beside this competition for usable water, allelopathic effects also retarded the biological yield of the agriculture crops.

**Productivity of grains (economic yield)**

The economic productivity includes the productivity of grain /seeds or edible parts of the agriculture crops. Table 3 shows the economic yield of agriculture crops under AHS system as 1326 kg/ha/year on site-N with a reduction of 45.05% compared to the sole agriculture crops (2471 kg/ha/year). In the site-S, the economic yield was recorded to be 1200 kg/ha/year as compared to 1749 kg/ha/year in the control condition (sole cropping) with a reduction of 29.08% from sole cropping.

In the present study, the reduction of grain yield under different agroforestry systems was in conformity with the findings of Wahua and Miller (1978), Shivaramu and Shivashankar (1992), Sharma and Chauhan (2003), who had also recorded poor performance of soybean crop under tree species. The studies of Khybri et al. (1992) on

**Table 2.** Aspect wise diversity of trees in Agrihortisilviculture (AHS) system.

| AF system/Aspect | Shannon index | Simpson Index | Richness | Equitability | Beta diversity |
|---|---|---|---|---|---|
| AHS/N | 1.118 | 0.094 | 2.233 | 0.387 | 1.556 |
| AHS/S | 0.994 | 0.120 | 1.551 | 0.388 | 2.154 |

AHS = Agihortisilviculture; N = Northern aspects, S = southern aspects, quadrat size 10 x 10 m.

**Table 3.** Aspect-wise productivity of Agriculture crops (kg/ha/yr) under the Agrihortisilviculture (AHS) systems.

| Agricultural crops | AHS system (productivity in kg/ha/year)* | | | | Control/Sole agriculture crop (productivity in kg/ha/year)* | | | | % Decrease from control | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Grain | Straw | B.Y. | H.I. | Grain | Straw | B.Y. | H.I. | Grain | B.Y. |
| **Northern aspect (site-N)** | | | | | | | | | | |
| ***Kharif (Summer season)*** | | | | | | | | | | |
| *Zea mays* | 621 | 1982 | 2603 | 23.86 | 1052 | 2398 | 3450 | 30.49 | 40.91 | 24.53 |
| *Eleusine coracana* | 830 | 1963 | 2793 | 29.72 | 1353 | 4020 | 5373 | 25.18 | 38.64 | 48.01 |
| *Echinochloa frumentacea* | 958 | 2648 | 3606 | 26.57 | 1331 | 1733 | 3063 | 43.45 | 28.00 | 17.72 |
| *Amaranthus caudatus* | 471 | 3919 | 4390 | 10.73 | 749 | 4188 | 4937 | 15.17 | 37.02 | 11.07 |
| *Fagopyrum esculentum* | 515 | 2184 | 2699 | 19.08 | 747 | 3055 | 3802 | 19.65 | 31.06 | 29.01 |
| *Phaseolus vulgaris* | 588 | 513 | 1101 | 53.41 | 988 | 957 | 1945 | 50.80 | 40.53 | 43.41 |
| *Glycine max* | 623 | 852 | 1475 | 42.24 | 1067 | 1112 | 2179 | 48.97 | 41.64 | 32.32 |
| Average | 658 | 2009 | 2667 | 24.67 | 1041 | 2494 | 3535 | 29.45 | 36.83 | 24.38 |
| ***Rabi (Winter season)*** | | | | | | | | | | |
| *Triticum aestivum* | 659 | 1676 | 2335 | 28.18 | 1435 | 1910 | 3345 | 42.93 | 54.15 | 30.21 |
| *Pisum sativum* | 678 | 1479 | 2157 | 31.43 | 1425 | 2121 | 3546 | 40.19 | 52.39 | 39.17 |
| Average | 668 | 1578 | 2246 | 29.74 | 1430 | 2016 | 3446 | 41.50 | 53.27 | 34.69 |
| Total (Rabi + Kharif) | 1326 | 3587 | 4913 | 26.99 | 2471 | 4510 | 6981 | 35.40 | 45.05 | 29.53 |
| **Southern aspect (site-S)** | | | | | | | | | | |
| ***Kharif (Summer season)*** | | | | | | | | | | |
| *Zea mays* | 674 | 1875 | 2549 | 26.44 | 836 | 2292 | 3128 | 26.73 | 19.38 | 18.51 |
| *Eleusine coracana* | 615 | 1745 | 2360 | 26.06 | 721 | 1582 | 2303 | 31.31 | 14.70 | -2.48 |
| *Echinochloa frumentacea* | 700 | 1382 | 2082 | 33.62 | 1056 | 2194 | 3250 | 32.49 | 33.71 | 35.94 |
| *Amaranthus caudatus* | 582 | 2185 | 2767 | 21.03 | 702 | 2733 | 3435 | 20.44 | 17.09 | 19.45 |
| *Phaseolus vulgaris* | 603 | 689 | 1292 | 46.67 | 753 | 1113 | 1866 | 40.35 | 19.92 | 30.76 |
| *Dolichos uniflorus* | 327 | 643 | 970 | 33.71 | 739 | 837 | 1576 | 46.89 | 55.75 | 38.45 |

**Table 3.** Contd.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| *Vigna umbellata* | 423 | 666 | 1089 | 38.84 | 534 | 1223 | 1757 | 30.39 | 20.79 | 38.02 |
| *Glycine max* | 578 | 777 | 1355 | 42.66 | 911 | 1098 | 2009 | 45.35 | 36.55 | 32.55 |
| Average | 563 | 1245 | 1808 | 31.14 | 782 | 1634 | 2416 | 32.37 | 27.24 | 26.40 |
| | | | | | | | | | | |
| ***Rabi (Winter season)*** | | | | | | | | | | |
| *Triticum aestivum* | 798 | 1284 | 2082 | 38.33 | 1295 | 1921 | 3216 | 40.27 | 38.38 | 35.26 |
| *Brassica compestris* | 382 | 838 | 1220 | 31.31 | 490 | 1154 | 1644 | 29.81 | 22.04 | 25.79 |
| *Coriandrum sativum* | 623 | 813 | 1436 | 43.38 | 785 | 983 | 1768 | 44.40 | 20.64 | 18.78 |
| *Pisum sativum* | 745 | 937 | 1682 | 44.29 | 1298 | 1743 | 3041 | 42.68 | 42.60 | 44.69 |
| Average | 637 | 968 | 1605 | 39.69 | 967 | 1450 | 2417 | 40.01 | 30.92 | 31.13 |
| Total (Rabi + Kharif) | 1200 | 2213 | 3413 | 35.16 | 1749 | 3084 | 4833 | 36.19 | 29.08 | 28.77 |

BY- Biological Yield, HI- Harvest Index, Control- sole/pure agriculture crops.* The decimal values are rounded to one, hence, the difference of one is observed.

tree-crop interaction under *G. optiva, Morus alba* and *Eucalyptus hybrid* with rice and wheat cropping systems showed that, all tree species had adverse effects on crop yields, whereas wheat was mainly affected by *G. optiva*. The deleterious effect on the average varied from 28 to 34%, depending upon the species. It was observed that the agriculture crops yield increased with an increase of crop distance from the tree (Sharma et al., 1996).

Further, it was also reported that in agroforestry systems the productivity was improved as the distance from the tree is increased (Dhyani and Tripathi, 1999). Similarly in comparison to sole crop, linseed yielded 79, 73, 65 and 56% grain yield, when grown with Albizia, Mandarin, Alder and Cherry tree species (Dhyani et al., 1994). Overall, the reduction in the yield of intercrops due to the presence of trees may be attributed to differential patterns of canopy spread, resulting in variation in light interception, severe competitions of the tree roots for moisture and shade effects. The study carried by Newaj et al. (2003) showed that, the grain yield of pure crops was higher, as compared to the grain yield from the tree-crop systems.

## Productivity of straw

The productivity of straw includes the yield of shoot and crop herbage from the unit area. Table 3 shows that under AHS system, the straw yield of agriculture crops is 3587 kg/ha/year on site-N as compared to 4510 kg/ha/year in sole agriculture crops. In site-S, the straw yield was recorded to be 2213 kg/ha/year as compared to 3084 kg/ha/year in the control condition (sole cropping). The straw yield was comparatively low under agrihortisilviculture system, as compared to sole agriculture system. The higher straw yield in the sole cropping system was attributed to the availability of high PAR (Photosynthetic Active Radiation), which helped in more reproductive phase development (Bellow, 2004).

In the present study, north aspect shown more diversity and luxuriant vegetation though there are more number of trees of a single species like *G. optiva* was observed in the southern aspect of the AHS system. Although, both northern and southern aspects receive almost the same amount of rainfall with alike soil and the similar elevation in this study area, still there are numerous environmental factors which make the difference in the growth and development of the vegetation (both trees and agricultural crops). The logic behind is, the northern aspect of the agrihortisilviculture site is shadier and cooler as in winter and spring; the sunlight is primarily fall on the southern aspect as compared to little direct fall on the northern aspect. As a result of this, the rate of evapotranspiration slow down and there is more moisture conservation in the northern site which resulted in good diversity and agricultural growth in the northern aspect.

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