The Ecoscan 10(3&4): 543-551, 2016
AN INTERNATIONAL QUARTERLY JOURNAL OF ENVIRONMENTAL SCIENCES
www.theecoscan.com

PLANT DIVERSITY IN HORTI-AGRICULTURAL SYSTEM OF DISTRICT BUDGAM, KASHMIR VALLEY: SEASONAL VARIATION IN STRUCTURE, COMPOSITION AND VEGETATION INDICES

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ABSTRACT

Floristic composition revealed the presence of 5 genera, 6 species of 4 families of cultivated herbage plants, 20 genera having 21 species belonging to 14 families of wild herbage plants and 3 genera and 2 species of single family of trees. Seasonal variation in quantitative parameters explicated dominance of *Phaseolus vulgaris* and *Brassica olearacea var. acephala* among cultivated herbaceous species with an IVI of 97.67 (spring), 95.03 (summer) and 122.17 (autumn) respectively. However, in wild herbaceous species, *Stellaria media* achieved maximum IVI of 28.98 (spring), 23.44 (summer) and 42.58 (autumn). Vegetation indices for cultivated and wild herbaceous species showed that Shannon-Weiner index decreased from spring to autumn season, attaining the values as 1.36 to 1.05 and 2.77 to 2.54 correspondingly. Whereas, Simpson diversity index demonstrated increasing trend as 0.25 to 0.35 and 0.06 to 0.08 for both cultivated and wild plant species from spring to autumn respectively. Tree diversity represented 3 genera, 3 species of 1 family with *Malus domestica* as the most important species with highest IVI of 134.50 in the studied agroforestry system.

KEY WORDS
Diversity
Vegetation indices
Quantitative attributes
Seasons

Received : 10.07.2016
Revised : 24.09.2016
Accepted : 13.10.2016

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INTRODUCTION

Biological diversity means the variation among living organisms from all sources and natural ecosystems of which they are a part of; this includes diversity of ecosystems, diversity within species and between species (Heywood and Watson, 1995). It is well established that biodiversity conservation and the maintenance of associated ecosystem services are vital for human well-being (Beaumont *et al*., 2011). But, as a result of anthropogenic activities like deforestation, land degradation, habitat destruction, over-exploitation, pollution leading to climate change, over 75 per cent of earth's terrestrial biomes have shown alteration. The impact of these changes on biological systems are manifested as shifts in phenology, interactions, species distributions, morphology, net primary productivity and losses of biodiversity (Gardner *et al*., 2009). Hence, international community is faced with the challenge of finding land use interventions that can mitigate or reduce the impact of these issues. In the past, the conservation of biodiversity has been mostly understood in terms of the management of protected areas and natural forests, ignoring the possible role of farm areas and the ways through which rural communities have promoted biodiversity in their subsistence agricultural production systems (Fifanou *et al*., 2011; Acharya, 2006). Considering the fact that ecosystems and species are disappearing at an alarming rate, the role of agroforestry as a conservation tool needs to be exploited (Bengtsson *et al*., 2000; Alavalapati *et al*., 2004; Jose, 2009 and 2011). Multi-strata agro-forests contribute to biodiversity conservation via: (i) the provision of supplementary habitat for species that tolerate a lower level of disturbance; (ii) conservation of remnant native species; (iii) buffering the pressure on natural habitats; (iv) provision of corridors for persistence and movement of species across landscapes (Negash *et al*., 2012). Many studies in several parts of world have revealed that different agroforestry systems like homegardens are dynamic systems and are highly acknowledged for retaining higher diversity, mimics the natural ecosystem and represents microenvironments within larger farming systems (Sahoo *et al*., 2010).

The traditional agroforestry systems identified in Kashmir Valley include; boundary plantations, agri-silviculture on sloping lands, agri-silviculture in plains, horti-silviculture, horti-silvi-pasture, horti-silvi-agriculture and homegardens (Mughal and Bhattacharya, 2002), which have been evaluated from economic point of view and no work has been reported regarding plant diversity assessment. So, in order to evaluate and summarize the plant diversity in Horti-agricultural system, the present investigation was conducted in District Budgam, Kashmir Valley.

MATERIALS AND METHODS

The present research study was conducted in Budgam District of Kashmir Valley, India during the year 2013 and 2014. The experimental site *i.e*. District Budgam is located between 34º1′12″ N latitude and 74º46′ 48 "E longitude at an

altitude of 1610 m above mean sea level (msl), roughly 15 km south east of Srinagar city. The topography of the district is mixed with both mountainous and plain areas. Climate is of the temperate type with the upper-reaches receiving heavy snowfall during winter. The average annual precipitation of the district is 585 mm. Preliminary information regarding number of tehsils, blocks within tehsils, villages within blocks, land use systems, land holdings and number of households were obtained from District Agriculture Department. After thorough reconnaissance of the said District, three tehsils namely: Budgam, Beerwah and Chadoora were selected to carry out the research problem on the basis of large of villages and households. Multistage stratified random sampling was used to select the blocks; villages within tehsils and then farmers within villages. A total of 252 farmers were selected and interviewed through pre-tested questionnaire regarding different land use patterns (agriculture, agroforestry, horticulture) and their socio-economic status.The methodology of the experimental study is given in Table-1.

Vegetation analysis

Random quadrats of 10 m × 10 m size for trees and within each of these quadrats two 1m × 1m quadrats for herbs (cultivated and wild) were laid down and replicated three times for each life form respectively. Herbarium specimens (herbaceous plants) were collected for three consecutive seasons *viz*; spring, summer and autumn (Saikia *et al*., 2012) and identified from the Division of Environmental Sciences, SKUAST-Kashmir and Centre for Biodiversity and Taxonomy Department of Botany, University of Kashmir. The data on vegetation were quantitatively analyzed for density, basal area, frequency as per the methods given by Phillips (1959). The relative values of these indices were summed up to get importance value index (IVI) of individual species following Curtis and Mc Intosh (1950).

species diversity (H) and species evenness were calculated by Shannon-Weiner's method (1963). Concentration of dominance (Cd) and Simpsons diversity were measured following Simpsons diversity index (Simpson, 1949) separately for each life form (herbs and trees).

Statistical Analysis

All the data sets were analyzed using descriptive statistics (MS excel work sheet) and by standard procedures given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

From the present investigation, it was appraised that 184 farmers out of 252 farmers in the study area practice different agroforestry systems, of which 70 farmers adopt Horti-agricultural system as one of the agroforestry land use system, covering about 11.78 hectares of area.

Floristic diversity, community structure and composition in Horti-agricultural system of District Budgam

Plant diversity / floristic composition revealed the presence of 5 genera, 6 species of 4 families of cultivated plants (herbage) and 20 genera having 21 species belonging to 14 families of wild plants (herbage). Tree diversity constituted by 3 genera, 3 species of a single family (Table-2).

Floristic composition and community structure are important attributes correlated with prevailing environmental as well as anthropogenic variables (Bisht and Bhat, 2011; Gairola *et al*., 2008). Vegetation stratas *viz*., herbage and trees recorded in the evaluated agroforestry system was quite lower than reported by Deb *et al*. (2014) as 44 woody plants in traditional agroforestry systems of Tripura, India; Guyassa and Raj (2013) in cropland agroforestry of Ethiopia (40 woody species); areca-nut based agroforestry of Meghalaya (88 woody species) by Tynsong and Das (2010); 70 cultivated and 35 wild species evaluated by Amberber *et al*. (2014) in homegarden agroforestry systems of Holeta town, Ethiopia; 98 cultivated/ edible species by Eichemberg *et al*. (2009) in old urban homegardens in Brazil; 75 wild plants by Shameem and Kangroo (2011) for forest ecosystem in Dachigam National Park, Kashmir; 571 alien species reported by Khuroo *et al*. (2007) for Kashmir Himalayas; 59 plant species evaluated by Ahmad and Habib (2014) for Dawarian Village, Neelum Valley, Azad Jammu and Kashmir, Pakistan.

Less vegetation diversity may be due to selective approach of landholders to grow plants that are required for their primary needs only. The motives for retaining different woody species depend on the uses or benefits that they render to the household, management strategy and for income generation to some farmers. As far as wild herbaceous species are concerned, about 21 plants were recorded in the system (Table-2) representing much lower diversity than reported by various workers. This less species richness may be due to the more human interferences/disturbances, micro-climate and edaphic conditions as also reported by Amjad (2015) and Lyaruu (2010). Since, farmers prime and for-most important motive in these agroforestry based land use systems is food (subsistence needs) and socio-economic well-being, thus they have negative attitude towards certain wild plants as weeds that may interfere with the better growth of the cultivated/ edible plants present there.

Seasonal variation in quantitative attribute (IVI) of cultivated plants

Importance value index (IVI) of cultivated herbaceous plants showed a marked variation from spring, summer to autumn season in the study area. Numeric values of importance value index (Table-3) revealed that *Phaseolus vulgaris* attained highest IVI values (97.67) during spring and summer (95.03), followed by *Brassica olearacea var. acephala* as co-dominant

Table1: Detailed methodology for the selection of sample areas

Selected Tehsils	Beerwah	Budgam	Chadoora
Selected Blocks (06)	2	2	2
Selected Villages (06 per Block)	6×2 = 12	6×2 = 12	6×2 = 12
Selected Farmers (7 per Village)	6×2×7 = 84	6×2×7 = 84	6×2×7 = 84
Grand Total	252		

Table2: Diversity recorded in Horti-agricultural system in the study area (District Budgam)

S. No.	Plant Names & Family	Global IUCN Status	English/Local Name
Cultivated Herbage			
1	*Brassica oleracea var. acephala* (Brassicaceae)	N.A	Kale/Hakh
2	*Brassica rapa* (Brassicaceae)	N.A	Turnip/Gogij
3	*Raphanus sativus* (Brassicaeae)	N.A	Radish/Muje
4	*Solanum tuberosum* (Solanaceae)	N.A	Potato/Aaelvi
5	*Phaseolus vulgaris* (Fabaceae)	N.A	Rajma/Beans/Razma
6	*Zea mays* (Poaceae)	N.A	Maize/Makai
Wild Herbage			
1	*Anagallis arvensis* (Primulaceae)	Not Evaluated	Shepherd's weather glass/Chari saben
2	*Anthemis cotula* (Asteraceae)	Not Evaluated	Mayweed/Stinking chamomile/Faki-gaasi
3	*Artemisia absinthium* (Asteraceae)	Vulnerable	Worm wood/Tethwan
4	*Chenopodium album* (Chenopodiaceae)	Not Evaluated	Leafy goosefoot/Dodich
5	*Convolvulus arvensis* (Convolvulaceae)	Not Evaluated	Bindweed/Hiran pug or Soi –posh
6	*Conyza Canadensis* (Asteraceae)	Not Evaluated	Canadian horseweed/Gur loute
7	*Daucus carota* (Apiaceae)	Vulnerable	Wild carrot/Bird's nest/Jangli –gazir
8	*Galinsoga parviflora* (Asteraceae)	Not Evaluated	Gallant soldier
9	*Hypericum perforatum* (Hypersiaceae)	Not Evaluated	St Jhon's wort/Amber
10	*Medicago polymorpha* (Fabaceae)	Not Evaluated	Toothed bur clover/Poshi- gassi
11	*Phragmites australis* (Poaceae)	Stable	Common reed/Narkon
12	*Plantago lanceolata* (Plantagionaceae)	Vulnerable	Ribwort Plantain/Lakut – gulli
13	*Plantago major* (Plantaginaceae)	Not Evaluated	Broadleaf plantain/Greater plantai n/Veuth - gulli
14	*Poa bulbosa* (Poaceae)	Least Concern(Increasing)	Bulbous meadow-grass/Gassi
15	*Potentilla reptans* (Rosaceae)	Least Concern	Creeping tormentil
16	*Rumex dentatus* (Polygonaceae)	Least Concern	Toothed dock/Obuj
17	*Scandix pectenveneris* (Apiaceae)	Least Concern	Shepherd's needle
18	*Stellaria media* (Caryphyllaceae)	Least Concern	Chickweed/Losdhi
19	*Taraxacum officinale* (Compositae)	Vulnerable	Dandelion/Maedan hande
20	*Thymus linearis* (Lamiaceae)	Least Concern	Himalayan thyme/Javind
21	*Veronica persica* (Plantaginaceae)	Not Evaluated	Bird's-eye/Common field-speedwell
Trees			
1	*Malus domestica* (Rosaceae)	Not Evaluated	Apple/Tchoonth
2	*Prunus domestica* (Rosaceae)	Not Evaluated	Plum/Aaer
3	*Pyrus communis* (Rosaceae)	Not Evaluated	Pear/Tang

Table3: Importance Value Index (IVI) of different cultivated plants in Horti-agricultural system of the study area (District Budgam)

S. No.	Plant species	Importance Value Index					
		Spring		Summer		Autumn	
		Mean	±S.E	Mean	±S.E	Mean	±S.E
1	*Brassica olearacea var. acephala L.*	82.33	4.92	77.32	2.43	122.17	9.2
2	*Brassica rapa* L.	-	-	-	-	83.9	10.21
3	*Phaseolus vulgaris* L.	97.67	5.66	95.03	8.26	-	-
4	*Raphanus sativus* L.	-	-	-	-	93.91	18.75
5	*Solanum tuberosum* L.	54.48	6.76	61.94	3.61	-	-
6	*Zea mays* L.	65.5	5.02	65.71	3.74	-	-
Total		300	-	300	-	300	-

species. On the other hand, the dominant species during autumn was *Brassica olearacea var. acephala* with IVI value of 122.17 and *Raphanus sativus* (93.91) as co-dominant. The reason that IVI peaked for a particular crop in a specific season can be ascribed to congenial growth conditions, available resource being utilized efficiently (better adaptability) by that crop species under such environmental conditions, market value (socio-economic factors), choice of the farmer, management intensity and families (at species level) often retain /or cultivate a large number of individuals of certain species that are commonly utilized by the households (Neelamegam *et al*., 2015; Kabir and Webb, 2009). Deb *et al*. (2014), Senanayake *et al*. (2009) and Millat-e-Mustafa and Haruni (2002) have reported similar findings and stated that a significant variation among crop combinations occur in different seasons that farmers choose based on their own wisdom, perceptions, availability of resources, market-oriented value, socioeconomic and cultural factors.

Seasonal variation in quantitative attributes of wild plants

Perusal of the data on quantitative attributes of the wild herbaceous plants in the system showed that density (individuals/ m^2), basal area (cm^2/m^2) and frequency (%) of wild herbaceous plant species increased gradually from spring to summer and thereafter declined in autumn season (Table-4,5,6), while importance value index (IVI) showed an irregular increasing and decreasing pattern (Table-7) in subsequent seasons. Among the recorded species, *Stellaria media* was the

Table4: Density of different wild plants in Horti-agricultural system of the study area (District Budgam)

S. No.	Plant species	Density/m^2					
		Spring		Summer		Autumn	
		Mean	±S.E	Mean	±S.E	Mean	±S.E
1	*Anagallis arvensis* L.	11.33	4.17	19	4.58	1.66	0.08
2	*Anthemis cotula* L.	8.83	1.59	24	1	4.66	0.88
3	*Artemisia absinthium L.*	3.16	0.16	7.66	1.36	1.33	0.03
4	*Chenopodium album* L.	5.5	1.92	15.33	3.84	2.16	0.01
5	*Convolvulus arvensis L.*	9.16	2.45	18.83	1.59	-	-
6	*Conyza canadensis* L. Cronquist	10.66	1.74	18.66	4.56	4.5	1.73
7	*Daucus carota* L.	13.66	1.01	19.16	1.45	7.5	1.5
8	*Galinsoga parviflora* Cav.	17.16	0.28	29.16	1.96	8.66	2.42
9	*Hypericum perforatum* L.	6	1.15	16	3.51	3	0.5
10	*Medicago polymorpha* L.	8.66	4.37	14.5	1.44	5.33	0.72
11	*Phragmites australis* Cav.	3.16	0.87	8.16	3.19	2	0.02
12	*Plantago lanceolata* L.	17.5	1.52	30.5	0.5	10.66	2.84
13	*Plantago major* L.	18.66	3.44	30.66	4.25	12.16	2.58
14	*Poa bulbosa* L.	11.33	5.76	23.5	11.85	-	-
15	*Potentilla reptans* L.	5.83	0.44	15.16	3.41	2.66	0.16
16	*Rumex dentatus* L.	14.16	7.12	21.83	4.33	11.16	0.44
17	*Scandix pectenveneris* L.	7.66	3.84	17	5.25	3.83	0.09
18	*Stellaria media* L.(Vill.)	21.83	1.87	34.83	2.24	14	0.28
19	*Taraxacum officinale* Weber	8.66	1.45	14.5	4.35	3.33	1.71
20	*Thymus linearis*	9.16	4.63	20	1.68	-	-
21	*Veronica persica* Poiret	9	0.5	15	7.5	4.83	0.09
Total		221.07	-	413.44	-	103.43	-

Table5: Basal area of different wild plants in Horti-agricultural system of the study area (District Budgam)

S. No.	Plant species	Basal area(cm^2/m^2)					
		Spring		Summer		Autumn	
		Mean	±S.E	Mean	±S.E	Mean	±S.E
1	*Anagallis arvensis* L.	0.5	0.07	0.84	0.14	0.14	0.01
2	*Anthemis cotula* L.	0.22	0.06	0.84	0.11	0.16	0.02
3	*Artemisia absinthium L.*	0.07	0.01	0.16	0.01	0.02	0.008
4	*Chenopodium album* L.	0.19	0.04	0.81	0.05	0.11	0.05
5	*Convolvulus arvensis L.*	0.46	0.1	0.82	0.15	-	-
6	*Conyza canadensis* L. Cronquist	0.5	0.05	0.77	0.14	0.16	0.02
7	*Daucus carota* L.	0.85	0.02	1.08	0.01	0.43	0.07
8	*Galinsoga parviflora* Cav.	1.09	0.03	1.1	0.21	0.98	0.02
9	*Hypericum perforatum* L.	0.2	0.04	0.76	0.01	0.13	0.02
10	*Medicago polymorpha* L.	0.2	0.1	0.54	0.04	0.13	0.009
11	*Phragmites australis* Cav.	0.14	0.01	0.16	0.01	0.04	0.04
12	*Plantago lanceolata* L.	1.09	0.004	1.11	0.05	1	0.001
13	*Plantago major* L.	1.09	0.001	1.13	0.006	1	0.002
14	*Poa bulbosa* L.	0.53	0.26	0.83	0.44	-	-
15	*Potentilla reptans* L.	0.21	0.04	0.57	0.003	0.12	0.012
16	*Rumex dentatus* L.	0.96	0.05	1.09	0.006	0.76	0.16
17	*Scandix pectenveneris* L.	0.21	0.04	0.82	0.03	0.12	0.01
18	*Stellaria media* L.(Vill.)	1.19	0.0002	1.42	0.05	1.11	0.02
19	*Taraxacum officinale* Weber	0.21	0.05	0.68	0.01	0.1	0.05
20	*Thymus linearis* Cav.	0.5	0.17	0.88	0.44	-	-
21	*Veronica persica* Poiret	0.43	0.26	0.72	0.36	0.17	0.01
Total		10.84	-	17.13	-	6.68	-

major contributor to the total density, basal area, frequency and IVI of vegetation. Its contribution ranged from 21.83, 1.19 and 83.33 (spring); 34.83, 1.42 and 94.44 (summer) and 14.00, 1.11and 77.77 (autumn) respectively. Whereas, minimum values for density, basal area and frequency in different seasons was recorded for *Artemisia absinthium* as 3.16, 0.07 and 8.33 (spring), 7.66, 0.16 and 25.00 (summer) and 1.33, 0.02 and 6.66 (autumn). Numeric values of importance value index in Table-7 of different species revealed that *Stellaria media* attained highest IVI values of 42.58 in autumn, 23.44 in summer and 28.98 during spring compared to other plant species. However, *Artemisia absinthium* recorded lowest values for IVI exhibiting 2.66, 4.48 and 2.78 during spring, summer and autumn respectively.

Cruz-Garcia and Struik (2015) and Kehlenbeck *et al*. (2007) emphasized that no individual factor alone determines the plant diversity, rather a complex combination of agro-ecological, socio-economic, cultural, and political factors causes spatial and temporal variation of plant species. The changing pattern in quantitative attributes of species can be

Table6: Frequency of different wild plants in Horti-agricultural system of the study area (District Budgam)

S. No.	Plant species	Frequency (%)					
		Spring		Summer		Autumn	
		Mean	±S.E	Mean	±S.E	Mean	±S.E
1	*Anagallis arvensis* L.	58.33	8.33	75	25	33.33	16.66
2	*Anthemis cotula* L.	50	2.5	69.44	2.78	41.66	8.33
3	*Artemisia absinthium* L.	8.33	0.33	25	2.31	6.66	0.66
4	*Chenopodium album* L.	66.66	16.66	66.66	8.33	33.33	16.66
5	*Convolvulus arvensis L.*	50	1.3	58.33	8.33	-	-
6	*Conyza canadensis* L.Cronquist	66.66	16.66	66.66	16.66	50	3.3
7	*Daucus carota* L.	58.33	8.33	83.33	16.66	43.33	6.66
8	*Galinsoga parviflora* Cav.	66	10.01	76.66	8.33	40	16.66
9	*Hypericum perforatum* L.	50	6.2	66.66	16.66	43.33	6.66
10	*Medicago polymorpha* L.	33.33	16.66	75	14.43	30	5
11	*Phragmites australis* Cav.	25	4.43	41.66	8.33	16.66	1.66
12	*Plantago lanceolata* L.	50	5.5	88.33	11.66	43.33	6.66
13	*Plantago major* L.	61.66	7.26	90	10	50	4.9
14	*Poa bulbosa* L.	33.33	16.66	66.66	33.33	-	-
15	*Potentilla reptans* L.	50	6.2	66.66	16.66	41.66	8.33
16	*Rumex dentatus* L.	33.33	16.66	83.33	16.66	21.66	3.33
17	*Scandix pectenveneris* L.	33.33	16.66	66.66	16.66	13.33	0.26
18	*Stellaria media* L.(Vill.)	83.33	7.5	94.44	5.55	77.77	2.77
19	*Taraxacum officinale* Weber	66.66	16.66	83.33	16.66	50	8.86
20	*Thymus linearis* Cav.	33.33	16.66	50	7.86	-	-
21	*Veronica persica* Poiret	33.33	16.66	66.66	33.33	16.66	8.33
Total		927.61	-	1460.47	-	652.71	-

Table7: Importance Value Index (IVI) of different wild plants in Horti-agricultural system of the study area (District Budgam)

S. No.	Plant species	Importance Value Index					
		Spring		Summer		Autumn	
		Mean	±S.E	Mean	±S.E	Mean	±S.E
1	*Anagallis arvensis* L.	15.56	3.6	14.26	1.72	8.58	4.13
2	*Anthemis cotula* L.	10.98	1.78	15.52	1	13.6	1.96
3	*Artemisia absinthium* L.	2.66	0.64	4.48	0.11	2.78	0.67
4	*Chenopodium album* L.	10.63	2.14	13.08	1.93	8.64	4.19
5	*Convolvulus arvensis* L.	13.47	2.57	13.58	2.27	-	-
6	*Conyza canadensis* L.Cronquist.	16.13	3.61	13.4	1.02	14.48	0.75
7	*Daucus carota* L.	20.46	1.62	16.57	0.78	20.66	2.45
8	*Galinsoga parviflora* Cav.	24.3	0.98	18.82	0.96	29.48	3.27
9	*Hypericum perforatum* L.	9.52	1.2	12.82	2	11.59	0.36
10	*Medicago polymorpha* L.	8.65	4.27	11.91	1.21	12.07	1.65
11	*Phragmites australis* Cav.	5.33	1.38	5.81	0.93	5.21	1
12	*Plantago lanceolata* L.	23.71	1.87	20.39	1.6	32.79	1.94
13	*Plantago major* L.	25.25	1.74	20.43	1.27	35.06	3.84
14	*Poa bulbosa* L.	12.71	6.33	15.24	7.52	-	-
15	*Potentilla reptans* L.	9.41	0.33	11.45	0.65	10.95	1.33
16	*Rumex dentatus* L.	17.7	8.86	17.76	2.73	21.52	0.71
17	*Scandix pectenveneris* L.	9.07	0.65	13.47	2.57	7.76	3.66
18	*Stellaria media* L.(Vill.)	28.98	1.08	23.44	2.21	42.58	2.11
19	*Taraxacum officinale* Weber	12.28	1.97	12.96	1.28	12.29	5.94
20	*Thymus linearis* Cav.	11.48	1.95	12.72	1.67	-	-
21	*Veronica persica* Poiret	11.61	2.83	11.79	5.86	9.87	0.82
Total		300	-	300	-	300	-

attributed to a range of factors acting independently or in concert (Nogues-Bravo *et al.,* 2008). Descriptive analysis of the data revealed that there exist marked variation among seasons owing to conducive growth and development conditions, suitable edaphic and climatic conditions that favors growth and survival of species, availability of soil moisture for optimum nutrient flow in soil-plant system, amount of litter and rate of litter decomposition which may be influenced by tree density and other environmental factors *i.e.* humidity and solar radiation from spring onwards which declined with the commencement of autumn (Lebret *et al*., 2001). Pappoe *et al*. (2010), Shameem *et al*. (2010), Mahmoud (2009), Semwal *et al*. (2008), Alhassan *et al*. (2006) and Shadangi and Nath (2005) have also stated that during autumn season, the rate of

Table8: Seasonal variation in vegetation indices of herbaceous plants in Horti-agricultural System in District Budgam

Plant species	Vegetation Indices	Seasons		
		Spring	Summer	Autumn
Cultivated	Shannon-Weiner index	1.36	1.37	1.05
	Simpson's diversity	0.25	0.24	0.35
	Species evenness	0.98	0.99	0.96
	Concentration of dominance	0.26	0.25	0.36
Wild	Shannon-Weiner index	2.77	2.89	2.54
	Simpson's diversity index	0.063	0.05	0.08
	Species evenness	0.9	0.95	0.88
	Concentration of dominance	0.068	0.06	0.09

Table9: Quantitative attributes of trees in Horti-agricultural systems of the study area (District Budgam)

Quantitative attributes → Tree species↓	Density (plants ha^{-1})		Basal area (m^2 ha^{-1})		Frequency (%)		Importance value index (IVI)	
	Mean	±S.E	Mean	±S.E	Mean	±S.E	Mean	±S.E
Malus domestica Borkh.	466.67	33.54	4.91	0.19	100	10.76	134.5	20.18
Prunus domestica L.	366.66	31.32	3.28	0.32	66.66	12.12	93.01	9.68
Pyrus communis L.	200	20.31	2.76	0.22	66.66	20.8	72.48	9.523
Total	1033.33	-	10.95	-	233.32	-	300	-

sprouting of root/seed stock is diminished and species number declined owing to adverse climatic conditions. Density reveals strength of any species in a landscape (Baig *et al*., 2013; Alhamad, 2006).

Frequency is a measure of the uniformity of the distribution of a species; thus a low frequency indicates that a species is either irregularly distributed or rare in a particular stand or a forest. Pattern of distribution of a species depends both on the physico-chemical natures of the environment as well as on the biological peculiarities of the organisms themselves (Jhariya and Oraon, 2012) and vegetative reproduction by certain species in addition to their sexuality (Ilorkar and Khatri, 2003). High frequency values during summer season, could be ascribed to optimum resources availability either through litter already present on the ground surface or through fertilizers which farmers apply to enhance growth and production of cultivated crops, good soil-moisture, humidity and temperature. The high frequency percentage of some of the species like *Stellaria media* in this agroforestry system appraises their greater ecological amplitude or niche breadth (Behera *et al.*, 2005). Another reason could be their ability to form dense mat like structure (fibrous roots in *Stellaria media*) hence utilizing the available resource efficiently for their growth development and long survival. Since the diversity was assessed in human dominated landscapes, the possible reasons for low frequency of certain species *viz*., *Artemisia absinthium* could be their utility either as herbal medicines or for commercial exploitation in terms of spices are the important sources of low frequency/disturbance. Man *et al*. (2012) and Verma *et al*. (2005) also reported frequency values between the range of 5-31.67% and 10-100% respectively and attributed this to change in microclimate.

High IVI of few species indicated their dominance and ecological success, their good power of regeneration and greater ecological amplitude. It does vary with the season. Also, disappearance of some species may be due to the mechanical damage by the man and animals. Favorable observations in support of results achieved were also reported by Bijalwan *et al*. (2011) and Kukshal *et al*. (2009). A close observation of IVI of different species in the system showed that there was irregular increase and decrease of this parameter in subsequent seasons with highest IVI values during autumn. It may be due to the reason that most of the available resources are being utilized by that species (having high IVI) and left over are being trapped by another species as the competitors and the associates *i.e*. their inter-relationships with ambient environment and associate species, light availability etc. Other factors affecting the vegetation distribution include biotic such as dispersal limitation, competition, and predation (Wright, 2002; Munzbergova and Herben, (2005) and Gupta and Dass (2007). According to Molla and Kewessa (2015), IVI values can also be used to prioritize species for conservation and species with high IVI value need less conservation efforts, whereas those having low IVI value need high conservation efforts. Based on the results, the herbaceous community in Horti-agicultural system of the study area is christened as *Stellaria media- Plantago major- Artemisia absinthium* .

Vegetation indices of cultivated and wild herbaceous plants

The evaluated data obtained in terms of vegetation indices showed that seasonal Shannon- Weiner index of cultivated herbaceous vegetation were 1.36 (spring), 1.37 (summer) and 1.05 (autumn). Whileas, for wild plants, this index was found to be 2.77 (spring), 2.89 (summer) and 2.54 (autumn). Species evenness was found to be analogous to Shannon- Weiner index *i.e*. maximum value was achieved during summer season and minimum in following season *viz*., 0.98 and 0.90 (spring), 0.99 and 0.95 (summer) and 0.96 and 0.88 (autumn) for cultivated and wild plants correspondingly. Perusal of the data for both cultivated and wild herbaceous plants explicated that Simpson's diversity index and concentration of dominance (Cd) recorded for three consecutive seasons showed inverse relationship to Shannon-Weiner index as 0.25 and 0.26 (spring), 0.24 and 0.25 (summer) to 0.35 and 0.36 (autumn) for cultivated and 0.063 and 0.068 (spring), 0.05 and 0.060 (summer) to 0.08 and 0.09 (autumn) for wild herbage respectively (Table-8). The important and possible reason for

higher values of Shannon-Weiner index and species evenness during summer season could be higher species diversification maintained by farmers in case of cultivated plants, congenial growth conditions in terms of nutrient availability, soil moisture, humidity, light and temperature for a large number of wild plants as reported by Shameem *et al*. (2010); Peyre *et al*. (2006) and Kharkwal *et al*. (2004). Decreased diversity index of plants during autumn could be due to lower rate of evolution and diversification of communities (Simpson, 1949; Fischer, 1960) and severity in environment (Connel and Oris, 1964). Simpson index and concentration of dominance showed a reverse trend in the system with respect to Shannon-Weiner index, species evenness and seasons *i.e*. achieved lowest values during spring and summer season and highest in autumn. Compatible results of inverse relationship between diversity and dominance were also reported by Pokhrel *et al*. (2015); Singh and Singh (2013); Negash *et al*. (2012); Shameem and Kangroo (2011).

Quantitative attributes of Trees

Detailed analysis of the data revealed that *Malus domestica* explicated maximum density of 466.67 ha^{-1} with basal area of 4.91 m^2ha^{-1}, 100 % frequency and 134.50 as IVI indicating dominance in the evaluated agroforestry system. Minimum values for density, basal area, frequency and IVI of 200 ha^{-1}, 2.76 m^2 ha^{-1}, 66.66 % and 72.48 respectively was recorded for *Pyrus communis* (Table-9). The assessment of species diversity is crucial, since it represents a fundamental property of ecological communities and provides a tool to compare assemblages in time and space, independently from species identities (Guyassa and Raj, 2013). Bijalwan, (2012); Rawat *et al*. (2010); Sonwa *et al*. (2007) and Maikhuri *et al*. (2000) have documented that higher value for quantitative attributes of few trees may be due to ecological/environmental adaptability, farmer's preference for their subsistence requirement fulfillment as cash crop and variety of multipurpose uses such as fuelwood, easy propagation and management. As per the results summarized in Table-9, *Malus domestica* was found to explicate high IVI value because this fruit tree species have greater economic value *i.e*. it provides huge monetary benefits to farmers in addition to agricultural crops, good market value *i.e*. its great demand locally and country wide, long shelf life than other fruit tree species evaluated.

ACKNOWLEDGEMENT

The financial support (INSPIRE- Fellowship) provided by the Department of Science and Technology, Government of India, New Delhi during the pursuit of this study is gratefully acknowledged by the first author.

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