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Short communication

Impact of different silvipastoral systems on understorey vegetation and soil properties

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Abstract

The present investigation was carried out in seven different silvipastoral systems *viz*. T_1-*Cedrus deodara,* T_2-*Robinia pseudoacacia,* T_3- *Cupressus torulosa,* T_4- *Prunus armeniaca,* T_5- *Ailanthus altissima*, T_6- mixed plantations and T_7- grassland (control) of Sindh range, Ganderbal Forest Division, Kashmir Province. It aimed to assess floristic composition of different plantations and their impact on understorey vegetation and soil nutrients. The results revealed that 12 shrub and 43 herb species were found in all these systems. *Cyanodon dactylon* was the dominating species under grassland (control), *Ailanthus altissima* and *Cupressus torulosa* plantations. *Oxalis acetosella* was dominating under *Cedrus deodara* plantations. *Lolium perenne* was dominating species under mixed stand, *Robinia pseudoacacia* and *Prunus armeniaca* plantations. Maximum available nitrogen was recorded in T_2- *Robinia pseudoacacia* plantation (363.76 kg ha^{-1}), whereas the highest values for phosphorus and potassium (23.44 kg ha^{-1} and 312 kg ha^{-1} respectively) were recorded in T_5-*Ailanthus altissima* plantation. Maximum soil organic carbon and electrical conductivity (2.14% and 0.51 dSm^{-1}, respectively) was recorded in T_5- *Ailanthus altissima* plantation. pH in different plantation types followed the trend of $T_7 > T_5 > T_4 > T_6 > T_2 > T_1 > T_3$ plantations.

Keywords: Floristic composition, Nutrients, Silvipastoral systems, Similarity index

Jammu and Kashmir is known for its rich biodiversity and for this reason it has also been termed as 'Biomass State'. Forests not only occupy considerable importance in the economy of the state but also restore ecological balance of ecosystem, maintain biological diversity, act as catchments for soil and water conservation and are, therefore, termed as green gold. In order to understand the forest ecology and ecosystem functions, botanical assessments such as floristic composition, species diversity and structural analysis studies are essential for providing information on species richness of the forests, also useful for forest management purpose. Floristic composition is a measure of species diversity in a community and it is a long term process to give clear cut information of species diversity of an area as it is liable to change with season as well as the effect of biotic factors, microclimate and their interaction in any community (Husain *et al*., 2019). In addition the vegetation also influences the soil properties to a great extent. The selective absorption of nutrient elements by different tree species and their capacity to return them to the soil brings about changes in soil properties (Singh, 1980). Concentration of elements in the soil is thus a good indicator of their availability to plants (Pandit and Thampan, 1988). Most of the established forests on hilly areas developed under pastoral farming, where significant accumulation of organic matter and associated nutrients (nitrogen, phosphorus, sulphur) occurred in these soils as a consequence of fertilizer input. This change in land-use was attributed to a combination of declining returns from pastoral farming and the expectation of increased future returns from forestry. In addition to the potential economic benefits associated with the establishment of plantations, development of forestry in grassland areas may help to restore degraded lands and control soil erosion, especially in hill and high country areas (Davis, 1998). Closer examination of changes in soil properties over time following establishment of different tree species is necessary to understand the mechanisms responsible for changes in the soil organic matter and nutrient availability (Binkley and

Hogberg, 1997) which in turn will assist in the development of effective long term strategies to maintain soil quality and fertility. In Kashmir valley tree plantations are mostly done in grasslands under afforestation programs and comprises of species like Kail (*Pinus wallichiana*), Deodar (*Cedrus deodara*), Fir (*Abies pindrow*), Spruce (*Picea smithiana*), Poplar (*Populus deltoides*), Elm (*Ulmus wallichiana*), Ailanthus (*Ailanthus altissima*), Apricot (*Prunus armeniaca*) and Robinia (*Robinia pseudoacacia*) etc. No sincere efforts have been made in Sindh forest division to analyse the effect of different tree species on understorey vegetation and change in soil properties over time in the past. Hence, the present investigation was carried out to assess floristic composition of different plantations and their impact on understorey vegetation and soil nutrients.

The study was carried out during 2017-2018 at Sindh range of forest division Ganderbal. The experimental site is spread over an area of 21807 hectares (39 compartments) at an altitude of 1600-5200 m. Geographically the site lies between 74º42' to 75º26' East longitude to 34º28' North latitude in central Circle of Kashmir Province. The study was conducted by stratified random sampling, quadrates of 10m x 10m were laid down for trees. Each quadrant was further divided into 5m x 5m and 1m x 1m quadrats for shrubs and herbs, respectively. This silvopastoral system consisted of seven treatments *viz*., *Cedrus deodara*, *Robinia pseudoacacia, Cupressus torulosa, Prunus armeniaca, Ailanthus altissima,* Mixed stand and Grassland denoted by T_1, T_2, T_3, T_4, T_5, T_6 and T_7 with three quadrats in each treatment and was laid out in randomised block design. The climate of the experimental site varied considerably with altitude. It was mild and salubrious in the lower elevations but very cold in higher altitudes. The average minimum and maximum temperature varied from -14 to 38 °C with annual precipitation of 1327 mm.

Specimens were collected during growing season from study site and identified from Division of Environmental Science, SKUAST-Kashmir and Centre for Biodiversity and Taxonomy, Department of Botany, University of Kashmir. Seven composite soil samples from each sample plot were collected from top 0-30 cm depth with 3 replications. Samples were dried, crushed, passed through 2 mm sieve and stored in the cloth bags for estimation of N, P and K using methods described by Subbiah and Asija (1956), Olsen *et al.* (1954) and Merwin and Peech (1951), respectively. Organic carbon (OC) was estimated by wet combustion method of Walkley and Black (1934). The conductivity and pH of soil samples were measured at 20 °C with the help of a digital CD-601 conductivity meter (Jackson, 1973) and digital pH meter (Jackson *et al*., 1958). The data obtained were subjected to statistical analysis using O. P. Sheoran statistical software package (Sheoran *et al*., 1998).

The presence of any species in any area is determined by the prevailing environmental conditions and its tolerance and adaptation by it (Bhandari *et al*., 1999). The silvipastoral systems differed in composition and number of plant species (Table 1-2). The total number of identified shrub and herb species were 12 and 43, respectively. The maximum number of shrub species (09) were recorded in T_4 *i.e*. *Prunus armeniaca* plantations and minimum (01) were recorded in T_1 *i.e*. *Cedrus deodara* plantations (Table 1). Among the identified herbaceous species, maximum (36) were recorded in T_7 *i.e*. grassland, followed by 34 in T_4- *Prunus armeniaca* plantations and minimum (08) were recorded in T_1-*Cedrus deodara* plantations (Table 2). Among shrubs *Berberis lycium* was common in all silvipastoral systems, while among herbaceous species *Cynodon dactylon* was observed in all silvipastoral systems. It was ascertained that the experimental plots represented low species richness with low alpha and beta diversity. Higher tree layer diversity enhanced herbage layer diversity either by increasing environmental heterogeneity or by creating environmental conditions which were favorable to a greater number of herbage species (Beatty, 2003) that might have encouraged the shrub composition in apricot plantations. Least number of species in deodar plantation might be due to litter deposition on the forest floor which might have restricted germination of herbaceous flora. These results were in line with the findings of species composition in Chir pine forests in Himalayas (Dangwal *et al*., 2012) and biomass production of natural vegetation, agroforestry and cultivated land use systems along altitudinal gradient in north-western Himalaya (Singh *et al*., 2019). In addition, the strong competition for space and light accompanied by release of allelochemicals by trees might have prohibited the propagation of shrubs and herbages in these systems. It was observed that maximum similarity index recorded for shrubs between T_6- mixed stand and T_4- *Prunus armeniaca* while for herbs between T_4- *Prunus armeniaca* and T_7- grassland (control) with a value of 0.83 in both, whereas minimum similarity index for shrubs was recorded between T_4- *Prunus armeniaca* and T_6- mixed stand

Table 1. Floristic composition of shrub species under different silvipastoral systems

Name of species	Family	Common name	Treatments						
			T_1	T_2	T_3	T_4	T_5	T_6	T_7
Berberis aristata	Berberidaceae	Indian barberry	-	-	+	+	-	-	+
Berberis lycium	Berberidaceae	Berberis	+	+	+	+	+	+	+
Cotoneaster nummularius	Rosaceae	Rock spray	-	-	+	+	-	-	+
Daphne mucronata	Thymelaeaceae	Kashmir daphne	-	-	+	+	-	-	-
Indigofera heterantha	Fabaceae	Chinese bush clover	-	+	-	+	-	-	-
Parrotiopsis jacquemontiana	Hamamelidaceae	Parrotia	-	-	-	+	-	-	-
Rubus bramble	Rosaceae	Bramble	-	+	-	+	+	-	+
Rubus ellipticus	Rosaceae	Golden himalayan raspberry	-	+	-	+	-	-	+
Rubus niveus	Rosaceae	Mysore raspberry							
	+	-	+	+	-	+			
Spartium junceum	Fabaceae	Spanish broom	-	-	-	-	-	+	-
Spiraea arcuata	Rosaceae	Spirea	-	+	-	-	-	-	-
Ziziphus jujuba	Rhamnaceae	Indian jujube	-	+	-	-	-	+	+
Total			**01**	**07**	**04**	**09**	**03**	**03**	**07**

T_1: *Cedrus deodara*; T_2: *Robinia pseudoacacia*; T_3: *Cupressus torulosa*; T_4: *Prunus armeniaca*; T_5: *Ailanthus altissima*; T_6: Mixed stand *(Cupressus torulosa, Robinia pseudoacacia, Ailanthus altissima)*; T_7: Grassland (control); '+' Means presence and '–' Means absence

with a value of 0.17 (Table 3) and for herbs it was between T_5-*Ailanthus altissima* and T_6- mixed stand with a value of 0.19 (Table 4).

The nutrient analysis of soil varied significantly with the average effect of plantation types. It was evident that the maximum value for available nitrogen (363.76 kg ha^{-1}) was observed in T_2- *Robinia pseudoacacia* plantation followed by T_5- *Ailanthus altissima*, T_4- *Prunus armeniaca* plantations, whereas the lowest value (188.16 kg ha^{-1}) was recorded in T_1- *Cedrus deodara* plantations (Table 5). For phosphorus and potassium the highest values (23.44 kg ha^{-1} and 312 kg ha^{-1}, respectively) were recorded in T_5-*Ailanthus altissima* plantation followed by T_2- *Robinia pseudoacacia* and T_4- *Prunus armeniaca* plantation, whereas the lowest values (10.31 kg ha^{-1} and 214.76 kg ha^{-1}, respectively) were recorded in T_1- *Cedrus deodara* plantation. The differences in nutrient enrichment between the vegetation types could be due to differential leaf litter deposition and decomposition rates, nodulation behavior of leguminous tree species, availability of water and nutrient status of the site. The results were consistent with those of Kaushal *et al.* (2012), who noted that the biochemical quality, decomposition rate, timing of nutrient release, and crop nutrient demand mostly determined its influence on soil fertility and plant growth.

Maximum soil organic carbon and electrical conductivity (2.14% and 0.51 dSm^{-1}, respectively) was recorded in T_5- *Ailanthus altissima* plantation whereas, minimum values (0.78% and 0.13 dSm^{-1}) were recorded in T_3- *Cupressus torulosa* and T_1- *Cedrus deodara* plantation respectively . The highest organic carbon content in T_5-*Ailanthus altissima* plantation might be due to higher litter deposition accompanied by higher decomposition rate. The lower electrical conductivity values in soil were characteristic to the lesser release of ions from mineral weathering under different temperature and moisture regimes. The highest pH (7.6) was recorded for T_7- grassland (control), whereas the lowest pH (6.2) was recorded for T_3- *Cupressus torulosa* plantation. The pH level in all the plantation types was slightly acidic to alkaline, and could be ascribed to decomposition of organic matter and release of organic acids during the decomposition resulting in more acidity of soil. Various studies also indicated that litter quality changes soil pH differently with increasing acidity for coniferous species and decreasing acidity for deciduous and herbaceous litter (Sariyildiz *et al.*, 2005).

Understorey species composition in these silvipastoral systems differed which was a manifestation of type (species and density) of over storey trees and their influence on herbaceous layer diversity by modifying resource availability and environmental conditions. The broad leaved forests nurture higher number of shrub species, thus high number of shrubs occurred

Table 2. Floristic composition of herb species under different silvipastoral systems

Name of species	Family	Common name	Treatments						
			T_1	T_2	T_3	T_4	T_5	T_6	T_7
Achillea millefolium	Asteraceae	Yarrow	-	-	-	+	-	-	+
Agrimonia eupatoria	Rosaceae	Liverwort	-	-	-	+	-	+	+
Amaranthus caudatus	Amaranthaceae	Velvet flower	-	-	-	+	-	-	+
Amaranthus viridis	Amaranthaceae	Pigweed	-	+	-	+	-	-	+
Arctium lappa	Asteraceae	Great burdock	-	-	-	+	+	-	-
Artemisia absinthium	Asteraceae	Worm wood	-	-	-	+	-	-	+
Arnebia hispidissima	Boraginaceae	Arabian primrose	-	-	-	+	-	-	+
Asplenium species	Aspleniaceae	Andy's orchid	+	+	-	+	-	-	-
Bothriochloa ischaemum	Poaceae	Yellow bluestem	-	+	-	+	-	+	+
Centaurea iberica	Asteraceae	Iberian starthistle	-	+	+	-	+	-	+
Chenopodium album	Amaranthaceae	Lamb's quarters	-	+	+	-	+	-	+
Chenopodium axanthum	Amaranthaceae	Lamb's quarters	-	-	-	-	-	-	+
Cichorium intybus	Asteraceae	Chicory	-	-	-	+	-	+	+
Conyza canadensis	Asteraceae	Horseweed	-	+	-	+	+	-	+
Cynodon dactylon	Poaceae	Bermuda grass	+	+	+	+	+	+	+
Cymbopogon nardus	Poaceae	Palmarosa	-	-	-	-	-	-	+
Daucus carota	Apiaceae	Wild carrot	-	-	-	+	-	-	+
Fragaria nubicola	Rosaceae	Himalayan strawberry	-	-	+	+	-	-	-
Fragaria vesca	Rosaceae	Woodland strawberry	-	-	-	+	+	-	+
Lespedeza species	Fabaceae	Chinese bush clover	-	-	-	+	+	+	+
Lolium perenne	Poaceae	Rye grass	-	+	-	+	-	+	+
Malva neglecta	Malvaceae	Common mallow	-	-	-	+	-	-	+
Marrubium vulgare	Lamiaceae	Common horehound	-	-	+	+	-	-	-
Medicago minima	Fabaceae	Bur clover	-	+	-	+	+	-	+
Oxalis acetosella	Oxilidaceae	Wood sorrel	+	-	+	-	-	-	-
Oxalis corniculata	Oxilidaceae	Creeping wood Sorrel	+	-	+	-	-	+	-
Plantago lanceolata	Plantaginaceae	Ribwort	+	+	-	+	-	-	+
Plantago major	Plantaginaceae	common plantain	-	+	-	+	-	-	+
Poa annua	Poaceae	Annual meadow grass	-	+	-	-	+	-	+
Poa bulbosa	Poaceae	Bulbous meadow grass	-	+	-	-	+	-	+
Poa pratensis	Poaceae	Blue grass	-	-	-	-	-	-	+
Rumex nepalensis	Polygonaceae	Common Sorrel	-	-	-	+	-	-	+
Salvia moorcroftiana	Labiatae	Kashmir sage	+	-	+	+	+	-	+
Scandix pectenveneris	Apiaceae	Shepherd's needle	-	+	-	+	+	-	+
Setaria viridis	Poaceae	Green foxtail	-	-	-	+	-	-	+
Solanum nigrum	Solanaceae	Black nightshade	-	-	-	+	-	-	-
Sorghum halepense	Poaceae	Johnson's grass	-	-	-	+	-	-	+
Stipa sibirica	Poaceae	Feather grass	+	+	+	+	-	+	+
Taraxacum officinale	Asteraceae	Common dandelion	-	-	-	+	-	-	+
Trifolium pratense	Fabaceae	Red clover	+	+	-	+	+	-	+
Trifolium repens	Fabaceae	White clover	-	-	-	+	-	-	+
Urtica dioica	Urticaceae	Stinging neetle	-	-	-	+	-	-	+
Viola odorata	Violaceae	Wood violet	-	-	-	+	-	-	+
Total			**08**	**16**	**09**	**34**	**13**	**08**	**36**

T_1: *Cedrus deodara*; T_2: *Robinia pseudoacacia*; T_3: *Cupressus torulosa*; T_4: *Prunus armeniaca*; T_5: *Ailanthus altissima*; T_6: Mixed stand *(Cupressus torulosa, Robinia pseudoacacia, Ailanthus altissima)*; T_7: Grassland (control); '+' Means presence and '–' Means absence

Table 3. Similarity index and dissimilarity index for shrubs under different treatments

Dissimilarity \ Similarity	T_1	T_2	T_3	T_4	T_5	T_6	T_7
T_1: *Cedrus deodara*	-	0.25	0.40	0.20	0.50	0.50	0.25
T_2: *Robinia pseudoacacia*	0.75	-	0.18	0.63	0.60	0.40	0.72
T_3: *Cupressus torulosa*	0.60	0.82	-	0.62	0.29	0.33	0.55
T_4: *Prunus armeniaca*	0.80	0.37	0.38	-	0.50	0.17	0.75
T_5: *Ailanthus altissima*	0.50	0.40	0.71	0.50	-	0.33	0.60
T_6: Mixed stand	0.50	0.60	0.67	0.83	0.67	-	0.40
T_7: Grassland (control)	0.75	0.28	0.45	0.25	0.40	0.60	-

Table 4. Similarity index and dissimilarity index for herbs in different treatments

Dissimilarity \ Similarity	T_1	T_2	T_3	T_4	T_5	T_6	T_7
T_1: *Cedrus deodara*	-	0.42	0.59	0.29	0.29	0.38	0.23
T_2: *Robinia pseudoacacia*	0.58	-	0.32	0.44	0.62	0.33	0.58
T_3: *Cupressus torulosa*	0.41	0.68	-	0.23	0.36	0.35	0.22
T_4: *Prunus armeniaca*	0.71	0.56	0.77	-	0.38	0.33	0.83
T_5: *Ailanthus altissima*	0.71	0.38	0.64	0.62	-	0.19	0.49
T_6: Mixed stand	0.62	0.67	0.65	0.67	0.81	-	0.32
T_7: Grassland (control)	0.77	0.42	0.78	0.17	0.51	0.68	-

Table 5. Physico-chemical characteristics of soil under different silvipastoral systems

Treatments	OC (%)	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	EC (dSm^{-1})	pH
T_1: *Cedrus deodara*	0.97	188.16	10.31	214.76	0.13	6.6
T_2: *Robinia pseudoacacia*	1.95	363.76	19.86	306.28	0.36	6.9
T_3: *Cupressus torulosa*	0.78	213.24	11.29	221.41	0.18	6.2
T_4: *Prunus armeniaca*	1.56	313.60	17.24	288.93	0.44	7.3
T_5: *Ailanthus altissima*	2.14	338.68	23.44	312.00	0.51	7.4
T_6: Mixed stand	1.36	275.96	16.67	276.33	0.28	7.1
T_7: Grassland (control)	1.17	250.88	14.93	252.18	0.21	7.6

OC: Organic carbon; EC: Electrical conductivity

in apricot plantations. Different trends of soil enrichment could be attributed to the differences in species-site interaction, quantum of litter produced, difference in the rate of decomposition and mineralization and differential nutrient uptake and cycling. Therefore, differential changes in soil properties under tree plantations owing to differences in nutrient biocycling.

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