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Seasonal Variation in some Chemical Characteristics of the Soil under different Land Uses of Jhilmil Jheel Wetland, Haridwar-Uttrakhand, India

Mohd Salim, Pramod Kumar, M.K. Gupta* and Saurabh Kumar

Forest Ecology & Environment Division, Forest Research Institute, Dehradun
*Forest Soil & Land Reclamation Division, Forest Research Institute, Dehradun

Abstract- A study was conducted to investigate the seasonal changes of the nutrients in the soil under different land uses i.e., natural forest, plantation and grassland of Jhilmil Jheel wetland, situated in Haridwar district of Uttrakhand, India. It is a saucer shape swampy wetland where fragmented sections of swamp deer (*Cervus duvauceli duvauceli*) is present and happens to be the last refugee for this magnificent and highly endangered species. Soil samples were collected from the depth of 0-30 cm from all the three land uses during different seasons i.e., autumn, winter, spring and summer. The higher values of soil pH was observed in summer season and the least in autumn season under different land uses i.e., higher in grassland followed by plantation and least was under natural forest. The soil organic carbon content was higher in winter season followed by spring, autumn and the least was observed in summer season under different land uses. The organic carbon content was higher in the soils under natural forest followed by plantation and the least under grassland. Total nitrogen values were observed higher in winter season and the least was observed in summer season. The different land uses followed the same trend with the higher values of total nitrogen under natural forest soils followed by plantation and the least was under grassland. Available phosphorus content in the soils was observed higher in winter season under natural forest followed by plantation and least was under grassland. The least values of available phosphorus were observed during summer season with little fluctuation between autumn and spring season. Same seasonal and land use trend was followed by available potassium with the higher values in winter season under natural forest followed by plantation and least under grassland. The values of available potassium was found least in summer season. SPSS 16.0 model was used to analyse the data for one way ANOVA to observe the variations of the chemical properties in different seasons under different land uses at (P = 0.05 level).

Index Terms- wetland, pH, organic carbon, total nitrogen, available phosphorous and available potassium.

I. INTRODUCTION

Study of wetland is very important as they are highly productive and fragile ecosystem. Wetlands have also been called as "Biological Supermarkets" for the extensive food chain and rich biodiversity they support. They play major roles in the landscape by providing unique habitats for a wide variety of flora and fauna. Some common names for different types of wetlands are swamp, marsh and bog. Depending on the type of wetland, it may be filled mostly with trees, grasses, shrubs or moss. Wetlands in India occupy 58.2 million hectares, including areas under wet paddy cultivation (Directory of Indian Wetlands, 1993). Majority of the inland wetlands are directly or indirectly dependent on the major rivers like, Ganga, Brahmaputra, Narmada, Godavari, Krishna, Kaveri, Tapti. They occur in the hot arid regions of Gujarat and Rajasthan, the deltaic regions of the east and west coasts, highlands of central India, wet humid zones of suth peninsular India and the Andaman and Nicobar & Lakshadweep islands. According to Champion and Seth (1968), all the fresh water swamp forests in India comes under the category of 4C/FS1 and are mainly occur in the valleys of Western Ghats (Krishnamoorthy, 1960) and in the foot hills of Himalayas (Dakshini 1960; Ghildial and Srivastava, 1989).

Soil is a major source of nutrients needed by plants for growth. The three main nutrients are nitrogen (N), phosphorus (P) and potassium (K). Together they make up the trio known as NPK. One of the important factors to determine quality of soil and serves as sources of nutrients for improving physical and biological properties of soils in addition to productivity is Organic matter. The soil chemical environment is dynamic and reactions that maintain dilute solution of nutrient elements are indispensable for continual plant growth. The nutrient transformation and its availability in soils depend on pH, clay minerals, cation and anion exchange capacity (Reddy and Reddy, 2010). The presence of dense vegetation affords the soil adequate cover, thereby reducing the loss in macro and micro nutrients that are essential for plants growth and energy fluxes (Iwara *et al.*, 2011). Change in the soil chemical properties in the form of P mineralization-immobilization of organic P, are strongly influenced by seasonal variations in temperature, moisture, plant growth and root activity, and by organic matter accumulation from litter fall (Perrot *et al.*, 1990; Mc Grath *et al.*, 2000). Land cover changes also affects the soil properties and biogeochemical process (Ross *et al.*, 1999; Zeng *et al.*, 2000). Bodner *et al.*, (2008) discussed the impact of the rainfall intensity, soil drying and the frost on the seasonal changes of the soil hydraulic properties in the texture related range. The information of soil quality of Jhilmil Jheel wetlandis very important as no such work was carried out. Thus, the present investigation was an attempt to analyse and document the seasonal variations of the chemical properties under different land use. It is hoped that the study will provide useful knowledge in the future.

Study site:

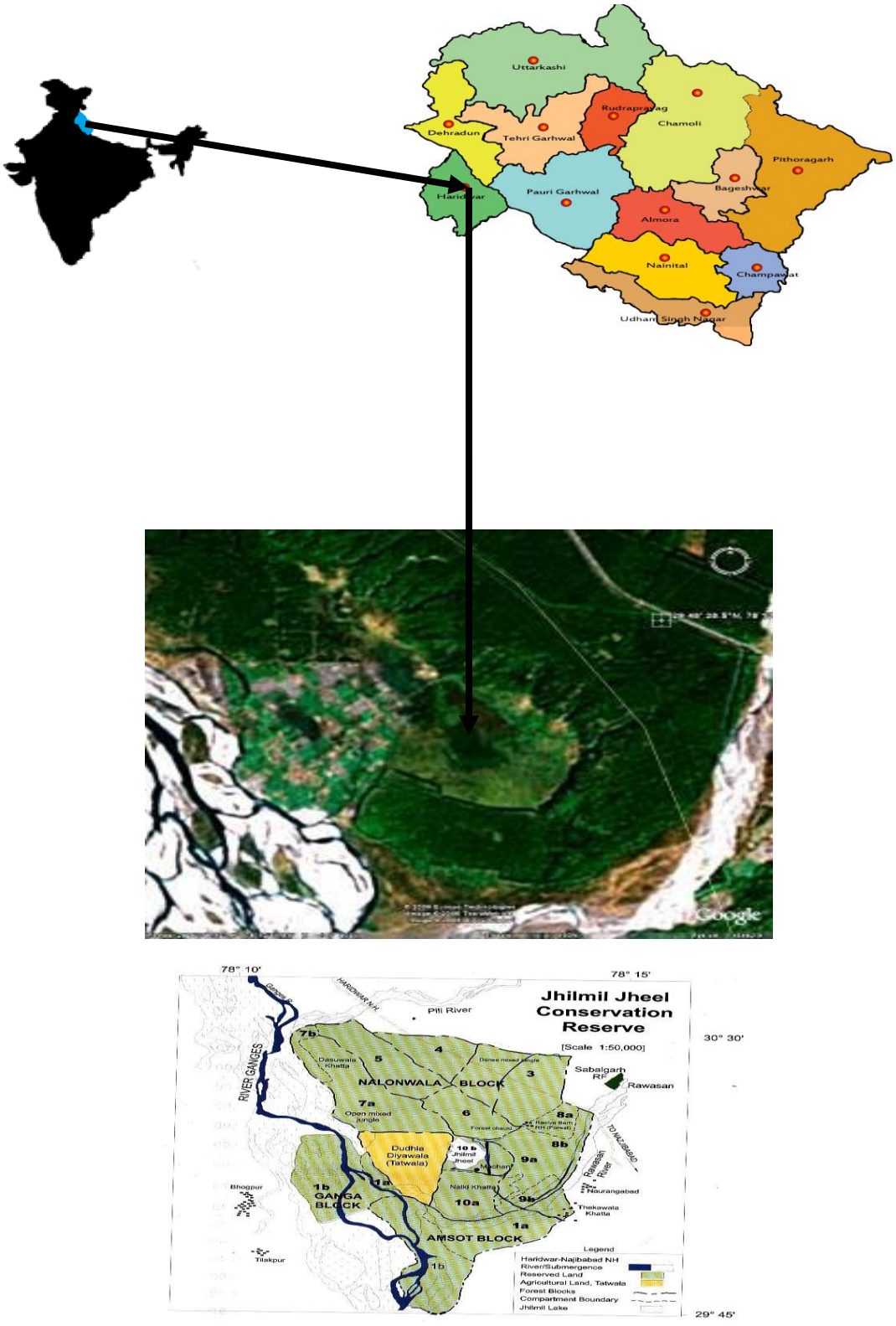

Figure 1. Map of the study area (source: unanimous)

II. STUDY AREA

Jhilmil Jheel is a saucer shaped wetland situated on the left bank of River Ganges between N 290 32' to 290 50' and E 780 to 78 0 15' covering an area of 3783.50 ha of Reserve Forest. The altitude of the area varies from 200 to 250 meters above mean sea level. It is located on the Haridwar – Highway and besides the natural course of the Ganges to the south of it in Chidiyapur Forest Range of Haridwar Forest Division, Uttarakhand. It is connected to River Ganga and is surrounded by Reserve Forest of Chidiyapur Range. The habitat is located at the junction of the Bhabhar and Terai formations representing a unique and species rich ecosystem which encompasses spectacular landscapes, tall grasslands, and tropical moist deciduous forests (Fig. 1).

III. MATERIAL & METHODS

Soil samples were collected randomly from 0-30 cm depth during each season i.e., autumn, winter, spring and summer and was brought into laboratory further analysis. Soil organic carbon was estimated by Walkley and Black (1934) method, total nitrogen by kjeldhal method (Misra, 1968), pH (Piper, 1950), phosphorus by colorimetric method and potassium by flame photometry (Jackson, 1973).

IV. RESULTS & DISCUSSION

pH: Soil pH influences plant growth by way of improving the soil physical condition and nutrients availability, whereas, high or low pH of nutrient medium has adverse effect on plant growth. The results in (Fig. 2) have shown that the value of the pH was nearly neutral. Soil pH under all the three different land uses followed the same pattern as it was observed higher in summer followed by spring, winter and the least was observed in autumn respectively. The result revealed that maximum pH was observed in summer season and the minimum was in autumn (rainfall) season. Soils become acidic because of warm temperature and high rainfall because under such conditions, soils weather quickly. Basic cations (e.g., Ca, Mg, K) which are essential to living organisms, are leached from soil profile, leaving behind more stable materials rich in Fe and Al oxides. This natural weathering process makes soil acidic and generally devoid of nutrients (Uchida and Hue, 2000). Shaikh (1996) also reported that the soil pH was maximum in summer and minimum in winter at Bilawali Tank Indore. The result also revealed that the grassland had the maximum pH values while natural forest had the minimum pH values. This may be due to high organic matter content and undisturbed nature of the natural forest soils as compare to plantation and grassland. The natural forest has low pH as compare to the grassland because organic matter in the form of plant litter, compost, and manure will decrease soil pH through the decomposition process (Brady & Weil, 2002). Robertson and Vitousek, (1981) and Adams and Sidle (1987) have also recorded low pH in undisturbed natural forest soils as compared to disturbed forest soils. It was reported that forest soils should be slightly acidic for nutrient supply to be balanced (Leskiw, 1998). Semwal *et al,* (2009) reported that the pH values were highly acidic in the undisturbed forest as compare to disturbed forest. High amount of humus in forest soils is responsible for low pH (Dimri, et al., 1987). Reduction in pH can be attributed to accumulation and subsequent slow decomposition of organic matter, which releases acid (de Hann, 1977).

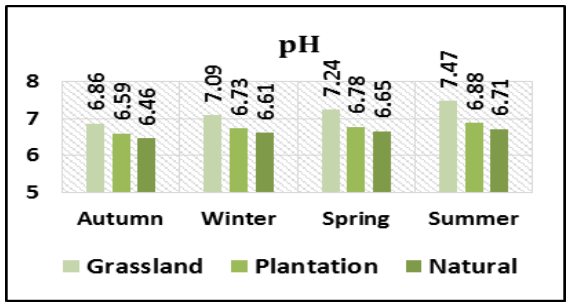

Figure 2

Organic Carbon: The level of soil organic carbon determines the multiplication of microorganisms and makes the system more dynamic. The results revealed in (Fig. 3) that the organic carbon content followed same trend under all the three different land uses i.e., higher in winter followed by spring, autumn and least was observed in summer. The results showed that the maximum percentage of OC was observed under natural forest during winter season and the minimum was observed under grassland in the summer season. Declining trend during the summer season may be because organic carbon content decreases with increase in temperature (Kirschbaum, 1995; Albrecht and Rasmussen, 1995), and decomposition rates (microbial respiration) doubles with every 10^{o}C increase in the temperature (Schlesinger, 1997; Hartel, 2005). Dick and Gregorich (2004) compared relative decomposition rates of organic matter in tropical (Nigeria) and cold dry climates (Canada), and found that decomposition rates were 10 times faster in the tropical site. Sevgi and Tecimen (2008) reported that higher organic carbon in the natural forest was due to production and return of higher amount of litter in natural forest. The release of nutrients from litter decomposition is a natural process in the internal biogeochemical cycle of an ecosystem, and decomposers recycle a large amount of carbon that was bounded in the plant or tree to the atmosphere. The results also revealed that natural forest soils had the maximum content of organic carbon in all the seasons and the minimum was observed under grassland in all the seasons. It may be because forests have grater canopies and provide the litter in larger quantity as compare to grasslands therefore, accumulation of carbon was higher. About 40% of the total SOC stock of the global soils resides in forest ecosystem (Bhattacharyya *et al.,* 2008).

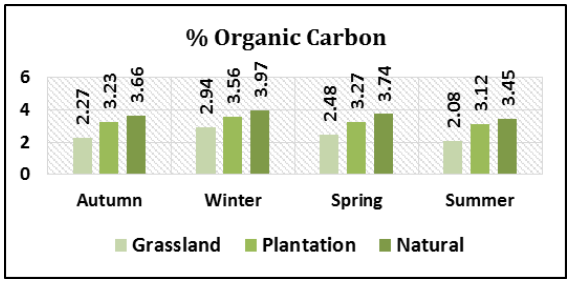

Figure 3

Total Nitrogen: Nitrogen is an important factor affecting soil fertility and plant strata. It is mostly present in the form of nitrates in the soil. The results revealed in (Fig. 4) that the total nitrogen in the soils under natural forest in autumn season was higher followed by winter, spring and the least as observed in summer respectively with same trend also followed under plantation. Total nitrogen in the soils under grassland was higher in autumn followed by spring, winter and least was observed in summer respectively. The results showed that total nitrogen was observed maximum in natural forest during autumn season and the minimum was observed in grassland in the summer season. The increased nitrogen contents during the rainy season could be best explained by the possible activity of nitrogen fixing microbes. Evidence exists to show that increased biological nitrogen fixation along with increased mineralization rates occur during the rainy season, which resulted in increased nitrogen content at this time (Bergeron *et al.,* 2002). Higher values of total nitrogen in the soil profile during rainy season reflects blue green algae fixation, rain water input and higher rate of release of mineral nitrogen through microbial decomposition (Birch 1958, Choudhri and Sharma 1975). Singh and Singh (2006) reported that during dry periods, plant uptake of nutrients is greatly reduced and the N-mineralization and nitrification are either immobilized in microbial biomass or accumulate in the soil as inorganic nitrogen.

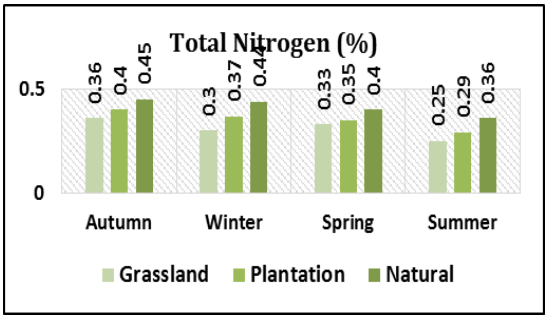

Figure 4

Available Phosphorous: The result revealed in (Fig. 5) that the available phosphorous under natural forest in winter season was higher followed by spring, autumn and the least was in summer respectively. Under plantation, it was higher in winter season followed by autumn, summer and least was in spring respectively. Under grassland, it followed the same trend as natural forest. The results showed that the maximum values of phosphorous was observed in natural forest during winter season and the minimum was observed under grassland during summer season. It may be due to more accumulation of minerals in winter season. The results showed that during winter season with less or no rain, there is no leaching of nutrients from the soil which results in the accumulation of high nutrients in winter after monsoon season. Less amount of available Phosphorus occur in autumn (rainy season) because of leaching due to rain and soil erosion. Ashraf *et al.,* (2012) reported that soil with maximum leaching are known to contain low amount of phosphorus as compared to the soil with minimum leaching. The result showed that there was maximum amount of organic carbon and phosphorus in winter season. (Fith and Nelson (1956) and Keogh *et al.,* (1972) in their studies also reported that when soil levels for phosphorus and percent organic matter are high, the amount of potential seasonal variation of phosphorus values tends to increase. Semwal *et al.,* (2009) reported in their study that the available phosphorus was found maximum in winter season and that the reason was because more accumulation of minerals takes place in winter season. Miller and Donahuer (2001) reported that the soil with high organic matter content have better supplies of organic phosphate for plant uptake than have the soils with low organic content. Phosphorus values trend higher in the winter and early spring months (Fine *et al.,* (1940) and Keogh *et al.,* (1972). Gupta and Sharma (2008) also reported that carbon and phosphorus were positively correlated because all these attributes were intimately linked with soil humus.

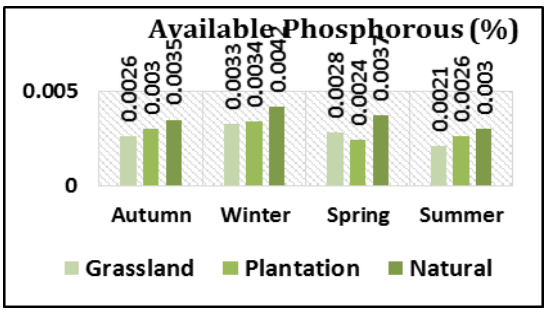

Figure 5

Available Potassium: The results revealed in (Fig. 6) that under natural forest, available potassium during winter season was higher followed by spring, autumn and least was in summer respectively. Under plantation, available potassium during winter was higher followed by autumn, spring and least was in summer respectively. Available potassium under grassland followed the same trend as natural forest. The results showed that the maximum value of available potassium was observed under natural forest during winter season and the minimum was observed under grassland in the autumn season. It may be due to the presence of dense vegetation affords the soil adequate cover, thereby reducing the loss in soil micro and macro nutrients that are essential for plants growth and energy fluxes as there is less vegetation cover in the grassland (Iwara *et al.,* 2011). Potassium values generally increase during the winter months because of shifts in soil equilibrium conditions due to freezing and thawing actions releasing fixed potassium from non-

exchangeable forms, depending upon the type of clay minerals present (Fine *et al.*, 1940; and Keogh, *et al.*, 1972). It was observed from the above results that more the organic matter, more is the accumulation of minerals in the soil. This was also reported by Chauhan (2001) that they found a positive co-relationship between organic matter and available potassium and that with the increase in organic matter tends to increase the accumulation of available potassium in the soil.

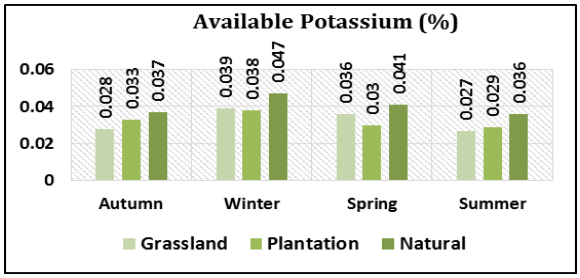

Figure 6

V. STATISTICAL ANALYSIS

SPSS 16.0 model was used to analyse the data for One-way ANOVA to compare the chemical characteristics in different seasons under different land uses at (P = 0.05 level).

Statistically significant mean difference on the basis of Tukey (HSD) of different chemical parameters in different seasons under natural forest *(Means for groups in homogenous subsets are displayed).*

Table 1.1 pH

Seasons	N	Subset for alpha = 0.05		
		1	2	3
Autumn	10	6.4570		
Winter	10		6.6060	
Spring	10		6.6450	6.6450
Summer	10			6.7070
Sig.		1.000	.589	.201

Table 1.2 Organic Carbon

Seasons	N	Subset for alpha = 0.05			
		1	2	3	4
Summer	10	3.4470			
Autumn	10		3.6620		
Spring	10			3.7390	
Winter	10				3.9710
Sig.		1.000	1.000	1.000	1.000

Table 1.3 Total Nitrogen

Seasons	N	Subset for alpha = 0.05		
		1	2	3
Summer	10	.3550		
Spring	10		.4030	
Winter	10		.4400	.4400
Autumn	10			.4460
Sig.		1.000	.105	.981

Table 1.4 Available Phosphorus

Seasons	N	Subset for alpha = 0.05		
		1	2	3
Summer	10	.003010		
Autumn	10	.003540	.003540	
Spring	10		.003720	.003720
Winter	10			.004200
Sig.		.058	.809	.100

Table 1.5 Available Potassium

Seasons	N	Subset for alpha = 0.05	
		1	2
Summer	10	.03600	
Autumn	10	.03670	
Spring	10	.04060	
Winter	10		.04680
Sig.		.159	1.000

The analysis showed (Table 1.1) that under natural forest, soil pH in autumn season showed significant difference. While no significant difference were observed between winter and spring season. Also, no significant difference were observed between spring and summer season. Organic carbon content showed (Table 1.2) significant difference between all the seasons. Total nitrogen showed (Table 1.3) significant difference against the rest of the seasons, while no significant difference were observed between spring and winter season. Likewise, no significant difference were observed between winter and autumn season. Available phosphorus showed (Table 1.4) no significant difference between summer and autumn season, autumn and spring season and between spring and winter season. Available potassium showed (Table 1.5) no significant difference between summer, autumn and spring season but winter season showed significant difference against the rest of the season.

Statistically significant mean difference on the basis of Tukey (HSD) of different chemical parameters in different seasons under plantation *(Means for groups in homogenous subsets are displayed).*

Table 2.1 pH

Seasons	N	Subset for alpha = 0.05		
		1	2	3
Autumn	10	6.5930		
Winter	10		6.7250	
Spring	10		6.7830	
Summer	10			6.8800
Sig.		1.000	.353	1.000

Table 2.2 Organic Carbon

Seasons	N	Subset for alpha = 0.05			
		1	2	3	4
Summer	10	3.1200			
Autumn	10		3.2260		
Spring	10			3.2720	
Winter	10				3.5600
Sig.		1.000	1.000	1.000	1.000

Table 2.3 Total Nitrogen

Seasons	N	Subset for alpha = 0.05		
		1	2	3
Summer	10	.2860		
Spring	10		.3480	
Winter	10		.3680	.3680
Autumn	10			.4010
Sig.		1.000	.591	.177

Table 2.4 Available Phosphorus

Seasons	N	Subset for alpha = 0.05	
		1	2
Spring	10	.002350	
Summer	10	.002560	
Autumn	10		.003030
Winter	10		.003350
Sig.		.580	.225

Table 2.5 Available Potassium

Seasons	N	Subset for alpha = 0.05	
		1	2
Summer	10	.02890	
Spring	10	.03030	
Autumn	10	.03270	.03270
Winter	10		.03780
Sig.		.222	.058

The analysis showed (Table 2.1) that under natural forest, soil pH in autumn season showed the same trend except that the summer season showed significant difference against the rest of the seasons. Organic carbon content (Table 2.2) and total

nitrogen (Table 2.3) showed same trend as natural forest. Available phosphorus showed (Table 2.4) no significant difference between spring and summer season, and between autumn and winter season. Available potassium showed (Table 2.5) no significant difference between summer, spring and autumn season. Likewise no significant difference were observed between autumn and winter season.

Statistically significant mean difference on the basis of Tukey (HSD) of different chemical parameters in different seasons under grassland *(Means for groups in homogenous subsets are displayed).*

Table 3.1 pH

Seasons	N	Subset for alpha = 0.05			
		1	2	3	4
Autumn	10	6.8560			
Winter	10		7.0850		
Spring	10			7.2370	
Summer	10				7.4710
Sig.		1.000	1.000	1.000	1.000

Table 3.2 Organic Carbon

Seasons	N	Subset for alpha = 0.05			
		1	2	3	4
Summer	10	2.0770			
Autumn	10		2.2260		
Spring	10			2.4820	
Winter	10				2.9360
Sig.		1.000	1.000	1.000	1.000

Table 3.3 Total Nitrogen

Seasons	N	Subset for alpha = 0.05		
		1	2	3
Summer	10	.2470		
Winter	10		.3020	
Spring	10		.3280	.3280
Autumn	10			.3560
Sig.		1.000	.369	.305

Table 3.4 Available Phosphorus

Seasons	N	Subset for alpha = 0.05		
		1	2	3
Summer	10	.002110		
Autumn	10		.002570	
Spring	10		.002770	
Winter	10			.003250
Sig.		1.000	.474	1.000

Table 3.5 Available Potassium

Seasons	N	Subset for alpha = 0.05	
		1	2
Summer	10	.02720	
Autumn	10	.02820	
Spring	10		.03580
Winter	10		.03860
Sig.		.965	.561

The analysis showed (Table 3.1) that under natural forest, soil pH in autumn season showed significant difference between all the seasons. Organic carbon content (Table 3.2) and total nitrogen (Table 3.3) showed same trend as natural forest and plantation. Available phosphorus showed (Table 3.4) no significant difference between autumn and spring season while summer and winter season showed significant difference with the rest of the season. Available potassium showed (Table 3.5) no significant difference between summer and autumn season. Likewise no significant difference were observed between spring and winter season.

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AUTHORS

First Author – Mohd Salim,
Qualification:- Post Graduate (Environment & Solid Waste Management),
Institute:- Forest Research Institute, Dehradun,
Email:- vgassizfri10@gmail.com, vgassiz_polars3@yahoo.com