Impact of different land uses on soil physico-chemical properties under sub-tropical condition in north- western India

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The research is financed by: None *(Sponsoring information)*

Abstract

The present study was conducted in the year 2020 at SKUAST-Jammu, to explore the variability in soil physical (bulk density, porosity, available water content, maximum water holding capacity) and chemical properties (soil organic carbon, available N, P, K, S and Zn) under different land use systems. The results showed that soil of different land use systems was found slightly acidic to neutral (6.6-7.2 pH) in nature. The mean values of soil physical properties bulk density, porosity, available water and maximum water retention capacity varied from 1.3 to 1.58 gcc^{-1}, 40.25 to 50.78 %, 10.60 to 20.40 %, and 29.58 to 40.94, respectively. The SOC varied from 0.45 to 1.14 %. While the MWHC of the soils is non-limiting in most part except some isolated patches. The mean values of available N, P, K, S (kg ha^{-1}) ranged from 169.24 to 358.63, 10.50 to 26.73, 101.19 to 359.81, and 8.24 to 22.45, respectively. Better soil physico chemical status was observed under forest soil over other land use. Resultssuggested that about 80% portion of the district were found to be deficient in zinc content with poor soil physical status which is harmful for root growth of the plants. This information can assist us for optimizing fertilizer and management practices which may need urgent attention.

Keywords: land use systems, nutrient status, soil physical properties, soil mapping

1. Introduction

Continuous use of fertilizers and intensive farming system has become a major challenge for environment pollution and deterioration in soil health. To maintain the soil sustainability it is vital to improve soil physical, chemical and biological properties. The assumption of the sustainability of agricultural ecosystems also depends to a great extent on the maintenance and proper understanding of spatial distribution of soil physico-chemical properties that assist in site specific nutrient management (Krasilnikov et al, 2022). To assess the suitable indicators, changes in soil physical, chemical and biological properties in relation to plant growth are of prime importance. Soil organic carbon (SOC) is a key indicator as it affects the other indicators such as bulk density, water content, porosity, nutrient retention and microbial population (Sharma et al, 2023). However, different land-uses and management practices affect its dynamics and composition (Abrol et al, 2019).

The predominantly hilly area (86%) and 14% plain tract of Shiwalik Himalayan Region (SHR) of India suffers low crop productivity due to soil nutrient deficiencies and low water retention capacity (Bhattacharyya, 2016). Long term application of imbalanced nutrients, increased crop yield through high yielding varieties and intensive cultivation could lead to secondary and micronutrients deficiency (Shukla et al, 2021). Monitoring changes in soil physico-chemical properties is a challenge due to excessive and indiscriminate use of fertilizers, fragmented fields and heavy rainfall in Shiwalik Himalayan Region. Knowledge about physicochemical status of soil in different land use systems plays a vital role in enhancing production and productivity of the agricultural sectors on sustainable basis. However, practically oriented basic information on the up to date status of soil physico-chemical properties in the study area remains poorly understood. Therefore, this study was conducted with specific objectives to assess and explore the status of soil physico-chemical characteristics of five different land use systems of representative area of Udhampur district of Jammu and Kashmir.

2. Materials and Methods

The study area lies under the sub-tropical zone of foothills of Shawalik (32° 34' to 39° 30' N and 74° 16' to 75° 38'E) (Figure 1). Out of approximately 2380 km^2 area, the forest areas is 960.58 km^2, land put to non-agriculture uses is 24516 hectare , barren and uncultivated land is 43700 hectare, permanent pasture and other grazing land is 5572 hectare, land other tree crops groves not included area in net sown area is 9576 hectare, cultivated land uses 14106 hectare, fallow land and other than current fallows is 320 hectare, current fallows 12391 hectare, gross sown area is 81494 hectare, net sown area is 44853 hectare, and net irrigated area is 7803 hectare.

Soil surface (0-15cm) samples were collected in the year 2020 by random manner from each site across whole of the district with the help of global positioning systems (GPS). The physical and chemical properties of soil were analyzed in laboratory includes particle size distribution, pH, EC, organic carbon content, bulk density, available water retention capacity, porosity, maximum water holding capacity, available nitrogen, available phosphorus, available sulphur and DTPA extractable Zn. Soil pH and EC was determined by potentiometric method (Jackson, 1973). Bulk density was measured by core method. Soil porosity was measured by keen box method (Keen & Raczkowski, 1921). SOC was measured by Walkley & Black (1934) method. Hydrometer method was used to measure the soil texture (Bouyoucos 1962). The available N, P and K were determined by standard methods (Subbiah & Asija 1956; Olson et al, 1954; Jackson, 1973 respectively). The variability in soil properties were described using discriptive statistics such as mean, median, minimum, maximum, standard deviation, skewness and kurtosis.

Figure 1. Location map of the study area.

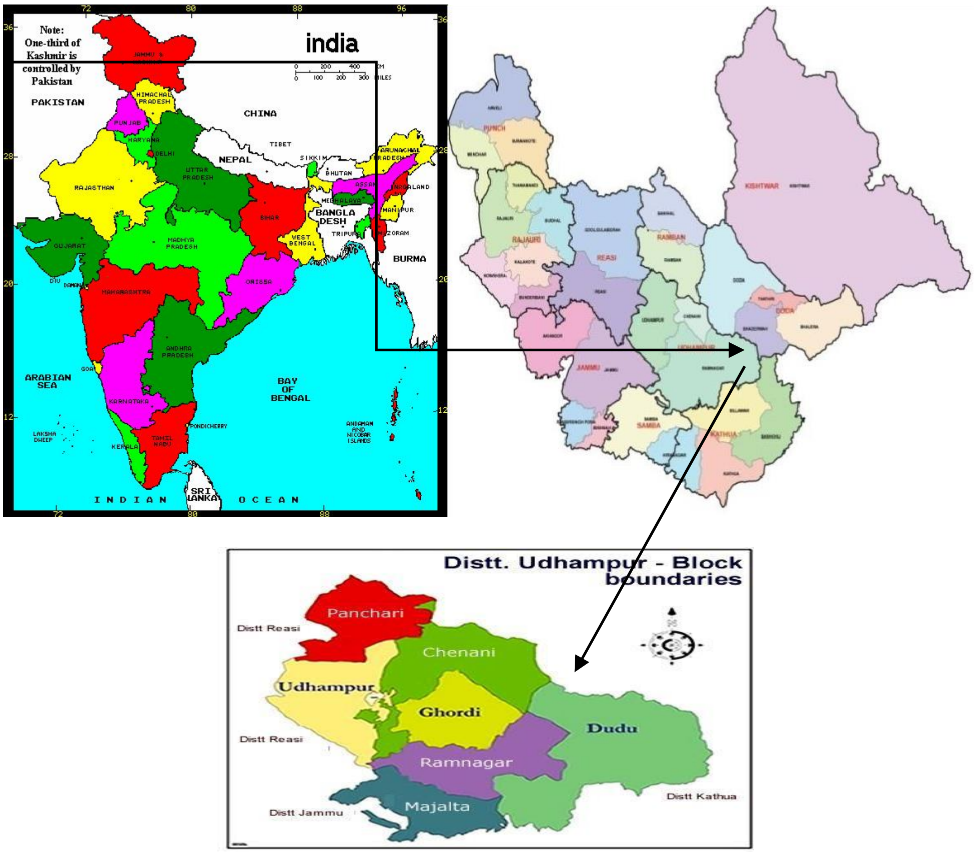


Figure 2. Mean value of soil pH and electrical conductivity under different land use systems

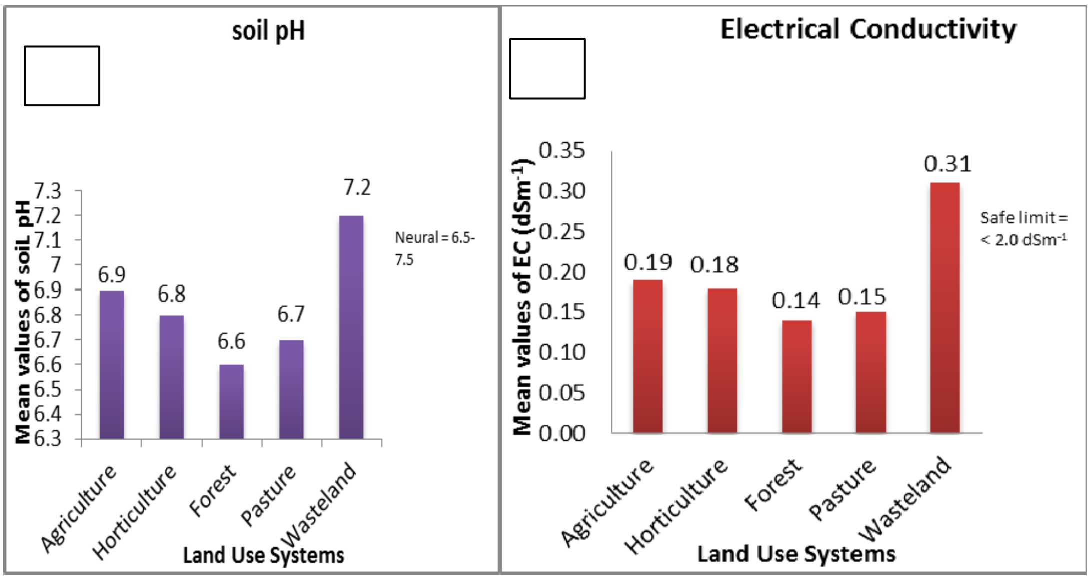
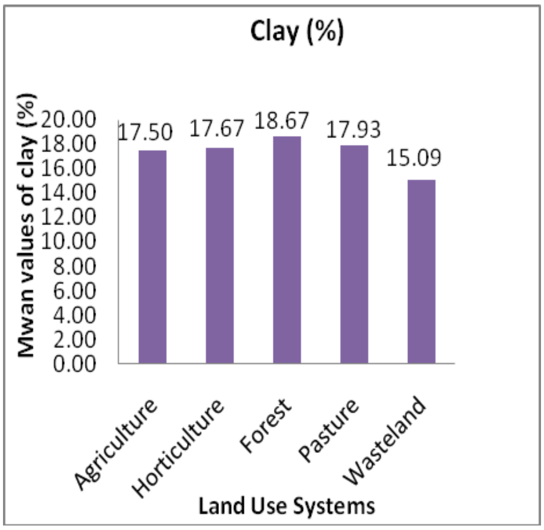
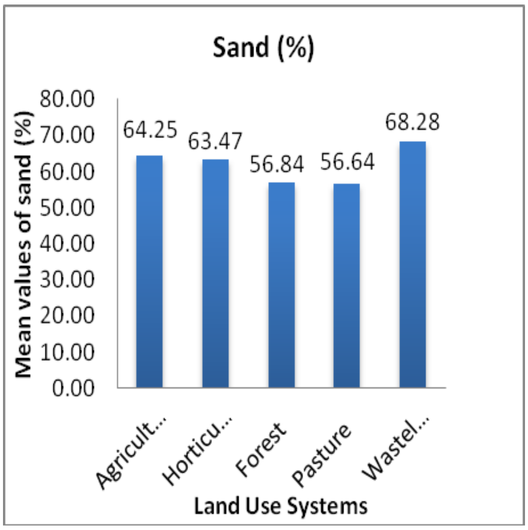


Figure 3. Mean value of soil clay (%) and sand (%) under different land use systems



a)



(b)

Figure 4. Mean value of soil silt (%) under different land use systems

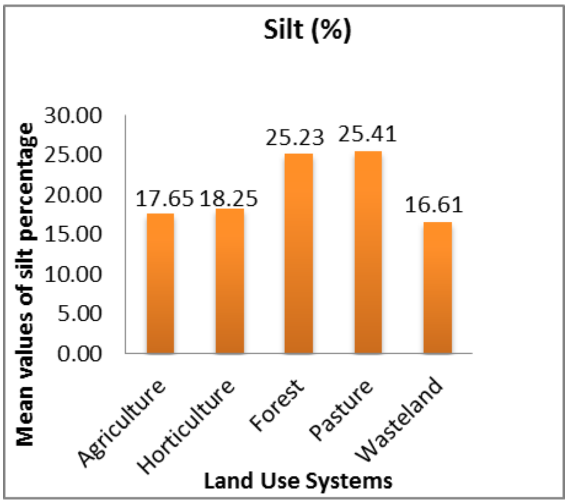


Figure 5. Mean value of soil bulk density and porosity under different land use systems

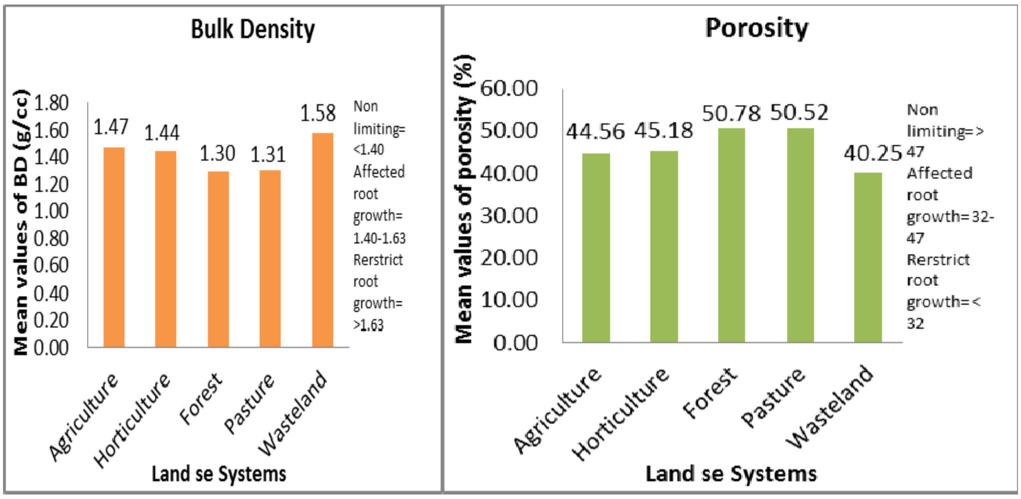


Figure 6. Mean value of soil maximum water retention capacity and available water retentioncapacity under different land use systems

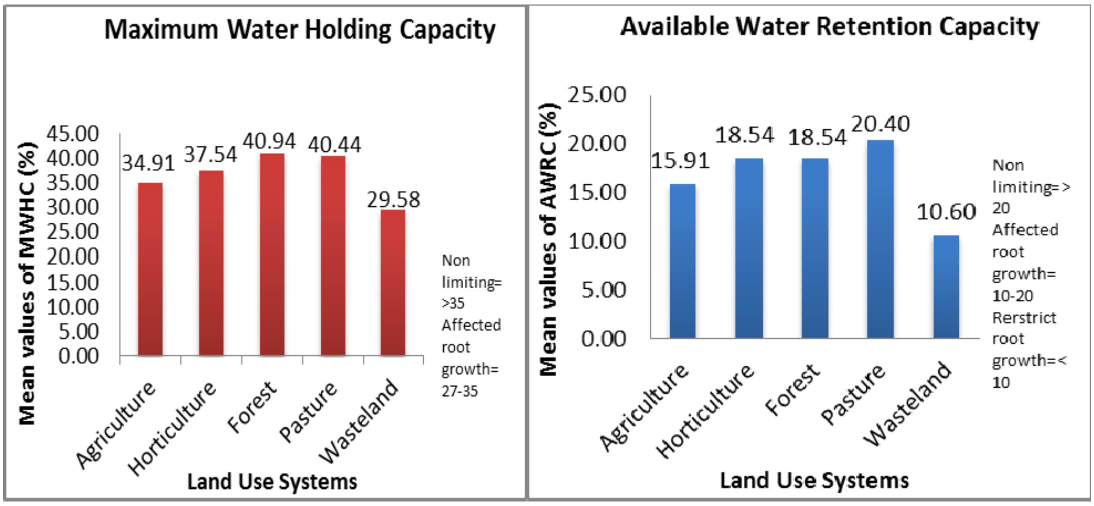


Figure 7. Mean value of soil organic carbon under different land use systems

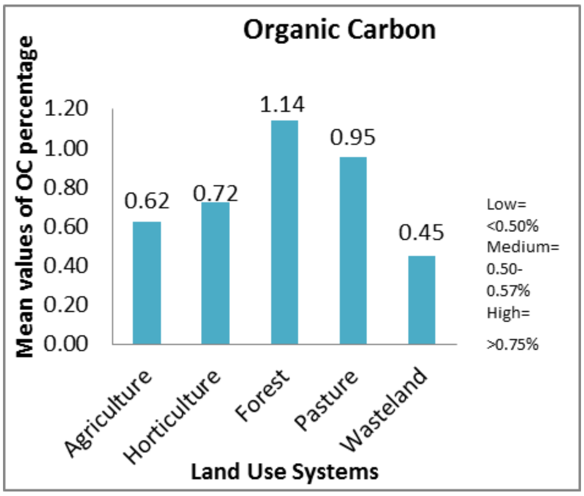


Figure 8. a Mean value of soil available N and available P under differentland use systems

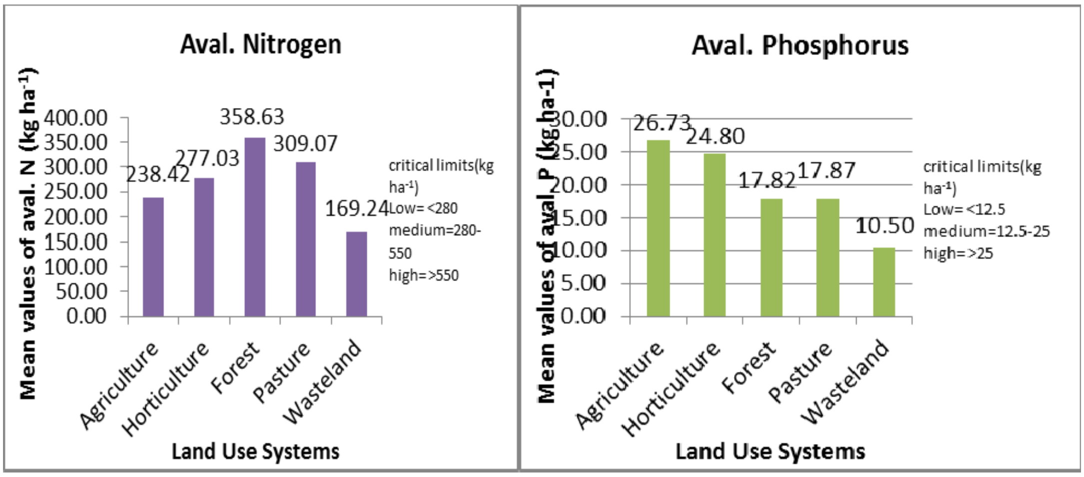
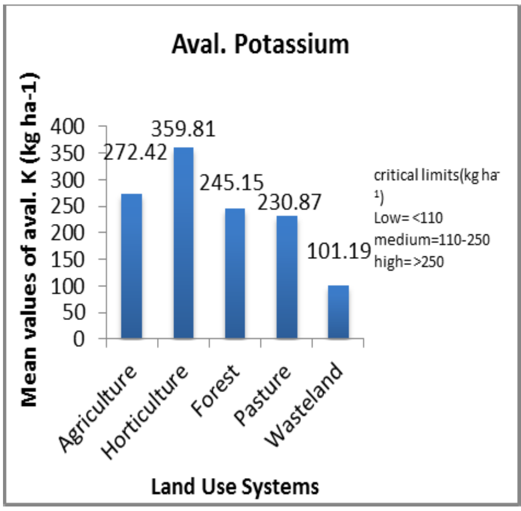


Figure 8.b. Mean value of soil available K and available S under differentland use systems



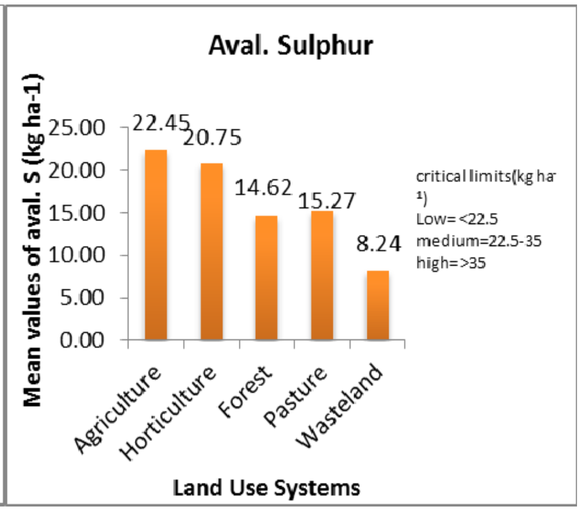


Figure 9. Mean value of DTPA Zn under different land use systems

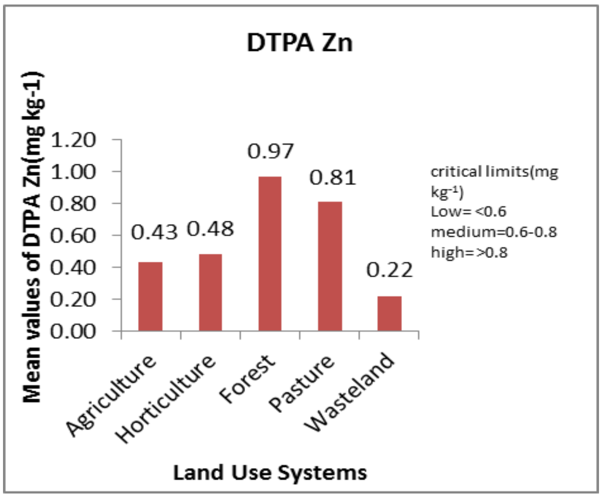


Figure 10. Spatial distribution maps of soil properties

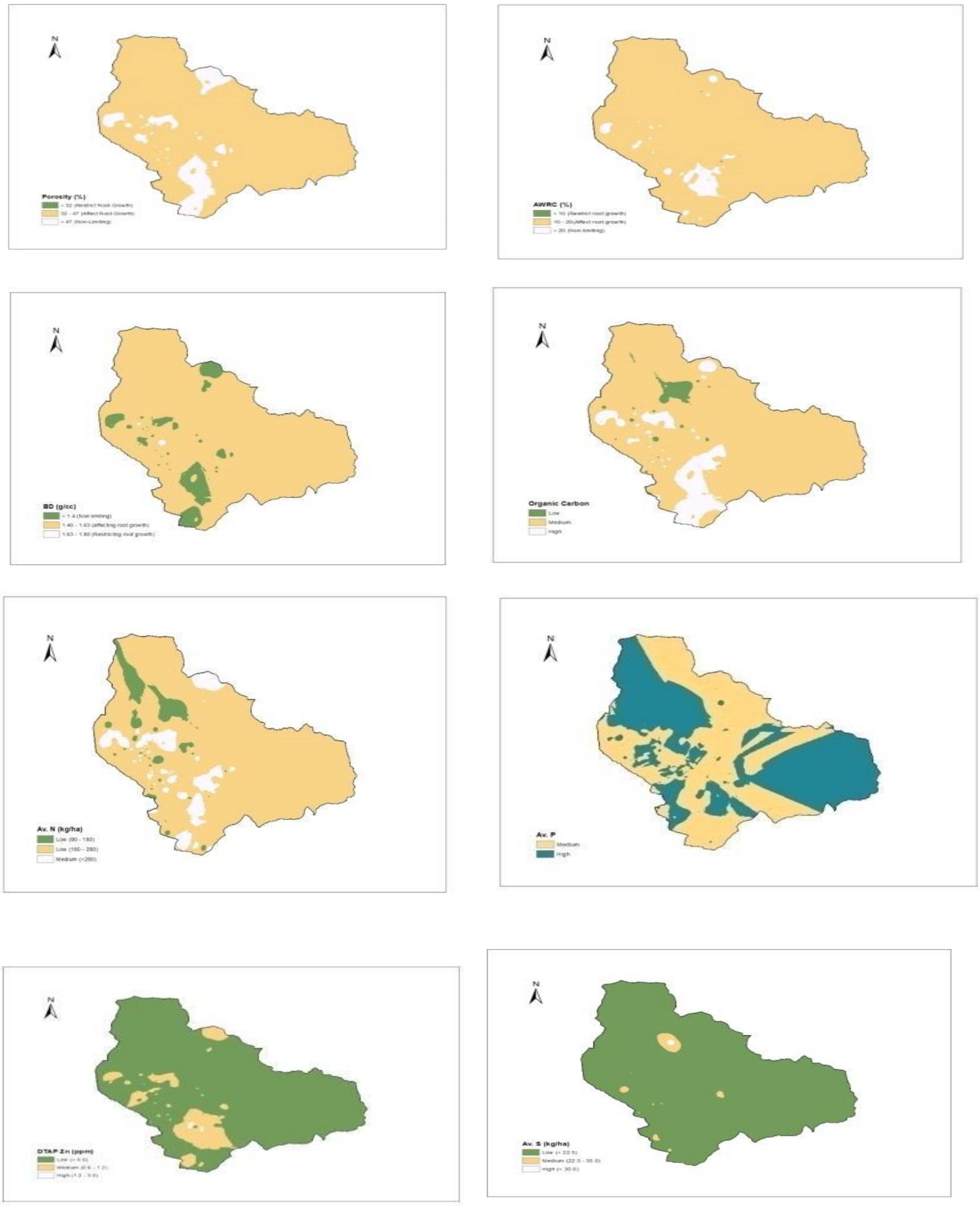


Table 1. Soil textural classes under different land use systems

Type of land use systems	Textural Class
Agriculture	Sandy Loam to Clay Loam
Horticulture	Sandy Loam
Forest	Sandy Loam to Loam
Pasture	Sandy Loam to Loam
Westland	Sandy Loam

Table 2 . Correlation among soil properties

Model	Regression equation	R^2 (%)	F-values
1st	$OC= 3.595^{**}-1.994^{**}$ BD	60.40	374.58^{**}
2nd	$OC= 3.092^{*}- 1.751^{**}$ BD + $.009^{**}$ AWRC	62.00	199.96^{**}
3rd	$OC= 2.330 - 1.758^{**}$ BD + $.023^{**}$ AWRC + $.009^{**}$ Clay	64.60	148.23^{**}

3. Results and Discussions

Soils basic and physical properties

Soils of different land use systems have neutral reaction, with a mean pH range of 6.6 to 7.2 (Figure 2a). The lowest pH was found under forest soils followed by pasture shows the presence of high organic matter and leaching of basic cations due to heavy rainfall (Islam & Weil, 2000). The electrical conductivity of all soils of different land use systems was within the safe limit below 1 dSm^{-1}(Figure 2b). The forest and pasture land has lower EC than the otherland use systems while the highest was in wasteland. Abbasi & Rassol (2005) explained that heavy rainfall caused accumulation of soluble salts in hilly area. The predominant texture class of the study area was sandy loam in texture (Table 1). Clay content was highest in soils of forest land, followed by those under pasture, horticulture and agriculture and least in wasteland (Figure 3). The results are conformity with the findings of Gupta et al, (2010). Themean bulk density was generally higher in wasteland (1.58 gcc^{-1}) followed by agriculture, horticulture, pasture and lowest was in forest (Figure 5a). The soils of forest and pasture lands had higher values of porosity as compared tothose of wasteland and cultivated lands (Figure 5b). MWHC and AWRC vary among the different land use and highest was in forest followed by pasture and the lowest was in wasteland. The large part of the area having soil BD, AWRC and porosity in the range of 1.40-1.63 gcc^{-1}, 10-20% and 32-47%, respectively which affect the plant root growth (Figure 10) because of low organic carbon, high sand content soil erosion (Gupta et al, 2010). Higher mean value of MWHC and porosity was found under forest land and pasture land use system followed by soils of agriculture, horticulture and wasteland (Figure 6) it's may be ascribed to presence of higher organic matter and clay fractions that leads to high porosity and permeability (Emadi et al, 2008). These findings are consistent with Sharma & Qahar, 1989 and Gupta et al, 2010. Hajabbasi et al, (1997) reported similar findings. Hassan et al, (2012) has also reported that cultivated soils were considerably lower in silt and slightly lower in clay content than the adjacent soils under forest, most likely as result of preferential removal of silt by accelerated water erosion during the monsoon months (Emadi et al, 2008). The maps showed (Fig. 10) that the most of the part of the study area having poor physical status of the soil as the BD, AWRC and porosity were found affecting the root growth of the plants. While the MWHC of the soils is non limiting in most part except some isolated patches.

Soil chemical properties

The highest mean SOC was observed in forest (1.14 %) followed by pasture (0.95%) and lowest was in wasteland (0.45%) (Figure 7). Uncovered surface in arable soils resulted in poor carbon and other nutrients content (Basu & Behera, 1993). The mean value of available nitrogen was low in wasteland, agriculture, horticulture and medium in forest (358.63$kgha^{-1}$) and pasture lands (309.07 $kgha^{-1}$), respectively (Figure 8 a). Available phosphorus was medium in all land use types except wasteland soils where the nutrient concentration was low (Table 4, Figure 8b). The mean concentration of potassium was highest in agriculture and horticulture; medium in forest and pasture while lowest in wasteland (Figure 8c). The S concentration was low in all land use systems (Figure 8d). Available N in soils of almost whole of the district is below 280 kg/ha i. e it is in low category due to the high leaching losses of nitrate ionsduring rainfall periods. Variability in soil nutrient status revealed that organic carbon, available N, P, K was medium in most part of the study area, however Zn and S were low (Figure 10). Forest areas of the district has higher amountof available N than rest areas it's may be due the strong positively correlation between available N and organic carbon. Available P in soils of the entire district ranged from medium to high because of incorporation of phosphate containing fertilizers in these areas. Available K was mostly in the medium range (110 to 280 kg) in almost whole of the district because of dominance of potassium bearing minerals. The higher levels of available P and K in agriculture and horticulture land use systems was possibly due to addition of fertilizers (Figure 8, Figure 10). In forest land use system recycling of nutrients due to falling leaves of leguminous tree species was the possible reason for high available N, P and K values. These results are in accordance with those of Gilley et al, (1997). Soils of about 80% portion of the district were found to be deficient in Zinc content ie it was below < 0.6 ppm this might be due to low organic matter application coupled with no application of Zn in a rice-based system. Linear multiple regression of soil physical parameters (sand%, silt %, clay%, BD, MWHC, AWRC and porosity) showed that only bulk density, AWRC and clay per cent affect the soil organic carbon significantly. In the first model of regression equation found that contribution of bulk density (r^2=60.40 per cent) was negatively significant. The model second shows that the value of r^2 was increased (1.60 per cent) along with available water retention capacity. With the addition of sand percentage distribution in model third the value of r^2 (64.60 per cent) was significantly increased (2.60 per cent). Results revealed that the overall soil physical health of Udhampur district was medium to good.

4. Conclusions

To sum up, the research conducted in the Udhampur area of Jammu and Kashmir provided significant understandings of the dynamics of nutrients in soil under different land use regimes in subtropical environments. The pH range (6.6-7.2) of the soils was suitable for plant development, however there were differences in electrical conductivity. The most common soil type was sandy loam, with the highest bulk density found in wasteland, suggesting possible compaction problems. In terms of soil organic carbon, forests performed better than agriculture and horticulture, which showed greater amounts of nutrients. Concerns were raised by an 80% soil zinc deficit. Superior water retention and porosity were found in forest and pasture areas, which is important for sustainable agriculture. The necessity of site-specific nutrient management was highlighted by spatial variances, which have useful ramifications for improving agricultural methods.

5. Acknowledgement

We would like to thank all the people and organisations that helped us to successfully complete this study. We are grateful to the landowners and farmers in the Udhampur area for allowing us to take soil samples from their crops and for their cooperation. We gratefully thank the collaborators and researchers for their help with fieldwork and laboratory analysis. Our mentors and advisers provided invaluable help and direction that made this study feasible. Their knowledge and support were invaluable over the whole investigation.

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