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Altitudinal variations of soil physico-chemical properties in pear orchards of district Pulwama under temperate Jammu and Kashmir, India

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Abstract
An in-depth study of soil physico-chemical properties across different elevations in pear growing orchards provides information pertinent to soil-site suitability for production of fruit crops. Hence, the present investigation was undertaken to know altitudinal variations in soil physico-chemical properties in temperate climate. For this, soils from pear growing orchards were collected from three different physiographic altitudes viz. Low Altitude (<1600mts.amsl), Mid Altitude (1600-1800mts.amsl) and High Altitude (>1800mts.amsl) in Pulwama district of south Kashmir. Interestingly, sand percentage in soil was significantly high at high altitude and decreased gradually with the altitude. In contrast to sand level, silt and clay concentration was high at site I and decreased significantly ($p<0.05$) with increasing altitude. Significantly ($p<0.05$) lower bulk density (BD) at higher altitude and higher particle density (PD) at higher altitude were observed. Highest porosity was recorded at higher altitude. There were a significantly ($p<0.05$) higher OC content, OM, exchangeable cations and base saturation at higher altitude pear orchards whereas highest pH and CEC at lower altitude. Pearson correlation coefficient analysis showed significantly negative correlation ($p<0.01$, $p<0.05$) of clay, silt, BD, PD, pH and CEC whereas positive correlation of sand and OC ($p<0.01$) with altitude. Hence, these findings suggest the altitudinal variations in soil physico-chemical properties.

Keywords: Altitude, Pear orchards, Physico-chemical properties, Variation

1. Introduction

Soil is a dynamic and complex natural body which provides a medium for the growth of plants. Almost all soil properties exhibit variability as a result of dynamic interactions between natural environmental factors including climate, parent material, land use and topography (Jenny, 1941) [9]. Parent material and climate are of major importance in affecting soil variability on regional and continental scales. However, slope gradient, Cos (aspect), relative elevation, soil properties, solar radiation have major influences on the spatio-temporal distribution of soil properties under a hillslope (Dai and Huang, 2006) [4] and variability of soil properties can thereby affect the pattern of crop production, litter formation and its decomposition, which can further feedback on local C and N processes (Wang *et al*., 2001) [25]. Studies on spatial variability of soil properties are most often conducted in homogenous fields or landscapes such as arid zones (Hattar *et al.,* 2010) [7] forests, pasture areas and broad acre cropping, but there is a paucity of reports on soil variability in intensively managed, non-homogenous fields such as orchards.

Altitude is an important ecological factor of soil formation and development. With the variations in altitude, climatic factors (temperature, precipitation and solar radiation) of an area also change. Further, with variations in altitude, there is a contrasting change in soil biota which results in a differential composition of soil organic matter dynamics (Dar *et al.,* 2012) [5]. The change in altitudinal gradients influences soil organic matter by controlling soil water balance, soil erosion, geologic deposition processes, species and biomass production of the native vegetation and cultivated plants (Tan *et al,* 2004) [21]. There were considerable changes in horizon composition, including dramatic differences in soil texture, horizon depth and temperature. There were correlation between soil chemistry and elevation (Bromley, 1995) [3]. Soil pH may also control biotic factors such as the activity and biomass composition. The sustainable crop production and soil managements depend on the kind of soils and their physico-chemical behavior (Sharma *et al*., 2006) [18].

The detailed information about the relationship between soil properties with changing altitude and more particularly for pear orchards is scanty in our state. Keeping the above circumstances, the present study was designed to know the variation of physico-chemical characteristics of pear growing soils along the altitudinal gradients.

2. Material and methods

The study area i.e., Pulwama district is an important part of Kashmir valley with respect to the horticultural perspective surrounded by Srinagar in the North, Budgam and Poonch in the West and Anantnag and Shopian in the East and South side. The district is situated between 33º50’ to 33º54’ N Latitude and 74º52’ to 75º58’ E Longitude with a mean elevation of about 1630 m amsl. The topography of the location is highly uneven characterized by moderately steep to very steep slopes in upper reaches, moderately undulating in the middle karewas (rain-fed) and flat to moderately sloping land under cultivation and near habitation. Total thirty six composite orchard soil samples were collected from various depths at an interval of 30cm up to 90cm from by quartering method of the selected 12 representative sampling sites of pear orchards located in three different physiographic altitudes and locations of the sampling sites (Map-1) were recorded by GPS (global positioning system) coordinated in the center.

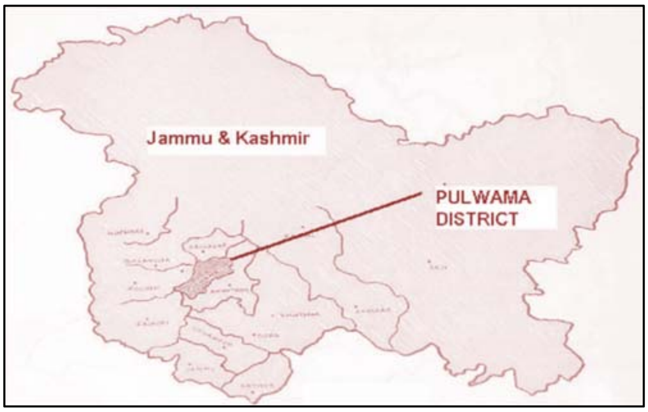

Fig 1: Map of the study area

Stratified random soil sampling was preferred due to large number of pear orchards present in this region. Root part and other plant residues were removed from the soil and then these soil samples were air dried at room temperature, sieved with <2.0mm test sieve. For analysis of organic carbon (OC) and calcium carbonate, soil samples were further sieved with 0.2 mm test sieve. The pH, EC, clay, sand and silt were determined in 2.0 mm test sieve soil samples. The soil organic carbon (OC) was analyzed by wet digestion method (Walkley and Black, 1934). Bulk density and particle density were determined by Core method (Blacke and Hartge, 1986a) [1] and Pycnometer method (Blacke and Hartge, 1986b) [2] respectively. The soil organic matter (OM) was calculated by multiplying SOC content with Van Bemmelen factor (1.724) Total calcium carbonate content was estimated by Back titration method (Piper, 1966) [16] and pH, Electrical conductivity (EC) were measured as described by Tandon (1993) [22] by preparing (1:2) soil and water solution for one hour was at rotary shaker. However, silt, sand and clay proportions (texture) were determined by international pipette method. The exchangeable cations were extracted with neutral normal ammonium acetate. Potassium and sodium were determined by flame photometer while, calcium and magnesium were determined by AAS procedure suggested by Hesse (1972) [8]. Data generated through the study were analyzed for mean and standard error (SE). Significance level (p<0.05) was generated among the different altitudinal study sites by one way ANOVA. Pearson correlation coefficient was done for the analysis of correlation in different physico-chemical properties of soil with altitudes using the computer program SPSS statistical software 17.0 versions for Windows (SPSS. 1996) [20].

3. Results

3.1 Physical properties

3.1(a) Clay, Silt and Sand proportions (%)

The present study revealed significantly (p<0.05) higher clay (%) content in pear orchard soils located in lower altitude as compared to that in mid and higher altitude, whereas silt content (%) significantly (p<0.05) decreased with the altitude (Table 1). However, sand (%) content showed reversed trend, as it increased significantly (p<0.05) with the altitude (Table 2). It was observed that in soils of pear orchard located in higher altitude, sand (%) content was significantly higher by about 40% and 19% compared to that of low and mid soils. Based on sand, silt, and clay content, textural class of pear growing orchard soil comes under silt loam at low altitude and clay loam at mid and high altitude (Table 1).

The correlation analysis revealed that clay (%) and silt (%) content are significantly (p<0.05) negatively correlated with the altitude and the rate of correlation coefficient in between clay and altitude is -0.284 whereas sand (%) content was significantly but positively correlated with the altitude (r= +0.348) as shown in Table 2.

3.1 (b) BD, PD (gcm^{-3}) and Porosity (%)

The values of BD and PD (gcm^{-3}) have shown significant (p<0.05) difference with altitude and significantly (p<0.05) lower values were reported in pear orchard soils located in mid and higher altitude as compared to that located in lower altitude sites (Table 1). On the other hand the porosity (%) showed significantly (p<0.05) higher values in pear orchard soils located in higher altitude as compared to that in mid and lower altitudes (Table 1). Pearson correlation coefficient (r) analysis revealed that the BD and PD (gcm^{-3}) was significantly (p<0.05) negative correlated with altitude with correlation coefficient in between BD and altitude is - 0.142 in the present study (Table 2).

Table 1: Altitudinal variations in soil physical properties of pear growing orchards

Parameter	Study Sites		
	Low Altitude (<1600mts.amsl)	Mid Altitude (1600-1800mts.amsl)	High Altitude (>1800mts.amsl)
Clay (%)	31.68^{b} ±1.32	29.34^{a} ± 1.18	26.94^{a} ±1.80
Silt (%)	50.25^{a} ±1.50	46.05^{b} ±1.31	42.76^{c} ±1.08
Sand (%)	18.07^{a} ±1.34	24.61^{b} ±1.22	30.28^{c} ±1.76
BD (g cm^{-3})	1.60^{b} ±0.07	1.43^{a} ±0.04	1.27^{a} ±0.03
PD (g cm^{-3})	2.71^{b} ±0.05	2.50^{a} ±0.08	2.28^{a} ±0.06

Porosity (%)	40.90 ^{a} ±0.08	42.80 ^{a} ±0.12	44.30 ^{b} ±0.12
Textural Class	Silt loam	Clay loam	Clay loam

Values (mean ±SE) bearing different superscript (a,b,c) in a same row differ significantly (p<0.05)

3.2 Chemical properties

3.2 (a) $CaCO_3$ (%), OC (gkg^{-1}) and OM (%)

$CaCO_3$ (%) content varied significantly (p<0.05) with the altitude and significantly maximum values of $CaCO_3$ (%) was reported in pear orchard soils located in mid altitude as compared to higher and lower altitude sites (Table 1). The OC (g kg^{-1}) and OM (%) content showed significantly (p<0.05) increasing trend with altitude. In pear orchard soils of higher altitude, OM content was significantly higher by about 53% and 29% compared to that of low and mid soils. The correlation analysis revealed that $CaCO_3$ (%) content was negatively correlated with the altitude whereas OC (%) content was significantly (p<0.01) but positively correlated with the altitude and the rate of correlation coefficient in between OC and altitude is +0.346 (Table 2).

3.2(b) EC (dSm^{-1}), pH (soil reaction) and CEC (cmol (p^{+}) kg^{-1})

The EC (µscm^{-1}) did not show any significant change with altitude. Interestingly, pH (soil reaction) showed significantly (p<0.05) decreasing trend with altitude while as CEC(cmol (p^{+})kg^{-1}) showed significantly (p<0.05) maximum values in pear orchard soils located in lower altitude followed by those located in mid and higher altitude sites (Table 1). Pearson correlation coefficient (r) analysis revealed that pH and CEC (cmol (p^{+}) kg^{-1}) significantly (p<0.05) negative correlated with the altitude with correlation coefficient of pH and CEC with altitude as -0.228 and -0.254.

3.2(c) Exchangeable cations (cmol(p^{+})kg^{-1}) and Base saturation (BS%)

Among the exchangeable cations, calcium was the dominant followed by magnesium, potassium and sodium in three different physiographic altitudes pear orchard sites. Significantly (p<0.05) higher exchangeable calcium (cmol$_c$ kg^{-1}soil) content was reported in pear orchard soils located in higher altitude as compared to that in mid and lower altitude. Exchangeable magnesium and potassium (cmol$_c$kg^{-1}soil) increased with the altitude significantly (p<0.05). Significantly (p<0.05) higher contents of exchangeable magnesium and potassium (cmol$_c$ kg^{-1}soil) were observed in pear orchard soils located in high altitude as compared to that in mid and low altitude whereas significantly (p<0.05) higher contents of exchangeable potassium (cmol$_c$ kg^{-1}soil) were observed in pear orchard soils located in high altitude as compared to that in mid and low altitude (Table 1). The exchangeable sodium did not show any significant change with altitude. The BS (%) revealed significantly (p<0.05) increasing trend with altitude. It was observed that in soils of pear orchard located in higher altitude, BS (%) was significantly higher by about 20% and 12% compared to that of low and mid soils.

The correlation analysis revealed that BS (%) significantly positive correlated with the altitude and the rate of correlation coefficient in between BS and altitude is +0.438 in the present study as shown in Table 2.

Table 2: Altitudinal variations in soil chemical properties of pear growing orchards

Parameter		Study Sites		
		Low Altitude (<1600mts.amsl)	**Mid Altitude (1600-1800mts.amsl)**	**High Altitude (>1800mts.amsl)**
$CaCO_3$ (%)		2.08 ^{b} ±0.12	4.35 ^{a} ±0.27	3.16 ^{b} ±0.18
OC (g kg^{-1})		6.04 ^{c} ±0.16	8.36 ^{b} ±0.12	10.90 ^{a} ±0.25
OM (%)		0.84 ^{c} ±0.10	1.26 ^{b} ±0.16	1.78 ^{a} ±0.28
EC (dSm^{-1})		0.44 ^{a} ±1.00	0.27 ^{a} ±1.04	0.18 ^{a} ±0.92
pH		7.20 ^{c} ±0.09	6.94 ^{b} ±0.06	6.65 ^{a} ±0.05
CEC(cmol$_c$ kg^{-1}soil)		16.84 ^{b} ±0.36	14.35 ^{b} ±0.24	12.82 ^{a} ±0.17
Exchangeable cations (cmol$_c$ kg^{-1}soil)	Ca^{2+}	7.60 ^{b} ±0.12	7.92 ^{a} ±0.08	8.60 ^{a} ±0.06
	Mg^{2+}	1.92 ^{b} ±0.03	2.17 ^{b} ±0.03	2.64 ^{a} ±0.05
	K^{2+}	0.52^{b} ±0.01	0.70 ^{a} ±0.02	0.80 ^{a} ±0.01
	Na^{2+}	0.18 ^{a} ±0.01	0.14 ^{a} ±0.01	0.07 ^{a}±0.02
Base saturation (%)		62.40 ^{a} ±1.18	68.21 ^{b} ±1.40	77.65 ^{c} ±1.26

Values (mean ±SE) bearing different superscript (a,b,c) in a same row differ significantly (p<0.05)

Table 3: Correlation analysis of physico-chemical properties with altitude

Pearsons correlation Coefficient (r)	**Clay (%)**	**Silt (%)**	**Sand (%)**	**BD (gcm^{-3})**	**PD (gcm^{-3})**	**$CaCO_3$ (%)**	**OC (gkg^{-1})**	**pH**	**CEC (cmol (p^{+}) kg^{-1})**	**BS (%)**
	-0.284 *	-0.410 *	+0.348*	-0.142 *	-0.176 *	-0.152	+0.376**	-0.228 *	-0.254 *	+0.438 *
Significant	0.042	0.003	0.000	0.020	0.042	0.078	0.001	0.035	0.008	0.001

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

4. Discussion

4.1(a). Clay, Sand and Silt proportions (%)

The present study revealed significantly higher clay content in pear orchard soils located in lower altitude as compared to that in mid and higher altitude. The silt content decreased and sand content increased significant with the altitude. Hence, our findings indicated that proportion of coarse grained sand particles increased as the elevation and slope gradient increased, which might be due to translocation of clay or removal of finer fractions of soil by eluviation or surface erosion due to high rainfall in these zones (Najar *et al.* 2006) [2]. Higher silt but lower sand proportion observed at lower altitude in our study that indicates the presence of quartz, feldspars, hornblende and micas in the soil (Ley *et al.*, 2000) [11].

4.2. (b) BD, PD (gcm^{-3}) and Porosity (%)

In the present study, BD have shown variation with altitude and significantly lower values were reported in pear orchard soils located in mid and higher altitude as compared to that located in lower altitude sites. This decrease in bulk density with altitude may also be attributed to the increase in organic matter content. The bulk density at higher altitudes is good indication of soils that has occupied coarser structure of organic matter and enriches the spaces by soil organic carbon (Sanjay *et al*., 2010 and Garhwal *et al.,* 2013) [17, 6]. Decreasing trend of PD with altitude reflects the increase in total sand content and hence could be attributed to more amounts of sand fraction of the soil separates (Sitangang *et al.*, 2004). The increasing trend in soil porosity with altitude may be attributed to the compaction of soil finer particles and to the decreasing trend in organic matter content. Our present findings have got support of Sitangang *et al.*, (2004) and Garhwal *et al.* (2013) [6].

4. 3 Chemical properties

4.3 (a) $CaCO_3$ (%), OC (gkg^{-1}) and OM (%)

This study indicated uniform high $CaCO_3$ (%) in the mid altitude followed by higher and lower altitude sites The higher content of calcium carbonate in mid altitude might be due to the calcareous nature of these soils (calcite mineral in soil profiles). These results are in conformity with the findings of Dar (2012) [5] while working on soils in Kashmir valley. Significant leaching under low temperature and high precipitation can lead to a favorable environment for pedogenic inorganic carbon accumulation (Nordt *et al*., 2000) [15]. The increasing trend of OC and OM with altitude may be attributed low temperature and high rainfall favouring luxurious vegetation and increase in soil acidity that favours low rate of decomposition or mineralisation leading to consequent accumulation of organic matter. The results were corroborating with the findings of Najar *et al.,* (2009) [13] and and Dar (2012) [5]. The change in altitudinal gradients can also influences soil organic carbon by controlling soil water balance, soil erosion and soil forming processes (Tan *et al*., 2004) [21]. We did not find any significant differences in EC with altitude. These findings indicate that no major or significant difference in cumulative salt accumulation along the altitude. This is in accordance with the findings of Kirmani, (2004) [10] and Najar *et al.*, (2009) [13].

4.4 (b) EC (dSm^{-1}), pH and CEC (cmol (p^+) kg^{-1})

We observed significant differences in pH (soil reaction) with variation in altitude. Significantly lower pH in higher altitudes may be attributed to higher amount of organic carbon / matter and or higher precipitation level as well as temperature gradient. Najar *et al.* (2009) [13] also reported similar trend of pH with change in altitude. The present study suggested significant increase in CEC (cmol (p^+) kg^{-1}) with decrease in altitude which results from substantial rise in soil pH values, because of increase in charge on exchange sites and number of exchangeable sites on translocated or illuvated clay minerals from higher altitudes. The results are in agreement with the observations of Kirmani (2004) [10] and Mahajan *et al.* (2007) [12]. The low cation exchange capacity values of higher altitudes may be attributed to the low active illitic and kaolinitic mineral dominance (Kirmani, 2004) [10].

4.4 (c) Exchangeable cations (cmol (p^+) kg^{-1}) and Base saturation (%)

We observed significantly higher amounts of exchangeable calcium and magnesium in pear orchard soils located in high altitude. Higher amounts of exchangeable calcium could be ascribed to the differential content of exchangeable calcium due to vegetation community. This is supported by the similar observations as reported by Najar *et al* (2009) [13]. Higher amounts of eexchangeable magnesium and potassium in higher altitude soils could be attributed to the prevalence of magnesium and potassium bearing clay minerals. Our present findings have got support of Verma *et al.*, (2012) [23]. BS (%) revealed significant increasing trend with altitude. This might be attributed to increase in clay content with decrease in altitude thereby increasing cation exchange capacity and hence more exchangeable bases were adsorbed on the exchange sites of illuvated clay minerals. Similar results were obtained by Verma *et al.*, (2012) [23].

5. Conclusion

These results of the study revealed that soils come under silty loam to clay loam texture, slightly acidic to slightly alkaline in nature with adequate porosity, sufficient OM, exchangeable cations and BS especially in the mid and high altitude regions indicating potential for nutrient supplying power to maintain soil fertility. The present study indicates that these physico-chemical properties are in good coordination with the necessities for sustainable and better quality fruit production. However, this study demands more attention of soil science researchers for advanced and site-specific management approaches along the altitudinal gradients of this naturally diverse agro-ecological potential region.

6. References

1. Blacke GR, Hartge KH. Bulk density. In: Methods of Soil Analysis (Ed. A. Klute), American Society of Agronomy, Madison, WI. 1986a, 363-375.
2. Blacke GR, Hartge KH. Particle density, In: Methods of Soil Analysis, American society of Agronomy, Madison, WI, 1986b, 377-382
3. Bromley P. The effect of elevation Gain on soil. Environmental studies, 1995, 102.
4. Dai WH, Huang Y. Relation of soil organic matter concentration to climate and altitude in zonal soils of China. Catena, 2006; 65:87-94.
5. Dar MA, Wani JA, Raina SK, Bhat MY, Malik MA, Najar GR. Effect of altitude and depth on available nutrients in pear orchard soils of Kashmir. Agropedology, 2012; 22(2):115-118.
6. Garhwal RS, Qureshi FM, Giri JD. Characteristics and Classification of soils of Sirohi district of Rajasthan. Agropedolo*gy*, 2013; 23(1):8-15.
7. Hattar BI, Taimeh AY, Ziadat FM. Variation in soil chemical properties along toposequences in an arid region of the Levant. Catena, 2010; 83(1):34-45.
8. Hesse PR. A textbook of soil chemical Analysis. Chem. Publ. Co., Inc., New York. NY, 1972.
9. Jenny H. Factors of Soil Formation: A System of Quantitative Pedology. McGraw-Hill, New York, 1941.
10. Kirmani NA. Characterization, classification and development of lacustrine soils of Kashmir valley. Ph. D Thesis submitted to SKUAST-Kashmir Srinagar, 2004, 1-96.
11. Ley RE, Lipson DA, Schmidt SK. Microbial biomass levels in barren and vegetated high altitude Talus soils.

Soil Science Society of America Journal. 2000; 65:111-117.

12. Mahajan A, Sharma SK, Gupta RD, Sharma R. Morphological, physical and chemical properties of soils from Northwest Himalayas. Bulgarian Journal of Agricultural Science. 2007; 13:607-618
13. Najar GR, Akhtar F, Singh SR, Wani JA. Characterization and Classification of some apple growing soils of Kashmir. Journal of the Indian Society of Soil Science 2009; 57(1):81-84.
14. Najar GR, Rahman FH, Farida A. Effect of altitude on distribution and forms of nitrogen in some apple growing soils of Kashmir. Environment and Ecology. 2006; 24(2):433-436.
15. Nordt LC, Wilding LP, Drees LR. Pedogenic carbonate transformations in leaching soil system: implications for the global C cycle. In: Global Climate Change and Pedogenic Carbonates (eds Lal, R., Kimble, J.M., Eswaran, H., Stewart, B.A.), CRC Press, Boca Raton, USA. 2000, 43-64.
16. Piper CS. Soil and Plant Analysis. 5th edition. Hans Publisher, Bombay, 1966, 464.
17. Sanjay K, Munesh K, Mehraj AS. Effect of Altitudes on Soil and Vegetation Characterstics of *Pinus roxburghii* Forest in Garhwal Himalaya, Journal of Advanced Laboratory Research in Biolo*gy*. 2010, 1.
18. Sharma VK, Dwivedi KS, Tripathi D, Ahmed Z. Status of available major and micronutrients in the soils of different blocks of Leh district of cold arid region of Ladakh in relation to soil characteristics. Journal of the Indian Society of Soil Science. 2006; 54:248-250.
19. Sitangang M, Rao YS, Nayan Ahmed, Mahapatra SK. Characterization and classification of soils in watershed area of Shikohpur, Gurgaon district, Haryana. Journal of Indian Society of Soil Science. 2006; 54:106-110.
20. SPSS. Statistical Packages for Social Sciences, Version 11.5. SPSS Inc., Chicago, IL, USA, 1996.
21. Tan ZX, Lal R, Smeck NE, Calhoun FG. Relationships between Surface Soil Organic Carbon Pool and Site Variables, Geoderma, 2004; 121(3):185-187.
22. Tandon HLS. Methods of analysis of soil, plants, water and fertilizers. Publ. FDCO. 1993, 144.
23. Verma TP, Singh SP, Gopal R, Rao RVS, Tarsem Lal. Characterization and Evaluation of soils of Trans Yamuna area in Etawah district, Uttar Pradesh for Sustainable land use. Agropedology. 2012; 22(1):26-34.
24. Walkley A, Black CA. An examination of different methods for determining soil organic matter and proposed modifications of the chromic acid titration method. Soil Science. 1934; 37:29-38.
25. Wang J, Fu BJ, Qiu Y, Chen LD. Soil nutrients in relation to land use and landscape position in the semi-arid small catchment on the loess plateau in China. Journal of Arid Environments. 2001; 48:537-550.