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SPATIAL VARIABILITY IN SOIL PROPERTIES AND DIAGNOSTIC LEAF CHARACTERISTICS OF APPLE (*MALUS DOMESTICA*) IN APPLE GROWING REGION OF DHEERKOT AZAD JAMMU AND KASHMIR (AJK), PAKISTAN

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Abstract

Scientific information on the spatial variability in soil properties and nutrient status is important for understanding ecosystem processes and evaluating agricultural land management practices. This study aims to characterize the spatial variation of selected soil properties and the nutrient status of ten representative sites of apple growing region, and also to evaluate the nutrient contents of apple leaves of the same sites from sub-division Dheerkot, Azad Jammu and Kashmir, (AJK) Pakistan. The sampling sites were: Hill, Chamankot, Chamyati-1 (upper), Chamyati-2 (lower), Dheerkot, Kotli, Karry, Sanghar, Neelabut, and Hanschoki. The treatments included; sites = 10; depths = 04 (0-15, 15-30, 30-45, and 45-60 cm) with 3 replications. Results indicated that texture of all the sites (except one) were loam or clay loam having silt and clay the dominant soil fractions. The soils were neutral to slightly alkaline, pH ranging from 7.2 to 8.3, non-saline, and moderately calcareous ($CaCO_3$ 0.00–8.97%). The nutrient index (NI) value for soil organic matter (SOM), available P and K were 2.5, 1.5 and 2.1 showing high, medium, and medium range, respectively. The concentration of AB-DTPA extractable Fe, Mn, Cu, and Zn showed high levels of Fe (10.2–16.8 mg kg^{-1}) and Mn (0.90–2.71 mg kg^{-1}) while Zn (0.42–2.31 mg kg^{-1}) deficiency was observed in few samples. All the sites were severely deficient in Cu concentration (1.35–2.05 mg kg^{-1}). The diagnosis of apples leaves indicated that none of the samples was deficient in N (2.30–3.49%) and P (0.13–0.33%) while out of ten sites, nine sites showed severe deficiency of K (0.85–1.40%). The study demonstrated a significant variation in different physico-chemical properties of the soils collected from the same ecological region. In order to overcome the deficiency of some of the nutrients observed both in soil and plant samples, proper fertilization especially the use of organic manures is highly recommended to maintain the fertility status of the soil and also to protect the soil against the threat of degradation.

Key words: Topography, Soil properties, Soil fertility, Nutrient status, Nutrient index.

Introduction

Land and resource degradation have been identified as major ecological issues throughout the world but the problem is more serious in the heavily populated, under-developed, and ecologically fragile areas of the Hindu Kush Himalaya (HKH) region; where large amounts of soil and nutrients are lost from sloping uplands mainly as a result of soil erosion and surface run-off each year (Tiwari *et al*., 2010). Depletion of soil fertility is considered to be the fundamental biophysical root cause for declining per capita yield in smallholders' fields in the region. The predominant causes for low soil fertility and productivity are (i) loss of finer fraction of top soils, organic matter, and nutrients because of soil erosion and runoff, (ii) virtually no or little addition of organic nutrient sources into the soil i.e. manures, crop residues, green manuring, compost and plant litter (Abbasi *et al*., 2013).

The State of Azad Jammu and Kashmir especially the northern slopes of the State have been covered with open woodland vegetation dominated by coniferous trees for thousands of years. During the last 50 years, as a result of increasing demand for firewood, timber, pasture, shelter and food, natural land covers, particularly forests, are being deforested at an alarming rate. This activity, in turn, increasing surface runoff and soil erosion in the hilly areas of AJK. Consequently, there is extensive topsoil loss, especially in the irregular steep slopes, hilltops and ridges. The extent of soil quality deterioration in the region is already severe and may lead to a permanent soil degradation, which may become the greatest environmental problem of our agro-ecosystem (Abbasi *et al.,* 2010).

As a result of human inference and natural hazards, the soil properties showed a wide variation which affected ecosystem functions particularly plant and crop productivity. It is believed that soil properties generally exhibit variability as a result of the dynamic interactions between natural environmental factors, i.e., climate, parent material, vegetation, and topography (Wang *et al.,* 2009). Even significant differences in the soil nutrients were observed from areas with uniform geology and topography. Soil properties, and plant growth, are significantly controlled by the variation in landscape attributes including slope, aspect, and elevation (Wang *et al*., 2009; Rezaei & Gilkes, 2005). These factors influence the distribution of plant nutrients in soil by affecting microbial activity and the exposure of soil to erosion (Rezaei & Gilkers, 2005). A linear relationship exists between vegetation attributes such as species richness, diversity, and maturity values and ecological factors such as altitude, aspect, and distance of the site from disturbance stimuli (Schuster & Diekmann, 2005; Shaheen *et al*., 2011).

Land management and soil degradation control measures of this region is important to increase agricultural production and ensure conservation of the land resources of the area. For this purpose, a better understanding of the spatial variability of soil nutrients is needed for refining the agricultural management practices and for improving sustainable land use. Therefore, the objectives of this study were to determine physico-chemical properties and nutrient status of some of the agriculturally important apple growing soils of Dheerkot for identifying the agricultural potential of these sites and future management strategies for better production and protection of natural resources.

Materials and Methods

Study area: The study sites located in and around Dheerkot town of the State of Azad Jammu and Kashmir, under the foothills of great Himalayas (Fig. 1). Bracing altitude of 5,499 feet (1,676m), mountainous landscape and dense forest make this region very charming and attractive. The region is hilly with steep slopes, hilltops and ridges with plain valleys and stretches under the foothills of mountains. The area is characterized by a temperate sub-humid climate with annual rainfall ranging from 1200−1500 mm (depending on season), most of which is irregular and falls as intense storms during the monsoon and sometimes in winter. Mean annual temperature is about 25^{o}C (maximum) in summer while winter is fairly cold with temperature going even below freezing point.

Sampling and processing of soil and plant samples: Ten different sites from sub-division Dheerkot were selected from apple growing areas on the basis of spatial and temporal variation in July 2011. Within each site, soil samples from four depths i.e. 0–20, 15–30, 30–45, and 45–60 cm were collected from five points by soil auger and mixed as one composite sample. Soil samples were brought to the laboratory, mixed and air dried for 2–3 days. About one kg soil was taken after sieving, sealed in the plastic bags and stored in a refrigerator at 4^{o}C prior to analysis. Detail meteorological data of selected sites were also recorded. The altitude of the sites varied between a minimum of 1265 m in Hill site to the maximum of 1916 in Hanschoki. Averaged soil temperature ranged between 19–27^{o}C, minimum in Neelabut and the maximum in Hill site.

Soil samples were analyzed for sand, silt, and clay fractions, soil pH, soil organic matter (SOM), NO_3^-–N, available phosphorus (AP), available potassium (AK), calcium (Ca), Magnesium (Mg), and calcium carbonate ($CaCO_3$) content. Particle-size distribution was determined by the Bouyoucos hydrometer method (Bouyoucos, 1962). Soil organic matter was determined using a modified Mebius method (Nelson & Sommers, 1982). Available N in the form of NO_3^-–N was determined with spectrophotometer. Available P from soil samples was determined according to Ryan *et al*. (2001) using AB-DTPA method modified by Soltanpour & Workman (1979). Exchangeable K was determined using a flame photometer following soil extraction with 1 M (mol L^{-1}) and ammonium acetate ($COOCH_3NH_4$) (Simard, 1993). Soil pH was measured with a glass electrode, samples having been diluted with distilled water (the ratio of soil to water was 1:2.5). The ammonium bicarbonate- diethylene triamine penta acetic acid (AB-DTPA) extraction procedure was used for the determination micronutrients i.e. Fe, Zn, Mn and Cu (Soltanpour & Workman, 1979) using atomic absorption spectrophotometer.

About eight to ten plants from an apple orchard of the selected sites were selected for leaf sampling. Ten to fifteen young, fully expanded leaves per plant of apple were collected from the selected plants of each site. Leaves were washed with distilled water, oven-dried at 70^{o}C for 48 h, ground to pass through a 1–mesh sieve in an ED-5 Wiley mill (Arthur H. Thomas Co) and stored for further analysis. The plant samples were digested in a diacid mixture of nitric and perchloric acid (HNO_3:$HClO_4$ 2:1 v/v ratio) for the determination of P and K (Ryan *et al*., 2001). Total N in plants was determined using Kjeldahl‘s method reported by Bremner & Mulvaney (1982). AB-DTPA extracts of plant digest (using HNO_3 and $HClO_4$ mixture for digestion) were prepared and analyzed for Cu, Fe, Mn and Zn using Atomic Absorption Spectrophotometer.

Soil nutrient index (NI): Nutrient index (NI) was calculated following the method described earlier (Parker *et al*., 1951) and reported by Khalid *et al.* (2012):

$$\text{Nutrient Index (NI)} = [(Ni\times1) + (Nm\times2) + (Nh\times3))/Nt]$$

where
Nt = Total number of samples analyzed in a given area
Ni = Number of samples falling in low category of given nutrient
Nm = Number of samples falling in medium category of given nutrient
Nh= Number of samples falling in high category of given nutrient

Statistical analysis: The Analysis of Variance (ANOVA) was done on the collected data of each site by considering the locations as separate variables using a MSTAT-C Version 3.1 statistical analysis package (Anon., 1990). The Least Significant Difference (LSD) among different treatments (sites) was tested individually on triplicate data. The overall significance/effectiveness of treatments (by considering the depth and locations as fixed variables) were also evaluated by applying LSD test on grand mean data at the 5% level of probability ($p\leq0.05$) based on the F-test of the analysis of variance (Steel & Torri, 1980).

Results and Discussion

Soil texture: The clay contents of selected sites varied between 23–39%, silt 16-46%, and the sand contents ranged between 32–56% (Fig. 2). A marked variation in individual soil particles among the sites had been shown by coefficients of variation (CV) for sand 27%, silt 26%, and clay 16%. Out of ten soils, eight were clay loam, one loam and one sandy clay. Results indicated that clay content in most of the cases was lower than the sand and silt indicating that clay content might have been removed from the upper soils due to the soil erosion, or the soils contained higher sand and silt in the parent material. Previous work indicated that clay is strongly related to soil structure stability and reduction in the clay content can therefore be equated to the loss of structure stability (Sahani & Behera, 2001). Such continuous process finally extended towards the physical deterioration and degradation of soil (Abbasi *et al*., 2007). On the whole, the particle size analysis suggested that the soils are moderately fine textured (loam and clay loam) and as such are best suited for cultivation of all kinds of agricultural crops and fruit trees.

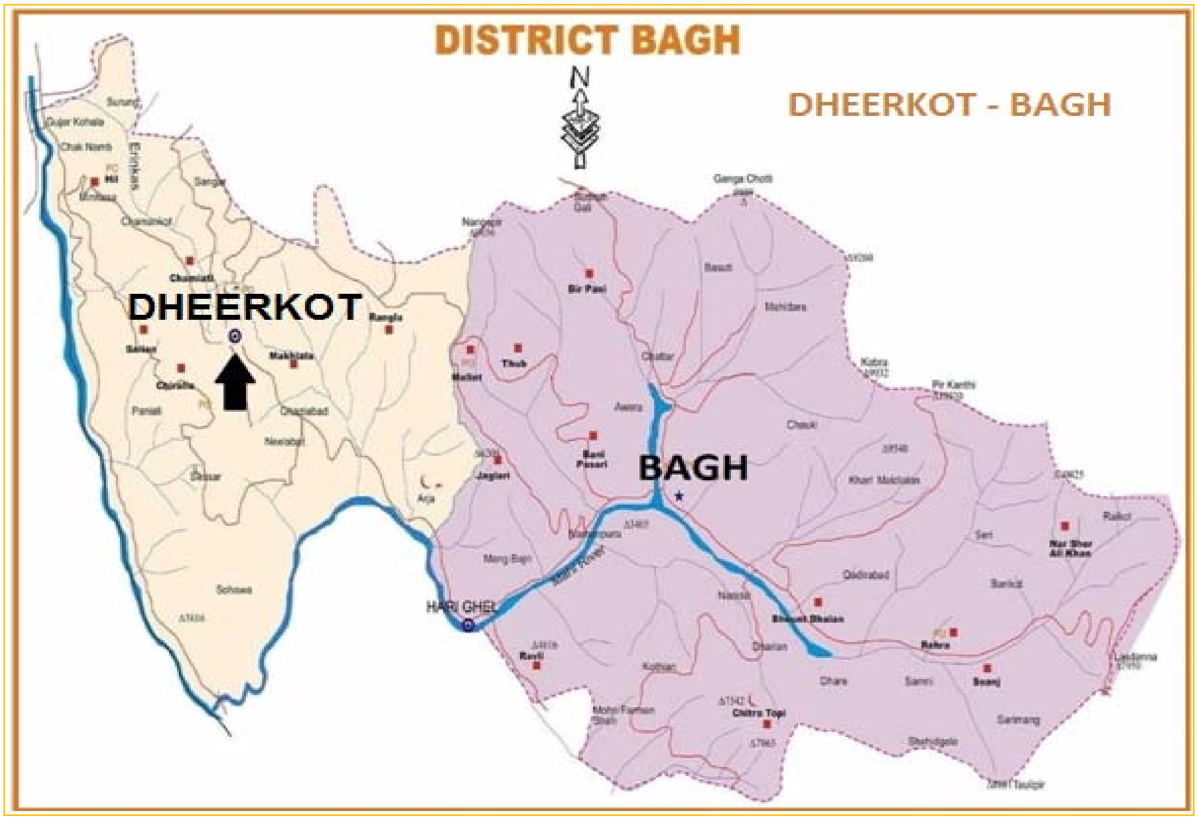

Fig. 1. Geographical presentation of the study area.

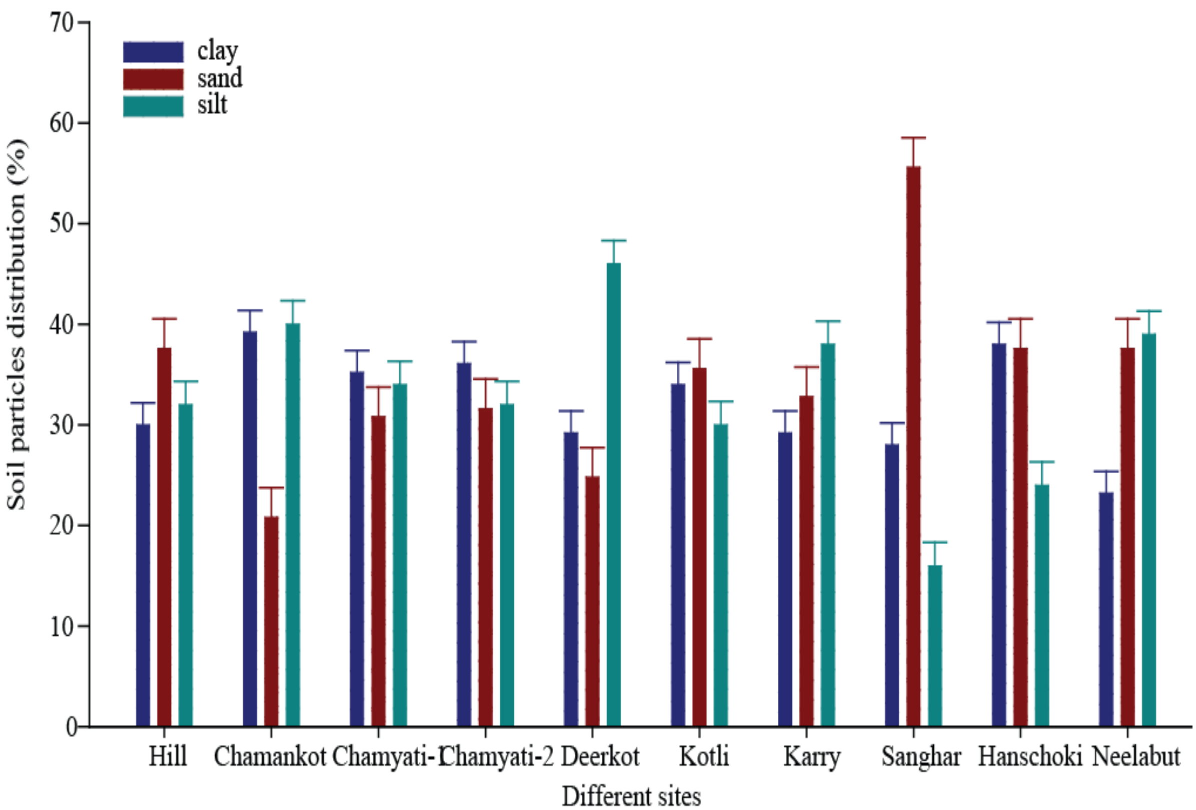

Fig. 2. The textural analysis of soils collected from ten different sites of Dheerkot region of Kashmir, Pakistan.

Soil pH, Electrical conductivity (EC) and $CaCO_3$ content: Results indicated a substantial variation in soil pH among soils and depths (Table 1); where a minimum pH of 6.90 was observed in 0-15 cm depth of Chamyati-1, while the maximum pH of 8.27 was found in 45-60 cm depth of Sanghar. Among 40 soil samples analyzed, 03 samples displayed pH below 7.5 while the remaining 37 soil samples had pH above 7.5 but below 8.5. Averaged over depths, the pH of the soils ranged between 7.23–8.17. These results suggested that pH of the study area were neutral to alkaline in reaction. Soil pH showed increasing trend down the profile that may be attributed to the variability in calcium carbonate equivalent, soil organic matter and in leaching of bases (Khattak & Hussain, 2007; Khan *et al*., 2011).

Electrical conductivity (EC) of the selected soils ranged from a minimum of 0.17 dSm^{-1} at Chamyati-1 surface layer (0-15 cm) to a maximum of 0.46 dSm^{-1} at Dheerkot soil in the sub-surface layer (30-45 cm) (Table 1). As compared to the surface soil, in most of the cases EC was higher in the subsurface layers within the profile. This may be attributed to the leaching of salts from top soil and accumulation in the compact subsoil. These results revealed that the soils of the region have very low content of soluble salts and may be considered as non-saline. The low electrolyte concentration of the selected soils was probably due to leaching induced by heavy rainfall. These results were similar to those reported earlier (Perveen *et al*., 2010) for soils of the Peshawar, Pakistan where the investigated 36 soils had EC <1.0. Under similar ecological and geographical conditions, a total of 74 soil samples from Abbotabad region of Pakistan were analyzed and the results indicated that the investigated soils had low EC (<2-4 dS m^{-1}) (Khattak & Hussain, 2007).

The lime content showed wide variation among the soils and the depths (Table 1). The soils collected from upper Chamyati (Chamyati-1) and Hanschoki sites had lime content almost zero (0.0–1.09%). On the other hand, soils from Chamankot, Sanghar, Kerry and Dheerkot had substantial $CaCO_3$ contents of 12.01, 10.94, 10.81 and 7.90%, respectively. This marked variation in $CaCO_3$ content among the selected soils is indicated by the CV (%) within each depth that varied between 72-94%. Response of $CaCO_3$ to soil depth was inconsistent and trend changed with the soils. However, in most of the cases lime content was higher in surface soils compared to the subsurface soils similar to the response reported earlier (Khan *et al*., 2011). Averaged across the depths, $CaCO_3$ contents showed significant variation among the soils and the values ranged between 0.00 –8.97% with the CV of 69%. The effect of parent material on lime concentration is important. If parent material contains more lime stone, more $CaCO_3$ is expected in C-horizon (Khattak, 1996).

Soil macronutrient status: Variation in soil organic matter (SOM) content among different soils was significant (p<0.05) (Table 2). The co-efficient of variation (CV) varied between 21-40%, higher in the sub-surface than the surface layers. The highest organic matter content of 3.51 and 3.38% was recorded in the surface layer of Hill and Sunghar soils, respectively. The SOM of the remaining soils in the upper surface layer (0-15 cm) ranged between 1.90–2.80%. The lowest organic matter content of 0.82 and 0.83% was found in the subsurface layer (45-60 cm) of soils collected from Karry, Dheerkot and Chamankot. Averaged across the depths, a significant differences in SOM among different soils had been observed. The highest SOM of 2.78% was recorded in the soil collected from Hill, followed by 2.19% from Sunghar while the lowest SOM of 1.22% was observed at Chamyati-1. Results of the study indicated that among 40 soil samples analyzed, only three samples fall under poor range as reported in generalized guideline for interpreting soil nutrient status of Pakistani soils (Ryan *et al*., 2001) while 13 samples were in the medium range and the remaining 24 samples had high SOM. Soil depths also showed a significant variation in SOM content and SOM significantly decreased with increasing depth. The relative reduction in SOM at 15-30, 30-45 and 45-60 cm depths compared to 0-15 cm was 33, 48 and 59%, respectively. Despite a heavy rainfall and slopping uplands, the selected soils of the region had SOM in a satisfactory range most likely because of well-covered vegetation protecting the soil against erosion and continuous adding organic matter through plant/grass biomass and debris. The significant difference in SOM at some locations might be associated with the low density of natural vegetation.

A wide variation in available P was recorded in the range of 0.30 to 9.84 mg kg^{-1} depending on site and depth (Table 2). The CV varied from 59–85%. Results showed that 28% of the samples had P in the range of 3.0 mg kg^{-1}, followed by 82% samples in 3.1-10.0 mg kg^{-1} and none of the soil sample had P >11 mg kg^{-1} i.e. high range. Averaged across the depths (0–60 cm), the P content of the ten sites varied between 0.79–7.34 mg kg^{-1} with CV of 61%, showing a significant variation in P among the sites. Among the sites, 50% had shown available P<3.0 mg kg^{-1} displaying that 50% soils are deficient in P while the remaining 50% are in the medium range i.e. 3.47–7.34 mg kg^{-1}. None of the soil had available P in high range. Despite relatively high level of SOM, the available P of these soils is generally low. It is commonly believed that in high SOM, most of the P is in organic fraction that is less sensitive to ABDTPA (Khattak & Hussain, 2007). Given these SOM and pH values, it is possible that organic P fraction of the soils was not fully extracted by AB-DTPA. Malik *et al*. (1984) and Rashid (1994) reported that 75-95% soils in Punjab are deficient in P. They also indicated that 61% soils contained up to 3 mg kg^{-1} and 34% soils had 3-12 mg kg^{-1} P contents.

The K contents in the surface 0-15 cm ranged from 88-229 mg kg^{-1} (Table 2) showing that 04 sites had available K of 60-120 mg kg^{-1} in the medium range while 06 sites had available K>120 mg kg^{-1} fall under high range (Ryan *et al*., 2001). The CV among different sites was 31%. The concentration of K decreased with increasing depth and fall in low, medium and high range. The mean values indicated a significant variation in soil available K ranged from 60–208 mg kg^{-1} with CV of 31%. None of the site was found K deficient, 09 sites had available K in medium range while one site (Karry) had adequate K contents of 208 mg kg^{-1}. Potassium concentrations were found sufficient in almost all the soils which might be attributed to the presence of K bearing minerals in this region. Additionally, the high K concentrations found in these soils might be due to high organic matter and moderately calcareous nature of these soils.

Table 1. Meteorological data of the sampling sites of sub-division Dheerkot Azad Jammu and Kashmir in the year 2011.

Locations	Soil temp. (˚C)		Air temp. (˚C)	Humidity (%)	Heat index (˚C)	Barometric pressure (kPa)	Altitude (m)
	0-15cm	15-30 cm					
Hill	28	26	29.2	42.5	31.5	871.0	1265
Chamankot	26	23	24.5	53.9	24.1	864.4	1496
Chamyati-1	23	23	26.4	51.7	25.8	839.4	1565
Chamyati-2	24	22	26.7	68.1	28.8	853.6	1427
Dheerkot	26	23	27.7	37.6	24.4	843.7	1522
Kotli	22	21	28.5	33.7	32.4	842.8	1532
Karry	21	20	26.5	40.8	26.6	844.4	1515
Sanghar	23	22	27.7	47.8	26.5	833.2	1625
Neelabut	19	18	19.5	61.5	20.5	803.1	1902
Hanschoki	23	20	20	52.5	16.5	804.4	1916
CV (%)	11	10	13	22	19	03	13

*Source of data collection: Weather Tracker (Model: Kestrel 4500 & Thermometer); CV = Co-efficient of variance

Table 2. Variation in pH, electrical conductivity and calcium carbonate content of soils in response to the location and depth in the mountainous region of Dheerkot Azad Jammu & Kashmir.

Locations	Soil pH					Electrical conductivity (ECe, dSm^{-1})					Calcium carbonate content ($CaCO_3$, %)				
	Depth (cm)														
	0-15	15-30	30-45	45-60	mean	0-15	15-30	30-45	45-60	mean	0-15	15-30	30-45	45-60	mean
Hill	8.00	8.11	8.17	8.21	8.12ab	0.24	0.26	0.36	0.39	0.31c	5.33	0.24	7.05	0.60	3.30c
Chamankot	8.12	8.15	8.18	8.24	8.17a	0.25	0.28	0.33	0.34	0.30d	12.01	8.29	7.56	8.03	8.97a
Chamyati-1	6.90	7.16	7.33	7.51	7.23c	0.17	0.19	0.2	0.21	0.19f	0.00	0.00	0.00	0.00	0.00d
Chamyati-2	7.74	7.91	8.04	8.13	7.96b	0.3	0.32	0.35	0.36	0.33b	5.59	6.57	10.09	10.69	8.24a
Dheerkot	7.91	8.00	8.04	8.13	8.02ab	0.32	0.36	0.46	0.45	0.40a	7.90	2.42	2.76	3.19	4.07b
Kotli	7.85	7.91	7.95	8.07	7.95b	0.29	0.31	0.37	0.36	0.33b	3.92	3.53	4.48	4.56	4.12bc
Karry	8.04	8.10	8.11	8.17	8.11ab	0.22	0.25	0.46	0.37	0.33b	10.81	0.66	4.39	1.56	4.36b
Sanghar	7.96	8.08	8.15	8.27	8.12ab	0.28	0.35	0.35	0.32	0.33b	2.55	10.94	10.69	12.18	8.09a
Neelabut	7.92	8.06	8.19	8.12	8.07ab	0.29	0.31	0.39	0.25	0.31c	4.05	4.50	4.30	2.33	3.80bc
Hanschoki	8.05	8.17	8.18	8.26	8.17a	0.19	0.24	0.23	0.21	0.22e	1.09	0.62	0.00	0.32	0.51d
CV (%)	4	4	3	3	4	20	26	23	19	24	83	84	94	72	69
LSD ($p \leq 0.05$) for locations (L) = 0.17; for depths (D) = 0.11; for Interaction (L x D) = 0.34						LSD ($p \leq 0.05$) for locations (L)=0.006; for depths (D) = 0.004; for Interaction (L x D)= 0.012					LSD ($p \leq 0.05$) for locations (L) = 0.91; for depths (D) = 0.82; for Interaction (L x D) = 1.13				

*LSD = Least significant difference at $p \leq 0.05$

The NO_3^-–N concentrations of soils under study ranged between 0.90 and 3.65 mg kg^{-1} (Table 3) very low to a critical level of <10 mg kg^{-1}. However, high concentration of NO_3^-–N in soils under high rainfall with steeping landscape is not expected because of chances of leaching. The Ca and Mg level of these soils varied between 4.38 and 6.33 (mean), and 4.01 and 4.36 mg kg^{-1} respectively (Table 3). The optimum level of Ca and Mg are not available, hence fertility category of these nutrients is not further discussed.

Soil micronutrient status: Micronutrients showed large variation in concentrations in the study sites with high concentrations of Fe and low concentration of Cu (Table 4). The concentration of Fe varied between 6.8 and 18.5 mg kg^{-1} with CV of 19–33%, while the Mn concentration ranged between 0.57 and 5.50 mg $kg^{-1,}$ with CV of 33–43%. The Cu concentration of these soil varied between 0.93 and 2.96 mg kg^{-1} with CV 16-28% and the Zn level was in the range of 0.15 – 4.47 mg kg^{-1} with CV of 66-81%. According to the generalized guideline for interpreting soil nutrient status of Pakistan (Ryan *et al*., 2001), Fe and Mn content of the soils were adequate (high), while Zn content in three soils was deficient, and the remaining soils contained marginal and adequate range. All the tested soils are deficient in Cu content. The concentrations of Fe, Mn, Cu, and Zn in soils of Dir district, KPK Pakistan were 8.58, 1.9, 1.88, and 17.25 mg kg^{-1} (Adil, 1987), while the Cu, Mn and Zn concentrations in the soils of Madison country, Missouri (USA) ranged from 1 to 450, 17 to 1227 and 14 to 142 mg kg^{-1}, respectively.

Soil nutrient index (NI): Soil fertility level was measured in terms of nutrient index (NI) values as reported in earlier study (Khalid *et al*., 2012). The NI value of <1.5 is taken as low, values between 1.5 and 2.5 indicates medium and >2.5 as higher fertility status of the given area (Motsara, 2002). In the present study, the NI value for SOM was 2.5 (Table 5) showing SOM in adequate range while the NI for available P and K were 1.5and 2.1, respectively displaying that bot soil available P and K were found in the medium range.

Table 3. Variation in organic matter, available P, and available K content of soils in response to the location and depth in the mountainous region of Dheerkot Azad Jammu & Kashmir.

Locations	Soil organic matter (SOM, %)					Soil available P (SAP, mg kg^{-1})					Soil available K (SAK, mg kg^{-1})				
	Depth (cm)														
	0-15	15-30	30-45	45-60	mean	0-15	15-30	30-45	45-60	mean	0-15	15-30	30-45	45-60	mean
Hill	3.51	3.49	2.24	1.89	2.78a	2.97	2.52	1.43	1.56	2.12e	146	109	92	102	112b
Chamankot	2.52	1.20	0.97	0.83	1.38d	2.61	1.56	1.37	1.11	1.66f	229	88	76	85	120b
Chamyati-1	1.94	1.04	0.97	0.94	1.22d	0.90	0.99	0.96	0.30	0.79g	88	80	79	77	81c
Chamyati-2	3.01	1.88	1.08	0.99	1.74c	9.84	2.01	2.14	2.04	4.01b	129	116	94	104	111b
Dhirkot	2.52	1.20	0.97	0.83	1.38d	9.06	7.91	7.86	4.54	7.34a	126	82	72	75	89c
Kotli	1.90	1.73	1.70	0.98	1.58c	4.05	2.61	5.16	2.06	3.47c	110	93	93	91	97bc
Karry	2.36	1.78	1.34	0.82	1.57c	5.51	3.43	3.11	2.91	3.74bc	249	229	180	174	208c
Sanghar	3.38	2.00	1.99	1.41	2.19b	9.84	2.01	2.14	2.04	4.01b	129	116	94	104	111b
Neelabut	2.41	1.99	1.39	1.07	1.71c	4.91	2.34	0.90	1.44	2.40d	105	52	42	42	60c
Hanschoki	2.80	1.39	1.15	1.12	1.62c	1.48	1.18	1.31	1.44	1.35f	104	56	62	78	75c
CV (%)	21	40	33	31	27	66	75	85	59	61	31	53	39	50	38
LSD (p≤0.05) for locations (L) = 0.17; for depths (D) = 0.11; for Interaction (L x D) = 0.34						LSD (p≤0.05) for locations (L) = 0.47; for depths (D) = 0.31; for Interaction (L x D) = 0.24					LSD (p≤0.05) for locations (L) = 33.4; for depths (D) = 27.1; for Interaction (L x D) = 21.3				

* LSD = Least significant difference at p≤0.05

Table 4. Generalized guideline for interpreting soil nutrient status of Pakistani soils.

Nutrient	Deficient	Marginal	Adequate	Very high
AB-DTPA – extractable (mg kg^{-1})				
NO_3^--N	≤10	11 – 20	21 – 30	>30
P	≤3	4 – 7	8 – 11	>11
K	≤60	61– 120	121 – 180	>180
Fe	≤ 3.0	3.1–5.0	> 5.0	________
Mn	≤0.5	0.6 – 1.0	>1.0	________
Zn	≤0.9	1.0 – 1.5	>1.5	________
Cu	≤3.0	3.1 – 5.0	>5.0	________
HCl – extractable (mg kg^{-1})				
B	≤0.6		>0.6	________

*Ryan *et al*. (2001)

Table 5. Variation in NO_3^-–N, calcium and Magnesium concentration of soils in response to the location and depth in the mountainous region of Dheerkot Azad Jammu & Kashmir.

Locations	NO_3^-–N					Calcium (Ca, mg kg^{-1})					Magnesium (Mg, mg kg^{-1})				
	Depth (cm)														
	0-15	15-30	30-45	45-60	mean	0-15	15-30	30-45	45-60	mean	0-15	15-30	30-45	45-60	mean
Hill	1.03	2.00	0.95	2.15	1.53d	5.76	5.30	5.29	4.83	5.30f	4.16	4.31	4.15	4.35	4.24b
Chamankot	1.70	1.19	1.06	1.43	1.35ef	5.21	4.39	4.15	3.76	4.38j	4.18	4.14	4.15	4.22	4.17d
Chamyati-1	1.09	0.90	1.05	0.91	0.99h	4.34	4.78	5.26	4.63	4.75i	4.36	4.35	4.35	4.35	4.36a
Chamyati-2	1.58	1.45	1.05	1.07	1.29fg	6.16	6.22	5.99	5.63	5.99b	4.06	4.09	4.15	4.12	4.107f
Dhirkot	1.47	2.59	2.15	1.65	1.96b	5.75	6.08	5.67	5.61	5.78d	4.17	3.10	4.06	4.11	4.09fg
Kotli	1.03	1.28	1.17	1.11	1.15gh	6.11	5.73	6.09	5.61	5.88c	4.05	4.10	4.12	4.06	4.082g
Karry	2.10	1.17	2.24	2.20	1.93b	6.43	4.86	4.35	6.31	5.49e	4.18	4.24	4.13	4.24	4.10c
Sanghar	2.12	1.31	1.26	1.35	1.51de	5.14	5.29	4.97	5.17	5.14g	4.07	4.12	4.17	4.18	4.13e
Neelabut	3.65	3.26	2.72	1.27	2.73a	6.27	6.12	6.41	6.52	6.33a	4.07	4.04	4.14	4.10	4.09fg
Hanschoki	2.24	2.30	1.24	1.14	1.73c	4.31	5.03	5.06	5.22	4.90h	4.06	3.99	3.96	3.99	4.01h
CV (%)	44	44	42	31	31	14	12	14	15	11	2	9	2	3	2
LSD (p≤0.05) for locations (L) = 0.17; for depths (D) = 0.11; for Interaction (L x D) = 0.34						LSD (p≤0.05) for locations (L) =0.046; for depths (D) = 0.029; for Interaction (L x D) = ns					LSD (p≤0.05) for locations (L)= 0.024; for depths (D) = 0.015; for Interaction (L x D) =0.047				

*LSD = Least significant difference at p≤0.05

Table 6. Nutrient Index (NI) value of soils collected from nine different areas (locations) of apple growing region of Dheerkot Azad Jammu & Kashmir, Pakistan.

Available nutrients	% Soil samples			Nutrient index
	Poor	Satisfactory	Adequate	(NI)
Organic matter (OM)	8	33	60	2.5
Available P	50	50	0	1.5
Available K	13	63	25	2.1

Table 7. Macro and micro nutrient concentration of apple leaves collected from apple orchards of ten different sites of the mountainous region of Dheerkot Azad Jammu & Kashmir.

Locations	N	P	K	Ca	Mg	Fe	Mn	Cu	Zn	B
	%			mg kg^{-1}						
Hill	2.98abcd	0.20c	1.11c	728.2d	419.9bcd	270.7b	34.1f	2.97b	18.9cd	29.0a
Chamankot	2.84bcd	0.16d	0.93ef	619.2g	484.8a	256.7bc	36.0d	2.20c	15.7fg	28.4a
Upper Chamyati	3.27abc	0.20c	1.26b	510.4i	394.8cd	211.3 e	41.1c	3.73a	16.9ef	21.6c
Chamyati	3.38 a	0.33a	1.04cd	510.0i	449.7ab	259.4bc	22.6h	3.50ab	22.0ab	30.4a
Deerkot	3.36ab	0.13f	1.10c	648.1f	426.4bc	274.2b	34.4f	1.97c	14.3g	23.4c
Kotli	2.30e	0.15de	1.40a	608.1h	385.57d	235.7d	62.5a	3.57ab	16.1efg	14.3d
Karry	2.70de	0.15de	0.98de	913.0b	385.50d	189.7f	42.0b	1.60c	17.8de	21.4c
Sanghar	2.81cde	0.22b	1.12c	889.9c	416.5bcd	248.3cd	30.3g	2.97b	16.0efg	29.5 a
Neelabutt	3.49a	0.14ef	0.85f	1075.6a	428.6bc	336.7a	36.7d	3.13ab	22.8a	28.0ab
Hanschoki	2.97abcd	0.22bc	0.91ef	715.0e	437.3b	242.6cd	35.4e	3.03b	20.8bc	23.9bc
LSD ($p\leq0.05$)	0.519	0.0156	0.101	7.80	38.19	18.9	0.78	0.61	1.91	4.02

*LSD = Least significant difference at $p\leq0.05$

Table 8. Index values for total N, P, K, Cu, Fe, Mn, Cu and Zn in apple plants reported by various sources.

Elements	Deficient	Sufficient	Toxic
	Macronutrients (%)		
Total N	<2.0	2.0-2.38	>2.4
P	<0.13	0.13 - 0.33	>0.34
K	<1.3	1.3-1.8	>1.8
Ca	<1.0	1.0-2.0	>2.1
Mg	<0.3	0.3-0.5	>0.6
	Micronutrients (mg kg^{-1})		
Cu	<4	5-20	>20
Zn	<15	15-100	>100
Fe	<50	50-250	>250
Mn	<20	20-500	>500
B	<20	20-60	>60

*(Cline, 1990; Fallahi *et al*., 2001) (Jones *et al*., 1972)

Nutrients concentration in apple orchard leaves: Significant differences among the macro- and micronutrient in the leaves of apple trees were determined (Tables 6). The optimum content of N, P and K in the leaves of the apple-tree should be 2.0–2.4%, 0.13–0.33, and 1.3–1.8%, respectively (Fallahi *et al*., 2001) (Table 7). The concentrations of total N, P, and K in the leaves ranged between 2.30 and 3.38%, 0.14 and 0.33%, and 0.85 and 1.14%, respectively (Table 8). None of the samples was deficient in N and P while out of ten, nine samples showed severe deficiency in K. The concentration of N, P, and K recorded in the leaves were in accordance with the previous studies. Khattak & Hussain (2007) evaluated the macronutrient status of apple trees from the Galliyat region of district Abbotabad, KPK, Pakistan and reported that the total N, P and K in leaves ranged from 1.2–2.87, 0.01–0.166 and 2.02–4.25% with the mean values of 2.02, 0.091, and 3.12%, respectively. In the high yield apple orchards in Henan province, China, leaf N, P and K were 2.22, 0.198, and 1.32% (Xia *et al*., 1998). According to Svagzdys (1999) the total N, P and K concentrations of 2.0, 0.23, and 1.53%, in the leaves of apple orchards were recorded in Lithuania, Russia. The K concentration observed in the majority of the samples, suggesting K deficiency that may be critical for production and quality. The K concentration recorded in the present study was lower than that recorded by Khattak & Hussain (2007) in the apple trees from Abbotbad, KPK, Pakistan but the values were comparable to those previously reported from British Columbia, Canada (0.82%) and Henan province, China (1.32%) (Neilsen *et al*., 1998; Xia *et al*., 1998).

The concentrations of Fe, Mn, Cu, Zn and B of apple leaves ranged between 189.7–336.7, 34.1–62.5, 1.60–3.73, 15.7–22.8, and 21.4–30.4 mg kg^{-1}, respectively with mean values of 252.5, 37.5, 2.9, 18.4, and 25.0 mg kg^{-1}, respectively (Table 8). These values when compared with the optimum range of nutrient concentration described for apple in the earlier studies (Cline, 1990; Fallahi *et al*., 2001) showing that none of the samples collected from all nine sites showed deficiency of Fe and Mn while only one sample displayed deficiency of Zn and B. All the sample had shown sever deficiency of Cu. The concentrations of Fe, Mn, Cu, and Zn in apple leaves collected from the orchards of district Abbottabad, KPK, Pakistan were reported to 147–1521, 10.1–866, 1.8–109, and 7.5–31.5 mg kg^{-1}, respectively (Khattak & Hussain, 2007). A survey was conducted to assess the Zn, Cu, Fe, Mn, and B status of 50 peach (*Prunus persical* L.) orchards in Swat Valley of Khyber Pakhtunkhwa province during 2008. The leaf tissue analysis showed that none of the orchards was low in Cu, Mn and Fe. However, B was deficient in 6 % and Zn in 2 % peach orchards (Samiullah *et al*., 2013). The deficiency of Fe (chlorosis) is wide spread in orchards and is by far the most difficult to correct especially in calcareous soils (Zia *et al*., 2006). However, in our case the presence of high organic matter in most of the soils and the low $CaCO_3$ contents may attributed the presence of high level of Fe both in soil and plant samples.

Conclusions

The present study was conducted to evaluate the fertility status and variability of the selected properties of soils collected from different sites/locations of mountain region of Dheerkot Kashmir, Pakistan. Soils of the study sites were generally clay loamy in nature, with silt and clay are the dominant fractions. Despite heavy rainfall and slopping uplands, the fertility status of the soils and the nutrient content of apples leaves were found satisfactory and encouraging. The adequate level of essential nutrients in soil and plant may be due to well-covered vegetation protecting the soil against erosion, and by continuous adding organic matter through plant/grass biomass and debris. However, the apple leaves showed severe deficiency of K and Cu. On the basis of soil pH, $CaCO_3$ content and the nutrient status, the soils of the region are quite suitable/appropriate for crops, vegetable and orchards cultivation.

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