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EFFECT OF SLOPE POSITIONS ON SOIL PHYSICO-CHEMICAL PROPERTIES OF CHAGHARZAI VALLEY DISTRICT BUNER

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Abstract

The research work was conducted in Chagharzai valley of District Buner to determine the effect of slope positions on soil physico-chemical properties and micronutrients. Samples were collected from top-slope, mid-slope, and bottom-slope at two depths 0-15 and 15-30 cm. The results showed that there were significant differences among the physico-chemical properties and micronutrients of top-slope, mid-slope and bottom-slope positions. Almost all the soil samples had acidic pH and were non-saline (EC <4dSm-1) in both surface and sub-surface soil. Top slope had higher bulk density (1.60 g cm^{-3}) than both Mid-slope (1.58 g cm^{-3}) and Bottom-slope (1.53 g cm^{-3}). Bottom-slope had high electrical conductivity (0.077 dSm^{-1}), phosphorus (12.5 mg kg^{-1}), potassium (76.85 mg kg^{-1}), organic matter (2.13%), zinc (1.01 mg kg^{-1}), iron (4.55 mg kg^{-1}), manganese (3.23 mg kg^{-1}), copper (1 mg kg^{-1}) and clay (12.34%), while Top-slope had the lowest. Surface soil was significantly different from sub-surface soil in almost all physico-chemical properties and micronutrients. Sub-surface soil had the highest bulk density (1.57 g cm^{-3}) and lower electrical conductivity (0.043 dSm^{-1}). Surface soil had higher phosphorus (15.75 mg kg^{-1}), potassium (80 mg kg^{-1}), organic matter (1.12%), copper (0.98 mg kg^{-1}), zinc (0.91 mg kg^{-1}) and silt (21%) than sub-surface soil. There were difference in soil physico-chemical properties and micronutrients of the three slope positions. From the study, it has been concluded that the position of slope affected soil properties and fertility of sloping land. To control these adverse effects of slope conservation measures needs to be adopted such as afforestation, contouring, terracing, and selection of suitable crops for these sloping land.

Key words: Slope position, Physical, Chemical, Biological properties and Soil

INTRODUCTION

Soil is an important natural resource for growing plants, food and fiber. The suitability of soil for crop production is based on the quality of the soil's physical, chemical and biological properties. One of the naturally occurring processes that affect detrimentally these soil properties and subsequent crop production is soil erosion. Slope is one of the important factors of universal soil loss equation. Its geometry, such as slope angle, length and curvature influence runoff, drainage, and soil erosion (Aandahl, 1948) causing a significant difference in soil physico-chemical properties (Brubaker et al., 1993). Erosion would normally be expected to increase with increase in slope length and slope steepness, as a result of respective increase in velocity and volume of surface runoff.

Soil physico-chemical properties could be varied depend upon the slope position, slope class, and slope aspects (Abolghasem et al 2014). No research work had been done in the past in study area (Chagharzai valley District Buner) to determine the effect of slope positions on physico-chemical properties and micronutrients status of soils. Furthermore, 25% of the cultivated area is rainfed. In Buner generally slope steepness is the main factor resulting in erosion and eroded soil material affect chemical and physical properties of the soil . The collection of data for the relationships among slope steepness and soil physico-chemical properties and micronutrients status would be helpful in formulating soil management factors and to restore crop productivity of these soils (Khan et al 2011). The effect of slope positions on soil physico-chemical properties and micronutrients status in district Buner is not well known and required further research.

In the area under study, water erosion takes place in which slope steepness is the dominant factor where the accumulating water removes the finer soil particles including soil organic matter and plant nutrients thus adversely affecting the soil physico-chemical properties and crop productivity. The study aimed to investigate the effect of slope position on physico-chemical properties of soil in order to provide the basic information about the fertility status of the eroded land of the area. Such information would be helpful in recommending the type and amount of fertilizer and other soil management practices in future crop production strategies on such soils.

MATERIALS AND METHODS

Study Site: The research work was conducted to assess the effect of slope positions on physico-chemical properties and micronutrients status of soil in sloping land in chagharzai valley of district Buner Khyber Pakhtunkhwa. Chagharzai is arable land but the topography of landscape is vulnerable to erosion. Therefore, water erosion is more frequent in these areas. Besides erosion, poor management practices and improper use of fertilizers are other important factors resulting in low crop productivity in the area.

Sites Selection: Seven different locations i.e Bazarkot, Chamo, kooztiraj, Inzarmira, Topai, Mekhokhpa, and Gishar were selected in chagharzai district Buner. Samples were collected from different slope positions, i.e. Top, Mid and Bottom positions because most of the fields of the study area slopy and farmers are practicing contour farming in their fields Based on the said facts and because the hill slope positions has long been important in soil geo morphology at the scale a locality level, soil maps, topography than any other soil factors (Bradley et al 2015).

Field work: Collection of soil samples: seven locations in district Buner were surveyed and soil samples were collected from three different slope position i.e top-slope, Mid-slope, Bottom-slope in July 2014. A total of 42 soil samples, six samples (Top, mid and bottom in duplicates) from each location of the valley from the farmers' fields (Bazarkot, Chamo, Koztiraj, Inzarmaira, Topai, Mekhokhpa and Gishar) were collected at two depth i.e. 0-15cm and 15-30 cm.

Soil Samples Preparation: Soil samples collected were brought to the soil and water testing laboratory of ARI (N) Mingora. The samples were air dried, grounded and sieved from 2 mm sieve. Each sample was put in a plastic bag, which was properly labeled with permanent marker and was stored for laboratory analysis.

Laboratory Procedure: The samples were analyzed for the physico-chemical properties like Mechanical analysis (Gee and Bauder, 1986), Organic matter (Nelson and sommers,1982), Electrical conductivity (Rhoads and Miyanmoto, 1990), Soil pH (McLean, 1982), Bulk density (hydrology/1.nmsu.edu/), AB-DTPA extractable P and K (Soltanpour and Schwab, 1977) and AB-DTPA Extractable Copper, Iron, Manganese and Zinc (Soltanpour and Schwab, 1997).

RESULT AND DISCUSSION

Physical properties of soil: Soil bulk density was affected by slop position shown in table 1. Top slope had the highest bulk density (1.604 g cm^{-3}) while bottom-slope had the lowest (1.535 g cm^{-3}). Bulk density of mid-slope was 1.585 g cm^{-3}. The results showed that with the increase in slope bulk density increases. Difference in bulk density were observed as slope increased from top to bottom i.e. bulk density was 5% higher for top-slope as compared to the bulk density of mid-slope while the bulk density was 8% higher in mid-slope as compared to bottom-slope and was almost 12% higher in top-slope as compared to bottom slope. Data showed that soil bulk density had a decreasing trend down slope and an increasing trend down the profile both of which are presumed to be due to soil erosion processes. Thus, it was clear from the data that the soil bulk density had an inverse relationship with soil clay and silt content and had a direct relationship with sand content. Actually, when soil erosion takes place, finer particles get suspended in the accumulating water and are transported down the slope thus leaving coarser material at the top slope positions with less micro pore spaces and higher soil bulk density. These results are supported by Midkiff et al., (1985)

Soil organic matter as affected by slope position is shown in table 1. Bottom-slope had the highest soil organic matter (2.132%) as compare to top-slope (1.264%) while that of the mid-slope was about 1.844%. Difference were found in soil organic matter contents in response to different slope positions. Soil organic matter was 14% lower for mid-slope as compared to that of bottom-slope while the soil organic matter was 32% lower from top-slope when compared with mid-slope. Soil organic matter was 41% lower for top-slope compared to bottom-slope. The variation of erodibility along the slopes reflected soil property trends. The greatest erodibility was associated with upper slope positions where soils tended to be shallow, coarse, poorly leached and low in organic matter, while lower erodibility was found at lower slope positions with deep, organic-rich and leached soils (Martz, 1992). Soil clay, silt and sand contents differed in response to varying slope positions as presented in table 1. Average soil clay value of Top-slope, Mid-slope and Bottom-slope were 8.32%, 8.82% and 12.34% respectively. Bottom slope resulted in highest soil silt content (20.52%) while Top-slope had the lowest (19.54%). Soil silt content of Mid-slope was 20.08%. Difference in soil silt content of different slope position were observed i.e. soil silt contents was 2% lower for mid-slope as compared to bottom-slope while was about 3% lower from top-slope when compared to the mid-slope. Soil silt content was 5% lower for top-slope as compared to bottom-slope. Likewise, soil sand content value of Top-slope, Mid-slope and Bottom-slope were 71.14%, 71.08% and 68.09% respectively. The suspended finer particles are transported down the slope where they accumulate at the bottom thus increasing the clay and silt content at the bottom slope positions with higher micro porosity and lower bulk density which are in line with that of the work of previous researchers (Shafiq et al., 1988 and Brady, 1984).

Table 1. Physical properties of soil as affected by different slope position and its depths of Chagharzai valley district Buner

Traits	Slope Position	Soil depth (cm)		Mean
		0-15	15-30	
Bulk Density	Top	1.59	1.61	1.60
	Mid	1.59	1.58	1.58
	Bottom	1.55	1.52	1.53
Organic matter (%)	Top	1.676	0.852	2.552
	Mid	2.151	1.538	1.713
	Bottom	2.552	1.844	2.132
Soil clay content	Top	8.97	7.68	8.32

		Continued Table 1…..		
	Mid	8.11	9.54	8.82
	Bottom	10.8	13.88	12.34
Soil silt content	Top	18.97	20.11	39.08
	Mid	22.34	17.82	40.16
	Bottom	21.68	19.37	41.05
Soil sand content	Top	69.34	72.94	71.14
	Mid	69.54	72.62	71.08
	Bottom	70.22	65.97	68.09

Chemical properties of soil: Electrical conductivity (EC) of soil was affected by slope position as given in Table 2. Bottom-slope had the highest soil electrical conductivity (0.077 dS m^{-1}) while top-slope had the lowest (0.041 dS m^{-1}). Soil electrical conductivity of mid-slope was 0.065 dS m^{-1}. The results showed that as slope increased soil electrical conductivity was decreased i.e. soil electrical conductivity was 34% lower for (mid-slope) as compared to the soil electrical conductivity of bottom-slope while the soil electrical conductivity was 66% lower from top-slope as compared to the soil electrical conductivity of mid-slop. Soil electrical conductivity was 123% lower for top-slope as compared to bottom-slope. Data showed an increasing trend in soil EC down the slope. Along with suspended clay in accumulating water soluble cations and anions also move down the slope with surface runoff and accumulate there at the bottom slope which might have caused an increase in EC at the down slope positions. The work of other researchers (Putman and Alt., 1987; Ahmad and Khan, 2009) also confirmed the increase in EC with depth which they have presumed to be due to the downward movement of soluble ions (Na+, K+, Mg2+ Cl-, HCO3-) with percolating water during the erosion processes and its accumulation in the compact subsoil.

Likewise, pH of soil pH was affected by slope positions as shown in Table 2. Bottom-slope had the highest soil pH 6.44 while top-slope had the lowest 5.53.Soil pH of mid-slope was 6.15. The results showed that as slope increased soil pH was decreased. Lower on the mountain slope, pH was slightly higher. There is clear relationship between soil acidification and position on the mountain (Freidenet al., 1992).

Table 2. Chemical properties of soil as affected by different slope position and its depths of Chagharzai valley district Buner

Traits	Slope Position	Soil depth (cm)		Mean
		0-15	15-30	
Electrical Conductivity	Top	0.05	0.032	0.041
	Mid	0.081	0.05	0.065
	Bottom	0.107	0.047	0.077
Soil pH	Top	5.52	5.55	5.53
	Mid	6.11	6.2	6.15
	Bottom	6.48	6.4	6.44

Macronutrients: Effect of slope position on AB-DTPA extractable Phosphorus and Potassium is given in Table 3. Average soil AB-DTPA extractable phosphorus value of Top, Mid and Bottom slope were 0.44 mg kg^{-1}, 0.45 mg kg^{-1} and 0.50 mg kg^{-1} respectively. Likewise, average soil Extractable potassium of top, mid and bottom slope were 68.57, 68.85, and 76.85 mg kg^{-1} respectively. Results revealed that an increasing trend from top to bottom slope position which might be due to their downward movement with runoff water from top slope and accumulation there at the bottom slope postion which are in agreement with Bullock (1992).

Table 3. Macronutrients status of soil as affected by different slope position and its depths of Chagharzai valley district Buner

Traits	Slope Position	Soil depth (cm)		Mean
		0-15	15-30	
AB-DTPA Extractable phosphorus (mg kg^{-1})	Top	0.49	0.398	0.44
	Mid	0.46	0.43	0.45
	Bottom	0.50	0.04	0.50
AB-DTPA Extractable potassium (mg kg^{-1})	Top	78	59.14	68.57
	Mid	75.42	62.28	68.85
	Bottom	80	73.71	76.85

Micronutrients: Effect of slope position affected soil AB-DTPA Extractable zinc, Copper, Iron and Manganese as shown in table Table 4. Bottom-slope had the highest soil AB-DTPA Extractable zinc (1.019 mg kg^{-1}) while Top-slope had the lowest (0.761 mg kg^{-1}). Soil AB-DTPA Extractable zinc of Mid-slope was 0.848 mg kg^{-1}. Simillarly bottom-slope had the highest soil AB-DTPA Extractable copper (1 mg kg^{-1}) followed by Mid-slope (0.932 mg kg^{-1}) while Top-slope had the lowest (0.900 mg kg^{-1}). Likewise, bottom-slope had the highest soil AB-DTPA Extractable iron (4.55 mg kg^{-1}) followed by of Mid-slope (4.32 mg kg^{-1}) while top-slope had the lowest (4.21 mg kg^{-1}) AB-DTPA Extractable iron. Also soil AB-DTPA Extractable manganese value of Top-slope, Mid-slope and Bottom-slope were 1.34 mg kg^{-1}, 1.43 mg kg^{-1} and 3.23 mg kg^{-1} respectively. Previous researches also reported results which are in line with (Webb and Dowling, 1990, Khan et al., 2004)

Table 4. Macronutrients status of soil as affected by different slope position and its depths of Chagharzai valley district Buner.

Traits (mg kg^{-1})	Slope Position	Soil depth (cm)		Mean
		0-15	15-30	
AB-DTPA Extractable Zinc	Top	0.875	0.647	0.761
	Mid	0.94	0.757	0.848
	Bottom	1.106	0.933	1.019
AB-DTPA Extractable Copper	Top	0.917	0.83	0.90
	Mid	1.00	0.859	0.932
	Bottom	1.021	0.97	1.00
AB-DTPA Extractable Iron	Top	4.685	3.742	4.21
	Mid	4.742	3.91	4.325
	Bottom	4.28	4.82	4.55
AB-DTPA Extractable Manganese	Top	1.32	1.37	1.34
	Mid	1.44	1.43	1.43
	Bottom	3.11	3.35	3.23

CONCLUSIONS

Differences among the physico-chemical properties and micronutrients of Top, Mid and Bottom positions were found. Almost all the soil samples had acidic pH and were non-saline (EC<4 dS m^{-1}) in all the surface and sub-surface soil. Top-slope had higher bulk density than both mid-slope and Bottom-slope. Bottom-slope had highest electrical conductivity, phosphorus, potassium, organic matter, micronutrients, clay and silt contents, while Top-slope had the lowest. Surface soil was significantly different from sub-surface soil in almost all physico-chemical properties and micronutrients. Surface soil had the lowest bulk density and electrical conductivity than sub-surface soil and micronutrients. Surface soil had lower potassium, micronutrients, clay and silt contents than sub-surface soil due to sloping land and erosion.

RECOMMENATIONS

Generally good soil cover and terraces are recommended to adjust soil physico-chemical properties and micronutrients of the sloping soils and selection of proper cropping system is needed for conservation of these sloping lands in district Buner. As the sloping soils are deficient, particularly in organic matter and micronutrients, therefore proper fertilizer management is necessary to adjust nutrients deficiencies. Soil erosion in sloping land must be controlled through plantation of trees, terracing and improvement of field bunds in the sloping land of Chagharzai valley, District Buner, Khyber Pakhtunkhwa, Pakistan.

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