Physico-chemical Properties of Soils of Kohat and Bannu Districts NWFP Pakistan

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Summary: Physico-chemical properties of soils in Kohat and Bannu districts of North West Frontier Province (NWFP), Pakistan, were determined for better management. Soil samples were collected from two depths i.e. 0-15 and 15-45 cm, respectively from 86 locations in Kohat and 73 in Bannu during 2004. Soil samples were analyzed for various soil properties. Results showed that soils of Kohat district varied from clay to sandy loam at both depths with saturation percentage from 25.15 to 71.76 and 16.60 to 82.64 % in upper and subsurface, respectively. Bulk density of the surface soil ranged from 1.10 to 1.75 g cm^{-3}. Soil pH was found to be alkaline in both the depths. Electrical conductivity of these soils showed 14 % area as saline. Soils were found to be slightly strongly calcareous in both the depths. Organic matter content of the surface soil showed that 25 % samples were medium, whereas 75 % were low. In Bannu district, soil texture in both the depths ranged from clay to loamy sand. Saturation water percentage of the surface soils and subsoil ranged from 23.98 to 76.81 and 24.37 to 76.81 %, respectively. Bulk density of the surface soil ranged from 1.01 to 1.62 with an average of 1.31 g cm^{-3}. Soil pH showed alkaline reaction in both the depths. According to ECe and SAR, 21 % of soils were classified as saline and 4.1 % sodic in nature. Soils of both the depths were moderately to strongly calcareous. Twenty-six percent of the surface soils were low and 74 % medium in organic matter.

Introduction

Kohat district occupies the central part of North West Frontier Province (NWFP) and lies between 982420 and 1057680 m north latitude and 3114496 and 3037567 m east longitude [1]. Its reported area is 295054 hectares. Out of the total area, 71213 ha is cultivated with only 15868 ha as irrigated [2]. Similarly, Bannu district is bound between 2965412 and 3020169 m east longitude and 939816 and 983851 m north latitude [3]. The area of Bannu is 118958 ha with 74135 ha as cultivated. Most of the area of Bannu district is Barani while only 13.2 % is irrigated.

Soil physical properties influence the germination and emergence of young seedlings, root penetration and growth into the soil, besides affecting the movement of water within the soil [4]. The composition of soil air and the availability of plant nutrients influence plant growth. Having comprehensive information of these characteristics at hand, inferences about the probable performance of a soil for different uses can be made with considerable confidence. Texture, for example, is related with till ability, compact ability, water holding capacity, permeability and potential plant nutrient retention. Important management decisions and the judgment about practically valued concerns, i.e., timely tillage operations and appropriate adoption, for instance, are based on the knowledge of soil physical properties [5]. Similarly, the chemical properties of soil control the solubility and bioavailability of essential plant nutrients and thus establish a strong relationship between soil constituents and plant productivity. Therefore, understanding the physical and chemical properties of soil as they effect agricultural productivity is extremely important [6].

The available cultivated area is rapidly reducing due to the conversion of agriculture land into non-agriculture usage such as roads, buildings and industries etc. This exerts enormous pressure on the already scarce natural resource base of the province. In view of the increasing population and prospective food crises, it can not be affordable to continue squandering and abusing such precious resource i.e. soil. To face the challenges of trade liberalization of the World Trade Organization (WTO), especially in Agriculture, only best quality and high production will compete in the market. For the best management of soil resources of an area, it is very important to have information about the soils of that area. This piece of research work was carried out

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to determine physico-chemical properties of Kohat and Bannu districts of NWFP to delineate areas into different categories of soils for realizing the agricultural potential of these areas and future planning.

Results and Discussion

Kohat District

Soil Texture

Sand content of the surface soil ranged from 1.20 to 70 % with a mean value of 29.58 %, while it ranged from 1.20 to 80.80 % in the subsoil with a mean value of 29.13 % (Table-1). However, the mean and the coefficient of variation of both the depths were almost similar. Silt content of the surface soil varied from 11.20 to 73.20 % with a mean value of 37.42 %, while subsoil samples ranged from 6.40 to 56.40 % with a mean value of 33.58 % (Table-1). Clay content of the surface soil ranged from 11.60 to 59.60 % with an average value of 33 % while it ranged from 2.8 to 70.80 % with a mean value of 37.30 % in the subsoil (Table-1). Though the coefficient of variation for silt and clay in both the depths was almost the same, it was quite lower than that for sand content. Based on the average as well as the minimum and maximum values, silt content was lower in the subsoil than the surface but vice versa for clay. On comparing with A. H. Ansari *et al.*, reconnaissance soil survey Kohat Area, the same trend was reported. The soil texture in both the depths varied from clay to sandy loam.

Saturation Percentage

Saturation percentage of the surface soil ranged from 25.15 to 71.76 % with a mean value of 45.93 %. In the subsoil, it ranged from 16.60 to 82.64 % with a mean value of 50.10 % (Table-1). Saturation percentage of the subsoil was higher than the surface soil, which may be due to higher clay content in the subsoil.

Bulk Density

Bulk density of the surface soil ranged from 1.10 to 1.75 g cm^{-3} with a mean value of 1.37 g cm^{-3} (Table-2). Variation in bulk density was very high with a coefficient of variation of about 87 %.

Soil pH

Soil pH of the surface soil ranged from 7.08 to 8.36 with a mean value of 7.66, while it ranged from 7.20 to 8.05 in the subsoil with a mean value of 7.57 (Table-2). Variation in pH was greater in surface soil than in the subsoil. Almost all of the soil samples

Table-1:Descriptive statistics of soil physical properties of Kohat district

Property	Mean	Minimum	Maximum	C.V (%)
	(0-15 cm depth)			
Sand (%)	29.58	1.20	70.00	65.11
Silt (%)	37.42	11.20	73.20	35.44
Clay (%)	33.00	11.60	59.60	37.30
Saturation percentage	45.93	25.15	71.76	26.04
Bulk Density (g cm^{-3})	1.37	1.10	1.75	86.83
	(15-45 cm depth)			
Sand (%)	29.13	1.20	80.80	68.03
Silt (%)	33.58	6.40	56.40	36.96
Clay (%)	37.30	2.80	70.80	38.25
Saturation percentage	50.10	16.60	82.64	27.58

Table-2:Descriptive statistics of soil chemical properties of Kohat district

Property	Mean	Minimum	Maximum	C.V. (%)
		(0-15 cm depth)		
pH	7.66	7.08	8.36	23.84
ECe (dS m^{-1})	3.06	1.09	17.76	69.27
SAR	1.56	0.00	6.68	85.42
Lime (%)	13.72	1.75	29.75	48.30
Organic matter (%)	0.75	0.28	1.69	49.99
		(15-45 cm depth)		
pH	7.57	7.20	8.05	18.89
ECe (dS m^{-1})	3.26	1.31	16.75	62.65
SAR	1.79	0.14	5.85	67.04
Lime (%)	15.09	2.50	37.50	50.97
Organic matter (%)	0.68	0.17	1.45	43.76

were alkaline in reaction. N. Rehman *et al.*, [7] reported similar results.

Electrical Conductivity

Electrical conductivity of the surface soil ranged from 1.09 to 17.76 dS m^{-1} with a mean value of 3.06 dS m^{-1} (Table-2). Out of the total samples, 14% were found saline, considering the cutoff value of 4 dS m^{-1}. In the subsoil, it ranged from 1.31 to 16.75 dS m^{-1} with an average of 3.26 dS m^{-1}. Seventeen percent of the soils surveyed were found to be saline in the subsoil.

Sodium Adsorption Ratio (SAR)

Sodium adsorption ratio (SAR) of surface soil ranged from 0 to 6.68 with a mean value of 1.56 and the coefficient of variation being 85.42 % (Table-2). In the subsoil, it ranged from 0.14 to 5.85 with a mean value of 1.79 and C.V. 67.04 %. No sodicity problem was observed in the soil samples of both the depths, as the SAR values were less than 15 H. L. Bohn *et al.*, [8].

Lime Content

Lime content of the surface soil ranged from 1.75 to 29.75 % with an average of 13.72 %, while it ranged from 2.5 to 37.50 % with an average of 15.09 % in subsoil (Table-2). Coefficient of variation of the surface soil was lower than the subsoil. Lime content ranged from slightly calcareous to strongly calcareous in both the depths.

Organic Matter

Organic matter content of the surface soil ranged from 0.28 to 1.69 % with a mean value of 0.75 % (Table-2). Twenty-five percent samples were medium in organic matter, while rest of the samples were low. N. Rehman *et al.*, [9] reported almost similar results. In case of subsoil, organic matter ranged from 0.17 to 1.45 % with an average of 0.68 %. Organic matter was considerably lower in subsoil than in the surface soil.

Bannu District

Soil Texture

Sand content of the surface soils ranged from 8 % to 84 % with a mean value of about 20 % and the highest coefficient of variation (C.V.) of 115 % (Table-4). In the subsoil, the range was the same with a mean of about 19 %. Soil was homogeneous in sand vertically. Silt content in surface soil varied from about 5 to 64 % with an average of about 37 % while it ranged from about 2 % to about 53 % with a mean value of about 36 % in subsoil. Regarding clay content, it ranged from about 10 to about 65 % with a mean value of 43.19 % and 11 to about 65 % with a mean value of 45.62 % in surface and subsoil, respectively (Table 3). Coefficient of variation of silt and clay was almost the same for both depths but much lower than the sand content. It seems from these results that most of the soils were fine textured. Comparing the data with M. Ahmad *et al.*, [1] Reconnaissance Soil Survey Bannu Basin, almost similar trend was reported. Texture varied from clay to loamy sand in surface and clay to sandy loam in sub soils.

Saturation Percentage

Saturation percentage of the surface soil ranged from 23.98 to 76.81 % with a mean value of 55.83 % (Table-3). In case of subsoil, it ranged from 24.37 to 76.81 % with a mean value of 58.06 %. However, it was slightly higher in the subsoil than in the surface soil because of higher clay content.

Bulk Density

Bulk density of the surface soil ranged from 1.01 to 1.62 g cm^{-3} with an average of 1.31 g cm^{-3} (Table 3). The range seems normal.

Soil pH

Soil pH ranged from 7.52 to 8.1 with a mean value of 7.77 in the surface soil showing that the soils have alkaline reaction (Table-4). Similarly in the subsoil, pH ranged from 7.29 to 8.38 with an average of 7.90 showing an alkaline reaction. N. Rehman *et al.*, [9] reported almost similar results.

Electrical Conductivity

Electrical conductivity of the surface soil ranged from 1.43 to 23.37 dS m^{-1} with an average of 3.77 dS m^{-1} (Table-4). Twenty-one percent of the area surveyed was found to be saline. In the subsoil, it ranged from 1.15 to 8.20 dS m^{-1} with an average of 2.37 dS m^{-1} showing salinity in 11 % area.

Sodium Adsorption Ratio (SAR)

Sodium adsorption ratio of surface soils of Bannu ranged from 0.00 to 20.60 with a mean value of 5.49 and C.V. of 85.41 % (Table-4), while in the

Table-3:Descriptive statistics of soil physical properties of Bannu district

Property	Mean	Minimum	Maximum	C.V. (%)
		(0-15 cm depth)		
Sand (%)	19.99	8.00	84.40	115.06
Silt (%)	36.82	5.200	64.40	34.13
Clay (%)	43.19	10.40	64.80	31.40
Saturation percentage	55.83	23.98	76.81	23.59
Bulk Density (g cm^{-3})	1.31	1.01	1.62	98.24
		(15-45 cm depth)		
Sand (%)	18.51	8.00	84.80	122.86
Silt (%)	36.04	2.40	53.20	32.91
Clay (%)	45.62	10.80	64.80	29.66
Saturation percentage	58.06	24.37	76.81	22.40

Table-4: Descriptive statistics of soil chemical properties of Bannu district

Property	Mean	Minimum	Maximum	C.V. (%)
		(0-15 cm depth)		
pH	7.77	7.52	8.10	14.60
ECe (dS m^{-1})	3.77	1.43	23.37	84.62
SAR	5.49	0.00	20.60	85.41
Lime (%)	14.46	5.75	27.00	22.91
Organic matter (%)	1.38	0.35	2.38	36.78
		(15-45 cm depth)		
pH	7.90	7.29	8.38	21.89
ECe (dS m^{-1})	2.37	1.15	8.20	60.41
SAR	2.71	0.56	26.10	107.49
Lime (%)	14.75	3.75	20.25	22.15
Organic matter (%)	0.59	0.04	2.00	102.84

subsoil, it ranged from 0.56 to 26.10 with a mean value of 2.71 and C.V. of 107.49 %. In case of surface soils, 4.1 % soils were sodic in nature considering SAR value of 15 as cutoff point while 1.4 % subsoils were sodic in nature.

Lime Content

Lime content of the surface soil ranged from 5.75 to 27.00 % with a mean value of 14.46 % (Table-4). The soils ranged from moderately to strongly calcareous. In the subsoil, it ranged from 3.75 to 20.25 % with an average of 14.75 %. Soils in the subsoil were also moderately to strongly calcareous.

Organic Matter

Organic matter content ranged from 0.35 % to 2.38 % with an average of 1.38 % (Table-4). Twenty-six % of the soils were low in organic matter and 74 % were medium. In the subsoil, it ranged from 0.04 to 2.00 % with an average of 0.59 %, showing low content in 25 % and medium in 75 % area surveyed.

Experimental

Intensive soil sampling from two districts (Kohat and Bannu) of North West Frontier Province (NWFP) of Pakistan was done on a grid system using Global Positioning System (GPS) during 2004. Soil samples were collected from 86 sites (Fig.1) along Bannu road, Shakardara road, Rawalpindi road, Chorlaki Nizampur road, Hangu road and surroundings of Kohat city in district Kohat. Similarly, in Bannu district, soil samples were collected from 73 various locations at D. I. Khan road, Kohat road, Kurram Garhi road, Haweed road, Miranshah road (Fig. 2), Kakki road and surroundings of Bannu city. Soil samples were collected from two depths i.e. 0-15 cm and 15-45 cm from five cores for composite sample at each location. One core sample was also taken for bulk density. Soil samples were analyzed for texture [10], bulk density [11], pH [12], electrical conductivity [13], organic matter [14] and lime content [15] in laboratory of Soil and Environmental Sciences, NWFP Agricultural University, Peshawar. The data were subjected to classical statistical techniques [16] to obtain summary statistics and soils were categorized into different categories.

Conclusion

Texture of the soil in Kohat district ranged from clay to sandy loam. All the soils of Kohat

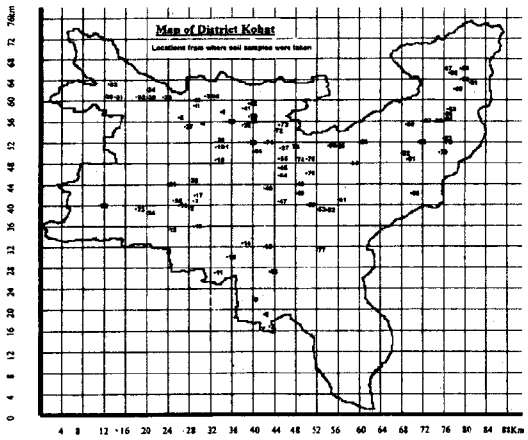

Fig. 1: Soil sampling locations in Kohat district.

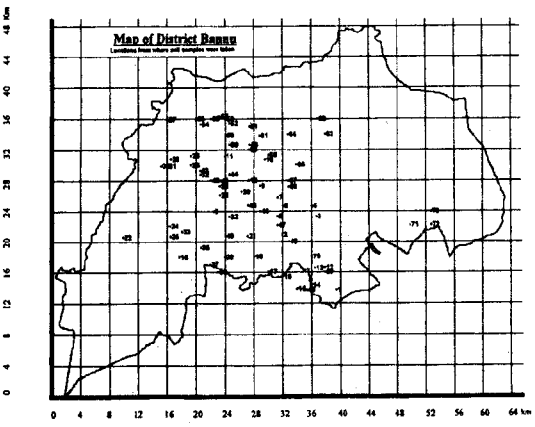

Fig. 2: Soil sampling locations in Bannu district.

district were alkaline in reaction and calcareous of different degree. Salinity problem existed in various areas of Kohat district ranging from 14 to 17 % area in mainly central irrigated parts. No sodicity problem was observed. Organic matter of all the soils was low in eastern and western parts as compared to central parts of the district Kohat. All types of soil textures were present in Bannu district. All the soils were alkaline in reaction and calcareous in nature of different degrees. Surface salinity was found in 21 % of the area surveyed. Surface soils showed 4.1 % sodicity problem, in the central south part of the district. Organic matter content was lower in eastern and western parts as compared to central irrigated soils of Bannu district. Nitrogenous fertilizers should be incorporated in to soil to avoid NH_3 gas losses in calcareous soils. Phosphatic fertilizers should be applied as banding or in strips. Farmyard manure application or green manuring should be practiced to increase organic matter in soils of both the districts and also for management of saline soils. Gypsum should be applied to sodic soils in Bannu district based on gypsum requirement of the soils. Deep tillage should be practiced once in three years in fine textured soils.

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