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Distribution and indexation of plant available nutrients of rainfed calcareous soils of Pakistan

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Abstract

Soil characteristics of Chakwal district were evaluated through physical and chemical analyses. Representative soil samples received/collected from farmers fields were analyzed for texture, electrical conductivity (EC), pH, organic matter (SOM), available phosphorus (P) and potassium (K) contents. Texture of the soils varied from sandy loam to loam. About 97% soils had EC values within the normal range (< 4 dS m^{-1}). The pH values of 64% soils ranged from 7.0 to 8.7 with an average of 7.9 and 6% soils had pH > 8.5. About 86% soils were poor in SOM and P, only 11% samples had satisfactory level of SOM (> 0.86%) and P (>7.0 mg kg^{-1}) contents. The K status of most of soils (68%) was in satisfactory range. The frequency distribution indicated that most of the soils of Chakwal had SOM content in the range of 0.4-0.6%, P in the range of 2.1-4.0 and K in the range of 81-120 $mgkg^{-1}$. The nutrient index values of Chakwal soils in respect of SOM and P were poor, whereas satisfactory for potassium.

Key words: Soil analysis, EC, pH, SOM, P, K, Chakwal, Nutrient index

Introduction

A number of factors and their interaction impede sustainable growth in agriculture. Among these factors depletion of soil fertility through mining of soil nutrients from cropped area is real threat to food security and environmental degradation. Most of the soils in Pakistan have poor status of available plant nutrients and cannot support optimum levels of crop productivity (Rafiq, 1996; Ahmed and Rashid, 2003). Widespread nutritional deficiencies losses occur of relatively fertile soils layers by water erosion, coupled with continuous nutrient mining by crops in Pothwar area of Pakistan (Rashid *et al.*, 1997). The primary objective of soil testing is to help making soil test based fertilizer use recommendations. It helps in applying different nutrients in balanced ratio so as to get maximum efficiency of the applied fertilizers and profitable crop production (Motsara, 2002). Soil test measure some fraction of total supply of nutrients in the soil and indicate its available nutrient level. The higher soil test values mean higher level of nutrients and thus the lower will be the need for fertilization and *vise-versa*. There is a network of Soil and Water Testing Laboratories in the country to provide advisory service to farmers on soil and water management (Ahmed and Rashid, 2003).

Chakwal district is situated at 450 to 1050 m above mean sea level with average annual rainfall of 850 mm. It is continuously divided into mountainous area of famous salt range, the unleveled areas of Pothwar Plateau and fertile belt of Soan river valley. Soils of this area have derived their parent material from underlying rocks like sandstone, limestone and shale. The soils are generally homogenized with week structure and are calcareous. Chakwal District contains a large highly eroded area, either with rocks exposed to surface or lands with big gullies and cuts. Unbroken lands of thick material like gravels, stones and boulders also exist in the area. Dry farm agriculture is the main land use in the area (Soil Survey of Pakistan, 1975). The soils of Chakwal are sandy loam to loam in texture. The pH of soils is in alkaline range of 7.7-7.8. The fertility status is poor having SOM and P in the range of 0.36-0.61 and 5.9 to 7.1 mg kg^{-1}, respectively, whereas K is in the satisfactory (80-180 mg kg^{-1}) range (Latif *et al*, 2008; Mahmood *et al.*, 2008; Rashid *et al*, 2008). The main objective of this study was to compile information on soil fertility and soil salinity/ sodicity status of Chakwal district on the basis of soil samples analyzed during the years 2006-2009.

Materials and Methods

The soil samples were analyzed at Soil & Water Testing Laboratory, Chakwal during the year 2006-09. Samples were air dried, passed through 2mm sieve and analyzed for soil texture, by measuring saturation

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percentage of soils (Malik *et al.,* 1984), electrical conductivity (EC) by preparing 1:10 soil and water suspension (Soil Salinity Lab. Staff, 1954), pH (Schofield and Taylor, 1955), organic matter (Nelson and Sommers, 1982), available P (Olsen and Sommers, 1982) and K (Helmke and Sparks, 1996). The data were subjected to statistical analysis using MS Excel 2007 package. Nutrient Index (NI) was calculated by following formula (Parker, 1951).

$$\text{Nutrient Index (NI)} = ((N_i \times 1) + (N_m \times 2) + (N_h \times 3))/ N_t$$

Where

N_t = Total number of samples analyzed in a given area
N_i = Number of samples falling in low category of given nutrient
N_m = Number of samples falling in medium category of given nutrient
N_h = Number of samples falling in high category of given nutrient

The criteria used to categorize the soil samples for various classes of texture, salinity/ sodicity and nutrients are given in table 1, 2 and 3 (Malik *et al.,* 1984).

Table 1: The criteria used to categorize the soil samples for various classes of texture

Saturation % age	Textural Class
0-20 %	Sand
21-30 %	Sandy Loam
31-45 %	Loam
46-65 %	Clay Loam
66-100 %	Clay

(Malik *et al*, 1984)

Table 2: The criteria used to categorize the soil samples for various classes of salinity/sodicity

Status	E.C (d Sm^{-1})	Soil pH
Normal	< 4.0	< 8.5
Saline	> 4.0	< 8.5
Saline Sodic	> 4.0	>8.5
Sodic	< 4.0	> 8.5

(Malik *et al*, 1984)

Results and Discussion

Soil texture

The saturation percentage ranged from 21 to 47 with a mean value of 27 (Table 4). The 60% soil samples were light and 30% were medium textured (Table 5) whereas, the proportion of heavy soil was only 10%. Rashid (1993) reported that the soils in Chakwal district were predominantly light textured as sandy loam and sandy clay loam were the dominant textured classes. The dissected old loess and alluvial terraces in the area have predominantly silt and silt loam texture, formed from parent material loess, residual material, old river alluvium and sub recent out wash. About 31% soils are sandy to sandy loam in texture and the remaining are highly eroded (Tager and Bhatti, 2001).These medium textured (loam) soils are suitable for cultivation of all common crops while the light soilshas less water holding capacity which needs to be enhanced through addition of farm yard manure to improve physical condition of these soils.

Soil salinity/ sodicity

The EC of the soil samples varied from 0.15 to 4.78 dS m^{-1} with an average value of 0.63 dS m^{-1}. The soil pH values ranged from 7.0 to 8.9 with an average value of 7.9. The data (Table 5) indicated that 64% samples had pH <7.5 while 30% samples had 7.5 to 8.5 and were classified as normal soil while 6% samples having pH value above 8.5 were considered as sodic. Similarly, 97% samples were found free from salinity hazard and 3% samples were either saline or saline sodic. Latif *et al.* (2008) also reported pH of Chakwal soils in alkaline range of 7.7-7.8. When the average values are taken in to consideration, the area looks free from salinity/ sodicity menace.

Soil organic matter contents (SOM)

Nitrogen requirements are usually recommended by the Soil Testing Laboratories, based on the estimation of nitrogen released by the SOM contents (Cooke, 1982). The data revealed that 86% soils of Chakwal district were poor in SOM contents. The SOM contents ranged from 0.18 to 1.20% with mean vale of 0.57% (Table 4). About 86% samples of Chakwal had poor SOM contents while 11% were in satisfactory range. Majority of samples (39%) were in the range of 0.41 to 0.60% whereas only 10% samples had SOM contents more than 1.0% (Table 6; Figure 1). Rashid (1994) reported and SOM contents ranged from 0.2-1.3% in surface soils of Chakwal. The soils of Pakistan are quite low in organic matter. Generally the soils in Punjab contained less then 1% organic carbon (Azam, 1988). The decline in SOM is due to crops grown without or very meager addition of plant and animal manners. When the SOM level declined to 40-60% of their original level, the soil productivity was affected, erosion loses of soil surface increased and net mineralization of soil fell below the level required for sustained grain crop production (Doran and Smith, 1987).

Available phosphorus (P)

The P contents ranged from 1.8 to 17.2 with a mean value of 4.35 mg kg^{-1} and standard deviation of 1.02 (Table

4). The 86% soils were poor, 11% had satisfactory level while only 3% had adequate P. The frequency distribution analysis (Table 7) indicated that majority of soils (45%) in Chakwal district had P in the range of 2.1-4.0 mg kg^{-1}, followed by 21% in 4.1-6.0 mg kg^{-1} range whereas only 2.5% samples had >14 mg kg^{-1}. 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.

Available potassium (K)

The K contents ranged from 43-278 with a mean value of 105 mg kg^{-1}. The classification (Table 5) showed that 68% samples contained satisfactory while 10% had adequate K contents. The frequency distribution data (Table 8) indicated that 48% soils had 81-120 mg K kg^{-1},

Table 3: The criteria used to categorize the soil samples for various classes of essential soil nutrients

Status	Organic Matter	Available Phosphorus	Available Potassium	Nutrient Index value (NI)
	%	mg kg^{-1}		
Poor	<0.86	> 7	> 90	< 1.5
Satisfactory	0.86-1.29	7-14	90-180	1.5 - 2.5
Adequate	>1.29	> 14	>180	> 2.5

(Malik *et al*, 1984; Motsara, 2002)

Table 4: Minimum, maximum and mean values of different soil parameters of Chakwal District

Estimation	Total No. of Samples	Range	Mean	SD
Saturation %age	10314	21- 47	27	2.3
Soil pH	10314	7.0 - 8.9	7.9	0.26
EC	10314	0.15 - 4.78	0.63	0.07
Organic Matter	10314	0.18 - 1.20	0.57	0.24
Available Phosphorus	10314	1.8 -17.2	4.35	1.02
Exchangeable Potassium	230	43 - 278	105	15.8

Table 5: Categorization of soil samples into different classes based on criteria described in Table-1 during 2006-09

Particular		Year				
		2006-07	2007-08	2008-09	Total	%
Soil texture						
1.	Light	1844	2043	2316	6203	60
2.	Medium	795	1236	1024	3055	30
3.	Heavy	187	659	210	1056	10
Salinity/sodicity						
1.	Normal (EC<4.0)	2801	3647	3550	9998	97
2.	Saline (EC>4.0)	25	291	0	316	03
Soil pH						
1.	>7.5	2397	2533	1707	6637	64
2.	7.5-8.5	381	909	1768	3058	30
3.	>8.5	48	496	75	619	06
Organic matter					0	
1.	Poor (< 0.86 %)	2595	3401	2829	8825	86
2.	Satisfactory (0.86-1.29 %)	172	456	525	1153	01
3.	Adequate (>1.29 %)	61	81	196	338	03
Available phosphorus						
1.	Poor (< 7.0 mg kg^{-1})	2593	3402	2827	8822	86
2.	Satisfactory (7.0 -14.0 mg kg^{-1})	169	461	542	1172	11
3	Adequate (> 14 mg kg^{-1})	64	76	181	321	03
Available potassium						
1.	Poor (< 80 mg kg^{-1})	0	0	51	52	22
2.	Satisfactory (80 -180 mg kg^{-1})	0	0	156	156	68
3	Adequate (> 180 mg kg^{-1})	0	0	23	23	10

Table 6: Frequency distribution of soil organic matter contents of Chakwal District for three years

Organic Matter Range (%)	2006-07	2007-08	2008-09	Total	%age
0.0 – 0.20	204	615	216	1035	10
0.21 – 0.40	670	680	410	1760	17
0.41 – 0.60	1210	1640	1129	3979	39
0.61 – 0.80	326	395	1050	1771	17
0.81 – 1.00	210	71	360	641	06
1.01– 1.20	76	350	110	536	05
1.21 – 1.40	70	81	196	347	03
> 1.40	60	106	79	245	02

Table 7: Frequency distribution of soil available phosphorus contents of Chakwal District for three years

Available P Range (mg $kg^{-1)}$	2006-07	2007-08	2008-09	Total	%age
0-2.0	256	790	50	1096	11
2.1-4.0	1733	2230	700	4663	45
4.0-6.0	505	297	1400	2202	21
6.1-8.0	156	300	610	1066	10
8.1-10.0	148	110	275	533	5
10.1-12.0	10	82	252	344	3
12.1-14.0	0	10	122	132	1
>14.0	18	119	141	278	3

Table 8: Frequency distribution of available potassium contents of Chakwal District for three years

Available K Range (mg kg^{-1})	2006-07	2007-08	2008-09	Total	% age
0-40	0	0	5	5	2
41-80	0	0	45	45	20
81-120	0	0	109	109	48
121-160	0	0	40	40	18
161-220	0	0	12	12	5
221-260	0	0	11	11	5
260-300	0	0	2	2	1
>300	0	0	1	1	0

Table 9: Soil Fertility Index of soils in Chakwal district

Available Nutrient	% soil samples			Nutrient Index (NI)
	Poor	Satisfactory	Adequate	
Organic Matter / nitrogen	86	11	3	1.18
Available Phosphorus	86	11	3	1.17
Exchangeable Potassium	22	68	10	1.87

while 22% soils had K in poor range (< 80 mg kg^{-1}). The K content had invariably been reported as adequate in Punjab soils except eroded or light textured soils (Bajwa, 1990). Rashid *et al*. (2008) reported K in the satisfactory range (80-180 mg kg^{-1}) in Chakwal soils. However, Rashid (1994) reported low K contents in 30% surface soils of groundnut growing areas of Chakwal.

Soil nutrient index (NI)

Soil fertility level was measured in terms of NI values. The NI values (Table 9) in present study indicated that SOM and P levels were low and K level (1.87) was found in medium range. Nutrient index value of <1.5 is taken as low, values between 1.5 -2.5 indicates medium and >2.5 as higher fertility status of the given area (Motsara, 2002).

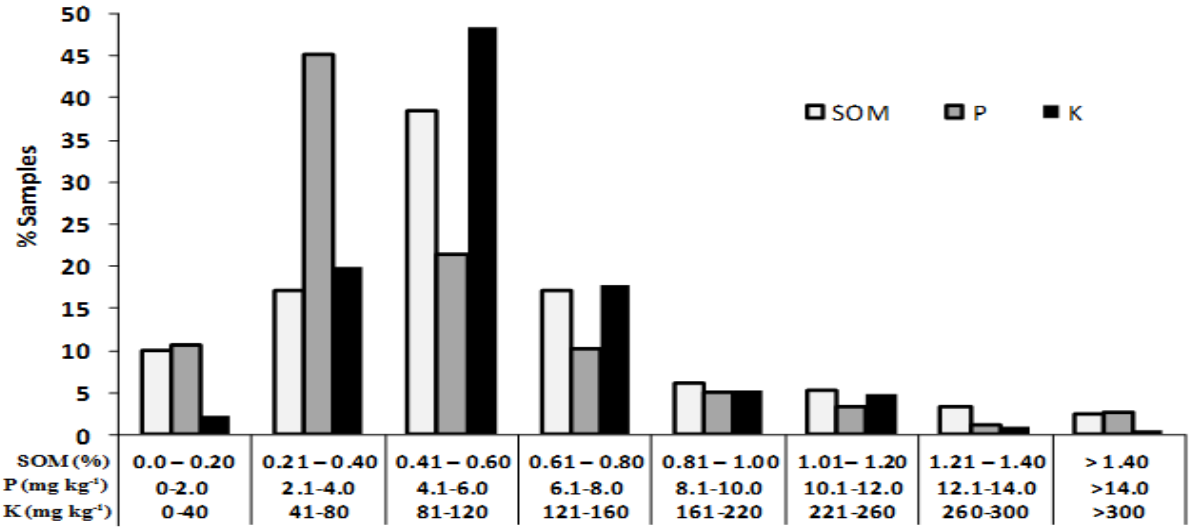

Figure1: Frequency distribution of soils for SOM, P and K in Chakwal district

References

Ahmed, N. and M. Rashid. 2003. Fertilizer Use in Pakistan. NFDC. Planning and Development division, Islamabad. 141p.

Azam, F. 1988. Studies on organic matter fractions of some agricultural soils of Pakistan. *Sarhad Journal of Agricultural Research* 4(3):355-365

Bajwa, M.1. 1990. Soil fertility management for sustainable agriculture. p. 7-23. *In:* Proceeding 3rd National Congress of Soil Science, March 20-22, 1990, Lahore.

Cooke , G.W.1982. An introduction to soil analysis. *World Crops* 1: 8-9.

Doran, J.W. and M.S. Smith. 1987. Organic matter management and utilization of soil and fertilizer nutrients. p. 53-71. *In:* Soil Fertility and Organic Matter as Critical Components of Production System. J.J. Mortvedt and D.R. Buxton (eds). Soil Science Society of America, WI, USA.

Helmke, P.A. and D.L. Sparks. 1996. Lithium, sodium and potassium. p. 551-575. *In:* Methods of Soil Analysis. part 2. Chemical and Microbial Properties. A.L. Page, O.A. Helmake, P.N. Sultanpure, M.A. Tabatabai and M.E. Summer (eds.).Soil Science Society of America, WI.USA.

Latif, R., S. Ali and R. Hayat. 2008. Nitrogen fixation and yield of peanut affected by inorganic fertilizers, variety and inoculums interaction in rainfed areas of Punjab. *Soil and Environment* 27(1): 77-83.

Mahmood, S., M.A. Qazi and I. Ali. 2010. Annual Report 2008-09. Soil & Water Advisory Service in Punjab. Soil Fertility Research Institute, Department of Agriculture, Lahore.

Malik, D.M., B. Ahmed and M. Ahmed. 1984. Survey of soil fertility status and quality of ground waters. Punjab Digest 1981-84. Department of Agriculture, Punjab, Lahore.

Malik, D.M., M.A. Khan and T.A. Choudhry. 1984. Analysis Manual for Soil, Water and Plants. Directorate of Soil Fertility and Soil Testing, Lahore.

Motsara, M.R. 2002. Available nitrogen, phosphorus and potassium status of Indian soils as depicted by soil fertility maps. *Fertilizer News* 47(8):15-21.

Nelson, S.W. and I.E. Sommers. 1982. Total carbon, organic carbon and organic matter. P. 539-80. *In:* Methods of Soil Analysis. Chemical and Microbial Properties. Agron. No. 9. Part 2, 2nd Ed. A.L. Page (ed.). American Society of Agronomy, Madison, Wisconsin, USA.

Olsen, S.O. and I.E. Sommers. 1982. Phosphorus. p. 403-430. *In:* Methods of Soil Analysis. A.L.Page (ed.). Chemical and Microbial Properties. Part 2, 2nd Ed. American Society of Agronomy, Madison, Wisconsin, USA.

Parker, F.W., W.L. Nelson, E. Winters and I.E. Miles. 1951. The broad interpretation and application of soil test Information. *Agronomy Journal* 43:105-112.

Rafiq, M. 1996. Soil resources of Pakistan. p. 439-469. *In:* Soil Science. E. Bashir and R. Bantel (eds.). National Book Foundation. Islamabad, Pakistan.

Rashid, A. 1993. Nutrient disorders of rapeseed-mutard and wheat grown in Potohar area. Micronutrient Project. Annual Report 1991-92. NARC, Islamabad.

Rashid, A. 1994. Nutrient Indexing Surveys and Micronutrient Requirement of Crops. NARC, Islamabad.

Rashid, A., E. Rafique and N. Bughio. 1997. Micronutrient deficiencies in rainfed calcareous soils of Pakistan. I. Iron chloresis in peanut. *Communication in Soil Science and Plant Analysis* 28: 135-148.

Rashid, M., M.N. Iqbal, M. Akram, M. Ansar and R. Hussain. 2008. Role of gypsum in wheat production in rainfed areas. *Soil and Environment* 27(2): 166-177.

Schofield, R.K. and A.W. Taylor. 1955. The measurement of soil pH. *Soil Science Society of America Proceeding* 19: 164-167.

Soil Survey of Pakistan. 1975. Reconnaissance Soil Survey of Salt Range. Directorate of Soil Survey (Reconnaissance), Lahore.

Soil Salinity Lab. Staff. 1954. Diagnosis and Improvement of Saline and Alkali Soils. *USDA Hand book 60*, Washington, D.C., USA.

Tager, S. and A. Bhatti. 2001. Physical properties of soil. p. 113-144. *In*: Soil Science. E. Bashir and R. Bantel (eds.). National Book Foundation, Islamabad, Pakistan.