Pak. j. sci. ind. res. Ser. A: phys. sci. 2021 **64A**(1) 46-51

Soil Characteristics and Fertility Indexation in Gujar Khan Area of Rawalpindi

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(received April 2, 2018; revised November 21, 2019; accepted December 9, 2019)

Abstract. Soil characteristics of Gujar Khan area of Rawalpindi district were evaluated through physical and chemical analysis. About 3002 soil samples were received/collected from farmers' fields of Gujar Khan during the period between 2012 and 2017 and analysed for texture, electrical conductivity (ECe), pH, organic matter (OM), available phosphorus (AP) and available potash (AK). The analysis results revealed that texture of the soils varied from sandy loam (33.5%) to loam (61.6%). The 98.6% soils had ECe values within the normal range (< 4 dS/m) and almost 74% soil had from 7.5 to 8.5 pH values with an average of 7.76. Thus there was no salinity/alkanity hazard in the area. Generally most of the soils were poor from the fertility point of view. About 96% soils were poor in both OM and AP contents, whereas, 3.0% soils have OM (>0.86%) and 3.4% satisfactory levels and AP (>7.0-14 mg/Kg). However, 62% soils has satisfactory to adequate AK status. The frequency distribution analysis indicated that 45% soils of Gujar Khan and OM content in the range of 0.4-0.6%, 57% and soil have AP in the range of 4.0-6.0 mg/Kg, while 50% and AK in the range of 81-120 mg/Kg. The soil fertility indexes in respect of OM and AP were low (1.0), whereas AK (1.7) indicating a medium fertility status of Gujar Khan soils.

Keywords: soil characteristics, Pothwar, NPK, Gujar Khan, fertility index

Introduction

In the North Eastern part of the Punjab province of Pakistan (latitude 32° 10' to 34º 9' N and longitude 71° 10' to 71° 55' E), the Pothwar plateau comprises of the district of Attock, Jhelum, Chakwal and Rawalpindi. It covers an area of 1.82 million ha, and topography ranges from flat to gently undulating, locally broken by gullies and low hill ranges. In general, the Pothwar soils are alkaline, calcareous, low in organic matter and deficient in plant nutrients like N and P (Khan and Joergensen, 2006; Nizami *et al*., 2004). Although it constitutes an important area for rainfed agriculture in the country, however crop yields are low as compared to irrigated regions of Pakistan. Main cause of low production are, highly erratic rainfall, water erosion and widespread deficiency of plant nutrients. Due to the loss of fine soil particles along with essential plant nutrients through runoff and inadequate fertilization, the soils of Pothwar suffer with multiple nutrient deficiencies (Rashid *et al*., 1997). In general, the Pothwar soils are alkaline, calcareous, low in organic matter and deficient in plant nutrients like nitrogen and phosphorus.

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Soil analysis is useful instrument for assessing the amount of nutrients availability. It is a rapid and less expensive method for evaluation of fertility status of soil and for recommendation of optimum fertilizer rates for economic crop production. There is a network of soil and water testing laboratories established throughout the country under the provincial setup. These laboratories are designed to meet the routine needs of farmers *i.e.* water analysis, soil analysis for texture, salinity/sodicity, and fertility status (Ahmed and Rashid, 2003).

The Gujar Khan area fall in Rawalpindi district lies between latitude 33° 10' to 33° 15' N and longitude 73° 15' to 73° -20' E. Soils of this area derived their parent material of underlying rocks like sandstone, limestone and shale, have medium (loam) to light (sandy loam) texture, poor fertility status in terms of organic matter and available phosphorus (Shaheen, 2016; Mahmood *et al*., 2010). However, majority of soils of Gujar Khan are generally well supplied with potassium (Khalid *et al*., 2002). Objective of this study is to evaluate soil fertility status of Gujar Khan area on the basis of soils samples collected from different areas during the years 2012-17.

Material and Methods

During the year 2012-17 approximately 3002 soil samples were either collected or obtained from farmers at the soil and water Testing Laboratory, Rawalpindi, Pakistan. Samples were dried, sieved and analysed for physico-chemical characteristics *i.e*., texture, EC_e, pH, soil organic matter, available P and available K by methods described by Page (1982). Soil texture was determined by measuring saturation percentage and Electrical Conductivity (ECe) by preparing soil and water (1:10) suspension (Malik *et al*., 1984a). The data was analysed using the MS Excel package for statistical analysis, shown in Table 1. Soil nutrient Index (SNI) was also 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 following criteria has been used for the categorisation of soil samples Malik *et al*. (1984a)

Results and Discussion

Soil texture. Soil texture is basic with many other properties and used as an indicator of water and nutrient holding capacity of soil. It is also a major factor in defining the proper soil management practices to be followed. Generally the soils of Gujar Khan area are light to medium textured. The analysis data showed that 33.5% soils was light and 61.6 % was medium textured (Table 2), whereas the proportion of heavy soil was just 4.9%. Khalid *et al*. (2002) reported 65% of soils as medium textured loam in Gujar Khan area. The soils of Gujar khan area derived from loess and sandstone parent material, moderately to severely eroded, have medium to light texture (Nizami *et al*., 2004). These light textured soils with less water holding capacity needs to be enhance through addition of organic manures. The medium textured (loam) soils, however, these are suitable for cultivation of all common crops. Ho *et al*. (2019) found siliceous sandy nature Spodosols soils in Sabal area of Malaysia, poor in nutrient retention capacity due to sandstone parent material and low clay contents.

Soil salinity/sodicity. In Gujar Khan region, the electrical conductivity (ECe) of most of the soil (98.6%) was within normal range (<4.0 dS/m) only 1.4% had salinity/sodicity with values > 4.0 dS/m. The soil pH ranged from 7.0 to 8.6 with in average value of 7.76 (Table 3). The data showed that 26 % soils has pH >7.5, while, 74% has 7.5-8.5 (Table 3). The soils have pH < 8.5 are considered as normal, while those having pH value > 8.5 as sodic. However, these were very rare (0.1%) in the study area (Table 2-3). Similar results were also reported by Shaheen (2016) and Fateh *et al*., (2006) for Gujar Khan area.

Table 1. Soil statistical analysis

(a)	**Soil texture**		
	SP (%)	Texture	
	19	Sandy	
	20-30	Sandy loam	
	31-45	Loam	
	46-60	Clay loam	
	> 60	Clay	
(b)	**Soil salinity/sodicity**		
	EC (dS/m)	Soil pH	Remarks
	<4.0	7.0 – 8.1	Normal
	>4.0	7.0– 8.5	Saline soil
	>4.0	> 8.5	Saline-Sodic soil
	< 4.0	> 8.5	Sodic soil
(c)	**Essential soil nutrients**		
	Organic matter (%)		Remarks
	< 0.86		Poor
	0.86 – 1.29		Satisfactory
	> 1.29		Adequate
	Phosphorus (mg/Kg)		Rating
	< 7.0		Poor
	7.1 – 14.0		Medium
	14.0 – 21.0		High
	> 21.0		Very high
	Potassium (mg/Kg)		Rating
	< 80		Poor
	80-180		Satisfactory
	> 180		Rich

a = soil texure; b = salinity/sodicity; c = essential soil nutrients.

Table 2. Soil characteristics of Gujar Khan

Parameter	Range	Mean	SD
Soil pH	7.0 – 8.6	7.76	0.26
EC	0.15 – 6.02	0.79	0.07
Organic matter	0.23- 1.29	0.53	0.25
Available phosphorus	2.3 -17.2	3.89	0.58
Available potash	40 - 320	103	12.01

Soil fertility status. The fertility status of the Gujar Khan soils was determined through estimation of organic matter for nitrogen, available phosphorus and potash. The results based up on analytical data are given as under.

Organic matter. Soil nitrogen requirement usually recommended on the basis of nitrogen released by the organic matter (OM) contents by soil testing laboratories (Cooke, 1982). There is a significant positive correlation between N and OM indicating that N nutrition of crops largely depends on the maintenance of organic matter levels in soil (Tsozue *et al*., 2016). The present data revealed that the OM ranges from 0.23-1.29% in the area with mean value of 0.53 (Tables 2). Majority (97%) of soils of Gujar Khan area had poor (< 0.86%) while, rest had satisfactory to adequate OM contents (Table 3). The frequency distribution data indicated that 45% fall in the range of 0.41 to 0.60% followed by 33% in 0.21-0.40% whereas, only 1.2% had OM contents more than 1% (Table 4). However, Shaheen (2016) reported OM in the range of 0.89 to 1.25% in eroded soils of Gujar Khan area. Khalid *et al*. (2012) reported OM content in the range of 0.4-0.6 %, in soils of Chakwal.

Organic matter makes its greatest contribution to soil productivity not only by providing nutrients but also improving its water holding capacity and physical properties (Sarwari *et al*., 2008). The soils of Pakistan are quite low in organic matter. Atreya *et al*. (2005) associated much of the soil OM loss from farm fields with the eroded sediments. Thus, higher the soil loss higher will be the soil OM losses. Erosion reduces organic matter and ultimately soil fertility. Soil fertility declination due to soil erosion and nutrients losses through runoff is a serious problem of hilly areas

Table 3. Analysis of Gujar Khan soil samples during the years 2012-17

Particulars	Year						
	2012-13	2013-14	2014-15	2015-16	2016-17	Total	(%)
a. Soil texture							
1. Light	2	733	288	281	203	1507	33.5
2. Medium	40	687	622	941	486	2776	61.6
3. Heavy	2	39	34	26	120	221	4.9
b. Salinity/sodicity							
1. Normal (ECe <4.0)	43	1439	941	1220	799	4442	98.6
2. Saline (ECe >4.0)	1	20	3	28	10	62	1.4
c. Soil pH							
1. >7.5	30	733	142	182	80	1167	25.9
2. 7.5-8.5	14	729	802	1066	720	3331	73.9
3. >8.5		6				6	0.1
d. Oraganic matter							
1. Poor (<0.86%)	41	1371	935	1213	797	4357	96.7
2. Satisfactory (0.86-1.29%)	2	80	9	35	8	134	3.0
3. Adequate (>1.29%)	1	7	0		5	13	0.3
e. Available phosphorous							
1. Poor (<7.0 mg/Kg)	37	1404	921	1196	767	4325	96.0
2. Satisfactory (7.0-14.0 mg/Kg)	6	51	18	46	30	151	3.4
3. Adequate (>14 mg/Kg)	1	3	5	6	13	28	0.6
f. Available potash							
1. Poor (<80 mg/Kg)	3	566	235	333	288	1425	31.6
2. Satisfactory (80-180 mg/Kg)	39	805	633	836	481	2794	62.0
3. Adequate (>180 mg/Kg)	2	87	76	79	41	285	6.3

(Tripathi *et al*., 2000). The presence of vast eroded lands might be one of the main reasons of low organic matter contents in soils.

***Available phosphorus*.** The data revealed that 96% soils of Gujar Khan were poor in available phosphorus (AP). About 3.4% soils was satisfactory and only 0.6% was adequated (> 14 mg/Kg) AP contents (Table 3). The frequency distribution analysis indicated that majority of soils (57%) in Gujar Khan area has AP in the range of 4.0-6.0 mg/Kg (Table 5), followed by 34% in 2.1-4.0 mg/Kg, whereas only 0.6% samples has >14 mg/Kg AP contents. Shaheen (2016) reported phosphorus deficiency (< 7 mg/Kg) in 95% soils of Gujar Khan. Similar results were reported by Khalid *et al*. (2012) for Chakwal soil of Pothwar areas. Malik *et al*. (1984b) and Rashid (1994) reported a wide spread phosphorus deficiency in Punjab and reported 75-95% soils are lacking this major nutrient. Kumar *et al*. (2017) described medium to low available P contents in Rajistan, India soils and low mobility of this nutrient in soil.

In soils with pH 7-8, the soluble H_2PO_4 quickly reacts with calcium to form products of having less solubility. The pH also affects the applied P fertilizer by changing it into extremely insoluble calcium phosphate form. This problem is common in calcareous soils (Ali *et al*., 2000). The poor AP status of Gujar Khan soils might be attributed to this phenomenon.

***Available potash*.** The satisfactory level of available potassium (AK) contents was observed in the study area ranging from 40-320 mg/Kg with mean value of 103 mg/Kg (Tables 2). As many as 62% soils contained satisfactory, 6.3% which has adequate and 31.6% of poor (<80 mg/Kg) AK contents. The frequency distribution data (Table 6) indicated that 50% soil was AK ranged from 81-120 followed by 30% in 40-80 mg/Kg ranged. Soils of Pakistan are generally considered rich in mica minerals, the rich source of natural potassium (Khattak and Hussain, 2007; Bajwa and Rehman, 1996). Similarly the high to medium range of available K in Rajistan soils of India was attributed by Kumar *et al*. (2017) to the presence of potash bearing minerals (Muscovites, biotits and feldspar) which on weathering slowly release potash. Available potash was invariably reported as adequate in Punjab soils except eroded or light texture soils (Khalid *et al*., 2002; Bajwa, 1990).

Table 4. Frequency distribution of Gujar Khan area soil samples for organic matter

Organic matter range (%)	2012-13	2013-14	2014-15	2015-16	2016-17	Total	(%)
0.0 – 0.20	0	195	89	13	76	373	8.3
0.21 – 0.40	32	456	214	369	432	1503	33.4
0.41 – 0.60	8	670	625	530	213	2046	45.4
0.61 – 0.80	0	50	7	301	76	434	9.6
0.81 – 1.00	3	59	6	18	8	94	2.1
1.01 – 1.20	0	21	3	17	2	43	1.0
1.21 – 1.40	1	7		0	3	11	0.2
> 1.40	0	0	0	0.	0	0	0.0

Table 5. Frequency distribution of Gujar Khan area soil samples for Av. phosphorus

Available P range (mg/Kg)	2012-13	2013-14	2014-15	2015-16	2016-17	Total	(%)
0-2.0	0	0	0	9	11	20	0.4
2.1-4.0	30	1021	132	192	165	1540	34.2
4.0-6.0	7	386	663	965	553	2574	57.1
6.1-8.0	0	32	127	30	38	227	5.0
8.1-10.0	2	12	2	14	5	35	0.8
10.1-12.0	4	4	12	32	23	75	1.7
12.1-14.0	0	0	2	0	3	5	0.1
>14.0	1	3	5	6	12	27	0.6

Table 6. Frequency distribution of Gujar Khan area soil samples for Av. potash

Available K range (mg/Kg)	2012-13	2013-14	2014-15	2015-16	2016-17	Total	(%)
0-40	0	34	0	21	13	68	1.5
41-80	3	532	235	312	265	1347	29.9
81-120	29	623	526	705	389	2272	50.4
121-160	10	182	106	131	102	531	11.8
161-220	2	65	59	63	34	223	5.0
221-260	0	22	14	11	7	54	1.2
260-300	0	0	3	5		8	0.2
>300	0	0	0	0	0	0	0.0

Table 7. Soil fertility index of soils in Gujar Khan area

Available nutrients	Poor	Satisfactory	Adequate	Soil nutrient index (SNI)
	(%)			
Organic matter/ nitrogen	96.7	3.0	0.3	1.04
Available phosphorus	96.0	3.4	0.6	1.04
Available potassium	31.6	62.0	6.3	1.74

However, Rashid (1994) reported 30% of surface soils in groundnut growing areas of Gujar Khan contained low AK-22-158 mg/Kg.

Soil fertility index (SFI). Soil fertility index at nutrient index value of >2.5 is taken as higher, while values between 1.5-2.5 indicates medium and < 1.5 as low fertility status of the given area (Motsara, 2002). The fertility index values of Gujar Khan soils (Table 7) in respect of OM & AP are low (1.04), whereas of AK (1.74) indicating a medium fertility status. Similar results are reported by Kausar *et al*., (2016) for Sargodah soils and Khalid *et al*. (2012) for Chakwal area of Pothwar. While, medium nutrient index values for organic carbon (2.3), available phosphorus (2.2) and high for potassium (3.0) are observed by Singh *et al*. (2018) in the soils of Varanasi district, UP, India.

Conflict of Interest. The authors declare no conflict of interest.

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