African Journal of Agricultural Research Vol. 6(16), pp. 3713-3717, 18 August, 2011
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR10.814
ISSN 1991-637X ©2011 Academic Journals

Full Length Research Paper

Evaluation of soil quality on the basis of chemical and microbial health for potential use in agriculture

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Accepted 20 June, 2011

The present study is a comparison of chemical and microbial status of wheat cultivated and non-cultivated soil from different localities. Soil samples were collected randomly and tested for soluble salts, pH, electrical conductivity, sodium adsorption ratio and microbial population. Soil samples pH, mostly lied in range between 7.29-7.94 [H^+]. The electrical conductivity (EC) of all soil samples except selected wheat agriculture land, lies within the standard range, that is, <4 ds/l which shows that soluble salts are present in the soils. The specific absorption rate (SAR) value varies greatly in wheat agricultural land due to more adsorption of sodium by roots in rhizosphere. Agricultural land soil samples showed high level of salinity and toxicity as compare to other test samples. Cocci and rod shape bacteria were present in the all soil samples. It has been also found that all the soil samples sites have less pathogenic microbes and have less accumulated salts and toxin and can be used efficiently for other crops cultivation. Uncultivated land was suitable for wheat cultivation but wheat cultivated lands was diverging towards salinity which is quite alarming. Agricultural lands need some amendments for salinity.

Key words: Soil bacteria, electrical conductivity, specific absorption rate, soil mycoflora, soil pH, wheat field soil.

INTRODUCTION

Soil quality may be defined as the ‘‘capacity of the soil to function within ecosystem and land-use boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health’’ (Doran et al., 1996). Biochemical properties are indicators of soil quality reflecting its reaction with plant population for productivity. By and large, biochemical properties are associated to the biocycles of the diagnostic elements. These properties consist of growth and multiplication of soil microbes and nutrient absorbance by affecting activity of hydrolytic enzymes (Gil-Sotres et al., 2005). In Pakistan, wheat is grown in different cropping systems, such as, cotton-wheat, rice-wheat, sugarcane-wheat, maize-wheat, and fallow-wheat. Of these, cotton-wheat and rice-wheat systems together account about 60% of the total wheat area whereas rain-fed wheat covers more than 1.50 m ha area. The yield in irrigated area ranges from 2.5 to 2.8 tones per hectare depending upon soil quality and input application.

Soil chemistry is a parameter for predicting the fate, mobility and potential toxicity of contaminants in the soil habitat. Crops differ in their yield potential and in the amounts of nutrients that they remove from the soil. Therefore, the rate of nutrients applied must be adjusted to the nutrient demand of the crop. Soil microbial communities are also integrally involved in biogeochemical cycles and their activities are crucial to the productivity of terrestrial ecosystems. Microbial analysis can help in predicting what types of microbes are present in the soil for application of pesticides and fertilizers. Soil status enables us to better predict the fate and toxicity of contaminants and provide the knowledge to develop scientifically correct and cost-effective remediation strategies.

To date, only limited information exists on microbial diversity for soils under various types of land use. The present study is designed to investigate opportunity of cultivating wheat in various soil types by comparing the

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Abbreviations: SAR, Specific absorption rate; **EC,** electrical conductivity; **EDTA,** ethylenediaminetetraacetic acid; **ESP,** exchangeable sodium percentage.

Table 1. Soil sampling and texture.

S/N	Sample	Soil color	Sample texture	Land use system	Remarks
1	Botanical garden	Whitish brown	Silty loam	Natural vegetation	Saline soil patches not reported for any disease
2	Un-cultivated land	Light brown	Sandy clay loam	Wheat –fallow-vegetable/fodder	Not reported for any disease
3	Agricultural land (P.U)	Light brown	Sandy clay loam	Wheat- fodder Wheat	Not reported for any disease
4	Agricultural land (Kasur)	Light brown	Sandy loam	Wheat- rice-Wheat	Not reported for any disease
5	Fallow land	Light brown	Sandy loam	Wheat –fallow-vegetable/fodder	Not reported for any disease
6	Housing scheme	Slightly dark brown	Sandy clay loam	High fertile land previously following Wheat-fodder/vegetable - wheat system now kitchen gardening at vacant plots	Damp soil, not reported for any disease
7	Un lined Water course	Dark brown	Clay loam	Irrigation depths sanctioned water course which irrigates land with canal water	Not reported for any disease but used for irrigation to pu field

biochemical status and evaluating nutrient availability, microbial status as well as suitability for agricultural practice.

MATERIALS AND METHODS

Samples collection

Seven soil samples were used in the current standard for the analysis of soil and were collected randomly from different localities. A visible or suspected salt crust on the soil surface was sampled separately. In case of distinct stratification, samples were taken by horizons or layers. In the absence of profile development or distinct stratification, the surface sample was taken to a depth of 6 or 7"(Table 1).

Land preparation scheme

Plowing depth: 15-20 cm; seed sowing depth: 5-7 cm; irrigation interval: germination to seedling stage: 10 days. Seedling to vegetative: 25 days and reproductive stage as required maturity irrigation stopped.

Preparation of soil paste and extract

Soil sample of 200 gm was mixed with distilled water to make homogenized soil paste and rested the paste for 24 h. For soil extract, a blotter paper was placed in the plate of the soil paste extractor. Soil paste was placed on the blotter paper under the extractor plate and the machine was started. Soil extract was used for electrical conductivity, soluble ions detection (that is, Ca^{+2}, Mg^{+2}, K^{+}, CO_3^{-2}, HCO_3, and Cl^{-}) and pH value.

Electric conductivity of soil sample

Soil extract was placed in a 50 mL bottle, the conductivity cell was immersed in the solution and the conductivity value of each soil sample was calculated.

Detection of ions

Soluble ions, that is, CO_3^{-2} and HCO_3^{-1} were evaluated by neutralization method. Soil extract (2 mL) was titrated against H_2SO_4 (N/100). For chloride ion, 2 mL extract was titrated against N/100 H_2SO_4, potassium chromate was added to the solution and titrated against N/100 $AgNO_3$. Calcium and magnesium ions were detected by adding 1-3 drops of NaOH in the solution along with a small amount of NH_3 appropriate for 2 mL of soil extract. Mixture was titrated against ethylenediaminetetraacetic acid (EDTA). Green, blackish, bluish, green, green coloration appeared as end point. To test for magnesium ion only, 3 drops of buffer solution with 3-4 drops ereocrome black was added to 2 mL soil extract; this gave a crimson coloration. Mixture was titrated against N/100 EDTA. Purple coloration appeared as end point. Sulfate was calculated by subtracting the value of (Co_3^{-2}+ HCO_3^{-1}+Cl^{-1}) from total ions.

$$SO_4^{-2} = T.C- (CO_3^{-2}+ HCO_3^{-1}+Cl^{-1})$$

$$SAR = Na^{+} \Big/ \sqrt{(Ca+Mg)^{++}/2}$$

Sodium concentration was calculated by flame photometer according to the instructions provided for the equipment. A series of suitable sodium standards were run and a calibration curve was drawn. Sodium ion (Na^+) in the soil extracts was measured by taking the emission readings on the flame photometer (Akhtar et al., 2004) at 589 nm, wavelength. Na^+ concentration was calculated by inferring to the calibration curve.

For potassium analysis, 5 g air-dried soil was weighed into a 50 mL centrifuge tube, 33 mL ammonium acetate solution was added and shaked for 5 min on a shaker. Mixture was centrifuged until the supernatant liquid was clear. Extract was filtered and collected in a 100 mL volumetric flask. This process was repeated two more times and the extract collected each time. Extract was diluted to 100 mL with 1 N ammonium acetate solution. A series of suitable potassium standards were run to draw a calibration curve. Potassium (K) concentration in the soil extracts was measured by taking the emission readings on the flame photometer at 767 nm wavelength.

Soil texture

50 g of soil was sieved; organic matter (a cementing agent) was removed by oxidizing the sample with hot H_2O_2 (50 mL of distilled water with 5 mL of 30% H_2O_2). Treated soil sample was filled in a one liter Bouyoucos cylinder and filled with distilled water to the 1000 mL mark, with the hydrometer in the suspension. Percentage of sand, clay and silt was calculated as follows:

1. Percentage of clay in the sample was calculated by dividing the number of grams of clay by the total weight of the sample;
2. Percentage of silt in the sample was calculated by subtracting the sum of the percentage of sand and clay from 100;
3. The class number or texture of the soil was determined by using the textural triangle.

Soil pH

For each sample, 50 g air-dried soil was put into a 100 mL glass beaker. 50 mL deionized water was added, mixed well with a glass rod, and allowed to stand for 1 h. Sample pH was determined by combined electrode. Electrode was put in the soil extract suspension (about 3 cm deep) and reading was noted after 30 s.

Isolation of bacteria and fungi

Bacteria and fungi were isolated by serial dilution method by suspending 10 g of air dried soil in 95 mL of sterilized saline solution to prepare 1/10 dilution of soil. 1 mL of the suspension was transferred to 9 mL saline blank and the procedure continued until a 10-fold dilution series ranging from 1/10 ,1/100, 1/1000, 1/10000 and 1/100,000 was gotten. 5 mL of each dilution was transferred into separate sterile, labeled test tubes. In case of bacterial isolation, dilution test tubes were placed in a hot water bath (80°C) for 20 min to kill the non-spore formers. For isolation of bacteria, 0.10 mL aliquot was spread to nutrient medium plates by sterilized spreader as evenly as possible. Bacterial colonies were counted after 2 days. For fungal isolation, 0.10 mL aliquot was spread onto potato dextrose agar (PDA) medium plates. Fungal colonies were counted after 5-6 days. Identification of bacterial and fungal isolates was done on the basis of their morphological characters.

Reference crop

In the present study, wheat is used as reference crop for considering land use potential in agriculture.

RESULTS AND DISCUSSION

The soil samples were analyzed under various parameters, that is, pH, EC, total cations and anions, SAR, and microbial status. Soil samples pH, mostly lied in range between 7.29-7.94 [H^+] neutral soils, that is, soils are non-acidic, non-basic but slightly alkaline because of more Mg and Ca ions available (Table 3). Nutrients in soil are strongly affected by soil pH due to reactions with soil particles and other nutrients, so in fact the availability of many nutrients have been determined as a function of soil pH (Wright et al., 2009). The soil quality indicators at farm level for good productivity soils should have a pH below 5.5 generally, and have a low availability of calcium, magnesium, and phosphorus. At this low pH, the solubility of aluminum, iron and boron is high; and low for molybdenum. At pH 7.8 or more, calcium and magnesium are abundant (USDA, 1998). The texture of the bulk soil samples were clayey loam to sandy and rhizosphere soils have sandy loam texture. So such soils have greater root growth.

The EC of the all soil samples except selected wheat agriculture land, lies within the standard range, that is, <4 ds/l which shows that soluble salts present in the soils does not that much cause salinity and effect the uptake of nutrients by the plant root (Table 2). Neutral soluble salts adversely affect the growth of most crop plants. Saline soils have an electrical conductivity of the saturation soil extract of more than 4 ds/m at 25°C (Richards, 1954). Soil salinity has been found to reduce wheat yields usually when values of electrical conductivity are above 6 decisiments per meter (dS/m) throughout the root zone (Ortiz-Monasterio et al., 2002). The total cations are more in sample of wheat cultivated lands that is 3.77 - 3.85 meq/L while in housing scheme and water course sample, is less; may be these ions have been leached down by water. The CO_3^{-2} is comparatively low in housing scheme soil sample (Waksman, 1916). The Cl^- ion is low in water course (1.5 meq/L) and high in fallow land (7.0 meq/L).

Soil sodicity is usually measured with one of two indices; one is the SAR which give information on the comparative concentrations of Na^+, $Ca^{2+}$and Mg^{2+} in soil solution and the second one is the exchangeable sodium percentage (ESP), which measures the degree to which the exchange complex is saturated with sodium (Rahimia et al., 2000). The SAR value was high in agricultural land of Punjab University (7.2) as compared to housing scheme that is (0.4) due to more adsorption of sodium by roots in rhizosphere (Table 3). It was because this land is irrigated by canal water, that more Na^+ is present in the soil and SAR value increased. The agricultural lands of

Table 2. Soil pH, electrical conductivity and soil texture.

S/N	Sample	pH (logs)	Electrical conductivity dS/l	Soil structure
1	Botanical garden	7.76	2.96	Silt loam
2	Uncultivated land	7.85	2.01	Sandy clay loam
3	Agricultural land (wheat)	7.94	3.85	Sandy clay loam
4	Agricultural land (wheat) kasure	7.83	3.77	Sandy clay loam
5	Agricultural land (fallow) kasure	7.92	1.85	Sandy loam
6	Housing scheme	7.29	0.72	Sandy loam
7	Water course	7.55	0.52	Sandy clay loam

Table 3. Chemical analysis of soil samples.

S/N	Sample	CO_3	Ca	Mg	Na	HCO_3	K	Cl	SO_4	SAR
		(meq/l)								
1	Botanical garden	1.5	14	18	24	6.3	0.4	3.1	38	4.0
2	Uncultivated land	0.9	13.0	6.5	1.9	4.5	0.1	6.0	11.0	0.61
3	Agricultural land (wheat)	1.1	18.0	1.0	21.7	3.5	0.9	4.5	33.5	7.2
4	Agricultural land (wheat) kasure	0.4	17.5	3.0	9.8	3.5	0.6	3.0	19.9	6.5
5	Agricultural land (fallow) kasure	0.6	8.5	6.5	4.5	3.0	3.0	7.0	12.8	1.66
6	Housing scheme	0.2	3.5	1.0	0.6	4.0	0.3	4.10	0.8	0.4
7	Water course	0.7	4.0	1.0	2.0	3.5	0.1	1.5	0.7	1.3

Kasur are irrigated by tube well and the SAR value is near to the agricultural lands of Punjab University. It was also observed that the pH of the agricultural land is high and it also affects the SAR of soil. It was also low in housing uncultivated land (0.61). The critical values for considering a soil sodic is 13 for SAR and 15 for ESP. All the soil sample has less SAR <10 so all are suitable for wheat crop.

Fertilizers and rain affect soil pH. Organic matter, soil texture, and soil microorganisms, are a few other factors that affect soil pH. Agricultural limestone normally is used to increase the soil's pH. Sulfur is normally used to lower the soil pH. But fertilizer and water normally change the soil pH more rapidly. Therefore, it is the soil microbial population which controls the productivity of these soils if other environmental factors (moisture, temperature) are suitable. In fact, fertilization of a soil represents our attempt to balance the competition between plants and soil microbes for available soil nitrogen. Nitrogen tied-up in microbial cells is not available for plants or other microbes until that tissue has been decomposed by other microbe (Soil biota, 2004).

Soil microbiological diversity, microbial biomass, and respiration are all influenced by intensity and diversity of cropping (Lupwayi et al., 1999). Soil quality can be assessed not only by the quantity, but the kind of microorganisms present in the soil. Bacteria that were mostly found in samples are gram -ve and endospore forming (Table 4). Impact of biological activities on soil productivity have been reported by several authors (Ananyeva et al., 1999; Technical Advisory Committee to the CGIAR, 1988)

Among soil organisms, fungi can be important in both the formation and stabilization of soil aggregates (Lynch and Bragg, 1985). The fungi, *Aspergillus niger* was present mostly in the soil samples but less in water course samples. Most of the fungi isolated, were *Aspergillus sp.*, *Fusarium sp.*, *Penicillium sp.*, *Mucour sp.* and *Rhizopus sp.* (Table 4). Jensen (1912) was the first to attempt a synthesis of data on soil mycoflora. Fungal species such as, *Penicillium, Mucor, Cladosporium, Fusarium* and *Rhizopus*, *Rhizoctonia solani, Gaeumannomyces graminis, Pythium, Rhizopus, Mortierella* and *Fusarium* has also been reported from wheat field soil (Warcup, 1957).

Conclusion

It is concluded that cultivated lands status is diverging towards salinity condition which is quite alarming. There is a need to amend cultivated lands for wheat and future cropping. It has also been found that all the soil samples have less pathogenic microbes and have less accumulated salts and toxin and can be used efficiently for other crops cultivation. In general, there is slight difference between cultivated and uncultivated soils which can be overcome by good agricultural practice.

Soil fungal communities are impacted by the recent trend towards reduced-tillage agricultural systems. Reduced tillage has been thought to lead to increased disease pressures from fungal pathogens, as residues

Table 4. Bacterial and fungal population in soil samples.

S/N	Sample site	Frequency	Bacteria (Gram +ve /-ve)	Fungal isolates	Frequency
1	Botanical garden	++	Cocci and rod(All gram –ve)	*Aspergilus flavaus , Mucor* sp *and Fusarium* sp.	+++
2	Uncultivated land	+++	Cocci (All gram –ve)	*Aspergilus niger* and *Penicilum* sp.,	+++
3	Agricultural land (wheat)	+++	Cocci (gram –ve) and rod (gram –ve and +ve)	*Aspergilus flavuas, Mucor* sp*, Aspergilus niger* and *Penicilum* sp.,	++++
4	Agricultural land (wheat) Kasure	++	rod (gram –ve and +ve) and Cocci (gram –ve)	*Aspergilus niger*	+++
5	Agricultural land (fallow) Kasure	+++	Cocci (gram –ve and +ve) and rod (All gram –ve)	*Aspergilus niger* and *Aspergilus flavaus*	+++
6	Housing scheme	++	Cocci and rod(All gram –ve)	*Mucor* sp and *Penicilum* sp.	++
7	Water course	++	Cocci and rod(All gram –ve)	*Aspergilus niger, Aspergilus* sp and *Mucor* sp	++

containing pathogenic fungal propagules are not exposed to competing soil microflora (Mansoor et al., 2006). In this regards Zaitlin et al. (2004) reported a positive relationship between soil management strategies and microbial inoculum count.

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