Soil Fertility and Salinity Status of Muzaffargarh District, Punjab Pakistan

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Abstract The main objective of this paper is to check the soil fertility and salinity status. For this purpose, a total of 3325 soil samples, collected from all tehsils of Muzffargarh district (from tehsil Muzaffargarh, Jatoi, Kot Addu and Ali Pur), were tested in the Soil and Water Testing Laboratory, Cane Development Cell, Fatima Sugar Mills, Muzaffargarh, Pakistan from 2012 to 2014. Samples were analyzed for soil reaction (pH1:10), electrical conductivity (EC1:10), soil organic matter (SOM), sodium adsorption ratio (SAR) and plant available phosphorus (Olsen-P). The results revealed that pH ranged between 8.5-9.0 in 75 percent of the samples while about 95 percent were normal with respect to salinity(EC < 4 dS/m) and 74 percent were not affected by sodicity (SAR < 15). Soils were poor in organic matter (92 percent samples had less than 0.80 percent OM) and available phosphorus (95 percent samples had less than 15 mg P/kg soil).

Keywords Soils, Soil Fertility, Salinity, Pakistan

1. Introduction

Muzaffargarh is one of the most important districts of Punjab from the agricultural point of view. It is located between 29° 6' to 30° 45 'N Latitude and 70° 30' to 71° 48' E Longitude, in the middle of Pakistan between the two famous rivers of the sub-continent, Chenab and Indus. Muzaffargarh district consists of four tehsils Alipur, Jatoi, Kot Addu and Muzaffargarh. Nearly most of the area of tehsil Alipur and some parts of Muzaffargarh tehsil are flooded every year. The district's towns include Khangarh, Rohillan wali, Shaher Sultan, Rangpur, Gujrat, Budh, Mehmood Kot, Sinawan, Thatta Gurmani, Daira Din Panah, Chowk Sarwar Shaheed, Shah Jamal, Mahrpur, Baseera, Wasanday wali, Jalwala, Pir Amir, BindaIshaq, Ehsan Pur, Bakaini, Seet Pur, Murad Abad, Ghazi Ghaat, Karam Dad Qureshi & Douna Alipur and Jatoi. Muzaffargarh region has an arid climate with very hot summers and mild winters; it is exposed to some of the most extreme weather condition in the country, with highest temperature recorded at 54°C (129 F) and the lowest temperature at −1°C (30°F), and an average annual rainfall of about 127 millimeters. The total area of the district of Muzaffargarh is 830 thousand hectares, of which 112.7 thousand hectare is salt affected and 1.17 thousand hectare is water logged *(Anonymous 2013)*. On average 440 thousand hectares can be used for crop production. Wheat, sugarcane and cotton are the main crops grown, rice, jawar, bajra, moong, mash, masoor, ground nuts, maize and oil seeds (rape seeds and sunflower) being grown at a much lower scale. Mangoes, dates, citrus and pomegranate are the main fruits trees grown whereas dates, jaman, pears, phalsa and bananas occupy a limited area *(Anonymous 2013)*.

Soil fertility status varies with nature of the cropping pattern and management practices. In Pakistan, most of the agricultural lands are nutrient deficient (Anonymous 2008 a).Ahmad and Khan (2006) declared that 75-92 percent soils of Pakistan are deficient in organic matter (0-1 percent), 70-95 percent in phosphates and 20-60 percent soils in potash. It has been found that micronutrients; such as zinc, boron and iron are also emerging as deficient nutrient in soils of Pakistan *(Anonymous 2008 b)*.

In spite of the inherent low soil fertility, crop yield can still be increased by 30-50 percent with the use of balanced fertilization *(Anonymous 2006),* on the basis of soil tests which is a pre-requisite for applying the right fertilizer at the right dose to optimize productivity. *Furrukh et al. (1992)* have studied farmers' soil fertility management strategies that are based solely on resources available, namely off counter chemical fertilizers type, land type, cropping pattern, fallowing and cultural practices. This approach however failed to address scientifically the soil fertility problem as it lacked soil testing facilities for an informed decision. The creation of the soil laboratory facility at Fatima Sugar Mills in 2012 has bridged the technological gap that existed in the Muzaffargarh crop production system by providing soil testing services to the community. After 2 years in operation, the objective of this study is to have a stock take of the severity of agricultural soil deficiencies in Muzaffargarh district and to identify the root cause(s) affecting agricultural productivity and thereby to develop sounder fertilization

practices and amendments that are more adequate to the individual characteristic of farms.

2. Materials and Methods

This study was conducted at the Soil and Water Testing Laboratory of the Cane Development Cell, at Fatima Sugar Mills Muzaffargarh Pakistan during the period 2012 to 2014. Composite soil samples from tehsil Muzaffargarh (840), Jatoi (670), Kot Addu (1225) and Ali Pur (590) were collected from 0-15 and 15-30 cm depths for crops and vegetables while 0-15, 15-30, 30-60, 60-90 and 90-120 cm depths for orchards. Samples were air-dried, ground and passed through a 2 mm sieve for analysis. Soil reaction (*pH*) and electrical conductivity (EC) were measured on a 1:10 soil-water suspension using a calibrated pH meter and EC meter, respectively *(Malik et al.1984).* Samples were also analyzed for organic matter by Walkley and Black method *(Cottenieet al. 1979),* for exchangeable sodium, potassium, calcium and magnesium extracted in 1M ammonium acetate pH 7.0 and for available phosphorous extracted with 0.5M $NaHCO_3$ pH 8.5 followed by colorimetry *(Watanabe et al. 1965).* The sodium adsorption ratio and CEC as the sum of bases were computed. To compute the total salt index, the electrical conductivity 1:10 is converted to ECe by multiplying with the factor Saturation percentage/100 as described by US Salinity Lab. Staff.*(Anonymous 1954).*

The soil test values were interpreted using the soil evaluation indices proposed by Abrol *et al.* (1988) for salinity and by Malik *et al*. (1984) for nutrient status, which are summarized in Table 1:

Table 1. Criteria of parameters used for classification:

(a) Soil Salinity and Sodicity

Status	pH	EC (dS/m)	SAR
Normal (Salt free)	<7.5	0-2	<15
Very Slightly Saline	<7.5	2-4	<15
Slightly Saline	<7.5	4-8	<15
Moderately Saline	<8.0	8-13	<15
Strongly Saline	<8.5	>16	<15
Saline-Sodic	>8.5	<4	≥15
Sodic	>8.5	≥4	≥15

(b) Nutrient Status

Status	Organic matter (%)	Olsen P (mg/kg soil)
Poor	<0.80	0-8
Satisfactory	0.81-1.29	8-15
Adequate	>1.29	>15

3. Results and Discussion

Dissolved salts (electrical conductivity)

Excessive amount of dissolved salts in soil solutions causes hindrance in normal nutrient uptake process either by imbalance of ions uptake, antagonistic effect between nutrients or excessive osmotic potentials of soil solution and or a combination of the three effects *(Obaidur Rahman et al. 2010).* The soil analysis data showed that 94 percent of the samples analyzed in district Muzaffargarh were not saline (EC<4 dS/m) and that 74 percent were not sodic (<15). *(Table 2).* This trend cuts across the different tehsils except for soil sodicity where it appears to be more prevalent at Ali Pur and Jatoi. It is worth noting that, although salinity was not as serious as expected, the high proportion (>50%) in soil having slight to higher sodicity appears to impact most on soil low productivity. Therefore under this condition classical mitigating measures, such as the application of gypsum, can contribute significantly to improve the soil production potential *(Suriyan et al. 2011).* Regarding the range of EC *(Table 3),* the minimum value (0.47 dS/m) was observed in tehsil Kot Addu while the maximum value (18.05 dS/m) was noticed in tehsil Muzaffargarh during the year 2012-14. However, higher EC was also observed in tehsil Jatoi (14.50 dS/m) and Kot Addu (17.90 dS/m). Ali Pur tehsil had dissolved salts ranging from 0.60 dS/m to 14.27 dS/m. The reason for high accumulation of salts in some places is due to water logging and application of poor quality irrigation water containing soluble salts. *(Ayers, R. S. and D.W. Westcot 1985).* The practice of irrigating the field with high EC-water (bore-hole) constitutes a limitation to agricultural activity. Yet the low proportion (<10%) of the salinity inflicted soils at Muzaffargarh indicated the low ionic exchange properties of the soils attributable to the sandy texture that is common to the soils in this region. This in turn indicates the poor ability of the soil to retain plant nutrient for crop production. This should be considered in the fertilization practices whereby residual values of fertilizers could not be reckoned with and the fate of excessive doses of fertilizer is lost to ground water.

Soil alkalinity

Twenty six percent of the soils had a pH 7.5-8.5, that are suitable for agriculture. Seventy-four percent of soils had pH > 8.5 which are limiting to agricultural production. These soils are calcareous and the level of exchangeable sodium is often high. Alkalinity problem in soils is due to the indigenous calcareous parent material with typical low organic matter content *(Brady, N.C. and R.R. Weil. 2005).* Resorting to high doses (as high as 10 tons per acre) of gypsum amendment is not sufficient to reclaim soils having high pH (>8.5) and high sodium content, thus acid and sulphur additions are often warranted *(Sherry Combs, 2007).* The reclamation can be so expensive that it might not be justifiable. These problematic soils are encountered mostly in areas prone to water logging conditions since as mentioned earlier sandy soils normally have low retention capacity for free ions. Indeed these are mostly common in fields with shallow water table induced by seepage water losses from feeder canals or by upward movement of water by capillary from the two adjacent sub-continental rivers.

Organic matter

Organic matter has a vital role in agricultural soil. It supplies plant nutrient, improve the soil structure, improve water infiltration and retention, feeds soil microflora and fauna, and the retention and cycling of applied fertilizer *(Johnston A.E. 2007).* Thus it contributes positively to higher crop yields. Over 95 percent of the soils were deficient in organic matter content leaving a meagre fraction of 4.5 percent that had satisfactory levels *(Table 2).* The low organic matter content is due to an increased rate of decomposition triggered by the high temperature exceeding 45 °C in summer. Burning or fodder use of the plant material remaining after harvest leave very little to replenish the soil in organic matter *(Azam et al. 2001).* Growers seldom use farmyard manure and green manuring is rarely done due to subsistence farming leaving little scope for such practice. Low productivity also leads to reduced crop leftover that can be returned to the soil. There is therefore a strong need to adopt measures that can improve the soil organic matter status; otherwise desertification is looming at the horizon for many of these soils. *(Sieglinde S. Snapp. 2011)*

Plant available phosphorus

The results *(Table 2)* showed that phosphorus availability to plants was satisfactory (above 90 percent) irrespective of the tehsil. 2 to 9 percent of the soils had values above the benchmark of 15 mg P/ kg *(Table 3).* Poor levels of plant available phosphorus result firstly from its fixation in calcareous soil due to the high levels of calcium carbonate *(Ray von Wandruszka, 2006)* and secondly to the recurrent application of phosphatic fertilizers below the recommended rates. Current agronomic recommendation rate for NPK is 1.0:0.6:0.4 but presently it is stagnant at 1.0:0.3:0.01 *(Anonymous 2008 b).*

Acknowledgments

Table 2. Results of Soil samples analyzed Tehsilwise (in %age)

Tehsil	Dissolved Salts					pH			Organic Matter			Olsen-P(Phosphorous)			SAR		
	Normal	Very slightly saline	Slightly saline	Moderately saline	Strongly saline	<7.5	7.5-8.5	>8.5	Poor	Satisfactory	Adequate	Poor	Satisfactory	Adequate	Normal	Slightly sodic	Sodic
Muzaffargarh	84	13	2	1	0	0	14	86	93	7	0	4	94	2	47	29	24
Kot Addu	72	17	5	6	0	0	21	79	94	6	0	4	93	3	45	30	25
Ali Pur	78	12	6	4	0	0	42	58	98	2	0	2	92	6	38	36	26
Jatoi	76	14	6	4	0	0	26	74	97	3	0	1	90	9	45	33	22

Table 3. Ranges of different soil parameters (Tehsilwise)

Tehsils	pH			EC (dS/m)			Olsen Phosphorous (mg/kg)			Organic Matter (%)			Sodium Adsorption ratio		
	Min.	Max.	S.D	Min.	Max.	S.D	Min.	Max.	S.D	Min.	Max.	S.D	Min.	Max.	S.D
Muzaffargarh	8.06	9.53	0.21	0.82	18.05	1.68	7	21	1.89	0.35	0.92	0.11	2	50	8.00
Kot Addu	7.82	10.24	0.26	0.47	17.90	1.50	6	22	1.94	0.24	0.96	0.12	2	54	7.30
Ali Pur	8.01	9.18	0.27	0.60	14.27	1.95	7	20	2.14	0.40	0.84	0.09	2	45	8.43
Jatoi	7.90	9.03	0.25	0.61	14.50	1.71	7	19	2.09	0.34	0.84	0.11	2	50	8.22

Recommendations

- Soil organic matter level and soil fertility status may be increased by green manuring (sesbania, guar, etc.) once in three years.
- Inorganic fertilizers (NPK) should be applied in balanced form according to soil test values and their use efficiency can be increased by band placement for row-sown crops.

Recommendations for district Muzaffargarh on the basis of analysis results are given below

Nutrients recommendations for different crops.				
Crops	Fertility status	Fertilizer rate (kg/acre)		
		N	P	K
Sugar Cane	Poor	78	30	50
Sugar Cane	Medium	58	26	37
Wheat	Poor	52	46	25
Wheat	Medium	42	34	25
BT Cotton	Poor	155	65	50
BT Cotton	Medium	140	52	50
Non BT Cottn	Poor	72	35	25
Non BT Cottn	Medium	60	35	25
Rice	Poor	58	33	25
Rice	Medium	48	25	25
Maize (Hybrid)	Poor	80	60	37
Maize (Hybrid)	Medium	65	46	37

Source: Soil Fertility, Survey and Soil Testing Institute, Punjab, Lahore.

(Annexure-I)

Nutrient deficiency extent in soils and fertilizer use efficiency

Nutrient	Percent soil deficiency	Percent fertilizer use efficiency
Nitrogen	100	40-60
Phosphorous	90	15-20
Potassium	50	75-85
Zinc	70	4-5
Iron	70	11-15
Boron	50	6-8
Copper	15	3-5

Source: Anonymous, (2008c). Pakistan Fertilizer Related Statistics. NFDC

Factors contributing to low fertilizer use efficiency

S.No.	Factors	Percent contribution to low fertilizer use efficiency
1	Poor seed bed preparation	10-25
2	Improper seeding	5-20
3	Delayed sowing	20-40
4	Inappropriate variety	20-40
5	Inadequate plant population	10-25
6	Improper fertilizer placement	5-10
7	Imbalanced fertilizer use	20-50
8	Inadequate irrigation	10-20
9	Weed infestation	15-50
10	Insect attack	5-50

Source: Anonymous, (2008c). Pakistan Fertilizer Related Statistics. NFDC

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