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Indexation of Soil Physico-Chemical Parameters and Fertility Status of Soils of D.G. Khan, South Punjab (Pakistan) in the Light of Climate Change Scenario

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Abstract

Ever increasing population and urbanization are the major threat to food security. Therefore, it is inevitable to use the scarce resources in an efficient manner. Further the application of different fertilizers prior considering the actual prevailing fertility status of soil and the nutrients requirements of upcoming crops may result permanent soil health issues. In order to meet the food needs of the nation we shall have to enhance the yield per unit area. Hence, a survey was conducted for the evaluation of the fertility status of Dera Ghazi Khan for the execution of recommendations regarding balanced use of fertilizers. Previous five years soil analysis data of 45 villages of Dera Ghazi Khan exhibited the average pH of 8.12, Electrical conductivity of 4.23 dSm^{-1}, about 99.3% soils were low in organic matter (<0.86%), and 07% soil have medium range of Organic matter (0.867 to 1.29), 81.5, 15.5% and 3% soils were found in poor, medium and adequate quantity with respect to available phosphorus. About 36.9%, 28.1% and 35% soils were found in poor, medium and adequate range of available potassium. The results indicated that the majority of the soil of Dera Ghazi Khan District was found to be normal and is good for the growth of different crops.

Keywords: Nutrients; Scenario; Indexing Fertility; Climate Change

1. Introduction:

Soil fertility is a complex property of soil and is defined as the inherent ability of the soil to supply important nutrients for the growth and development of crop plants (Tisdale *et al.,* 1993). Soil fertility is the result of interactive effect of soil physical, chemical and biological characteristics that are important for crop production. The depletion of soil fertility is a main concern globally as it is essential for agricultural production on sustainable basis and for food security (Tan *et al.,* 2005).

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The main reason of deterioration of soil fertility includes increased plant population, land use, climatic change, and fragmentation of land as well as deforestation. Constantly and rigorous cropping without supply of optimum quantity of essential nutrients and poor soil management practices may in turn result declined soil fertility.

Injudicious use of fertilizers particularly inorganic fertilizers without soil testing had disturbed the soil properties thus retarded the yield potential with concomitant reduction in crop yield (Sanchez & Lucas, 2002; Rituraj & Vacca, 2018). Hence, soil testing prior crop cultivation is inevitable for the assessment of soil fertility (Havlin *et al.,* 2010). Hence, keeping in view of these scientific reasons and suggestion, our study had been planned to quantify the soil fertility indexation whaich may become opted as a viable option to sustain the various crops in Dera Ghazi Khan District.

1.1. Objectives:

- To evaluate the fertility status of soil of Dera Ghazi Khan
- To explore the nutrient indexation of the area for formulation of site-specific recommendations of fertilizers in the light of physico-chemical properties and available nutrient status of soil of the area.

2. Materials and Methods:

This work was conducted at Soil and Water Testing Laboratory, D.G.Khan to evaluate the fertility status of soil. The soil pH was measured by soil water ratio (1:1) with the help of pH meter and the soil electrical conductivity of 1:10 soil water ratio as per given criteria and is demonstrated in Table 1.

Table 1: Criteria of classification of Fertility and salt affected Status of soil.

Soil Quality Parameter	Category			
	Poor		Medium	Adequate
Organic Matter (%)	<0.86		0.87-1.29	>1.29
Available-P (mg/kg)	<7		7-14	>14
Available-K (mg/kg)	<80		80-180	>180
	Normal	Saline	Saline sodic	Sodic
pH	< 8.5	<8.5	>8.5	>8.5
EC (dSm^{-1})	< 4	>4	>4	< 4

Source: (Malik *et al.*, 1984)

2.1. Soil Organic Matter:

The soil organic matter was determined through titration Weighed about 1.0 g of soil in 500 ml conical flask, added 5 ml of K_2Cr2O_7 and mixed well. Added 10 ml H_2SO_4. Kept the flask for 30 minutes. Distilled water (50ml) and 03 ml phosphoric acid and 5- 10 drops of indicator were added and titrated using standardized ferrous sulphate to sharp green end point through blue colour (Walkley, 1947).

2.3. Available-P:

Soil 2.5 g was taken and added 50 ml $NaHCO_3$ extracting solution. Shakeed for half an hour and filtered using Whatman (No. 42). Taken 5 ml of the aliquot. Added colour developing reagent (5 ml) in 250 ml volumetric flask. Allowed to stand for about 15 minutes. Made the volume up to mark. Bluish colour was developed. Take reading was taken at 880 nm wavelength on Spectrophotometer (Olsen *et al.,* 1982).

2.4. Available-K:

Available potassium was determined with the help of Flame photometer (PFP-7 Jenway).

3. Results:

3.1. Soil Reaction (pH):

The data in Table 2 revealed that the pH of soils of D.G. Khan District ranged from 7.3 to 9.5 with a mean value of 8.12. Most of the soil of the area was found to be normal in case of pH. However, some soils were found to be sodic in soil having pH >8.5. The availability of essential plant nutrients as well as their solubility solely depend on the pH of the soil.

Table 2: Range and average of different soil parameters

Parameters	Range	Mean
pH	7.3 – 9.5	8.12
Electrical Conductivity (dSm^{-1})	0.65- 15	4.23
Saturation %age	31-54	39.13

3.2. Electrical Conductivity:

The data given in Table 2 revealed that the electrical conductivity of soils of D.G. Khan District ranged from 0.65 to 15 with a mean value of 4.23. Most of the soil of the area was found to be normal, having EC <4 dSm^{-1}. Some soils in Taunsa area were saline (EC >4 dSm^{-1}). As such soils contain sufficient quantity of soluble salt that interfere with plant growth by hampering nutrient uptake by roots. Reclamation of such soils is done through use of canal water. After raising the boundaries of the saline field and then fill it with plenty of canal water so that salts may leach down beyond root zone.

3.3. Soil Texture:

Table 2 represents saturation percentage of soil. The saturation percentage of soils of Dera Ghazi Khan District ranged from 41 to 54% with a mean value of 39.13. In this region about 15%, 75% and 10% soils were found to be coarse textured, medium textured and fine textured, respectively.

3.4. Soil Organic Matter:

Table 3 represents the fertility status of soil of Dera Ghazi Khan on the basis of five years (2018-18 to 2021-22) data. The data in Table 3 revealed that out of 7905 soil samples about 99.3% of the soil of Dera Ghazi Khan District were found to be poor with respect to organic matter contents of soil and only 0.7% soils have medium range of organic matter. A pictorial map regarding organic matter contents of the soils of Dera Ghazi Khan district is also given to highlight the overall organic matter situation of the area. The major reason for the poor organic matter status of the soil of the area is because of high temperature (50 to 51 °C) during summer which accelerates its rate of decomposition (Fig. 1).

Table 3: Fertility status of soils under study (Five years Data)

Years	Organic Matter (%)			Available - P (ppm)			Available - K (ppm)		
	Poor	Medium	Adequate	Poor	Medium	Adequate	Poor	Medium	Adequate
2017-18	2047	28	0	1466	609	0	1151	438	486
2018-19	1170	0	0	894	271	5	347	110	713
2019-20	1515	7	0	1321	130	71	663	88	771
2020-21	1687	0	0	1513	102	72	647	617	423
2021-22	1433	18	0	1251	113	87	106	969	376
Total	**7852**	**53**	**0**	**6445**	**1225**	**235**	**2914**	**2222**	**2769**
Overall		7905			7905			7905	
Percentage	99.3	0.7	0.0	81.5	15.5	3.0	36.9	28.1	35.0

3.5. Soil Available Phosphorous:

The data in Table-3 highlighted the available phosphorus contents of the study area. The data exhibited that out of 7905 soil samples 81.5% (6445) soils were poor, 15.5% (1225) were in medium range while 3% (235) soils were contain adequate levels of phosphorus. A comprehensive map about available phosphorus levels of Dera Ghazi Khan district soils is also given to emphasize the overall phosphorus contents of the region.

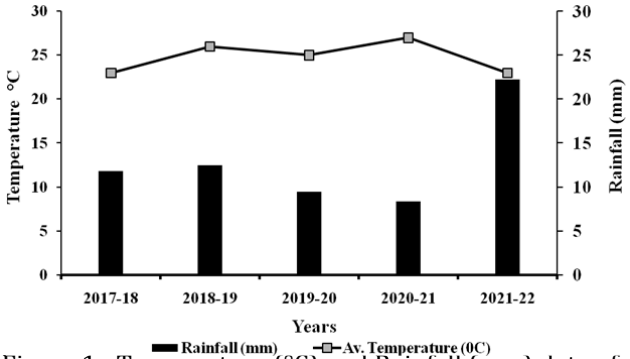


Figure 1: Temperature (°C) and Rainfall (mm) data of Dera Ghazi Khan District

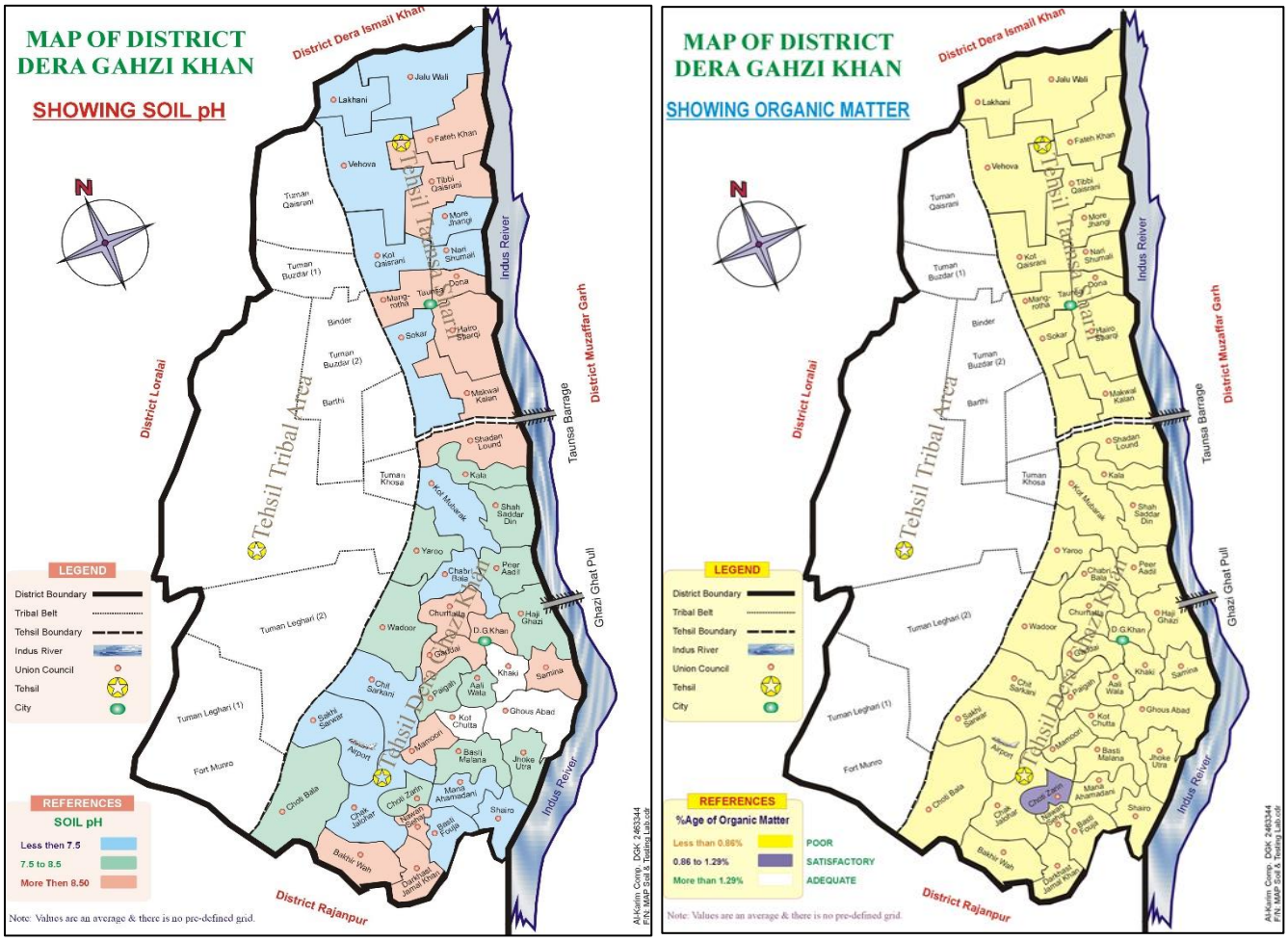
3.6. Soil Available Potassium:

Table-3 data about available-K showed that out of 7905 soil samples 36.9% (2914) soils were poor, 28.1% (2222) were in medium range while 35% (2769) soils contained adequate levels of potassium. A comprehensive map about available Potash levels of Dera Ghazi Khan district soils is also given to accentuate the overall potassium status of the region. Overall, in 36.9% area the potassium contents were found in poor category. This is because of less availability of canal water and low application rate of potassium fertilizers. In such areas, potassium fertilizer application is necessary to cope the potassium stress to get the maximum yield.

Table 4. Criteria of classification of Salt affected soil.

Soil parameters	Category			
	Normal	Saline	Saline sodic	Sodic
pH	< 8.5	<8.5	>8.5	>8.5
EC (dSm^{-1})	< 4	>4	>4	< 4

Source: (Malik *et al.*, 1984)



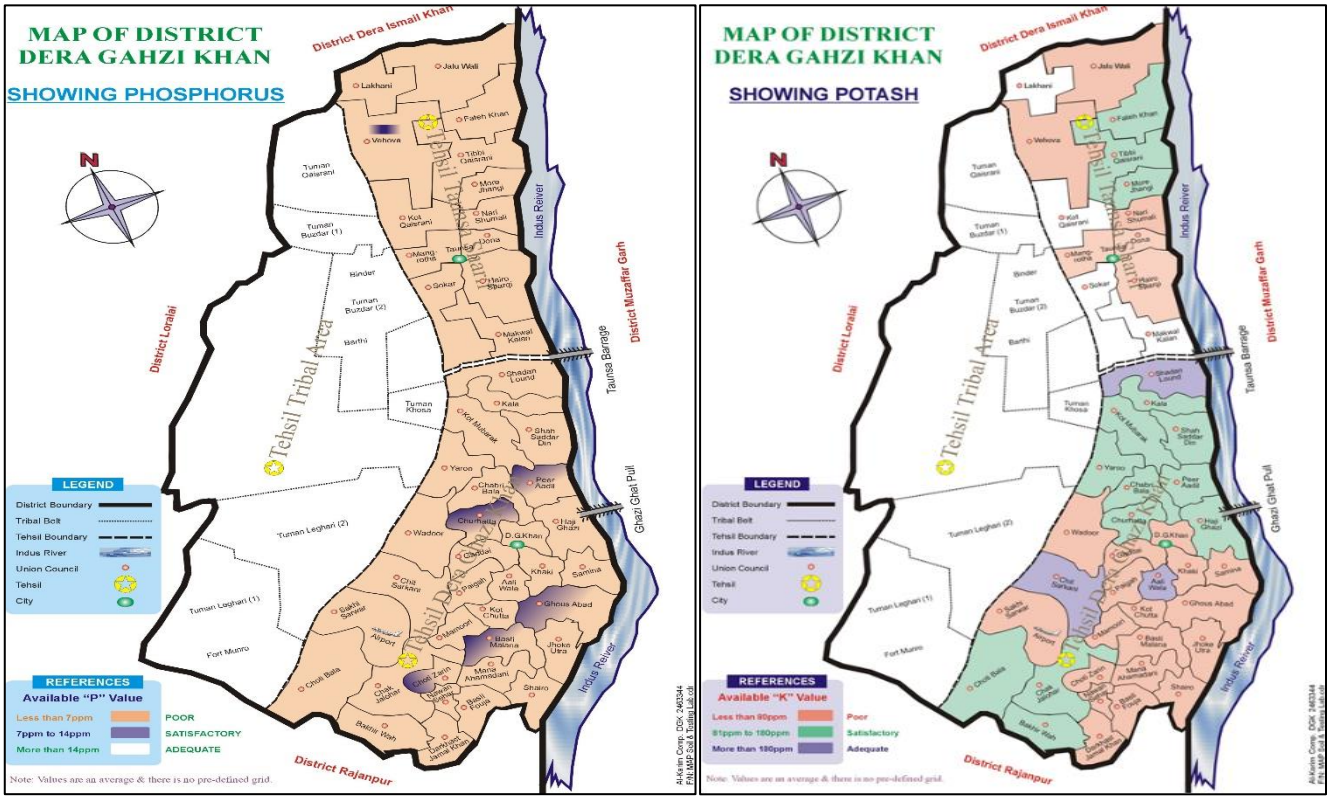


Figure 1: Soil pH, Organic matter, Available Phosphorus and Potash levels in Dera Ghazi Khan

4. Discussion:

In soil, with higher contents of calcium carbonate and with high pH vale phosphorus availability to the plants is decreased as phosphorus is precipitated as Di-calcium phosphate. Phosphorus availability to plants is maximum at pH range of 6.5 to 7.5). Micronutrients available at low pH (Shah & Fry, 2019).

In such soils there is a problem of root penetration, nutrients retention. So, for reclamation of such soil's gypsum should be applied according to the gypsum requirements of soil (Schofield & Taylor, 1955). After applying gypsum raise the boundaries of the field and fill the field with sweet water so that the sodium salts may leach down beyond root zone (Hopkin, 2015: Schofield & Taylor, 1955).

Chemical and physical properties of soil such as water retention, porosity, organic matter contents, root penetration, infiltration of water, soil aggregation and CEC of soil depends on soil textural class (Singh & Mishra, 2012).

Fine textured soils (clay) have more nutrients and water holding capacity than coarse textured soils (Chakraborty & Mistri. 2015). Application of organic amendments (farmyard manure, poultry manure and green manuring) can improve the physical and chemical characteristics of soil which in turn enhance the water and nutrient holding capacity of the soil.

Farmers of the area neither use organic amendments (i.e., Farmyard manure, poultry manure) nor adopt green manure practices. So, it is inevitable to apply organic amendments in soil in order to enhance the organic matter contents of the soil on sustainable basis (Mondini & Sequi, 2008). The use of organic amendments can improve soil health by retaining essential nutrients in soil (Dhaliwal *et al.,* 2021). Organic matter has high CEC (Cation exchange capacity) which help in the exchange of different essential nutrients which in turn improve soil health as well as fertility of soil (Hosseinzadeh *et al.,* 2021).

The reason for the low plant available phosphorus contents in the region is because of alkaline and calcareous soils of the area where fixation of P occurs due to high calcium carbonate contents. Further farmers of the area are poor with small land holding and they cannot afford high price Phosphatic fertilizers (Dawar *et al.,* 2022). Our results are in line with the previous findings of researchers as soils of the area are in poor range of plant available phosphorus contents.

5. Conclusion:

Application of different fertilizers prior considering the actual prevailing fertility status of soil and the nutrients requirements of upcoming crops may result permanent soil health issues. Hence, balanced use of organic and inorganic nutrient elements as well as site specific nutrient management is inevitable. Fertilizer should be applied keeping in view the existing fertility status of soil and nutrient requirements of upcoming crops at right time, right place, right quantity and right method of application for maintaining soil health and productivity on sustainable basis.

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