Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.5, No.21, 2015

Distribution and Indexation of Plant Available Nutrients of Soils in the District Bahawalpur, Pakistan

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Abstract
A total of 2600 soil samples collected from all tehsils of Bahawalpur district (590 samples from tehsil Bahawalpur, 227 samples from Khair Pur Tamewali, 594 samples from Ahmed Pur East, 439 samples from Hasilpur and 750 soil samples from Yazman) were tested in Soil and Water Testing Laboratory, Bahawalpur, Pakistan during 2011-2013. Soil characteristics of Bahawalpur 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 (OM), available phosphorus (P) and potassium (K) contents. Texture of the soils varied from sandy loam to loam. About 75% soils had EC values within the normal range (< 4 dS m^{-1}). The pH values of 94% soils ranged from 7.5 to 8.5 with an average of 8.09 and 5% soils had pH > 8.5. About 96% soils were poor (< 0.86%) in organic matter and only 4% samples had satisfactory level of organic matter (0.86-1.29%). About 63% soils were poor(< 7 ppm) in available phosphorus, 30 % samples had satisfactory level of available phosphorus (7-14 ppm) and only 7% samples had adequate level of available phosphorus (>14 ppm) contents. The K status of most of soils was in satisfactory (63%) and adequate range (23%). The nutrient index values of Bahawalpur soils in respect of SOM and P were poor, whereas satisfactory for potassium. Depending upon the soil analysis, farmers were guided and fertilizer recommendations were served according to crop, soil and water/rainfall conditions for harvesting higher yield of different crops.
Keywords: Soil Analysis, EC, pH, SOM, P, K, Bahawalpur, Nutrient index

Introduction

Bahawalpur Division consists of Bahawalpur, Bahawalnagar and Rahim Yar Khan districts covering on the area of 18176 square miles. Out of this,6500 square miles is canal irrigated and lies between altitude 27.42º and 30.25º South and longitude 64.31º and 74.10º east. This tract may be described as (i) pure desert Cholistan (Rohi) (ii) central tract mainly desert high in level than the adjoining Riverian areas (iii) alluvial tract formed by the action of rivers. The first tract is contiguous with the Indian desert in Rajhistan and is locally know as "ROHI". It extends over an area of 64 lac acres and 30.5 lac acres lie in Bahawalpur district. The surface soil consists of shifted sand, silt and clay mixed materials that rise in places to a height of 500 feet dunes. Bahawalpur division has been described as an arid tract that receives scanty rainfall. Occasionally rains fall at certain places from June to September; however it is rare in general. Annual rainfall is irregular and unpredictable and ranges from 130 to 175 mm. For the last few years, precipitation had increased and rains are coming from Arabian Sea crossing the Sindh area. This region has extreme type of climate, very hot in summer and chilling cold in winter. The tract experiences extremes of temperature, which rises to 50 ^{0}C in summer and falls down to freezing point during winter in January and February. Strong winds are general characteristics of the area, which blows from the southwest to north east in summer.

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).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).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).

The available cultivated area is rapidly reducing due to conversion of agriculture land into non-agriculture usage such as roads, buildings and industries etc. This exerts enormous pressure on the already scare natural resource base of the province. In view of the increasing population and prospective food crises, it cannot be affordable to continue squandering and abusing such precious resource i.e. Soil. For the best management of soil resources of an area, it is very important to have information about the soils of that area. This piece of research work was carried out to determine physio-chemical properties of Bahawalpur district to delineate areas into different categories of soils for realizing the agricultural potential of these areas and future planning.

Materials and Methods

This study was conducted in Soil and Water Testing Laboratory, Bahawalpur, Pakistan during 2011-13. Composite soil samples from all tehsils of district Bahawalpur (590 samples from tehsil Bahawalpur, 227 samples from Khair Pur Tamewali, 594 samples from Ahmed Pur East, 439 samples from Hasilpur and 750 soil samples from Yazman) were collected from 0-15 cm depths for crops and vegetables. Samples were air dried, passed through 2 mm sieve and analyzed for soil texture, by measuring saturation 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).

Nutrient Index (NI) = ((Nl × 1) + (Nm × 2) + (Nh × 3))/ Nt

Where

Nt = Total number of samples analyzed in a given area

Nl = Number of samples falling in low category of given nutrient

Nm = Number of samples falling in medium category of given nutrient

Nh= 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

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

Status	E.C (dSm^{-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)

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
	%	$mg\ kg^{-1}$	$mg\ kg^{-1}$	
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 Bahawalpur District

Estimation	Range	Mean	Standard Deviation
Saturation % age	26-52	36.09	4.62
Soil pH	7-9.6	8.09	0.28
EC	0.3-60	3.55	3.25
Organic Matter	0-1.09	0.49	0.21
Avail. Phosphorus	0.1-19.9	6.44	4.04
Exchangeable Potassium	20-870	150.10	84.82

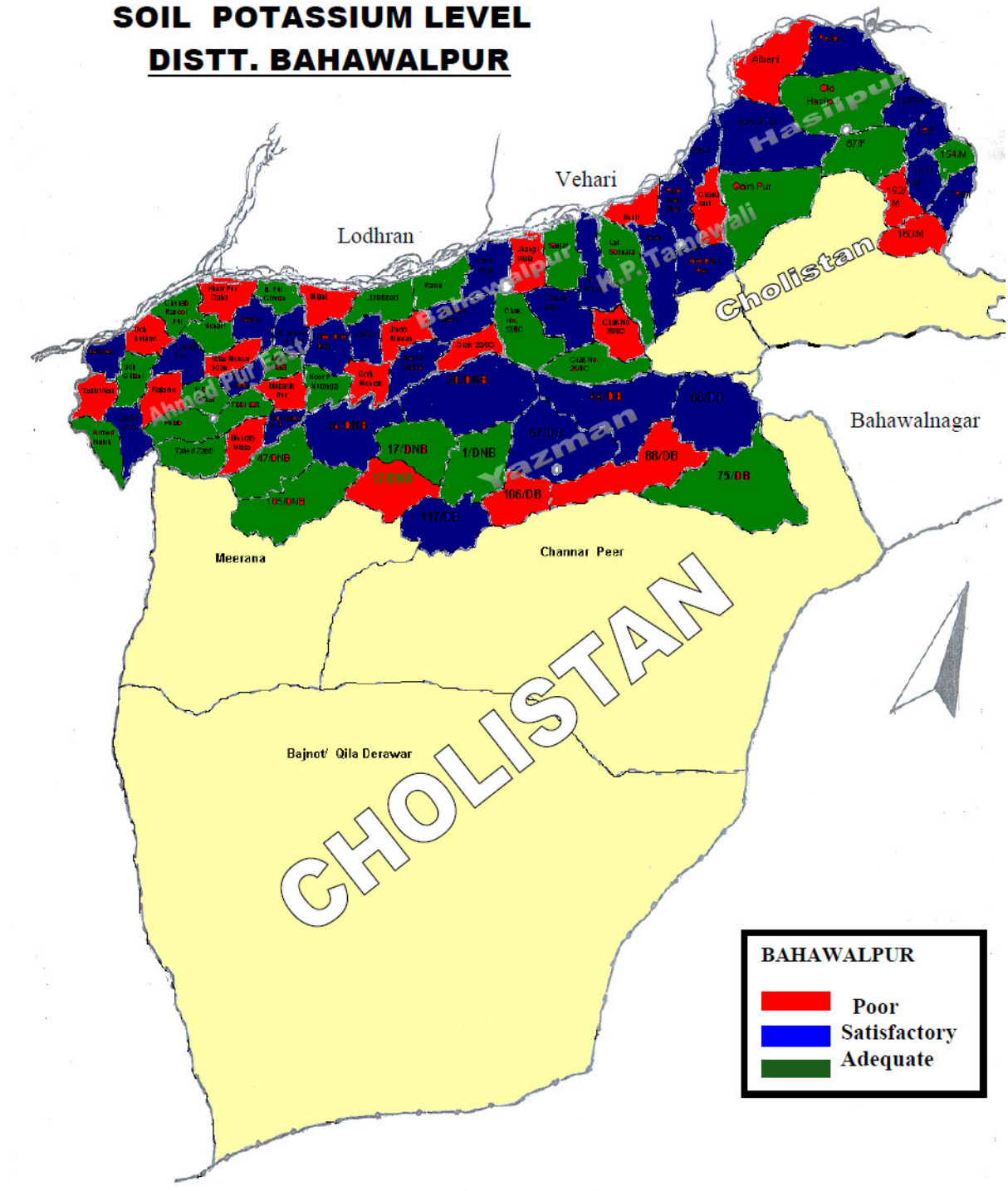
Results and Discussion

Soil Texture

Soil texture is basic to many other soil properties and serves as an indicator of water holding capacity, cation exchange capacity, aeration and organic matter content. Soil texture also controls the retention and losses of nutrients in soil-plant environment.

The saturation percentage ranged from 26-52 with a mean value of 36.09 (Table 4). The 12% soil samples were light and 85% were medium textured (Table 5) whereas, the proportion of heavy soil was only 3%.

These medium textured (loam) soils are suitable for cultivation of all common crops while the light soils has less water holding capacity which needs to be enhanced through addition of farm yard manure to improve physical condition of these soils.



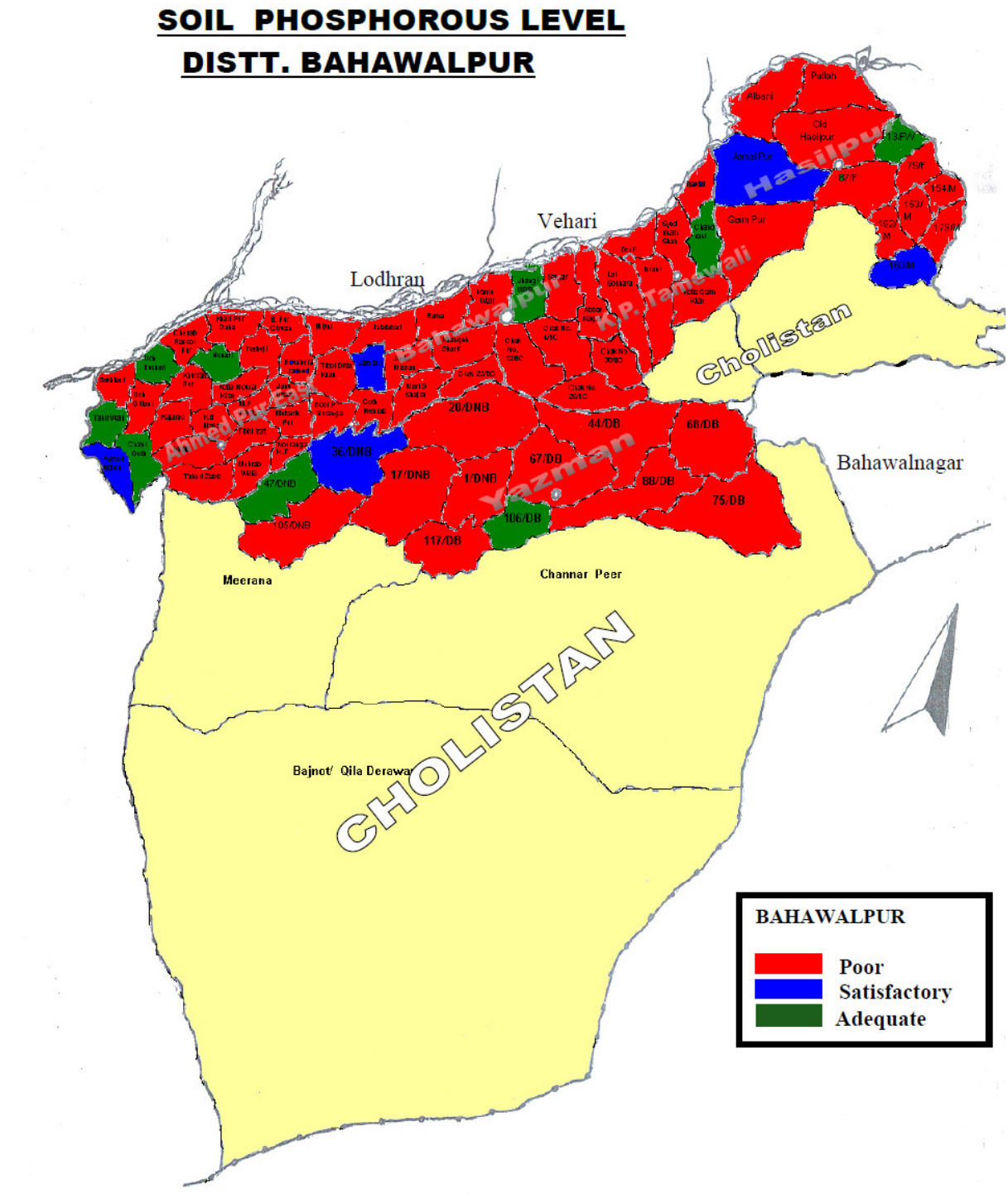

SOIL PHOSPHOROUS LEVEL
DISTT. BAHAWALPUR
Vehari
Lodhran
Cholistan
Bahawalnagar
Meerana
Channar Peer
CHOLISTAN
Bajnot/ Qila Derawar
Hasilpur
Yazman
Ahmedpur East
Bahawalpur
K.P.Tanwali
20/DNB
44/DB
68/DB
36/DNB
17/DNB
1/DNB
67/DB
88/DB
75/DB
47/DNB
106/DB
105/DNB
117/DB
BAHAWALPUR
Poor
Satisfactory
Adequate

Table 5: Categorization of soil samples into different classes based on criteria described in Table-1, 2 & 3.

Particular		No.of Samples	Percentage (%)
Soil Texture			
1.	Light	323	12
2.	Medium	2197	85
3.	Heavy	80	3
Salinity/Sodicity			
1.	Normal (EC< 4.0)	1955	75
2.	Saline (EC ≥4.0)	645	25
Soil pH			
1.	>7.5	30	1
2.	7.5-8.5	2437	94
3.	>8.5	133	5
Soil Organic Matter			
1.	Poor (< 0.86 %)	2484	96
2.	Satisfactory (0.86-1.29 %)	116	4
3.	Adequate (>1.29 %)	0	0
Available Phosphorus			
1.	Poor (<7.0 mg kg^{-1})	1644	63
2.	Satisfactory(7-14 mg kg^{-1})	774	30
3	Adequate (> 14 mg kg^{-1})	182	7
Available Potassium			
1.	Poor (< 80 mg kg^{-1})	354	14
2.	Satisfactory(80-180mg kg^{-1})	1644	63
3	Adequate (> 180 mg kg^{-1})	602	23

Table 6: Soil Fertility Index of Soils in Bahawalpur District

Available Nutrient	% Soil Samples			Nutrient Index (NI)
	Poor	Satisfactory	Adequate	
Organic Matter / nitrogen	96	4	0	0
Available Phosphorus	63	30	7	1.43
Exchangeable Potassium	14	63	23	2.09

Dissolved Salts (Electrical Conductivity)

Dissolved salts in soils create hindrance in normal nutrient uptake process by imbalance of ions, antagonistic and osmotic effects. Normally for research purpose, electrical conductivity of soil extract (ECe) is used for total dissolved salts but for assessing soil salinity and sodicity for advisory purpose, a soil-water suspension of EC1:10 is normally used as described in the manual of Malik *et al.,*1984. Various workers used the same method for electrical conductivity. However, EC1:10 is converted to ECe by multiplying with the factor Saturation percentage/100 as described by US Salinity Lab. Staff .The data (Table 5) showed that 75 percent of soil samples analyzed in district Bahawalpur were free from salinity/sodicity while 25 percent soil were saline/sodic. Regarding ranges of EC (Table 4), minimum value was 0.3 dS/m while maximum value 60 dS/m was noticed in district Bahawalpur, with an average value of 3.55 dS/m during the year 2011-13.The reason for low accumulation of salts in soils is that texture of the most of soils is sandy loam to loam, high and sporadic rainfall in monsoon season leaches / washes the salts, if any, from the root zone.

Soil Reaction (pH)

The pH has significant influence on solubility and bioavailability of nutrients. NO_3 and NH_4 -N are available in a relatively wider range of pH (6.0-8.5). In calcareous soils with high pH the availability of P to plants is decreased. The solubility of P is optimum over a narrow pH range (6.5-7.5). The micronutrients, Fe, Cu, Zn and Mn are more soluble in the pH range 5.0 to 6.0, and their availability in soils varies considerably with the seasonal changes in temperature, moisture and microbial activity (Hodgson, 1963).

The results (Table 5) further revealed that 1 percent soils at district level had pH < 7.5, which are considered as the best for agricultural use especially for growing high value crops, fruits and vegetables. Similarly 94 percent soils had pH 7.5-8.5. The soil pH values ranged from 7.0 to 9.6 with an average value of 8.09. The data (Table 5) indicated that 5% samples were either saline or saline sodic. These soils are also good for agriculture but pH towards higher side (i.e. > 8.5) has some limitations for high value crops. Soils having pH > 8.5 need special attention and some suitable amendment (acid or gypsum) is to be applied for their

reclamation according to the soil gypsum requirement. When the average values are taken in to consideration, the area looks free from salinity/ sodicity menace. As the pH of soils is alkaline due to the indigenous parent material, calcareousness and low organic matter, this situation is similar in almost all soils. These results are supported by the findings of earlier workers.

Soil Organic Matter (SOM)

Nitrogen may be removed from soil by cropping and grazing, as elemental N and ammonia. In undisturbed natural forests and grasslands with no massive N removals in crop production and grazing, the N in precipitation serves to restore the small quantities that are lost from these soils. Nitrogen requirements are usually recommended by the Soil Testing Laboratories, based on the estimation of nitrogen released by the SOM contents (Cooke, 1982).

Higher organic matter reflects the higher crops yield. The data (Table 5) showed that 96 percent soils in Bahawalpur district were poor and only 4 percent were satisfactory with respect to organic matter. The reason for low organic matter is that the temperature in summer exceeds 45 °C due to which its decomposition rate is increased. Also farmers generally do not use farmyard manure and remove crops totally (grain plus straw) from soils leaving it fallow. The trend of green manuring is also not observed. These results are in line with those of earlier scientists who found that soils in these areas are deficient in organic matter.

Plant Available Phosphorus

Losses of P occur through leaching and erosion. Leaching represents a major mechanism of P loss from the soils. The data (Table 5) showed that 63 percent soils in Bahawalpur district were poor, 30 percent satisfactory and only 7 percent were adequate with respect to phosphorus availability to plants. The reasons for poor plant available phosphorus is that the farmers do not apply phosphatic fertilizers to crops according to recommendations and only nitrogenous fertilizers are applied due to price hike of phosphatic fertilizers. These results coincide with the findings of previous scientists, according to which soils in this tract are poor in available phosphorus.

Available potassium (K)

The available K varies with the soil texture depending upon the parent material and its degree of weathering. Generally, clayey soils have more available K than loamy and sandy soils (Saleem and Bertilsson, 1978).

The data (Table 4) showed that the K contents ranged from 20-870 with a mean value of 150.10 mg kg^{-1}. The classification (Table 5) showed that 14% soil samples were poor, 63% samples contained satisfactory while 23% had adequate K contents. The K content had invariably been reported as adequate in Punjab soils except eroded or light textured soils (Bajwa, 1990).

Soil Nutrient Index (NI)

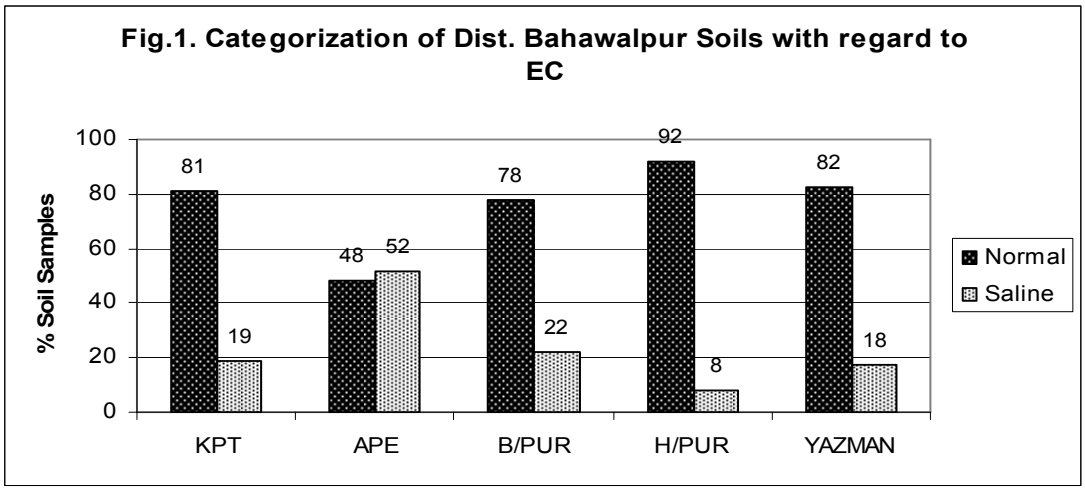
Soil fertility level was measured in terms of NI values. The NI values (Table 6) in present study indicated that SOM and P levels were low and K level (2.09) was found in medium range. Nutrient index value of <1.5 is taken as low, values between 1.5-2.5 indicates medium and >2.5 as higher fertility status of the given area (Motsara, 2002).

Recommendations

Soil organic matter level and soil fertility status may be increased by green manuring (sesbania, guar, etc.) once in three years. With this practice, the sufficient moisture can be preserved for rabi crops (wheat, canola, etc).

Inorganic fertilizers (NPK) should be applied in balanced form according to soil test value and their use efficiency can be increased by band placement for row-sown crops.

RANGES OF DIFFERENT SOIL PARAMETERS (TEHSIL -WISE)



KPT (Khair Pur Tamewali), APE (Ahmed Pur East), *B/Pur (Bahawalpur), * H/Pur (Hasilpur)

Fig. 2. Categorization of Dist. Bahawalpur Soils with regard to pH

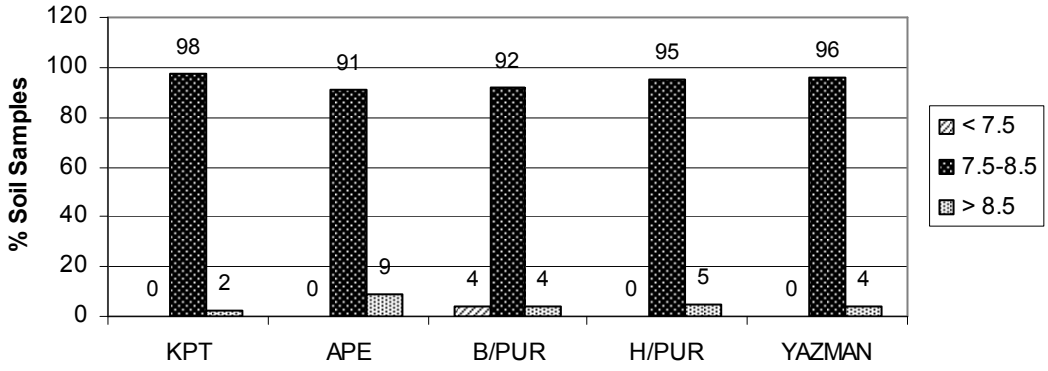


Fig. 3. Categorization of Dist. Bahawalpur Soils with regard to Organic Matter

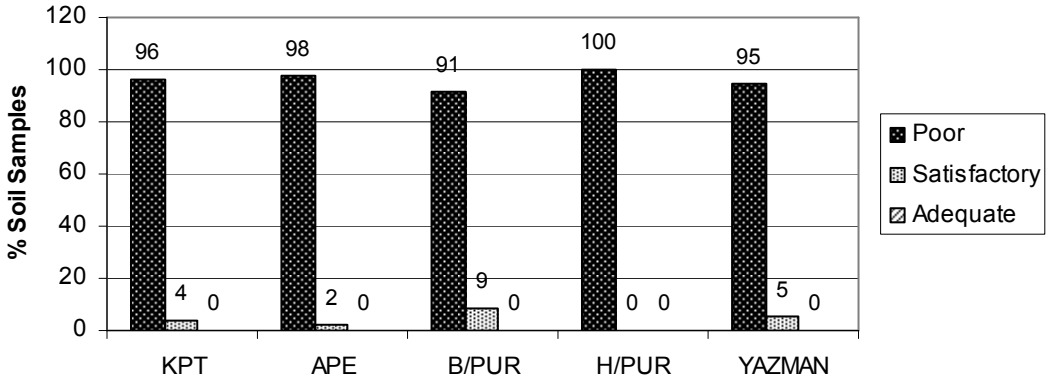
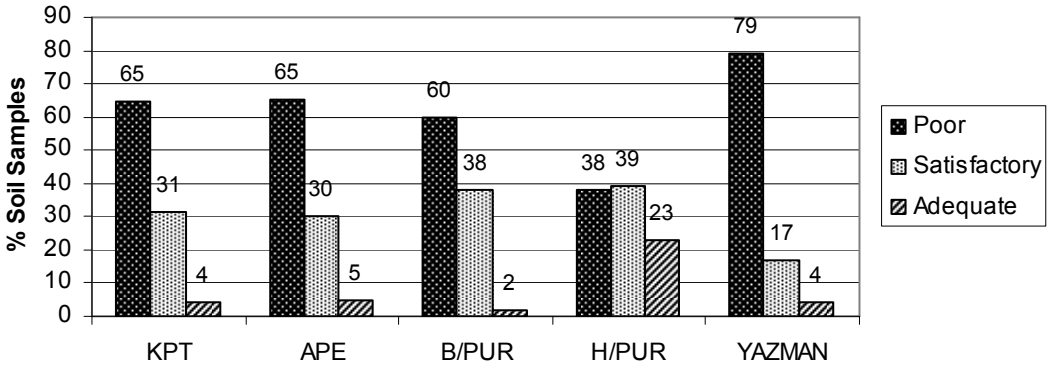
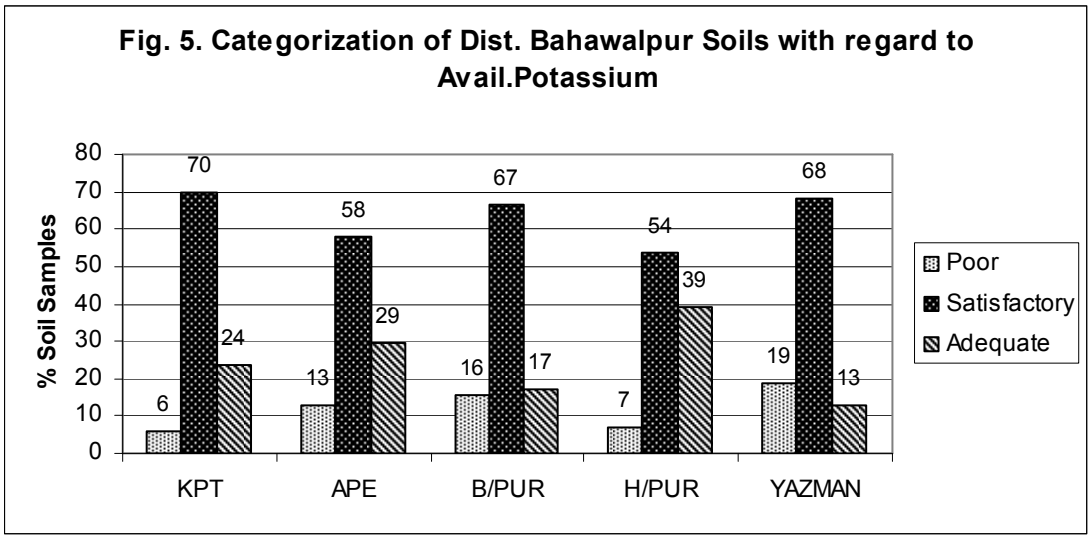


Fig. 4. Categorization of Dist. Bahawalpur Soils with regard to Avail.Phosphorus





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