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Soil Quality Assessment of Different Villages of Sanganer Block in Jaipur District of Rajasthan (India)

S.Sharma, Y. V. Singh, A. Saraswat, R. Meena, N. Khardia

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ABSTRACT

A study to examine soil fertility status was conducted in the study area lies between 26°49' N to 26°51' N latitude and 75°46' E to 75°51' E longitude at an altitude of 372 m above mean sea level. A total of forty soil samples were collected from eight different villages of the block at a depth of 0-15 cm. Soil sample thus, collected were examined for various physical and physico-chemical parameters which includes BD, PD, WHC, Porosity, pH, EC, OC, also macro and micronutrients including N, P, K, Ca, Mg, S, Fe, Mn, Zn and Cu by standard analytical methods. Results showed that the soil was neutral to alkaline in pH (6.2 to 8.9), low in organic carbon (0.3 to 1.92%) and available sulfur (0.97 to 11.47 mg kg^{-1}). The available nitrogen (150.32 to 350.3 kg ha^{-1}), zinc (0.21 to 0.64 mg kg^{-1}), iron (1.2 to 4.83 mg kg^{-1}) and manganese (0.14 to 1.02 mg kg^{-1}) were found low. Furthermore available potassium (123.2 to 504 kg ha^{-1}) was moderate and available phosphorus (14.68 to 36.13 kg ha^{-1}) and copper (1.19 to 4.68 mg kg^{-1}) were found high. The current study is expected to help the farmers of Sanganer block in guiding techniques required for long-term soil fertility management and creating future agricultural research strategies on the farm.

Keywords Soil fertility, Soil quality, Macronutrients, Soil sampling.

S.Sharma, Y. V. Singh*, A. Saraswat, R. Meena
Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh 221005, India

N. Khardia
Department of Soil Science and Agricultural Chemistry, Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, 313001, India

Email: yvsingh59@rediffmail.com
*Corresponding author

INTRODUCTION

Soil is an essential resource for human survival and the foundation of the agricultural economy. It is the most precious resource for the production of food, fiber, fuel and many other critical items necessary to fulfil human and animal requirements. It is a nutrient reservoir and plays a crucial role in promoting crop growth and vegetation to keep the environment clean. It also serves both as a source and sink of atmospheric gases (Sharma and Dogra 2011). Fertile and productive soil gives life, but hunger and famine results from unfertile and unproductive soils. However, soil faces severe degradation concerns since human pressure and use are incompatible with its ability.

Sustainable soil resource management is a critical task for scientists, administrators, planners and farmers in ensuring food security for future generations (Kanwar 2000).Soil characterization, especially soil fertility evaluation for a particular area or a region, is important for long-term agricultural productivity (Rajendiran *et al.* 2020).The most fundamental decision-making tool to efficiently plan a given land-use system is the soil fertility evaluation (Havlin *et al.* 2010). Soil fertility is the soil's inherent capacity to give essential plant nutrients when other variables are favorable (Panda 2010). It depicts plant growth in response to soil nutrient availability whereas soil productivity refers to the soil's capacity to produce crops under a specific management system and is expressed in yield. Soil fertility and productivity are critical pillars for food production and soil quality is equally important in the context of soil deterioration induced by a variety of circumstances (Shivanna and Nagendrappa 2014). Fertility management based on soil testing is an effective strategy for increasing the productivity of agricultural soils that exhibit a high degree of geographical variability as a result of the combined effect of physical, chemical and biological processes (Goovaerts 1998). Soil testing gives information on nutrient availability in soils, which serves as the foundation for fertilizer recommendation to enhance crop yields. Therefore, analyzing a region's soil fertility status is particularly important for sustainable resource management. Soil fertility is influenced by important soil elements which are macronutrients, that are needed in larger amount (N, P, K, Ca, Mg, S) and micronutrients, that are needed relatively in smaller amount (Fe, Mn, Zn, Cu).Variation in nutrient availability is a normal occurrence and certain nutrients may be abundant while others are scarce. Crop production cannot be increased without judicious management of macro-and micronutrient fertilizers to overcome existing deficiencies (Meena *et al.* 2006).

There has been very little research on the fertility status of soils in the Sanganer block in the district Jaipur region and variation in nutrient availability have been recorded. The soils of Jhotwara Panchayat samiti in the Jaipur District were neutral to alkaline in pH, low in soil organic carbon (SOC) and accessible nitrogen (N), medium in phosphorus (P) and high in potassium (K). Similarly, the village's soils were deficient in sulfur (S), zinc (Zn) and iron (Fe) whereas copper (Cu) and manganese (Mn) were above critical limit (Choudhary *et al.* 2017). Perhaps this is useful for determining the block fertility level; but, to get a comprehensive picture of the soil fertility condition of a region/block, a significant number of samples from throughout the area must be evaluated. This will be beneficial for planning and implementing policies related to nutrient/fertilizer management in the area. In light of the above, a significant number of soil samples were collected from the Sanganer region for this research and soil fertility status was assessed for macro-and micronutrients. Furthermore, variability in soil fertility status at the block level was illustrated and described. An effort has also been made to correlate soil nutrient content with main soil parameters.

MATERIALS AND METHODS

Description of the study area

The study was conducted at Sanganer block which is located in Jaipur District of state Rajasthan. It is situated 20 km away from Jaipur and covers an area of 635.5 km^2. Geographically it lies between 26°49' to 26°51' North latitude and 75°46' to 75°51' East longitude. The altitude of the area is on the average 372 m above mean sea level (a m s l). The block is well-known for its textile dyeing and printing industry, as well as waste paper recycling.

The study area is characterized by hot semi-arid climate with extremes of temperature (15-45°C) having an average rainfall of 650 mm. Maximum rainfall occurs between June to September due to south-west monsoon. The hottest month is June with an average temperature of 33.4°C while the coldest is January with an average temperature of 15.4°C. There are about 142 villages in the block. The study areas have sandy loam texture with medium to deep soil. Although these soils have varied levels of phosphorus and potassium, they are nitrogen-deficient. The block is marked with hilly areas with plain to undulating topography. The major annual crops grown in study area are bajra, barley, wheat, groundnut and gram while Pea, chili, tomato, cauliflower, Brijnal and cabbage are major vegetables grown in the block.

Table 1. Description of sampling sites.

Sl.No.	Name of village	Land type\
1	Balawala	Cultivated Wheat
2	Beelwa	Cultivated Wheat
3	Goner	Cultivated Mustard
4	Neota	Cultivated Wheat
5	Bagru	Cultivated Wheat
6	Dhanikalam	Fallow land
7	Bhankrota	Cultivated Wheat
8	Jaisinghpura	Cultivated Wheat

Soil sampling and laboratory analysis

Total forty surface soil samples (0-15 cm) were collected from eight different villages of Sanganer block with the help of a spade. Firstly, grass, dead plants and other soil surface materials were removed before sampling. A "V" shaped cut of 0–15 cm depth was made at random sites and soil samples were collected in a labeled polythene bag.

To reduce the sample size, quartering technique was adopted. For assessment of selected soil physical and chemical parameters, the soil samples were air-dried, mixed thoroughly and passed through a 2 mm sieve (Tables 1, 2).

Statistical analysis

The relationship between different soil characteristics and micronutrient contents in soils and plants were determined using correlation coefficients:

$$r = \sqrt{\frac{SP\ (xy)}{SS\ (x),\ SS\ (y)}}$$

Where,

r = Correlation coefficient,
SP (xy) = Sum product of x, y variables,
SS (x) = Sum of square of x variable,
SS (y) = Sum of square of y variable.

RESULTS AND DISCUSSION

Physico-chemical properties

The pH of the soil is an important property because it affects nutrients availability and supply, microbial growth and the physical state of the soil. The pH values represents, the combined effect of acid-base reactions occurring in the soil environment (Mokolobate and Haynes 2002). Soil pH of the study area ranged from 6.2 to 8.9 with a mean value of 7.43. Result of this study showed, soil was moderately alkaline to alkaline in nature. The acidic pH was observed in only one sample (sample no 23), neutral pH observed in 47.5% of the samples and 50% of the samples were alkaline in nature. The EC of soil

Table 2. Procedure used for physical and chemical analysis of soil.

Properties	Method applied	Reference
Physical properties		
Bulk density (Mg kg^{-1})	Pycnometer	Black *et al*. (1965)
Particle density (Mg kg^{-1})	Pycnometer	Black *et al*.(1965)
Water holding capacity	Keen box	Piper (1966)
Chemical properties		
pH	Glass electrode pH meter	Jackson (1973)
EC (dSm^{-1})	Electrical conductivity meter	Jackson (1973)
Organic carbon (%)	Wet oxidation method	Walkey and Black (1934)
Available nitrogen	Alkaline Potassium permanganate	Subbiah and Asija (1956)
Available phosphorus	Modified Olsen's method	Olsen *et al*.(1954)
Available potassium	Extractable K_2O Ammonium acetate	Schollenberger and Simon (1945
Exchangeable calcium and magnesium	EDTA titration method	Jackson (1973)
Available sulfur	Turbidimetric method	Chesnin and Yien (1950)
Cationic Micronutrient	DTPA solution by Atomic	Lindsay and Norvell (1978)
Zn, Fe, Cu and Mn (mg/kg)	Absorption Spectrophotometer	

Table 3. Soil Physico-chemical parameters of different villages of Sanganer block of Jaipur District in Rajasthan.

Soil parameters	Range	Mean	SD	CV
pH	6.2-8.9	7.43	0.54	7.21
EC	0.08-1.18	0.44	0.26	58.45
Organic carbon (%)	0.3-1.92	0.75	0.35	46.20
BD (g cm^{-3})	1.25-1.46	1.34	0.04	3.22
PD (g cm^{-3})	2.46-2.73	2.64	0.06	2.17
Porosity (%)	40.65-51.87	49.11	1.92	3.92
WHC (%)	32.52-21.25	39.53	4.72	11.94

Table 4. Nutrient rating of the soil test values. Source: (Ramamoorthy and Bajaj 1969).

Parameters	Low	Medium	High
Organic carbon (%)	<0.5	0.5-0.75	>0.75
Available N (kg/ha)	<280	280-560	>560
Available P (kg/ha)	<12.5	12.5-25	>25
Available K (kg/ha)	<135	135-335	>335
Available S (kg/ha)	<10	10-20	>20
	Deficient	Sufficient	
Magnesium (Meq/100 g)	<1.5	>1.5	
Calcium (Meq/100 g)	<1.0	>1.0	

varied between maximum 1.18 dSm^{-1} and minimum 0.08 dSm^{-1} with an average value of 0.44 dSm^{-1}. EC with value <1 dSm^{-1} indicates that soils are free from salinity (Desavathu *et al.* 2018), which account for 97.5% of the entire study. The maximum value (1.18 dSm^{-1}) obtained in Jaisinghpura village (S37). The soil organic carbon of the study area is low and ranged from 0.32 to 1.92% with a mean value of 0.75%. It was observed that only one sample from Goner village had a high value (1.92%) for organic carbon, while the majority of the samples were in the low organic carbon category (<0.5%) (Table 3). The particle and bulk density of the soil samples ranged from 2.46 to 2.73 Mg m^{-3} 1.25 to 1.46 Mg m^{-3} with a mean value of 2.64 Mg m^{-3} and 1.34 Mg m^{-3}, respectively. The water holding capacity and porosity of soil sample ranged from 32.52 to 51.52% and 40.65 to 51.87% with an average value of 39.53% and 49.11%, respectively.

Status of macronutrients

The perusal data presented in Table 4 revealed, low status in available nitrogen on the majority of the study area. The nitrogen content of the soil samples varied from 150.32 to 350.30 kg ha^{-1} with a mean value of 255.28 kg ha^{-1}. The lowest (150.32 kg ha^{-1}) range was observed in village Neota while highest (350.3 kg ha^{-1}) was observed in village Goner. As per limits suggested "(Ramamoorthy and Bajaj 1969), 65% of the soil samples obtained had low nitrogen levels and 37% had medium nitrogen levels (Table 4). Similar findings were also reported in Visakhapatnam district of Andhra Pradesh (Desavathu *et al*. 2018).

The available phosphorus of the soil samples varied from 14.68 to 36.13 kg ha^{-1} with an average value of 26.51 kg ha^{-1}. The lowest (14.68 kg ha^{-1}) value was observed in village Neota while highest (36.13 kg ha^{-1}) was observed in village Bagru. About 57.5% of the samples, showed high phosphorus content and remaining samples were medium in phosphorus which account for 42.5%. Similar results were also observed in Tonk District of Rajasthan Meena *et al.* (2006).

The potassium content in the study area was medium and ranged between maximum 504 kg ha^{-1} and minimum 123.2 kg ha^{-1} with a mean value of 259.40 kg ha^{-1}. The lowest (123.2 kg ha^{-1}) value of potassium was observed in village Bagru while highest (504 kg ha^{-1}) was observed in village Dhanikalam. About 87.5% of the samples, showed medium potassium content, 10% of the samples were high and rest (2.5%) showed, low in potassium content. Such results were also reported in Jhotwara Panchayat of Jaipur District (Choudhary *et al*. 2017). The data analyzed showed, high status of calcium content on the majority of the study area (90% samples). The range of calcium content determined was 0.8 to 39 Meq/100 g with a mean value of 12.22 Meq/100 g. The lowest (0.8 Meq/100g) range was observed in village Bagru while highest (39 Meq/100 g) was observed in village Balawala 90% of the soil samples were in high levels of calcium

Table 5. Status of available macronutrients viz., N, P, K, Ca, Mg, S in soils of Sanganer Block.

Soil characteristics	Range	Mean	SD	CV
N (kg ha^{-1})	150.32-350.3	255.28	45.92	17.99
P (Kg ha^{-1})	14.68-36.13	26.51	5.60	21.14
K (Kg ha-^{1})	123.2-504	259.40	75.54	29.12
Ca (Meq/100g)	0.8-39	12.22	8.96	73.37
Mg (Meq/100g)	1.4-91	38.02	24.69	64.95
S (mg kg^{-1})	0.97-11.47	4.78	2.35	49.13

Table 6. Micronutrient rating of the soil test values.

Micronutrients	Deficient	Sufficient	High
Zinc (mg kg^{-1})	<0.6	0.6-1.2	>1.2
Copper (mg kg^{-1})	<0.2	0.2-0.4	>0.4
Iron (mg kg^{-1})	<4.5	4.5-9	>9
Manganese (mg kg^{-1})	<3.5	3.5-7	>7

content and only 10% of soil samples were in low levels of calcium content.Magnesium is a major constituent of chlorophyll and act as powerhouse behind photosynthesis in plants. The magnesium content in the study area ranged from 1.4 to 91 Meq/100 g with an average value of 38.02 Meq/100 g. The lowest (1.4 Meq/100 g) value of magnesium was observed in village Bagru while highest (91 Meq/100 g) was observed in village Balawala. The data revealed that the magnesium level of all the samples (100%) was in the high range.The sulfur content in study area was low which varied from 0.97 to 11.47 mg kg^{-1} with a mean value of 4.78 mg kg^{-1}. The lowest (0.97 mg kg^{-1}) value of sulfur was observed in village Bagru while highest (11.7 mg kg^{-1}) was observed in village Goner. About 97% of the samples showed low sulfur content, 2.5% of the samples were marginal and 0% samples were high in sulfur content (Tables 4-9).

Micronutrients (Fe, Cu, Mn and Zn)

Intensive cropping system makes use of harmful fertilizers and high yielding varieties which leads to micronutrient deficiency in soil. Therefore, it is important to monitor the concentration of micronutrients (Fe, Mn, Cu and Zn) in soil.The range of iron content in soil samples varied from 1.28 to 4.83 mg kg^{-1} with an average value of 2.98 mg kg^{-1}. This showed low status of available iron in the study area which account for 92.5% of samples.The lowest (1.28 mg kg^{-1}) range was observed in village Goner while highest (4.83 mg kg^{-1}) was observed in village Neota. These findings are in confirmation with available micronutrient status in Jhunjhunu block of Sikar District (Kumar and Babel 2011).

Table 7. Status of available micronutrients viz., Fe, Zn, Mn and Cu in soils of Sanganer Block.

Micronutrients	Soil characteristics	Range	Mean	SD
Fe (mg kg^{-1})	1.2-4.83	2.98	0.84	28.35
Mn (mg kg^{-1})	0.14-1.02	0.44	0.19	42.37
Cu (mg kg^{-1})	1.19-4.68	3.41	1.04	30.47
Zn (mg kg^{-1})	0.21-0.64	0.30	0.10	34.06

Table 8. Nutrient index values of Sanganer Town in Jaipur District of Rajasthan.

Available nutrients	Nutrient index values	Category
Nitrogen	1.4	Low
Phosphorus	2.6	High
Potassium	2.1	Medium
Sulfur	1.0	Low
Organic carbon	1.4	Low
Copper	3.0	High
Manganese	1.0	Low
Iron	1.1	Low
Zinc	1.1	Low

The available manganese content in soil samples varied between, maximum 1.42 mg kg^{-1} and minimum 0.42 mg kg^{-1} with 0.44 mg kg^{-1} as an average value. The lowest (0.42 mg kg^{-1}) range was observed in village Neota while highest (1.42 mg kg^{-1}) was observed in village Beelwa. It was observed that entire study area was low (<3.5 mg kg^{-1}) in manganese content (as per critical limit suggested (Lindsay and Norvell 1978).

The available copper content in soil samples varied from 1.19 to 4.68 mg kg^{-1} with a mean value of 3.41 mg kg^{-1}.The lowest (1.19 mg kg^{-1}) value of copper was observed in village Goner while highest (4.68 mg kg^{-1}) was observed in village Balawala. The data revealed that the entire study area was high (>0.40 mg kg^{-1}) in copper content. The available zinc in the study area ranged from 0.21 to 0.64 mg kg^{-1} with a mean value of 0.30 mg kg^{-1}.The lowest (0.21 mg kg^{-1}) range was observed in village Neota while highest (0.64 mg kg^{-1}) was observed in village Bhankrota. It was observed that 95% of the study area was deficient (<0.60 mg kg^{-1}) in zinc content and only 5% study area was marginal in zinc content. Such results were also recorded in soils of Mokala region of Rajasthan (Bhanwaria *et al*. 2011).

Soil nutrient index

To compare the levels of soil fertility in different

Table 9. Correlation between soil physico-chemical properties of Sanganer block of Jaipur District in Rajasthan. Note: '*' represents significant at 0.05 level, '**' represents significant at 0.01 level.

	pH	EC	BD	PD	Porosity	WHC	OC	N	P	K	Ca	Mg	S	Fe	Mn	Cu	Zn
pH	1																
EC	. 383*	1															
BD	.076	-.198	1														
PD	-.112	-.005	.122	1													
Porosity	-.132	.173	-.805**	.490**	1												
WHC	-070	.307	-.432**	-.117	.311	1											
OC	-.283	.234	-.663**	-.081	.531**	.745**	1										
N	-.343*	.343*	-.441**	252	.537**	.530**	754**	1									
P	-.194	.035	-.310	.053	.292	.136	.110	.202	1								
K	-.036	.232	-.045	-.007	.042	.417**	.105	.097	. 096	1							
Ca	.100	-.262	.186	-.240	-.307	-.265	-.210	-.417**	-.254	. 030	1						
Mg	.181	.172	-.059	-.205	-.062	.259	.128	-.078	-.092	.268	.180	1					
S	.286	.608**	-.177	-.152	.072	.045	.123	.191	-.007	-.102	-.186	.163	1				
Fe	-.673**	-.082	-.015	.161	. 110	-.153	.133	.308	.169	-.099	.176	-.248	.060	1			
Mn	.048	-.053	.329*	. 213	-.150	.169	.086	. 070	-.286	.167	.092	.109	-.045	-.067	1		
Cu	.065	-.213	.588**	.080	-.469**	-.812**	-.857**	-.638**	-.090	-.117	.249	-.128	-.053	.160	-.167	1	
Zn	-.017	.005	.250	.157	-.119	-.239	-.145	-.117	-.723**	-.252	-.004-	.175	-.068	.123	.043	.220	1

areas, it was necessary to obtain a single value for each nutrient using nutrient index approach proposed (Parker *et al.* 1951). The nutrient index (N.I) is a measurement of the soil's ability to provide nutrients to plants (Singh *et al.* 2016). Based on nutrient index values, soil fertility is classified as low (<1.67), medium (1.67-2.33) and high (>2.33). The nutrient index values for macro and micronutrients of soil samples are given in Table 8. The NI was evaluated for the soil samples analyzed using following formula:

Nutrient Index (N.I.) = (NL × 1 + NM × 2 + NH × 3) / NT

Where,

NL: Indicates number of samples falling in low class of nutrient status,

NM: Indicates number of samples falling in medium class of nutrient status,

NH: Indicates number of samples falling in high class of nutrient status,

NT: Indicates total number of samples analyzed for a given area.

Correlation between physical and chemical properties of soil

The pH of the soil samples showed positive and significant correlation with EC (r = 0.383*) at 5% level of significance in overall sample observation and also negatively significantly correlated with nitrogen (r = -0.343*) and iron (r = -0.673*). The EC of soil samples showed positive and significant correlation with nitrogen (r = 0.343*) and sulfur (r = 0.608**) at 5% and 1% level of significance in overall sample observation.The bulk density of soil samples showed negative and significant correlation with porosity (r = -0.805**), water holding capacity (r = -0.432**), organic carbon (r = -0.663**) and nitrogen (r = -0.441**) at 5% and 1% level of significance. The particle density of soil samples showed positive and significant correlation with porosity (r = 0.490**) at 5% and 1% level of significance.The water holding capacity of soil samples showed positive and significant correlation with organic carbon (r = 0.745**), nitrogen (r = 0.530**) and potassium (r = 0.417**) at 5% and 1% level of significance.The porosity of the soil samples showed positive and significant correlation with organic carbon (r = 0.531**) and nitrogen (r = 0.537**) at 5% and 1% level of significance.The organic carbon in soil samples showed positive and significant correlation with nitrogen (r = 0.754**) at 1% level of significance. OC of soil also showed negative and significant correlation with copper (r = -0.857**).The available nitrogen in soil samples showed negative and significant correlation with calcium (r = -0.417**) and copper (r = -0.638**) and positively non – significantly correlated with phosphorus (r = 0.202), potassium (r = 0.097), sulfur (r = 0.191), iron (r = 0.308) and manganese (r = 0.070).

The available phosphorus in soil samples showed negative and significant correlation with zinc (r = -0.723**) at 5% and 1% level of significance and also negatively non – significantly correlated with sulfur (r = -0.007), calcium (r = -0.254), magnesium (r = -0.092), manganese (r = -0.286) and copper (r = -0.090).The potassium in soil samples showed negative and non – significant correlation with sulfur (r = -0.102), zinc (r = -0.252), copper (r = -0.117) and iron (r = -0.099) and also positively non– significantly correlated with calcium (r = 0.030), magnesium (r = 0.268) and manganese (r = 0.167).The iron content in soil samples showed positive non – significant correlation with copper (r = 0.160) and zinc (r =0.123) and negative and non – significant correlation with manganese (r = -0.067). The manganese content in soil samples showed positive non – significant correlation with zinc (r = 0.043) and negative and non – significant correlation with copper (r = -0.167). The copper content in soil samples showed positive non – significant correlation with zinc (r = 0.220). This result was similar in the spatial distribution of micronutrients in soils of Patiala District (Kumar and Babel 2011).

CONCLUSION

An attempt is made to study Soil fertility of Sanganer block by collecting 40 soil samples from the surface horizon (0-15 cm). The results revealed that soil of the study area is alkaline in reaction. The organic carbon content is low which may be due to low incorporation of organic manures (green manure, organic manure) and high temperature of the study area which increases the decomposition by increasing the activity of microorganisms and enzymes. By considering nutrient index, the soils of Sanganer block are low in nitrogen, organic carbon, sulfur, iron, zinc and manganese, medium in potassium and high in phosphorus and copper content. In the context of this study, it can be concluded that regular soil monitoring for residual soil nutrients is necessary because of the varying amounts of nutrients in soil and that only the appropriate quantities of macro and micronutrients should be applied. Also it would be helpful for the farmers to arrange the amount of which fertilizers and nutrients needed to soil in order to improve the quality of produce and increase the percentage yield of crops.

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