Research Article

Relationship between Soil Physico-Chemical Properties and Available Macronutrients in Loamy Sand Soils

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Abstract

Forty surface soil samples (0-15 cm) were collected from gharsana tehsil of Sriganganagar district were studied for the N, P and K status in relation to important soil factor. All the soil sample had low amount of available nitrogen, low to medium in phosphorus and medium to high in potassium content. Nitrogen and potassium are highly significantly positively correlated with organic carbon and CEC. However, nitrogen are negatively correlated with $CaCO_3$ and sand, these are positively correlated with clay, but the values are non significant. Available phosphorus in soil shows the positive and non-significant correlation with organic carbon and CEC, while significant negative correlation with clay and negative correlation with $CaCO_3$ content of soil.

Keywords: Correlation, macronutrient and organic carbon

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Introduction

The deficiency of nutrients has become major constraint to productivity and sustainability of soils. For the better growth of plants, amongst many other factors, thirteen essential elements are required to be present in soil in proper proportion and available form. Amongst these elements, nitrogen (N), phosphorus (P) and potassium (K) are categorized as macronutrients and are required in larger quantity than the other nutrients. The selection of proper rate of these plant nutrients is based on the knowledge of nutrient requirements of crop and nutrient supplying power of the soil. Macronutrients are important for maintaining soil health and also increasing productivity of crops. The most important constituents in soil is organic matter, an appreciable amount of organic matter in soil tremendously increase soil fertility. Decay of organic matter release nitrogen, phosphorus and mineral nutrients in a form available to plant. Availability of N, P and K induce better germination of seeds and hence subsequent better growth and stronger root development. Agriculture activities change the soil chemical, physical and biological properties. The core constraints in relation to land use include, depletion of organic matter due to wide spread use of biomass as fuel, depletion of nutrients, removal of top soil by erosion, change of physical properties and increased soil salinity. Hence an attempt was made to assess the available status of macronutrients and their relationship with different properties of soils of Gharsana tehsil of Sriganganagar district.

Materials and Methods

Forty soil samples (0-15 cm depth) were collected from different village of Gharsana tehsil of Sriganganagar district. Gharsana tehsil is located in north-west part of the Sriganganagar district (Rajasthan) and situated between 29°02’ north latitude and 73°05’ east longitude and elevation of 156 m from mean sea level. The climate of the area is typically semi-arid. Rainfall and temperatures are the two main elements of the climate. The rainfall is seasonal and not properly distributed and it varies between 100 to 350 mm annually which is mostly received during the months of July to September. The soil samples were air dried and passed through 2mm sieve and analyzed for their physico-chemical properties adopting standard procedures. Correlation coefficients between various soil parameters and available macronutrients were using the procedure given by [1].

Results and Discussion

Physico-chemical characteristics of loamy sand soils

The properties of soil presented in **Tables 1, 2** and **3**. Soils were in loamy sand, moderately to highly alkaline in nature, EC is varied from 0.04 to 0.87 dSm^{-1} with mean value 0.53 dS m^{-1}. The organic carbon content in varied between 0.07 to 0.29 per cent. On the basis of limits suggested by [2] all the soil samples under investigation rated low (< 0.5 per cent) in the soil organic carbon content. The calcium carbonate content in soils ranged between 2.80 to 6.40 per cent. The CEC of soils varied from 5.40 to 11.42 cmol.(p^+) kg^{-1}. The sand, silt and clay content of soils ranged from 76.60 to 81.50, 12.20 to 16.00 and 3.70 to 7.60 with a mean value 79.14, 13.91 and 6.09 per cent, respectively.

Table-1 Simpal correlation coefficients between soil parameters and available macronutrients

Sample Code No.	Content	1 EC	2 pH	3 OC	4 CaCO3	5 CEC	6 Sand	7 Silt	8 Clay	9 N	10 P	11 K
1	**EC**	1	-0.013	-0.054	-0.015	-0.114	-0.161	0.259**	-0.029	-0.169	0.229**	-0.280**
2	**pH**		1	-0.097	-0.185*	0.157	-0.218**	0.252**	0.015	-0.104	-0.347**	-0.235**
3	**OC**			1	-0.131	0.268**	-0.195*	0.055	0.226**	0.427**	0.002	0.375**
4	**CaCO3**				1	-0.307**	0.695**	-0.471**	-0.357**	-0.043	-0.064	0.255**
5	**CEC**					1	-0.336**	0.259**	0.318**	0.463**	0.059	0.299**
6	**Sand**						1	-0.541**	-0.720**	-0.038	0.013	0.207**
7	**Silt**							1	0.019	0.180*	-0.208**	-0.087
8	**Clay**								1	0.072	-0.17	-0.017

*indicates significant at 5% level ** indicates significant at 1% level of significance

Table 2 Physico-chemical characteristics of soils

Sr no.	Sample code no.	pH	EC (dSm^{-1})	Organic carbon %	$CaCO_3$ (%)	CEC	Macro nutrients		
							N	P	K
1	S_1	8.81	0.60	0.22	4.00	5.40	55.16	33.15	237.85
2	S_2	8.73	0.40	0.18	6.00	6.40	55.16	42.11	224.72
3	S_3	8.72	0.32	0.21	5.40	7.40	145.00	35.44	250.28
4	S_4	8.73	0.04	0.23	5.80	11.40	151.70	46.59	295.21
5	S_5	8.25	0.80	0.22	6.10	7.40	150.46	36.73	284.10
6	S_6	7.50	0.80	0.19	5.70	6.20	151.70	41.21	290.88
7	S_7	7.54	0.20	0.11	6.40	6.50	93.77	32.25	280.11
8	S_8	9.67	0.83	0.12	5.11	6.40	74.47	27.77	235.94
9	S_9	8.83	0.49	0.14	5.90	10.40	152.64	25.08	282.91
10	S_{10}	8.70	0.20	0.19	5.80	7.40	168.00	17.02	277.76
11	S_{11}	8.89	0.80	0.13	6.20	6.05	118.11	15.23	252.51
12	S_{12}	8.61	0.40	0.29	2.80	7.51	165.25	22.40	267.36
13	S_{13}	8.90	0.58	0.10	6.00	6.85	113.08	15.23	262.92
14	S_{14}	8.83	0.15	0.14	4.60	6.20	55.16	37.65	251.82
15	S_{15}	8.91	0.23	0.17	4.40	10.15	130.34	13.44	300.00
16	S_{16}	9.42	0.52	0.15	4.20	8.50	125.75	17.02	226.85
17	S_{17}	8.93	0.60	0.07	4.00	6.30	55.16	20.60	218.98

18	S_{18}	9.26	0.80	0.08	5.80	6.30	74.47	38.25	246.34
19	S_{19}	8.88	0.50	0.18	3.20	11.40	165.46	33.15	260.95
20	S_{20}	8.79	0.20	0.14	5.60	7.10	110.56	30.46	250.70
21	S_{21}	8.72	0.21	0.13	3.00	7.60	113.08	20.60	254.80
22	S_{22}	8.60	0.48	0.17	5.50	5.55	150.45	13.14	254.83
23	S_{23}	8.75	0.85	0.16	5.90	9.40	135.16	17.02	248.65
24	S_{24}	9.35	0.52	0.20	3.50	7.92	151.70	22.40	241.85
25	S_{25}	8.98	0.45	0.29	2.89	11.42	168.14	17.02	310.22
26	S_{26}	9.22	0.20	0.17	4.10	11.35	125.95	20.60	261.15
27	S_{27}	8.60	0.30	0.16	5.40	9.20	123.55	30.46	266.07
28	S_{28}	8.82	0.81	0.29	5.80	8.54	108.46	27.77	259.89
29	S_{29}	8.84	0.84	0.17	4.20	8.60	115.85	42.11	260.86
30	S_{30}	9.12	0.45	0.14	3.70	6.90	100.47	27.77	251.65
31	S_{31}	8.53	0.40	0.16	3.20	8.50	124.65	32.25	256.39
32	S_{32}	8.69	0.20	0.13	3.80	8.20	90.35	30.46	251.82
33	S_{33}	8.50	0.82	0.15	4.50	8.80	95.25	27.77	232.99
34	S_{34}	8.76	0.53	0.16	4.20	11.00	135.34	36.73	226.85
35	S_{35}	8.40	0.60	0.12	3.50	7.52	151.70	41.21	218.98
36	S36	8.32	0.85	0.21	4.00	7.40	55.16	41.59	246.34
37	S_{37}	8.70	0.84	0.17	3.30	9.60	137.12	42.45	230.16
38	S_{38}	8.52	0.87	0.15	3.00	9.20	102.76	42.11	238.88
39	S_{39}	8.58	0.75	0.14	3.40	8.90	92.25	39.42	212.92
40	S_{40}	8.82	0.85	0.13	4.50	9.60	95.18	46.59	296.16
MEAN		**8.74**	**0.53**	**0.17**	**4.61**	**8.16**	**117.10**	**30.01**	**255.49**
MAX.		**9.67**	**0.87**	**0.29**	**6.40**	**11.42**	**168.14**	**46.59**	**310.22**
MIN.		**7.50**	**0.04**	**0.07**	**2.80**	**5.40**	**55.16**	**13.14**	**212.92**

Macronutrient status in loamy sand soils

The available nitrogen in soils varied from 55.16 to 168.14 kg ha^{-1}. On the basis of criteria, suggested by [3] all the soils samples were found deficient in available nitrogen. The low level of available nitrogen may be ascribed to several factors, including low organic carbon, high pH and $CaCO_3$ content. These might have resulted in decomposition and nitrogen mineralization's favouring higher ammonia volatilization losses, reduced nitrification and subsided activity of nitrogen fixing microbes [4].

The phosphorus content of the soils ranged from 13.14 to 46.59 kg P_2O_5 ha^{-1} with a mean value 30.01 kg P_2O_5 ha^{-1}. The variation in available phosphorus appears to be due to marked variation in organic carbon, $CaCO_3$ and other soil characteristics. Considering the available phosphorus (P) rating values that is, low (<28 kg P_2O_5 ha^{-1}), medium (28-56 kg P_2O_5 ha^{-1}), and high (>56 kg P_2O_5 ha^{-1}) as suggested by [5]. It was observed that 45 per cent soils are low, 55 per cent soils are medium with respect to available phosphorus status of studied area.

The available potassium in soils ranged between 212.92 to 310.22 kg K_2O ha^{-1}. It might due to the presence of most of mica (biotite and muscovite both) in finer fraction (<0.002mm size). On the basis of limits, 80 per cent soils (32 soil samples) were medium and 20 per cent (8 samples) were high in respect to available potassium content.

Table 3 Partical size distribution and textural classes of soils

Sample code No.	Sand (%)	Silt (%)	Clay (%)	Textural class
S_1	80.50	12.80	5.60	Loamy sand
S_2	80.90	12.20	5.20	Loamy sand
S_3	80.10	12.90	5.40	Loamy sand
S_4	80.60	12.50	5.40	Loamy sand
S_5	80.90	13.80	5.10	Loamy sand
S_6	80.20	13.30	5.50	Loamy sand
S_7	81.50	12.60	5.40	Loamy sand
S_8	80.10	13.90	5.30	Loamy sand
S_9	80.40	13.60	5.80	Loamy sand
S_{10}	80.20	13.80	5.80	Loamy sand
S_{11}	80.80	13.90	5.10	Loamy sand
S_{12}	77.90	13.80	7.50	Loamy sand
S_{13}	80.60	13.20	5.10	Loamy sand
S_{14}	79.70	14.80	4.50	Loamy sand
S_{15}	79.00	14.00	6.80	Loamy sand
S_{16}	79.00	14.50	6.00	Loamy sand
S_{17}	78.70	14.20	6.90	Loamy sand
S_{18}	79.50	14.10	4.60	Loamy sand
S_{19}	80.00	16.00	3.70	Loamy sand
S_{20}	79.10	13.50	6.90	Loamy sand
S_{21}	78.00	13.90	6.80	Loamy sand
S_{22}	79.10	14.50	6.10	Loamy sand
S_{23}	79.60	14.20	6.00	Loamy sand
S_{24}	77.90	14.50	5.70	Loamy sand
S_{25}	77.90	15.10	6.90	Loamy sand
S_{26}	78.20	13.50	7.50	Loamy sand
S_{27}	79.40	13.30	6.80	Loamy sand
S_{28}	76.60	15.10	7.60	Loamy sand
S_{29}	78.80	13.00	6.90	Loamy sand
S_{30}	78.50	13.90	6.20	Loamy sand
S_{31}	78.00	14.30	6.70	Loamy sand
S_{32}	78.20	14.00	6.50	Loamy sand
S_{33}	78.60	14.20	7.00	Loamy sand
S_{34}	78.30	13.90	7.50	Loamy sand
S_{35}	78.50	14.50	6.00	Loamy sand
S_{36}	78.60	14.00	6.20	Loamy sand
S_{37}	78.00	13.90	6.50	Loamy sand
S_{38}	77.90	14.80	6.00	Loamy sand
S_{39}	77.90	14.20	6.40	Loamy sand
S_{40}	78.00	14.30	6.70	Loamy sand
Mean	**79.14**	**13.91**	**6.09**	
Maximum	**81.50**	**16.00**	**7.60**	
Minimum	**76.60**	**12.20**	**3.70**	

Relationship between macronutrient status and soil properties in loamy sand soils

Available nitrogen

The positive and highly significant correlation were found between available nitrogen and organic carbon (r= 0.427^{**}), CEC (r=0.463^{**}) and silt (r=0.180^{**}) and non significant and positive correlation with clay (r= 0.072), while

non significant and negative correlation with $CaCO_3$ (r=- 0.043) and sand (r=- 0.038). The significant positive correlation of available nitrogen with organic carbon could be due to adsorption of NH_4^+- N by humus complex [6]. Secondly, most of the soil nitrogen is found in organic form, therefore, this relationship was observed to continuous addition of farm residues and FYM which being still under the state of decomposition and the higher rate of mineralization of organic matter due to soil condition being optimum. The similar result are found by [7].

Available phosphorus

Available phosphorus in soil under wheat cultivation show the positive and non-significant correlation with organic carbon (r= 0.002) and CEC (r=0.059), while highly significant and negative correlation with silt (r=-0.208**) and significant negative correlation with clay (r= -0.170*) and non significantly and negative correlation with $CaCO_3$ content (r= -0.064) of soil. This behaviour is due to the fact that decomposition of organic matter releases CO_2 which on dissolution forms H_2CO_3 which is responsible for decreases the pH of soil. Thus, the availability of phosphorus is affected not only available but even the potentially available forms of nutrient elements are concentrated in clay, silt and organic fractions in soil. Similar results were reported by several workers [8-9]. Available phosphorus was significant and negatively correlated with pH because at higher pH calcium can precipitate with phosphorus as Ca-phosphate and reduce availability [10].

Available potassium

Available K in soils had highly positive significant correlation with organic carbon (r= 0.375**), $CaCO_3$ (r= 0.255**), CEC (r= 0.299**) and sand (r= 0.207**) and non significant and positive correlation with clay (r= 0.004) of soil, while, non significant and negative correlation with silt (r= -0.017). This might be due to creation of favourable soil environment with presence of organic matter. The similar result are found by [11] stated that soil of arid and semi-arid regions were rich in available K. [12] generalized that K content of soil, series under Vertisols was higher than that of Alfisols and related soils. Present findings are in conformity with [13-14].

Conclusion

The soil fertility status of Gharsana tehsil anticipate problems in successful maintenance of irrigated agriculture due to majority of soils were found strongly alkaline and calcareous in nature and organic carbon is very low (< 0.50%). Available nitrogen and phosphorus status of soils of Gharsana tehsil shows 100 per cent and 45 per cent deficient, respectively. The poor fertility status of Gharsana tehsil and positive or negative interaction of nutrient and soil properties influenced the production of crop.

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