International Journal of Plant & Soil Science

20(1): 1-7, 2017; Article no.IJPSS.36858
ISSN: 2320-7035

Soil Characterization of Advance Research Centre for Rain Fed Agriculture Farm of Sher-e-Kashmir University of Agricultural Sciences and Technology-Rakh-Dhinsar, Jammu- (J&K)

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Authors' contributions

This work was carried out in collaboration between all authors. Author MPS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AKM, AS, KRS and RCB managed the analyses of the study. Authors APR and VMA managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2017/36858
Editor(s):
(1) Marco Trevisan, Professor, Institute of Agricultural Chemistry and Environmental Research Centre BIOMASS, Faculty of Agriculture, Catholic University of the Sacred Heart, Italy.
Reviewers:
(1) Omovbude Sunday, University of Port Harcourt, Nigeria.
(2) Adams Sadick, Soil research Institute, Ghana
Complete Peer review History: http://www.sciencedomain.org/review-history/21815

Original Research Article

Received 20th September 2017
Accepted 2nd November 2017
Published 9th November 2017

ABSTRACT

Soil characterization of Advance Research Centre for Rainfed Agricultural Farm, Rakh-Dhiansar, SKUAST-Jammu was undertaken to monitor the status of various soil physico-chemical and biological properties such as pH, organic carbon (OC), N, P_2O_5, K_2O, Zn, Cu, Mn, Fe, bacterial and fungal counts. Eighty-eight soil locations were selected and finally twenty two composites soil samples from four different blocks of the farm covering 14 ha of area were studied. All the soil samples were analysed as per standard methods. The results indicated that soil pH of all the blocks was almost neutral in reaction ranging from 6.4-6.9 whereas content of organic carbon falls in low to high category which varied from 1.20 to 7.80 $g.kg^{-1}$. The available nitrogen content falls in low to medium category, the value ranged from 31.4 to 162.9, $kg.ha^{-1}$ in all the blocks, whereas available phosphorous content ranged from low to high category values being 9.4 to 33.0 $kg.ha^{-1}$ and

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potassium content varied 67.76 to 198.44 kg.ha^{-1} and come in category of low to medium range. The DTPA extractable form of cationic micronutrients *viz*., Zn, Cu, Mn and Fe were also studied. Zinc was found insufficient range (0.72-1.24 mg g^{-1}), whereas Cu, Mn and Fe were under low to sufficient category as per their contents varied from 0.09 to 0.51, 0.12 to 4.17 and 1.39 to 49.37, mg.kg^{-1} respectively. Microorganisms such as bacteria and fungi counts attain the levels of medium range as their distribution varied from 21.75 to 53.34 and 3.20 to 4.25 (CFU)$^{-1}$ soil respectively in all the blocks. Majority of the soil characteristics were higher in Block-D followed by Block-C, Block-A and Block-B.

Keywords: Bacteria; condition; fungi; micronutrients; rainfed; soil properties.

1. INTRODUCTION

Rain fed agriculture contributes 58% of global food basket and constitutes 66% of the net sown area in India [1]. Site specific nutrient management has received considerable attention due to potential benefits of increasing input use efficiency, improving economic margins of crop production and reducing environmental risks [2].

Hence, a comprehensive understanding of spatial variability of soil properties is becoming increasingly essential in agriculture as soil properties vary from field to a large region scale and are influenced by geology, topography climate as well [3]. The Advance Research Centre for Rain fed Agriculture Farm of Sher-e-Kashmir University of Agricultural Sciences and technology- Rakh-Dhinsar, Jammu-(J&K) has 14 ha land, out of which 22.5 acres under cultivation, 2.2 acres occupied with agro forestry and rest 10.3 acres under buildings including water harvesting tank and water drainage. The mandate of the station is to increase and stabilize production of dry land crops in a harsh region of limited, erratic rainfall and nutrient poor soils through use of improved plant type, technologies, farm resources and the optimum use of limited natural resources. The Kandi belt consisting of sub mountainous area of Jammu region arising from Punjab plains with gentle slope of nearly three degrees and touching with low hilly Siwalik system of rocks lies in the outer Himalayas of Jammu region. The soils of this region are of lithosols type having undulated topography and scrub forest Gupta et al. [4]. Loss of organic matter, whether by erosion or high temperature in the rainfed agro-ecosystem, adds, to impoverishment of soil resources of several elements essential for plants growth. A decline in organic matter multiplies nutrient deficiency, it falls by the two-thirds symbolizes a serious suppression in nutrient availability. In addition, fertilizer consumption in rainfed areas is very low. The challenge of improving productivity in rainfed areas can be addressed by efficient utilization of available nutrients.

Efficient nutrient management demands understanding the pathways of nutrient losses through gaseous loss, leaching loss, erosion and runoff losses and developing technologies to minimize these losses. Many water-soluble nutrients are lost through run off during intense rainfall and nutrients absorbed on the surface of soil particles-clays and silts and soil organic matter are lost when the top soil is eroded by water or wind. These losses of nutrients are not merely economic losses but may cause serious environmental problems and hence must be controlled by developing appropriate site-specific technologies.

The native available nutrients should be optimally allocated among the crops to get maximum returns by allowing optimization of nutrient production functions which relate the crop responses to applied nutrients under given soil, climate, and management factors under rainfed conditions. To avoid any risk, the fertilizer recommendation in the rainfed region should be made only in the linear response range. Fertilizer allocation to crops based on soil test and crop correlation under rainfed condition for achieving targeted yield can help in improving nutrient use efficiency by crops. The yield targets can be decided based on availability of water other inputs and financial condition of the farmer depending on the inherent particular nutrient status of the soils.

2. MATERIALS AND METHODS

Eighty eight locations were selected and finally twenty two composites soil samples were collected using global positioning systems (GPS) from four different blocks of the farm of Advance Research Centre for Rain fed Agriculture Sher-e-Kashmir University of Agricultural Sciences and technology- Rakh-Dhinsar, Jammu- (J&K) covering 35 acres of area. The value of respective location was mentioned against each sample in the Table 1. Thereafter, samples were processed and analyzed for various soil physico-chemical, biological properties and available macro- and micro-nutrients. These soils not only suffer from severe problem of erosion but also remain dry during most part of the year due to uncertain and erratic rainfall which results in poor water and nutrient retention. The rainfed soils of this region are sometimes more hungry than thirsty which adds to its low productivity. The salient characteristics of the area includes accumulation of $CaCO_3$ in the upper 150 cm of soils which results in moderate profile development and low biological activities, low organic matter content and nutrient poor materials on which they are formed. These soils not only suffer from the severe problem of the erosion but also remain dry during most part of the year due to uncertain and erratic rainfall.

Soil pH was determined by using 1: 2 soil: water suspension; organic carbon by Walkley and Black method; [5] available N by $KMnO_4$ oxidized N by using method of Subbiah and Asija [6]. Available P was determined by Olsen method [7] and available K by extraction with 1N ammonium acetate NH_4OAc solution at pH 7.0 [8]. The soil DTPA-extractable nutrients *viz*., Zn, Cu, Mn and Fe were estimated by method of Lindsay and Norvell [9]. Bacterial and fungal populations were counted by using the serial dilution method as described by Premer and Schmidt [10]. In general, the soils of the site mostly belong to orders inceptisols and oxisols with ochric and cambic surface horizons are classified at great group levels into ustifluvent and ustiorthents. Quartz is found as the most dominant mineral in the light sand fractions followed by mica and muscovite, sericite and feldspars. The clay mineralogy consists of illite, chlorite, smectite, vermiculite and kaolinite [11]. The area is slightly sloppy having average annual rainfall ranging from 900-1200 mm.

3. RESULTS AND DISCUSSION

The soil pH values showed little variation and were acidic to neutral in reaction in different blocks of the farm (Table 1). However, pH value ranged from 6.3 to 6.9, 6.4 to 6.7, 6.4 - 6.7 and 6.3 - 6.6 with mean values of 6.63, 6.55, 6.58 and 6.47 in blocks A, B, C and D respectively. The normal value of pH in soils of all the blocks might be due to less concentration of soluble salts of carbonates and bicarbonates of sodium and less deposition of OH ions on the surface soils. The average pH values of surface soils were higher in Block-C followed by Block-A, Block-B and Block-D. This might be due to very meager clay content and associated with lower water retention of these soils. These findings corroborate with the observations of Reza *et al* [12]. The wide variation in organic carbon ranging 1.08-3.60 with average value of 2.94 was obtained in Block-C followed by Block-D which varied from 1.20-3.00 with mean value of 2.24, 1.20-3.00 with average of 2.00 in Block A and 1.20-2.52 with mean value of 1.84 $g.kg^{-1}$ in Block-B respectively. The higher values of organic carbon in Block-C may be due to more stubble left out by previous crops, hence enriched organic carbon content. These results are in conformity with the findings of Kern [13], Pal et al. [14] and Kumar et al. [15].

The available N content in respect of all the blocks was found low to medium in range. The values varied from 62.7-108.5, 75.3-112.9, 31.4-162.9 and 87.8-326.1 kg ha^{-1} with mean values of 87.26, 93.03, 95.11 and 150.72 kg ha^{-1} in Blocks A, B, C and D respectively. The highest available N (150.72 kg ha^{-1}) was observed in Block-D followed by -C (95.11), B (93.03) and A (87.26). The highest content of available N in Block D might be due to more addition of organic manures and crop residues which enhanced the available N content in long run. Similar findings were also reported by Gangopadhyay et al. [16]. and Rudramurthy et al. [17] The available P content in soils of different blocks fall in low to high range with maximum average value of 24.4 kg ha^{-1} under the surface soils of Block-D followed by Block-C (21.5 kg/ha ha^{-1}), Block-A (17.8 kg ha^{-1}) and a minimum of 13.9 kg ha^{-1} in Block-B. On an average, Block D had high content of available P followed by soils of Block C, Block-A while minimum average value of available P was recorded under Block-B. The higher available P content in Block-D may be due to more application of phosphatic fertilizer for rice-wheat cultivation and relatively lower fixation of nutrient. These results corroborate the findings of Sharma et al. [18] and wang et al. [19] Available K status varied 67.76 - 198.44, 91.96 - 160.93, 75.02 - 188.76, and 71.39 - 106.48 with mean value of 117.77, 107.20, 106.68, and 81.87 kg ha^{-1} in Block D, C, A and B respectively. The average value of available K was higher in soils of Block D followed by Block-C and Block-A, whereas lowest value of available K was noted in Block-B. The lower value of available K in Block-B may due to intensive cropping with less addition of K fertilizer nutrient in comparison of removal. The results are in conformity with the findings of Hegde [20].

Table 1. Soil characterization of advance research center for rainfed agriculture farm, Rakh Dhaianshar

S. no	Blocks	GPS Reading (±5 m)	pH	OC	N	P	K	Zn	Cu	Mn	Fe	Bacteria	Fungi
				g kg^{-1}		Kg ha^{-1}			$\mu g\ g^{-1}$			Colony forming unit (CFU) (g^{-1} soil)	
1	A	N32˚37.926’ E74˚55.185’	6.5	1.2	62.7	11.5	87.12	1.66	0.51	0.69	20.00	28.67	4.25
2		N32˚37.957’ E74˚55.215’	6.7	1.8	81.5	12.5	75.02	1.23	0.47	0.37	15.47	26.04	4.20
3		N32˚37.935’ E74˚55.251’	6.7	3.0	69.0	19.8	119.79	1.40	0.49	0.12	15.94	40.70	3.79
4		N32˚37.907’ E74˚55.226’	6.7	1.56	94.1	33.0	94.38	1.24	0.51	1.14	15.96	34.50	3.79
5		N32˚37.967’ E74˚55.200’	6.9	2.04	108.5	12.5	188.76	1.62	0.24	1.00	7.52	26.55	3.79
6		N32˚37.979’ E74˚55.203’	6.3	2.40	107.8	17.7	75.02	1.67	0.34	2.34	9.41	32.50	3.79
		Range	6.3–6.9	1.2–3.0	62.7-108.5	11.5 - 33.0	75.02-188.76	1.23 – 1.67	0.24-0.51	0.12-2.34	7.52-20.00	26.04-32.50	3.79-4.25
		Mean	6.63	2	87.26	17.8	106.68	1.47	0.42	0.94	14.05	31.49	3.93
7	B	N32˚38.024’ E74˚55.178’	6.7	1.80	75.3	13.1	106.48	1.27	0.58	2.71	13.05	32.88	3.63
8		N32˚38.063’ E74˚55.139’	6.6	1.80	106.6	11.0	71.39	1.75	0.39	0.76	16.43	34.29	3.75
9		N32˚38.100’ E74˚55.108’	6.6	2.40	112.9	9.4	76.23	1.00	0.45	0.64	1.39	29.03	3.75
10		N32˚38.089’ E74˚55.077’	6.5	1.32	87.8	23.0	82.28	1.16	0.55	1.09	2.29	31.79	3.79
11		N32˚38.032’ E74˚55.093’	6.5	2.52	81.5	9.4	64.13	1.35	0.23	0.14	26.05	30.79	3.70
12		N32˚38.000’ E74˚55.079’	6.4	1.20	94.1	17.7	90.75	1.15	0.27	0.69	49.37	21.75	3.33
		Range	6.4-6.7	1.20-2.52	75.3-112.9	9.4 -23.0	71.39-106.48	1.00 - 1.75	0.23-0.58	0.14-2.71	1.39-49.37	21.75-34.29	3.33-3.79
		Mean	6.55	1.84	93.03	13.9	81.87	1.28	0.41	1.00	18.09	30.08	3.65

S. no	Blocks	GPS Reading (±5 m)	pH	OC	N	P	K	Zn	Cu	Mn	Fe	Bacteria	Fungi
				g kg^{-1}		Kg ha^{-1}			µg g^{-1}			Colony forming unit (CFU) (g^{-1} soil)	
13		N32˚37.993’ E74˚55.054’	6.5	2.28	31.4	21.9	91.96	1.59	0.14	1.03	16.18	32.29	3.45
14	C	N32˚37.975’ E74˚55.021’	6.4	1.08	75.3	15.7	140.36	0.76	0.09	0.84	5.55	38.20	3.38
15		N32˚37.966’ E74˚55.045’	6.7	1.32	69.0	21.6	122.21	1.11	0.16	0.45	10.13	37.95	3.75
16		N32˚37.965’ E74˚55.069’	6.6	1.56	119.2	27.1	116.80	2.68	0.11	0.53	9.14	38.66	3.29
17		N32˚37.942’ E74˚55.070’	6.6	7.80	162.9	18.6	160.93	1.03	0.12	0.56	6.84	30.33	4.04
18		N32˚37.912’ E74˚55.075’	6.7	3.60	112.9	24.3	128.26	1.29	0.14	0.45	18.17	30.29	3.67
		Range	6.4-6.7	1.08-3.60	31.4-162.9	15.7 – 27.1	91.96-160.93	0.76 - 2.68	0.09-0.16	0.45-1.03	5.55-18.17	30.29-38.66	3.29-4.04
		Mean	6.58	2.94	95.11	21.5	107.2	1.41	0.126	0.64	11.00	34.62	3.59
19	D	N32˚37.923’ E74˚55.103’	6.3	1.92	138.0	10.4	67.76	0.72	0.12	2.20	17.09	31.45	3.54
20		N32˚37.930’ E74˚55.123’	6.6	1.20	87.8	32.8	73.81	0.91	0.15	4.17	22.43	34.84	3.20
21		N32˚37.878’ E74˚55.113’	6.4	3.00	106.6	28.6	198.44	1.20	0.19	0.56	23.22	30.91	3.45
22		N32˚37.891’ E74˚55.145’	6.5	2.16	326.1	25.9	141.57	1.24	0.23	0.42	45.85	53.34	3.75
		Range	6.3-6.6	1.20-3.00	87.8-326.1	10.4 – 32.8	67.76-198.44	0.72-1.24	0.12-0.23	0.42-4.17	17.09-45.85	30.91-53.34	3.20-3.75
		Mean	6.47	2.24	150.72	24.4	117.77	1.02	0.163	1.59	23.91	37.03	3.50

The DTPA extractable Zn ranged from 1.23 to 1.67 in Block-A, 0.76 to 2.68 in Block-C, 1.00 - 1.75 in Block-B, and 0.72-1.24 mg.kg^{-1} in Block-D. The average value of available Zn was maximum in Block-A (1.47) followed by 1.41 in Block-C, 1.28 mg.kg^{-1} in Block B, whereas lowest value of available 1.02 mg.kg^{-1} was recorded in Block-D. The higher content of available Zn in Block-A may be due to normal pH value and higher microbial activities in rhizosphere of surface horizon. These findings corroborate the results reported by Visalakshi Devi et al. [21]. The DTPA extractable Cu content varied from 0.24 to 0.51 in Block-A, 0.23 to 0.58 in Block-B, and 0.09 to 0.16 in Block-C.0.12-0.23 mg.kg^{-1} in Block-D. The average value of available Cu 0.16 was more in Block-D followed by 0.13 in Block-C, 0.42 mg.kg^{-1} in Block A while lowest value of available Cu 0.41 mg.kg^{-1} was recorded in Block–B. The DTPA extractable Mn ranged from 0.12 to 2.34 in Block–A, 0.14 to 2.74 in Block-B, and 0.45 to 1.03 in Block-C.0.42-4.17 mg.kg^{-1} in Block-D. The average value of available Mn 1.59 mg.kg^{-1} was higher in Block-D followed by 1.00 in Block-B, 0.94 in Block-A whereas lowest value of available Mn 0.64 mg.kg^{-1} was noted in Block-C. The DTPA extractable Fe content varied from 7.52 to 20.0 in Block-A, 1.39 to 49.37 in Block-B, and 5.55 to 18.17in Block-C 3.17.09-45.85 mg kg^{-1} in Block-D. The average value of available Fe 23.91 mg kg^{-1} was highest in Block-D followed by 18.09 mg kg^{-1} in Block-B, 0.14.05 mg kg^{-1} in Block-A and minimum value of available Fe 11.0 mg kg^{-1} was observed in Block-C. The observation recorded pertaining to microorganism *viz*. bacteria and fungi given very promising information. So far distribution of bacteria are concerned it ranged from 26.04-32.50 (CFU g kg^{-1} soil) in Block-A, 21.75 to34.29 in Block B, 30.29 to 38.66 in Block-C and 30.91 to 53.34 in Block-D. The maximum average value of bacteria 37.03 (CFU g.kg^{-1} soil) was obtained in Block-D followed by in Block-C-34.62, and 31.49 in Block-A, whereas minimum value of bacteria was noted in Block-B 30.08 (CFU g kg^{-1} soil). The number of fungi varied from 3.79 to 4.25 in Block-A, 3.33 to 3.79 in Block-B, 3.29 to 4.04 in Block-C and 3.20 to 3.75 in Block –D. The higher population of fungi 3.39 (CFU g.kg^{-1} soil) was recorded in Block-A followed by in Block-C (3.59), 3.65 in Block-B while Block-D showed lowest number of fungi (3.50 CFU g kg^{-1} soil). Jadav et al. [22] also reported increasing trend in proliferation of both bacteria and fungi under similar condition. The positive relation of nitrogen (0.56), phosphorus (0.34) and potassium (0.17) with bacteria count was observed, and fungal counts were positively related with available copper (0.54). However, other parameters had no significant relationship to each other. Thind et al. [23] reported similar observation while studying the interaction effect of nitrogen, farm yard manures and microorganisms for sustainable production of rice-wheat system.

4. CONCLUSION

The present study showed wide variation in all the soil characteristics of different blocks of the research farm. However, most of the characterized parameters were higher in Block-D followed by Block-C, Block-A and Block-B. The values of available nitrogen, phosphorus and potassium were found to be positively related with bacteria whereas similar relation of fungal counts was obtained with available copper. It is observed from overall soil parameters that soils of all the blocks of the farm were generally poor in fertility and as such needs balanced nutrient management by integrated application of major- and micro- nutrients along with organic manures and bio-fertilizers to maintain soil health for improving crop productivity under rainfed condition.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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