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Evaluation of Soil Health and Soil Quality Analysis of Different Blocks of Bundi District, Rajasthan, India

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A B S T R A C T

One of the most popular phrase in agriculture is the term "Soil Health". The health of soil determines agricultural sustainability. Soil quality assessment is of paramount importance to know the appropriate management practices to be adopted for sustainable crop production. In this study, all soil chemical properties and available macronutrients status with their spatial variability in different blocks of Bundi district in Rajasthan was conducted. It is concluded that soil reaction was neutral to slightly alkaline with EC mostly below <1.0 dS m^{-1} which are favourable for crop production. The organic carbon, nitrogen and phosphorus content of these soils were found to be low to medium. Potassium was in high range. Calcium and magnesium were found to be adequate. The available sulphur in soil was recorded in medium range. Soil health and soil quality were found to be affected by the management practices adopted by the farmers and the degree of manure and fertilizer usage over a period of time. We concluded that there is a need of proper nutrition and management approaches for sustenance of soil health and soil quality which optimize the multiple functions of soil, conserve soil resources, support strategies for promoting soil health and soil quality are important. The use of organic manure for fertilization management can be recommended as a means for promoting soil health and soil quality.

Introduction

"Dokuchaev defined soil as an independent natural body developed over time under the influence of five soil-forming factors: parent rock, living organisms, climate, relief and time" (Dokuchaev, 1948). "Soil is more or less a loose and crumby part of the outer earth crust in which, by means of their roots, plants may or do find foot hold and nourishment as well as other conditions essential to their growth" (Hilgard, 1892).

Agriculture is one of the world's most important activities supporting human life. Potential land use assessment is likely to the prediction of land potential for productive land use type (Dadhwal *et al.*, 2011). Land productivity capacity or land quality is a comprehension, at the same time a precise concept in terms of agricultural activities (Dengiz and Saglam, 2012). Agricultural intensification and massive infrastructure development in the recent years without considering the variability of entire production system enhances the risk of soil erosion and fertility depletion (Singh *et al.*, 2007). Soil is a component of the lithosphere and biosphere system. It is a vast natural resource on which the life supporting systems and socio-economic development depends. Organic matter is one of the most important constituents of soil, a good amount of organic carbon / matter in soil increase soil fertility. The core constraints in relation to land use include depletion of organic carbon, soil micronutrients and macronutrients, removal of top soil by erosion, change of physical properties and increased soil salinity (Kumar *et al.*, 2017).

Geographically, Rajasthan is located between 23˚ 3ˈ to 30˚ 12ˈ North latitude and 69˚ 30ˈ to 78˚ 17ˈ East longitude, with the tropic of cancer passing through the southernmost tip of the state. The climate of Rajasthan plain is characterized by extremely high range of temperature and aridity although sharing the monsoonal variations throughout the year it is the hottest region of India (mean June temperature 34.5 ˚C at Jaisalmer and Bikaner) with annual range of temperature between 14˚ to 17 ˚C. The rainfall is very low, highly erratic and variable seasonally. Average rainfall of Rajasthan is 52.26 cm with high degree of regional and temporal variability. The climate of Rajasthan state has varied contrasts and the presence of Aravallis is the greatest influencing factor. The state can broadly be divided into Arid, Semi-Arid and Sub-Humid Regions, on the basis of rainfall intensities. The Western Rajasthan i.e. in the arid region consist of the districts of Hanumangarh, Jaisalmer, Barmer, Ganganagar, Churu, Jhunjhunu, Sikar, Nagaur, Jodhpur, Pali and Jalore covering an area of nearly 1,43,842 square kilometres. The region is characterized by low and highly variable rainfall years creating inhospitable living condition to both human and livestock population. An area of 9,290 square kilometres in extreme western parts of the state has true desert conditions. With an improvement in rainfall pattern from the west towards the east Rajasthan semi-arid conditions are created in area of about 66,830 square kilometres in the districts of Alwar, Jaipur, Bharatpur, Ajmer, Tonk, Sawai Madhopur, Bhilwara, Bundi, Kota, Chittorgarh, Udaipur, Sirohi, Dungarpur and parts of Jhalawar and Banswara.

The soils of the Bundi district can be broadly classified as the Deep Brown Loamy, Deep Brown Clayey, Medium Brown Loamy, Shallow Yellowish Brown Gravelly Loamy, Deep Black Clayey and Red Gravelly Loam Hilly soils. Under the new system, most soils of Rajasthanbelong to only 5 orders-Aridisols, Alfisols, Entisols, Inceptisols and Vertisols (District Profile, KVK). Bundi is a district of Rajasthan. Bundi is located between25˚25'57.3132"N and 75˚38'53.7828" E. It has an average elevation of 268 meters (879 feet) from sea level. The district has an area of 5,550 square kilometres. The climate of the district is extremely hot in the summers and fairly cold in the winters. The average annual temperature is 26.5˚C in Bundi. The average annual rainfall of the region is 772 mm (District Factbook, 2019).

The term “soil health” originates in the observation that soil quality influences the health of animals and humans via the quality of crops (Warkentin, 1995). “Soil health, also referred to as soil quality, is defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals and humans.” According to Moebius-Clune *et al.,* (2016) a conceptual difference between the two terms may be that soil quality comprises both inherent and dynamic properties, whereas soil health is focused on the dynamic properties. The term “soil fertility” is often used as a synonym to the term “soil quality”. Indeed, the definition of

Mader *et al.,* (2002) that a fertile soil "provides essential nutrients for crop plant growth, supports a diverse and active biotic community, exhibits a typical soil structure, and allows for an undisturbed decomposition" went beyond the provision of yields. In line with this, the maintenance of "natural soil fertility" is at the heart of organic farming (Rusch, 1985). The concept of soil quality as introduced by Larson and Pierce (1991) and Doran and Parkin (1994) was heavily criticized in a series of papers (Letey *et al.*, 2003; Sojka & Upchurch, 1999; Sojka *et al.*, 2003) for being subjective and ill-defined.

A particular recommendation was to speak of soil use rather than soil functions, so that the responsibility to maintain the quality of the soil can be clearly assigned to the user of the soil. In particular, it was claimed to raise awareness and enhance communication between various stakeholders regarding the importance of soil resources (Karlen *et al.*, 2001).

According to USDA soil quality indicators are classified into four categories that include visual, physical, chemical and biological indicators. The physical indicators are related to the organization of the particles and pores, reflecting effects on root growth, speed of plant emergence and water infiltration; they include depth, bulk density, porosity, aggregate stability, texture and compaction. Chemical indicators include pH, salinity, organic matter content, phosphorus availability, cation exchange capacity, nutrient cycling and the presence of contaminants such as heavy metals, organic compounds, radioactive substances, etc.

These indicators determine the presence of soil-plant-related organisms, nutrient availability, water for plants and other organisms and mobility of contaminants. Finally, biological indicators include measurements of micro and macro-organisms, their activities or functions. Concentration or population of earthworms, nematodes, termites, ants, as well as microbial biomass, fungi, actinomycetes, or lichens can be used as indicators, because of their role in soil development and conservation; nutrient cycling and specific soil fertility (Anderson, 2003). Biological indicators also include metabolic processes such as respiration, used to measure microbial activity related to decomposition of organic matter in soil (Bastida *et al.*, 2008).

Materials and Methods

The present study entitled "Evaluation of Soil Health and Soil Quality Analysis of Different Blocks of Bundi District, Rajasthan, India" was conducted during the 2019-20 in three stages *i.e.* soil survey and mapping, collection of samples and their analysis for different soil parameters.

Site details

Bundi district is the south-east region of Rajasthan, from where the soil has been taken for analysis. Bundi is located between 25˚25'57.3132"N and 75˚38'53.7828" E. It has an average elevation of 268 meters (879 feet) from sea level. The district has an area of 5,550 square kilometres. The climate of the district is extremely hot in the summers and fairly cold in the winters.

The average annual temperature is 26.5˚C in Bundi. The average annual rainfall of the region is 772 mm (District Factbook, 2019).The soils of the Bundi district can be broadly classified as the Deep Brown Loamy, Deep Brown Clayey, Medium Brown Loamy, Shallow Yellowish Brown Gravelly Loamy, Deep Black Clayey and Red Gravelly Loam Hilly soils (District Profile, KVK).

Soil Sampling

Soil samples were collected from the three different blocks of Bundi district Rajasthan. They are Nainwan, Karwar and Indergarh. Soil samples were collected with the help of Khurpi, Spade and meter scale. In each block three village selected for sampling and samples obtained from two different depths 0-15 cm and 15-30 cm, totally eighteen soil sample were collected.

Results and Discussion

Soil reaction

In soil depth the highest mean pH was found in 15-30 cm (7.41) which is significantly higher than 0-15 cm (7.28). In villages the maximum mean pH was found at Mani (V_5) (7.75) and minimum mean pH was found in Gambhira (V_2) (6.99) (Table 1).

The increase in pH with depth of soil is possibly due to leaching down of salts from upper soil depth to lower soil depth, which is accumulation of salts in lower depth of soil and increase in soil pH. Similar results were reported by Mehta *et al*.(2012), Maheshwari and Sharma (2013) and Gill *et al.*, (2012).

Electrical conductivity

In soil depth the highest mean EC was found in 15-30 cm (0.63 dS m^{-1}) which is significantly higher than 0-15 cm (0.59 dS m^{-1}).In villages the maximum mean EC was found at Ramajpura (V_8) (1.01 dS m^{-1}) and minimum mean EC was found in Babai (V_9) (0.21dS m^{-1}).

The low EC may be due to good drainage conditions which favoured the removal of released bases by percolating and drainage water. Similar results were reported by Ram *et al.*, (2010) (Table 2).

Organic carbon

In soil depth the highest mean organic carbon was found in 0-15 cm (0.56%) which is significantly higher than 15-30 cm (0.41%). In villages the maximum mean organic carbon was found at Mani (V_5) (0.68%) and minimum mean organic carbon was found in Jainiwas (V_7) (0.36%). The organic carbon content of these soils was found to be low to medium and ranging from 0.36 to 0.68 %. The organic carbon content decreased with depth and this is due to the addition of plant residues and farmyard manure to surface horizons than in the lower horizons. Similar results were reported by Maheshwari and Sharma (2013) and Gill *et al.*, (2012) (Table 3).

Organic matter

In soil depth the highest mean organic matter was found in 0-15 cm (0.96%) which is significantly higher than 15-30 cm (0.70%). In villages the maximum mean organic matter was found at Mani (V_5) (1.16%) and minimum mean organic matter was found in Jainiwas (V_7) (0.62%). The organic matter % decreases abruptly with increase in soil depth. Similar results were reported by Kumar *et al.*, (2014).

Available nitrogen

In soil depth the highest mean available nitrogen was found in 0-15 cm (273.72kg ha^{-1}) which is significantly higher than 15-30 cm (251.94 kg ha^{-1}). In villages the maximum mean available nitrogen was found at Mani (V_5) (301.2 kg ha^{-1}) and minimum mean available nitrogen was found in Jainiwas (V_7) (192.19kg ha^{-1}). The available nitrogen decreases abruptly with increase in soil depth. However, available N content found to be maximum in surface horizons and decreased regularly with depth which is due to decreasing trend of organic carbon with depth and cultivation of crops are mainly confined to the surface horizon (Rhizosphere) only at regular interval the depleted nitrogen content is supplemented by the external addition of fertilizers during crop cultivation. Similar results were reported by Urmila *et al*. (2018).

Table.1 Soil chemical properties and their respective methods for analysis

S. No.	Parameters	Unit	Methodology	Author's
1.	Soil pH (1:2)	-	Digital pH Meter	Jackson, 1958
2.	Electrical conductivity (1:2)	dS m^{-1}	DigitalConductivity Meter	Wilcox, 1950
3.	Organic carbon	%	Rapid titration	Walkley, 1947
4.	Organic matter	%	%OM = %OC× 1.724	Van Bemmelen Factor
5.	Available nitrogen	kg ha^{-1}	Alkaline potassium permanganate	Subbiah and Asija, 1956
6.	Available phosphorus	kg ha^{-1}	Spectrophotometric	Olsen *et al*., 1954
7.	Available potassium	kg ha^{-1}	Flame Photometric	Toth and Prince, 1949
8.	Exchangeable calciumand magnesium	Cmol (p^+) kg^{-1}	1NNeutral ammonium acetate saturation /EDTA	Cheng and Bray, 1951
9.	Available Sulphur	ppm	Turbidimetric	Chesnin and Yien, 1950

Table.2 Chemical properties of soil of different villages of Bundi district, Rajasthan

Villages	Soil pH			Soil EC (dS m^{-1})		
	0-15 cm	15-30 cm	Mean	0-15 cm	15-30 cm	Mean
Kashpuriya (V_1)	7.50	7.52	7.51	0.64	0.70	0.67
Gambhira (V_2)	6.75	7.23	6.99	0.91	0.96	0.94
Manpura (V_3)	7.39	7.43	7.41	0.50	0.55	0.53
Karwar (V_4)	7.08	7.16	7.12	0.51	0.54	0.53
Mani (V_5)	7.66	7.83	7.75	0.23	0.29	0.26
Kashipura (V_6)	6.92	7.20	7.06	0.50	0.57	0.54
Jainiwas (V_7)	7.46	7.55	7.51	0.80	0.83	0.82
Ramajpura (V_8)	7.41	7.42	7.42	1.00	1.02	1.01
Babai (V_9)	7.38	7.39	7.39	0.18	0.24	0.21
Mean	7.28	7.41		0.59	0.63	
	F-test	S.Ed (±)	C.D. at 0.05%	F-test	S.Ed (±)	C.D. at 0.05 %
Due to depth	S	0.09	0.04	S	0.03	0.00003
Due to site	S	0.25	0.002	S	0.28	0.00000000003

Table.3 Chemical properties of soil of different villages of Bundi district, Rajasthan

Villages	Organic carbon (%)			Organic matter (%)		
	0-15 cm	**15-30 cm**	**Mean**	**0-15 cm**	**15-30 cm**	**Mean**
Kashpuriya (V_1)	0.52	0.35	0.44	0.90	0.60	0.75
Gambhira (V_2)	0.63	0.42	0.53	1.09	0.72	0.91
Manpura (V_3)	0.56	0.37	0.47	0.97	0.64	0.81
Karwar (V_4)	0.69	0.55	0.62	1.19	0.95	1.07
Mani (V_5)	0.75	0.6	0.68	1.29	1.03	1.16
Kashipura (V_6)	0.6	0.45	0.53	1.03	0.78	0.91
Jainiwas (V_7)	0.41	0.31	0.36	0.71	0.53	0.62
Ramajpura (V_8)	0.42	0.32	0.37	0.72	0.55	0.64
Babai (V_9)	0.45	0.3	0.38	0.78	0.52	0.65
Mean	0.56	0.41		0.96	0.70	

	F-test	S.Ed(±)	C.D. at 0.05 %	F-test	S.Ed (±)	C.D. at 0.05 %
Due to depth	S	0.11	0.000002	S	0.19	0.000002
Due to site	S	0.11	0.00001	S	0.19	0.00002

Table.4 Chemical properties of soil of different villages of Bundi district, Rajasthan

Villages	Available nitrogen (kg ha^{-1})			Available phosphorus (kg ha^{-1})		
	0-15 cm	**15-30 cm**	**Mean**	**0-15 cm**	**15-30 cm**	**Mean**
Kashpuriya (V_1)	291.3	281.2	286.25	12.09	11.23	11.66
Gambhira (V_2)	297.4	283.6	290.5	14.98	12.80	13.89
Manpura (V_3)	294.3	282.24	288.27	11.23	10.47	10.85
Karwar (V_4)	309.7	287.1	298.4	11.86	10.21	11.04
Mani (V_5)	313.6	288.8	301.2	11.26	9.96	10.61
Kashipura (V_6)	306.4	286.7	296.55	10.38	10.19	10.29
Jainiwas (V_7)	207.13	177.24	192.19	11.45	10.46	10.96
Ramajpura (V_8)	219.52	188.16	203.84	11.47	11.33	11.4
Babai (V_9)	224.17	192.4	208.29	10.85	10.82	10.84
Mean	273.72	251.94		11.73	10.83	

	F-test	S.Ed(±)	C.D. at 0.05 %	F-test	S.Ed (±)	C.D. at 0.05 %
Due to depth	S	15.41	0.00005	S	0.64	0.006
Due to site	S	46.48	0.0000002	S	1.06	0.003

Table.5 Chemical properties of soil of different villages of Bundi district, Rajasthan

Villages	Available potassium (kg ha^{-1})			Exchangeable calcium (Cmol (p^{+}) kg^{-1})		
	0-15 cm	**15-30 cm**	**Mean**	**0-15 cm**	**15-30 cm**	**Mean**
Kashpuriya (V_1)	418.67	408	413.34	6.86	6.47	6.67
Gambhira (V_2)	432	425	428.5	5.32	5.14	5.23
Manpura (V_3)	388	375	381.5	7.56	6.97	7.27
Karwar (V_4)	736.5	722	729.25	4.02	3.07	3.55
Mani (V_5)	538	529	533.5	9.39	8.77	9.08
Kashipura (V_6)	422	415	418.5	6.03	5.67	5.85
Jainiwas (V_7)	389	383	386	8.13	7.21	7.67
Ramajpura (V_8)	516	511	513.5	4.17	3.87	4.02
Babai (V_9)	326	319	322.5	5.09	5.02	5.06
Mean	462.91	454.11		6.29	5.8	
	F-test	S.Ed (±)	C.D. at 0.05 %	F-test	S.Ed (±)	C.D. at 0.05 %
Due to depth	S	6.22	0.00004	S	0.34	0.001
Due to site	S	120.51	0.00000000000004	S	1.79	0.0000001

Table.6 Chemical properties of soil of different villages of Bundi district, Rajasthan

Villages	Exchangeable magnesium (Cmol (p^{+}) kg^{-1})			Available sulphur (ppm)		
	0-15 cm	**15-30 cm**	**Mean**	**0-15 cm**	**15-30 cm**	**Mean**
Kashpuriya (V_1)	1.64	1.47	1.56	14.88	14.27	14.58
Gambhira (V_2)	3.18	3.09	3.14	15.45	15.14	15.3
Manpura (V_3)	2.20	2.03	2.12	15.03	15.02	15.03
Karwar (V_4)	5.28	5.21	5.25	16.67	16.39	16.53
Mani (V_5)	3.66	3.54	3.6	17.32	17.19	17.26
Kashipura (V_6)	3.14	3.06	3.1	16.11	16.04	16.08
Jainiwas (V_7)	4.26	4.17	4.22	13.55	13.28	13.42
Ramajpura (V_8)	2.77	2.71	2.74	13.85	13.68	13.77
Babai (V_9)	3.69	3.57	3.63	14.04	14.01	14.03
Mean	3.31	3.21		15.21	15.00	
	F-test	S.Ed (±)	C.D. at 0.05	F-test	S.Ed (±)	C.D. at 0.05 %
Due to depth	S	0.08	0.00004	S	0.15	0.01
Due to site	S	1.1	0.0000000000005	S	1.31	0.00000002

Available phosphorus

In soil depth the highest mean available phosphorus was found in 0-15 cm (11.73 kg ha^{-1}) which is significantly higher than 15-30 cm (10.83 kg ha^{-1}). In villages the maximum mean available phosphorus was found at Gambhira (V_2) (13.89 kg ha^{-1}) and minimum mean available phosphorus was found in Kashipura (V_6) (10.29 kg ha^{-1}). The available P varied from 9.96 to 14.98kg ha^{-1}in different depths and villages, which is low to medium content of phosphorus in soil. The highest P content was observed in the surface horizons and decreased with depth. Similar results were reported by Meena *et al.,* (2010) (Table 4).

Available potassium

In soil depth the highest mean available potassium was found in 0-15 cm (462.91kg ha^{-1}) which is significantly higher than 15-30 cm (454.11 kg ha^{-1}). In villages the maximum mean available potassium was found at Karwar (V_4) (729.25 kg ha^{-1}) and minimum mean available potassium was found in Manpura (V_3) (381.5 kg ha^{-1}). The available potassium in soil varied in high range (319 to 736.5 kg ha^{-1}) (Table 5).

The highest K content was observed in the surface horizons and showed more or less decreasing trend with depth. This might be attribute to more intense weathering, release of liable K from organic residues, application of K fertilizers and upward translocation of K from lower depths along with capillary rise of ground water. Similar results were reported by Urmila *et al.,* (2018) and Sharma and Chaudhary (2017).

Exchangeable calcium

In soil depth the highest mean exchangeable calcium was found in 0-15 cm (6.29 Cmol (p^+) kg^{-1}) which is significantly higher than 15-30 cm (5.8Cmol (p^+) kg^{-1}). In villages the maximum mean exchangeable calcium was found at Mani (V_5) (9.08 Cmol (p^+) kg^{-1}) and minimum mean exchangeable calcium was found in Karwar (V_4) (3.55Cmol (p^+) kg^{-1}). The calcium content decreases with increase in depth. Similar results were reported by Athokpam *et al.,* (2010).

Exchangeable magnesium

In soil depth the highest mean exchangeable magnesium was found in 0-15 cm (3.31 Cmol (p^+) kg^{-1}) which is significantly higher than 15-30 cm (3.21Cmol (p^+) kg^{-1}). In villages the maximum mean exchangeable magnesium was found at Karwar (V_4) (5.25Cmol (p^+) kg^{-1}) and minimum mean exchangeable magnesium was found in Kashpuriya (V_1) (1.56Cmol (p^+) kg^{-1}). The magnesium content decreases with increase in depth. Similar results were reported by Mehta *et al.,* (2012) and Gill *et al.,* (2012).

Available sulphur

In soil depth the highest mean available sulphur was found in 0-15 cm (15.21 ppm) which is significantly higher than 15-30 cm (15.00 ppm). In villages the maximum mean available sulphur was found at Mani (V_5) (17.26 ppm) and minimum mean available sulphur was found in Jaini was (V_7) (13.42 ppm). The available sulphur in soil varied in medium range (13.28 to 17.32 ppm).Similar results were reported by Urmila *et al.,* (2018) (Table 6).

It is concluded that soil pH was neutral to slightly alkaline in reaction with EC mostly below <1.0 dS m^{-1} for collected soil samples. The organic carbon, nitrogen and phosphorus content of these soils were found to be low to medium. Potassium was in high range. Calcium and magnesium were found to be adequate.

The available sulphur in soil was recorded in medium range. Soybean, paddy, maize, sorghum, black gram and green gram are the main Kharif crops whereas wheat, mustard, barley and gram are the major Rabi crops of the district.

We concluded that there is a need to pay greater attention in the role of macronutrient enhancement in the soil for good soil health and soil quality and proper nutrition of plants so as to attain optimum economic yield. These observed spatial variability used in further fertilizer recommendation and input management based on requirement of crop plants. The adoption of organic farming will be essential step for maintaining soil health and soil quality.

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