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Characterization, classification and Soil fertility status of dryland research farm, Dr. PDKV Akola, Maharashtra

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Abstract
The present study was carried out in Dryland Research Farm Dr Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra to characterize and classify the soils. Thirty-four surface soil samples were collected and analysed for various physical and chemical properties in the laboratory as per standard methods. The results indicated that soils under study were neutral to moderately alkaline in reaction with pH ranging from 7.5 to 8.07. The electrical conductivity (EC) data indicated that the soils are non-saline and are free from soluble salt hazard. The organic carbon content of soil was medium to high and it ranged from 0.41 to 0.93%, while the free calcium carbonate content varied from 2.8 to 6.9% indicating that these soils are moderately calcareous to calcareous in nature. The data of exchangeable cations showed that the calcium was the dominant cation followed by magnesium, potassium and sodium. The Ca/Mg ratio varied between 3.25 to 4.72. The CEC of soils varied from 52.6 to 62.9 cmol (p+) kg^{-1}. The soils were found to be low in available nitrogen content and it ranged from 150.4 to 200.4 kg ha^{-1}; low to medium in available phosphorus and it varied between 12.7 to 17.9 kg ha^{-1} whereas high to very high in available potassium and it varied from 267.6 to 459.2 kg ha^{-1}.
The shallow soil categorized as Entisols were classified as Typic Ustorthents; medium to deep soils as Inceptisols (Vertic Haplustepts and Typic Haplustepts) and deep to very deep soils categorized as Vertisols were classified as Typic Haplusterts.

Keywords: Characterization, classification, soil fertility

Introduction
Soil, water and vegetation are the most important natural resources, which are so much interdependent that one cannot be managed efficiently without the other two. Sustainable utilization of these resources involves understanding of various aspects of these resources. Soils are considered as the integral part of the landscape and their characteristics are largely governed by landform on which they are developed (Sharma *et al.*, 1999; [14] Sawhney *et al.*, 1992) [11]. Systematic study of morphology and taxonomy of soils provides information on nature and type of soils, their constraints, potentials, capabilities and their suitability for various uses (Sehgal, 1996) [12].
Land resources are scarce and shrinking rapidly. About 57 per cent of soils are under different kinds of degradation and these are getting further deteriorated (Sehgal and Abrol, 1994 [13]. With growing population and competing demands, the available land for cultivation is getting shrunk. In the absence of any possibility of increasing the availability of land, the need of time demands our focused attention on increasing per hectare yield potential of available land to meet the ever-increasing demand for food.
Precise scientific information on characteristics, potential, limitations and management needs of different soil is indispensible for planned development of land resources to maintain the soil productivity and to meet the demands of the future. Rational utilization of land resources can be achieved by optimizing its use and ensuring its sustainable use. Therefore, increased emphasis is being laid on characterization and classification of soils with their precise mapping.
In agriculture, soil tests are usually performed to measure the expected growth potential and possible remedial measures for a soil. It is difficult for farmers to decide the type of fertilizer which would match his soil. In using a fertilizer, he must take into account the requirement of his crops and the characteristics of the soil.

Fertilizing soils to bring all the deficient elements at high levels as to provide sufficient ionic activity in soil solution for crop uptake is one of the most important considerations for maximization of the crop yield. The assay of soil fertility status is essential for judicious use of fertilizers and assurance of better crop yields.

Increasing population and overexploitation of productive lands creates serious problem of lowering the fertility status of soil and it leads to deterioration of soil health. The deficiency of nutrients directly effects on the growth of crops and crop response become poor. Hence, it is necessary to assess the fertility status of soil with the consideration of available nutrients in soil and to recommend the specific nutrients for the proper management of soil. Information on soil fertility status in crop field is very important and useful for fertilizer requirement and also to the specific management of the crop and soil.

Chemical test have long been used to estimate the nutrient availability in soil to predict the probability of obtaining profitable response to applied nutrients on the basis of soil testing. Soils can be rated low, medium and high in nutrient status and suitable fertilizer amount can be recommended. Low fertile soil responds remarkably to the application of fertilizer, on the other hand, in high nutrients status soil, crop may show little or no response. In medium soil, the response is intermediate. The soils of Dryland research farm Dr. PDKV, Akola, Maharashtra have been assessed for their characterization and classification which will help in adjusting the amount of fertilizer and enhancing the efficiency of fertilizer use.

Materials and Methods

Study area

The area under study is the Research farm of AICRP for Dryland Agriculture, located at the Central Research Station of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. It is situated between 77^{0}02'42'' to 77^{0}02'56'' E longitude and 20^{0}43'02" to 20^{0}43'17'' N latitude and covers an area of 21.98 ha. The mean elevation of the area is about 295 m above MSL.

The geological formations in the area include the Deccan traps with intertrappean beds of cretaceous Eocene period. The geology of the area comprised predominantly of volcanic rocks, which consists chiefly of basalt. At places the intertrappean beds of different flows are encountered. Basaltic stones, boulders, pebbles etc. occur on the surface of the soils, particularly on uplands.

Agro-ecologically the area lies in 10.3 (K_5DM_4) sub region (Eastern Maharashtra plateau, hot moist semiarid with medium and deep clayey black soils, medium to high available water capacity and LGP 120-150 days). The climate is semiarid monsoonic characterized by three distinct seasons *viz*., summer becoming hot and dry from March to May. Monsoon characterized as warm rainy from June to October and winter with dry mild cold from November to February. Most of the rainfall is received from south west monsoon.

The surface soil samples at the depth of 0-20 cm were collected from each plot of the entire farm for analysis. The exact location of sampling sites was recorded with the help of Global Positioning System (GPS). In addition to thirty-four surface soil samples, seven soil profiles were also studied from the study area. The collected samples were air dried, gently ground, sieved through 2 mm sieve and stored in properly labeled bags for further analysis.

The standard analytical methods commonly adopted in most of the laboratories for research investigations were followed.

Results and Discussion

Physical properties of soil

Physical characteristics of soils (Table 1) like bulk density, hydraulic conductivity, water retention, mean weight diameter directly or indirectly affect crop growth and hence need to be considered in the land evaluation and land use planning.

Bulk density

Bulk density is defined as the ratio of mass of dry soil to the total volume of the soil including pore spaces. It is an index of workability of soil, moisture availability, aeration and root penetration. The bulk density of the surface soil ranged from 1.34 to 1.48 Mg m^{-3} and it showed increasing trend with depth and clay content.

Saturated hydraulic conductivity

The saturated hydraulic conductivity of soil is a good indicator of internal drainage conditions of the profile. It is influenced by texture, structure and moisture content of soil. It affects movement of water in the soil profile i.e. it indicates the measure of tendency of soil permeability and hence affects crop growth. The saturated hydraulic conductivity of these soils varied from 0.74 to 1.08 cm hr^{-1}.

Mean weight diameter (MWD)

The mean weight diameter of soils ranged from 0.72 to 0.97 mm and in general, it was higher in Vertisols.

Moisture retention

Soil water retention mainly depends on soil depth, texture and clay mineralogy of the soils or amount, type and surface area of clay fraction (Coulombe *et al*., 1996 [3]). The swell shrink soils due to the dominance of smectitic clay with a large area retains high amount of moisture at different metric suction due to inter layer absorption of moisture. The moisture retention at 33 kPa and 1500 kPa suction and the available water content in different surface soil of Dryland farm have been given in the Table 1. The data shows that the amount of water retention at 33 kPa and 1500 kPa suction varied from 24.75 to 46.88 and 12.40 to 31.05 per cent, respectively and the available water capacity ranged from 10.85 to 22.67 percent.

Table 1: Physical characteristics of surface soil

Plot No.	BD (Mgm^{-3})	HC (cm hr^{-1})	MWD (mm)	Water retention (%)		AWC (FC-PWP) (%)
				33 kPa (FC)	1500 kPa (PWP)	
1⁄1	1.40	1.01	0.78	39.26	26.48	12.78
1⁄2	1.42	0.91	0.82	35.47	24.47	11.00
2	1.44	0.84	0.75	27.83	12.40	15.43
3⁄1	1.38	0.96	0.76	42.26	25.38	16.88
3⁄2	1.37	1.07	0.74	35.61	15.23	20.38
3⁄3	1.39	0.99	0.74	33.82	19.27	14.55

4	1.36	1.04	0.93	36.39	23.35	13.04
5	1.35	1.04	0.82	42.65	24.16	18.49
6	1.45	0.98	0.96	32.35	17.98	14.37
7	1.38	1.08	0.92	29.43	18.58	10.85
8	1.40	0.92	0.85	44.55	28.05	16.50
9	1.48	0.82	0.77	35.79	23.32	12.47
11	1.47	0.89	0.78	42.05	30.16	11.89
12	1.46	0.86	0.74	28.42	16.53	11.89
13	1.40	0.97	0.74	40.33	26.78	13.55
14	1.40	0.91	0.76	44.44	31.05	13.39
15	1.43	0.74	0.72	39.15	26.82	12.33
16	1.48	0.69	0.73	35.21	24.01	11.20
17	1.43	0.78	0.87	33.41	21.59	11.82
18	1.42	1.04	0.87	34.39	19.86	14.53
19	1.39	0.98	0.78	33.98	19.48	14.50
20	1.46	0.76	0.84	38.65	25.43	13.22
21	1.44	0.74	0.72	38.96	18.66	20.30
23/1	1.46	0.84	0.91	41.31	26.46	14.85
23/2	1.46	0.89	0.81	46.88	24.21	22.67
24	1.38	1.06	0.97	41.17	24.54	16.63
25	1.48	0.82	0.94	41.30	24.18	17.12
26	1.34	1.00	0.79	35.54	19.88	15.66
27	1.47	0.86	0.79	34.43	18.46	15.97
28	1.40	0.99	0.94	24.75	13.52	11.23
29	1.41	0.85	0.90	35.65	20.49	15.16
30	1.41	0.81	0.95	39.67	27.31	12.36
31	1.44	0.79	0.84	39.40	26.96	12.44
32	1.43	0.84	0.87	31.75	17.37	14.38
Range	1.34-1.48	0.74-1.08	0.72-0.97	24.75-46.88	12.40 -31.05	10.85 -22.67

Chemical properties of soil

The chemical properties of soils (Table 2) play an important role in determining the retention and availability of plant nutrients and physical conditions of soil.

Table 2: Chemical characteristics of surface soil

Plot No.	pH (1:2.5)	EC (dSm^{-1})	OC (%)	$CaCO_3$ (%)
1/1	7.69	0.19	0.52	5.8
1/2	7.66	0.12	0.54	6
2	7.67	0.15	0.55	6.1
3/1	7.87	0.11	0.68	5.4
3/2	7.76	0.13	0.66	4.5
3/3	7.72	0.14	0.58	3
4	7.66	0.13	0.67	5.5
5	7.6	0.11	0.83	5.9
6	7.65	0.16	0.72	6.6
7	7.53	0.11	0.84	5.7
8	7.5	0.11	0.93	5.2
9	7.5	0.21	0.93	6.9
11	7.54	0.16	0.67	2.8
12	7.58	0.18	0.85	4.5
13	7.64	0.17	0.58	3.1
14	7.66	0.16	0.51	4.5
15	7.56	0.18	0.59	3.6
16	7.65	0.13	0.55	4.8
17	7.87	0.19	0.41	4.1
18	7.89	0.22	0.63	4.3
19	7.66	0.19	0.57	4.7
20	7.65	0.15	0.64	4.7
21	7.71	0.38	0.76	6.1
23/1	8.07	0.16	0.63	5.3
23/2	7.78	0.15	0.64	4.9
24	7.69	0.17	0.64	5
25	7.59	0.11	0.63	5
26	7.68	0.19	0.7	3.9
27	7.65	0.17	0.75	3.5
28	7.68	0.18	0.55	5.5
29	7.67	0.13	0.64	3.9
30	7.53	0.16	0.58	4.3
31	7.63	0.19	0.62	4.2
32	7.75	0.18	0.63	5.4
Range	7.5 - 8.07	0.11-0.38	0.41-0.93	2.8-6.9

Soil reaction (pH)

The pH is the negative logarithm of hydrogen ion activity and is indicative of degree of acidity or alkalinity of soil. Soil pH determines its suitability as a medium for plant growth and desirable microorganisms and it depends upon whether the soil is acidic, neutral or alkaline. Acidity of the soil is the result of leaching of exchangeable bases (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}) and concentration of H^{+} on the exchange complex whereas soil alkalinity is rated to the accumulation of salts and comparative high degree of saturation with bases.

The pH of the soils of Dryland farm ranged from 7.5 to 8.07 indicating that these soils are neutral to moderately alkaline in reaction. Similar results were reported by Gabhane *et al.* (2006 [4]) in the soils of Belura watershed in Akola district.

Electrical conductivity (EC)

The electrical conductivity is a measure of soluble salt concentration in the soils. Higher amount of salts in soils restricts the nutrient uptake and thus affect the plant growth and EC is a measurement that correlates with soil properties that affect productivity, including soil texture, cation exchange capacity (CEC), drainage conditions, organic matter level, salinity and subsoil characteristics (Corwin and Lesch, 2005 [2]).

The EC of the studied soils ranged from 0.11 to 0.38 dSm^{-1}, which is well within the acceptable limit of EC range for normal soils (Richards, 1954 [10]). The range showed that these soils are non-saline in nature. Similar observations were also recorded by Mondal *et al.* (2015) [7].

Organic Carbon

Carbon is an indication of organic fractions in soils formed from the microbial decomposition of residues. The presence of organic matter in soil is a symbol of life in the soil. It supplies all essential plant nutrients and it help to sustain soil fertility by improving soil structure, retention of mineral nutrients, increasing water holding capacity, water infiltration, drainage, aeration and root penetration and reduces soil erosion (Smith and Elliott, 1990) [15].

Thus the organic matter is an important contributes to soil fertility. It comes in a soil from remains of plants and animals. However, in addition to this, it also includes grasses, trees, bacteria, fungi, protozoa, earthworm and animal manure.

The organic carbon content of the surface soils varied from 0.41 to 0.93% (Table 2) and the distribution of organic carbon indicates that 35.3% soils were medium, 50% moderate and 14.7% high in organic carbon.

Calcium Carbonate

Impure calcium carbonate locally known as kanker usually occurs in neutral state in irrigated soils. The presence of calcium carbonate in soils is due to climatic factors and affects both the physical and chemical characteristics of the soil. High lime concentration may not severely restrict water movement but may prevent root penetration. The calcareousness influences the pH of soil as well as the availability of micro and macronutrients required by the plant growth.

The calcium carbonate content (Table 2) of the surface soils ranged from 2.8 to 6.9%. It indicates that these soils are moderately calcareous to calcareous in nature. The distribution of calcium carbonate indicates that 58.8% soils were moderately calcareous and 41.2% highly calcareous in nature. The precipitation of calcium carbonate from the solution rich in carbonate resulted in the high pH values. Similar results were indicated earlier by Paramasivan and Jawahar, 2014[8].

Exchangeable bases

The exchangeable calcium, magnesium, sodium, and potassium contents in soils of dryland farm varied from 34.2 to 43.0, 8.8 to 11.7, 0.21 to 1.59, 1.00 to 2.58 cmol(p+)kg^{-1}, respectively(Table 3). Similar results were reported by Kharche and Pharande (2010) [5]. The Ca/Mg ratio varied from 3.25 to 4.72.

Table 3: Exchangeable bases in surface soil

Plot No.	Exchangeable bases cmol (p^{+}) kg^{-1}				Sum bases cmol (p^{+}) kg^{-1}	Ca/Mg
	Ca	Mg	Na	K		
1⁄1	39.5	10.1	0.84	1.58	52.02	3.91
1⁄2	40.6	11.7	0.76	1.60	54.66	3.47
2	41	10.2	1.59	1.33	54.12	4.02
3⁄1	36.1	9.5	0.77	1.27	47.64	3.80
3⁄2	39.4	9.1	0.8	1.26	50.56	4.33
3⁄3	42.2	9.2	0.78	1.09	53.27	4.59
4	43	10.2	0.47	2.27	55.94	4.22
5	41.1	12.1	0.37	2.00	55.57	3.40
6	41	9.9	0.3	1.71	52.91	4.14
7	39.4	8.9	0.61	1.88	50.79	4.43
8	40.7	10.8	0.84	2.23	54.57	3.77
9	36.1	11.7	0.78	2.58	51.16	3.09
11	42.5	11.7	0.82	1.69	56.71	3.63
12	42.6	9.8	0.25	1.55	54.2	4.35
13	42.6	10.5	0.65	1.30	55.05	4.06
14	38.4	9.4	0.84	1.69	50.33	4.09
15	42	10	0.68	1.59	54.27	4.20
16	34.5	10.6	0.72	1.33	47.15	3.25
17	41.3	9.6	0.6	1.45	52.95	4.30
18	41.1	9.9	0.48	1.63	53.11	4.15
19	40.8	10.2	1.21	1.57	53.78	4.00
20	41.2	9.5	0.9	1.65	53.25	4.34
21	38.5	9.8	0.74	1.38	50.42	3.93
23/1	41.2	9.8	0.71	1.49	53.2	4.20

23⁄2	40.7	9.5	0.68	1.43	52.31	4.28
24	36.1	9.4	0.38	1.64	47.52	3.84
25	41.9	11.1	0.41	1.73	55.14	3.77
26	34.2	10.1	0.62	1.75	46.67	3.39
27	41.5	8.8	0.21	1.00	51.51	4.72
28	42	10.2	0.25	1.25	53.7	4.12
29	40.3	10.6	0.3	1.75	52.95	3.80
30	40.6	9.4	0.45	1.72	52.17	4.32
31	41	10.6	0.76	2.06	54.42	3.87
32	40.6	10.9	0.91	2.57	54.98	3.72
Range	34.2-43.0	8.8-11.7	0.21-1.59	1.00-2.58	46.67-56.71	3.25-4.72

Soil fertility
Nitrogen, phosphorus and potassium are the most vital and major nutrients required by plants for their proper growth and development.

Fertility status of surface soil
Available Nitrogen
Nitrogen is essential for plant growth and thus, causes problems, when it is deficient. The nitrogen deficient plants are light green in colour. The lower leaves are turning yellow and in some crops they quickly start drying up as if suffering of water (Carter and Knapp, 2001) [1].

Table 4: Fertility status of surface soil

Plot No.	Available nutrients (kg ha^{-1})		
	N	P	K
1⁄1	172.0	14.7	291.2
1⁄2	175.6	15.3	298.0
2	172.8	14.6	292.8
3⁄1	200.4	13.9	301.6
3⁄2	191.7	13.3	311.2
3⁄3	198.2	13.4	336.0
4	172.9	14.1	369.6
5	165.4	14.6	347.2
6	164.3	15.8	414.4
7	160.5	16.1	347.2
8	163.1	15.8	347.2
9	162.9	14.3	459.2
11	158.0	14.0	324.8
12	151.7	14.7	267.6
13	160.4	14.5	295.2
14	164.1	15.6	286.4
15	175.6	17.3	315.2
16	150.4	13.9	291.2
17	159.2	17.9	295.2
18	198.0	17.0	358.4
19	178.0	17.7	301.6
20	171.7	17.3	304.0
21	168.0	16.5	359.2
23/1	172.9	16.3	291.6
23⁄2	160.4	16.0	298.0
24	180.4	17.8	288.8
25	175.4	17.9	291.6
26	166.6	15.4	291.6
27	161.7	12.7	277.6
28	168.0	15.6	276.4
29	161.7	16.7	302.4
30	168.0	16.3	267.6
31	160.5	17.2	347.2
32	164.3	17.2	425.6

The data on available nitrogen content of the surface soils (Table 4) revealed that the average nitrogen content ranged from 150.4 to 200.4 kg ha^{-1}. Similar results were reported by Meenkshi Bai *et al.* (2017) [6]. On the basis of soil test rating the soils were categorized as low in available nitrogen content and its percent distribution indicate that 100% soils were low in available nitrogen content.

Available Phosphorus
Phosphorus is essential for growth, cell division, root growth, fruit development and early ripening, required for energy storage and transfer, constituent of several organic compounds including oils and amino acids. Generally, the phosphorus deficient plants are dark green, but the lower leaves may turn yellow and dry up. Growth is stunted and leaves become smaller (Tairo *et al.*, 2013) [16].
The available phosphorus content in surface soils (Table 4) of dryland farm varied between 12.7 to 17.9 kg ha^{-1}. On the basis of soil test rating, the soils were categorized as low to medium in available phosphorus content and its percent distribution indicate that 17.6% soils are low, 82.4% medium in available phosphorus content. Similar results were reported by Patil and Sonar (1994) [9].

Available Potassium
The available potassium content in surface soils (Table 4) of dryland farm varied from 267.6 to 459.2 kg ha^{-1}. The soils were categorized as high and very high in the available potassium content and its percent distribution indicated that 47.1% soils were high and 52.9% very high in available potassium.

Soil Classification
Based on surface soil properties and typifying soil profiles data, the shallow soil categorized as Entisols were classified as Typic Ustorthents; medium to deep soils as Inceptisols (Vertic Haplustepts and Typic Haplustepts) and deep to very deep soils categorized as Vertisols were classified as Typic Haplusterts.

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