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Assessment of the fertility status of different land use system in Nagpur district

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Abstract
The present investigation entitled "Assessment of the fertility status of different land use system in Nagpur district" was undertaken during 2018-2020 at Department of Soil Science and Agricultural Chemistry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra.
The four sites were selected based on different variation in Nagpur. This four representative pedons were selected in four different locations of the study area covering all types of soils. All the four pedons were described for their morphological features in the field and depth-wise samples collected from 20 cm depth interval and analyzed in the laboratory for physical, physico-chemical and chemical properties. Results indicated that soils under study were neutral to moderately alkaline in reaction with pH ranging from 7.02 to 8.23. The electrical conductivity (EC) data indicated that the soils were non saline and free from soluble salt hazard. The organic carbon content of soil was low and ranged from 0.49 to 0.81%, while the free calcium carbonate content varied from 4.25 to 8.81% indicating that the soils were moderately calcareous in nature. The data of exchangeable cations showed that the calcium was the dominant cation followed by magnesium, potassium and sodium. The base saturation per cent varied between 89.32 to 97.56%. The CEC of soils varied from 31.16 to 55.49 cmol (p+) kg^{-1}. The available nutrients content of the soils indicated trend along with depth and soils were found to be low to medium in available nitrogen content and ranged from 193.42 to 374.56 kg ha^{-1}. Available 'P' status recorded between 15.51 to 37.71 kg ha^{-1} which is medium to high. Whereas soils were found to be medium to high in available potassium and varied from 250.67 to 368.10 kg ha^{-1}. Available micronutrients Zn found as deficient and sufficient in available Cu, available Fe, available Mn, B and Mo.

Keywords: Soil, fertility, productivity, land use system, pedons, physical properties, chemical properties

Introduction

Soil is a valuable non-renewable resource, which provides essential support to ecosystems. Overexploitation of resources to meet the basic needs has depleted the finite land resources causing land degradation. The global demand for raw materials, industrial inputs and energy has been the main drivers of the depletion and degradation of resources. Sustainable management of land resources is essential for food security, maintenance of environment and general wellbeing of the people. Indiscriminate use of resources coupled with lack of management has, however, led to degradation echoing the concern of planners, researchers and farmers alike. It is essential to enhance the soil productivity to meet the future demand.

Intensively cultivated soils are being depleted with available nutrients especially secondary and micronutrients. Therefore, assessment of fertility status of soils that are being intensively cultivated with high yielding crops needs to be carried out. Soil testing is usually followed by collecting composite soil samples in the fields without geographic reference. The results of such soil testing are not useful for site specific nutrients recommendations and subsequent monitoring. Soil available nutrients status of an area using Global Positioning System (GPS) will help in formulating site specific balanced fertilizer recommendation and to understand the status of soil fertility spatially and temporally. Site specific nutrient management and soil health assessment is essential to arrest land degradation and to recover the soil fertility and productivity.

Crop nourishment in any region depends remarkably on soil nutrient availability and on their profile similarities. All these problems make it necessary to closely analyze the physico-chemical status of agricultural soils, if they are managed for benefits of the individual farmers and of mankind. For this purpose, soil survey and soil fertility evaluation was carried out which have given an account of anatomy as well as physiology of soil mantle.

It is not only helpful to choose correct fertilizer doses but also keep farmers informed about inherent qualities and deficiencies.

Due to intensive cultivation practices and inadequate use of chemical fertilizers, the fertility and productivity of agricultural soil is depleting. Secondly the heavy application of chemical fertilizer and their declining responses is in alarming position. Hence, it is essential to increase the productivity without causing any hazardous effect on soil, so that resource base of future generation can be maintained. Analysis of soil for available macro and micronutrients supplying capacity of soil is helpful in planning integrated nutrient system, preparing fertility index of soils, soil fertility map and also to apply the targeted yield approach for sustainable agriculture. The study was conducted on soils of Nagpur district, Maharashtra. The soil nutrient analysis should be done pedon wise so that we can judge the fertility status of particular area for formulating future management strategies.

Materials and Methods

The present investigation entitled "Assessment of the fertility status of different land use system in Nagpur district" was undertaken with object to evaluate the fertility status of different land use system in Nagpur district.

Two to three kilograms of soil samples were collected in cotton bags from 20 cm depth interval of the pedons under study and labelled properly. Soil samples collected were air dried. Some of the clods were used for bulk density determination and remaining were gently crushed (ground) with a wooden mortar with pestle and passed through the 2 mm sieve for physical, physico-chemical and chemical analysis at Department of Soil Science and Agricultural Chemistry, Dr. P.D.K.V., Akola during 2018-2020.

The standard analytical methods commonly adopted in most of the laboratories for research investigations were followed. The bulk density was determined by clod coating method. The soil pH and electrical conductivity was determined by digital pH meter using glass electrodes and conductivity meter respectively, using 1:2.5 Soil: Water ratio as described by Jackson (1973) [13]. Organic carbon content of the soils was determined by Walkley and Black method as described by Nelson and Sommers (1982) [18]. The CaCO3 content was estimated by using rapid titration method as described by Piper (1966) [19]. Exchangeable sodium and potassium were determined by leaching the soil with 1 N ammonium acetate (pH 7.0). Sodium and potassium in the leachate were determined by using flame photometer (Jackson, 1967) [12]. Exchangeable calcium and magnesium were determined by leaching the soil with 1 N KCl triethanolamine buffer solution (pH 8.2) and titrating the leachate with standard EDTA solution (Jackson, 1967) [12]. Percent base saturation was calculated by dividing exchangeable cations to cation exchange capacity and result multiplied by 100. Available Nitrogen was determined by using alkaline permanganate method as described by Subbiah and Asija (1956) [28]. Available Phosphorus was determined by using 0.5M sodium bicarbonate solution (NaHCO3) of pH 8.5 as extractant and P estimated colorimetrically by Olsen method (Watanabe and Olsen, 1965) [34]. Available Potassium was determined by using Neutral normal ammonium acetate using flame photometeras described by Jackson (1967) [12]. In available Sulphur, Sulphur was extracted with 0.15 percent CaCl2 extract (Chesnin and Yien, 1951) [7] and the soluble sulphur was to be estimated turbidimetrically using blue filter on spectrophotometer at 440 nm. Available micronutrients (Fe, Mn, Cu, Zn) were extracted by DTPA- CaCl2 extractant at pH 7.3 (Lindsay and Norvell, 1978) [15] and were determined by Atomic Absorption Spectrophotometer (AAS). Available Boron was determined by using CaCl2 extractable Boron Azomethine method as described by Gupta and Stewart (1975) [10] and available Molybdenum was determined by using Grigg's reagent method given by Grigg (1960) [9].

Results and Discussion

Physical parameters

Bulk density

Bulk density is a reliable index for determining presence of compact layers particularly in sub soils. An examination of data presented in Table 1. Indicates that values of bulk density increased down the depth of soil in all the pedons examined. Bulk density varied from 1.33 to 1.59 Mg m^{-3} in all samples. The highest value of bulk density (1.59 Mg m^{-3}) was observed in the 100-120 cm depth of pedon 3. Whereas lowest value of bulk density (1.33 Mg m^{-3}) was observed in 0-20 cm of pedon 2. Similar results were also reported by Bharambe *et al.*, (1999) [3].

Table 1: Bulk density of soil

Pedon	Depth (cm)	B.D. (Mg m^{-3})
P1	0-20	1.43
	20-40	1.47
	40-60	1.49
	60-80	1.53
	80-100	1.55
	100-120	1.57
P2	0-20	1.33
	20-40	1.35
	Weathered parent material	
P3	0-20	1.46
	20-40	1.49
	40-60	1.54
	60-80	1.56
	80-100	1.58
	100-120	1.59
P4	0-20	1.41
	20-40	1.46
	40-60	1.48
	60-80	1.51
	80-100	1.53

Chemical Parameters

Soil pH

The pH values of 1:2.5 soil water suspensions ranged from 7.02 to 8.23 indicating neutral to moderately alkaline in reaction in all pedons (Table no.2). All Pedons showed an increasing trend with depth. All pedons showed an increasing trend with depth due to accumulation of exchangeable bases and $CaCO_3$ lower horizons. Similar results were also made by Walia and Rao (1996) [33] in Bundelkhand region of Uttar Pradesh.

Electrical conductivity (EC)

The EC of the studied soils ranged from 0.14 to 0.38 DS m^{-1}, which is well within the acceptable limit of EC range for normal soils (Richards, 1954) [23]. The range showed that these soils are non-saline in nature. The low electrical conductivity may be due to free drainage conditions which favoured the removal of released bases by percolating and drainage water.

Table 2: Chemical characteristics of soil

Pedon	Depth (cm)	pH (1:2.5)	EC (dSm^{-1})	OC (%)	$CaCO_3$ (%)
P-1	0-20	7.45	0.25	0.65	5.75
	20-40	7.52	0.28	0.63	6.00
	40-60	7.65	0.30	0.60	6.75
	60-80	7.81	0.31	0.57	7.25
	80-100	7.97	0.32	0.53	7.75
	100-120	8.11	0.34	0.49	8.24
P-2	0-20	7.02	0.16	0.75	4.25
	20-40	7.11	0.14	0.67	4.75
	40-80	Weathered parent material			
P3	0-20	7.61	0.34	0.76	5.9
	20-40	7.72	0.32	0.71	6.41
	40-60	7.95	0.29	0.66	6.62
	60-80	8.04	0.34	0.61	7.75
	80-100	8.17	0.36	0.55	8.15
	100-120	8.23	0.34	0.52	8.81
P4	0-20	7.18	0.27	0.81	4.75
	20-40	7.33	0.36	0.75	5.25
	40-60	7.69	0.37	0.72	5.5
	60-80	7.81	0.34	0.67	6.25
	80-100	8.05	0.38	0.59	6.75

Organic Carbon
The data presented in Table 2 showed that the organic carbon content in different pedons ranged from 0.49 to 0.81 per cent indicating low in organic carbon status. The highest value of 0.81 was registered in pedon 4 and the lowest value was recorded in pedon 1. Pedons 1, 2, 3 and 4 exhibited a decreasing trend with depth. The organic carbon content decreased gradually with an increase with the depth, which is mainly due to the accumulation of plant residues on the soil surface and less movement down the profile due to rapid rate of mineralization at higher temperature and adequate soil moisture level. Similar results were observed by Sarkar *et al*., (2001) [25], Nayak *et al*., (2001) [17] and Rao *et al*., (2008) [22].

Calcium carbonate
The calcium carbonate content Table 2 of the surface and subsurface depth of soil ranged from 4.28 to 8.81%. It indicates that these soils are moderately calcareous in nature and pedon 1, 2, 3, and 4 showed an increasing trend with depth. The highest $CaCO_3$ content was noticed in the P3 and lowest in P2. This might be due to high clay content which led to impeded leaching, consequently accumulation of $CaCO_3$ in the lower horizon. Similar results were reported by Prakash and Rao (2002) [20] in soils of Krishna district, Andhra Pradesh.

Cation exchange capacity (CEC)
The CEC values varied from 31.16 to 55.49 cmol (p$^+$) kg^{-1} soil. The highest value of 55.49 cmol (p$^+$) kg^{-1} soil was noticed in the pedon 4 which might be due to comparatively higher clay content in this horizon and the lowest value 31.16 cmol (p$^+$) kg^{-1} soil was observed in P1 (Table 3). Whereas pedons 1, 2, 3 and 4 exhibited an increasing trend with depth. Clay and CEC in the present study suggest that clay contributes to CEC in these soils. Similar results were also reported by Thangasamy *et al.*, (2005) [30] and Sitanggang *et al*., (2006) [27].

Table 3: CEC and Exchangeable cations of soil

Pedon	Depth	CEC	Exchangeable cations (cmol (p+) kg^{-1})				BS (%)
			Ca	Mg	Na	K	
P1	0-20	40.65	22.18	14.15	0.19	0.59	91.29
	20-40	42.58	25.26	14.19	0.20	0.57	94.45
	40-60	48.11	29.56	12.81	0.25	0.46	89.32
	60-80	47.15	30.63	12.84	0.23	0.41	93.55
	80-100	50.15	34.81	12.88	0.28	0.38	96.35
	100-120	47.38	32.16	11.46	0.30	0.35	93.43
P2	0-20	31.16	21.83	7.13	0.17	0.51	95.21
	20-40	35.76	24.57	8.41	0.15	0.48	93.98
	40-80	Weathered parent material					
P3	0-20	48.25	35.11	7.81	0.48	0.94	91.89
	20-40	49.71	36.01	9.34	0.53	0.86	94.02
	40-60	50.68	37.06	10.12	0.59	0.79	95.81
	60-80	53.22	38.49	11.83	0.55	0.71	96.91
	80-100	54.95	39.12	12.15	0.61	0.63	94.62
	100-120	55.49	40.39	12.61	0.62	0.52	97.56
P4	0-20	37.19	23.15	09.89	0.15	0.95	91.79
	20-40	40.61	25.39	10.34	0.14	0.87	90.47
	40-60	43.06	28.54	11.24	0.16	0.88	94.79
	60-80	46.51	30.52	11.35	0.16	0.79	92.06
	80-100	45.62	31.81	10.11	0.21	0.71	93.90

Exchangeable cations
The data presented in Table 3 showed that the exchangeable calcium, magnesium, sodium, and potassium contents in soils varied from 21.83 to 40.39, 14.19 to 7.13, 0.14 to 0.62, 0.35 to 0.95 cmol (p+) kg^{-1}. Similar results were reported by Kharche and Pharande (2010) [14]. The percent base saturation on the exchange complex was in between 89.32 to 97.56. The highest value of 97.56 percent was observed in pedon 3 and the lowest value of 89.32 percent was noticed in pedon 1. Pedon 1, 2, 3 and 4 exhibited an increasing trend with depth. The higher base saturation observed in the pedons might be due to higher amount of Ca^{2+} in exchange sites on the colloidal complex. Similar results were reported by Tripathi *et al*., (2006) [31] in the soils of Kiar-Nagali micro-watershed in North-West Himalayas.

It is observed that the base saturation percentage increased with the pH which indicates the fewer amounts of H^+ ions in the soils and the dominance of basic cations (Tan, 1989). Exchangeable calcium is the dominant cation followed by magnesium, potassium and sodium.

Soil fertility parameters
Available Nitrogen
The available nitrogen ranged in between 193.75 to 374.56 mg kg^{-1} soil and these soils were low to medium in available nitrogen. All the pedons exhibited a decreasing trend with depth. Available nitrogen found to be maximum in the surface horizons and decreased regularly with depth of the pedons, which might be due to decreasing trend of organic carbon with depth. Low available nitrogen in these soils was attributed to be semi-arid condition of the area might have favoured rapid oxidation and lesser accumulation of organic matter, releasing more NO_3-N which could have been lost by leaching (Finck and Venkateswarlu, 1982) [8].

Available Phosphorus
A perusal of data on available phosphorus is presented in Table 4 indicates that content of phosphorus varied from 15.51 to 37.71 kg ha^{-1} in all the pedons. The maximum content of available phosphorus was observed in soils of pedons 1

followed by soils of pedons 2, 3, and 4. The pedons 1, 2, 3 and 4 showed a decreasing trend with depth. These soils were medium to high in available phosphorus. High organic matter in the surface and addition of phosphotic fertilizers to soils were the causes for high phosphorus content in the surface soils. Similar results were also observed by Sekhar *et al.*, (2014) [26] in soils of central and eastern parts of Prakasam district in Andhra Pradesh.

Available Potassium

The available potassium content varied from 250.67 to 368.10 mg kg^{-1} soil. Pedons 1, 2, 3, and 4 exhibited a decreasing trend with depth. This could be attributed to more intense weathering, release of liable K from organic residues, application of K fertilizers and upward translocation of potassium from lower depths along with capillary raise of ground water. Similar results were reported by Basavaraju *et al.*, (2005) [1] in soils of Chandragiri mandal of Chittoor district in Andhra Pradesh.

Table 4: Fertility status of soil

Pedon	Depth (cm)	Available nutrients (kg ha^{-1})			S (mg kg^{-1})
		N	P	K	
P1	0-20	309.12	37.71	368.10	17.54
	20-40	297.22	33.34	359.45	14.42
	40-60	278.47	28.74	347.23	13.52
	60-80	265.81	25.62	316.00	10.07
	80-100	241..28	21.87	281.91	9.68
	100-120	225.67	19.45	274.41	8.54
P2	0-20	374.56	19.83	288.14	14.88
	20-40	316.89	17.28	264.26	12.76
	40-80	Weathered parent material			
P3	0-20	287.42	25.09	352.62	18.96
	20-40	271.36	22.18	345.87	16.57
	40-60	265.74	19.51	289.32	15.77
	60-80	241.93	20.09	263.31	15.29
	80-100	216.11	17.45	245.56	12.49
	100-120	193.75	15.84	241.84	10.55
P4	0-20	293.42	23.87	345.79	15.20
	20-40	278.14	20.45	291.66	12.36
	40-60	265.58	18.69	280.52	10.25
	60-80	242.26	19.25	268.42	9.87
	80-100	228.89	15.51	250.67	7.83

Available Sulphur

The data presented in Table 4 showed that the available sulphur content in the different pedons ranged from 7.83 to 18.96 mg kg^{-1} soil. All pedons exhibited a decreasing trend with depth. Available sulphur content which might be due to regular addition of organic matter and sulphur containing fertilizers and pesticides. More or less all pedons showed a decreasing trend with increasing depth was observed. Similar results were also reported by Bhatnagar *et al.*, (2003) [4] in soils of Shivapuri district in Madhya Pradesh.

Available micronutrient status of soil

Iron

The DTPA extractable iron varied from 6.00 to 14.18 mg kg^{-1} soil. Which was low to medium in categeory and its higher values was observed in pedon P3 and lowest value in pedon 1. According to the critical limit (4.5 mg kg^{-1} soil) of Lindsay and Norvell (1978) [15] the soils were sufficient in available iron. Surface depth had higher concentration of DTPA-extractable Fe due to higher organic carbon (Prasad and Gajbhiye, 1999) [21].

Manganese

The data presented in Table 5 showed that the DTPA extractable manganese varied from 5.32 to 14.88 mg kg^{-1} soil. Which was medium to moderately high in category and its higher values was observed in pedon P3 and lowest value in pedon 1. All pedons exhibited a decreasing trend with depth. The DTPA extractable manganese content was sufficient because these values were well above the critical limit (1.0 mg kg^{-1}) of Lindsay and Norvell (1978) [15].

Copper

The DTPA extractable copper varied from 0.83 to 2.71 mg kg^{-1} soil. Which was high in category and its higher values was observed in pedon P3 and lowest value in pedon 4. All the pedons were found to be sufficient in available copper, since all the values were well above critical limit of 0.2 mg kg^{-1} soil as suggested by Lindsay and Norvell (1978) [15]. Similar results were expressed by Sarkar *et al.*, (2000) [24] and Verma *et al.*, (2005) [32] in soils of Madhubani district in Bihar and in soils developed on different physiographic units of Fatehgarh Sahib district of Punjab, respectively.

Table 5: Available micronutrients in soil

Pedon	Depth (cm)	Available micronutrients (mg kg^{-1})					
		Fe	Mn	Cu	Zn	B	Mo
P1	0-20	13.25	12.48	1.84	0.65	0.81	0.07
	20-40	10.42	11.78	1.73	0.59	0.78	0.10
	40-60	9.64	9.42	1.53	0.51	0.72	0.14
	60-80	8.04	7.85	1.28	0.48	0.64	0.19
	80-100	7.97	5.64	1.19	0.44	0.59	0.22
	100-120	6.00	5.32	0.84	0.39	0.46	0.25
P2	0-20	12.5	7.41	1.66	0.67	0.41	0.09
	20-40	8.20	6.00	1.54	0.63	0.37	0.14
	40-80	Weathered parent material					
P3	0-20	14.53	14.88	2.71	0.80	0.76	0.04
	20-40	13.85	12.71	1.64	0.76	0.74	0.07
	40-60	12.5	9.16	1.58	0.53	0.63	0.11
	60-80	10.45	7.75	1.32	0.58	0.58	0.15
	80-100	8.78	5.96	0.98	0.55	0.51	0.18
	100-120	7.32	5.37	0.86	0.49	0.45	0.21
P4	0-20	13.6	9.74	1.84	0.74	0.53	0.05
	20-40	10.25	7.25	1.62	0.62	0.57	0.09
	40-60	9.57	8.18	1.16	0.60	0.51	0.12
	60-80	7.35	6.59	0.94	0.43	0.48	0.18
	80-100	7.14	5.76	0.83	0.39	0.43	0.29

Zinc

The DTPA extractable zinc varied from 0.39 to 0.80 mg kg^{-1} soil. Which is deficient in soil. The DTPA extractable-Zn Pedons 1, 2 and 4 exhibited a regular decreasing trend with depth. The low DTPA extractable zinc was possibly due to high soil pH values which might be resulted in the formation of insoluble compounds of zinc or insoluble calcium zincate (Sarkar *et al.*, 2000) [24].

Available Boron

The available boron content of the profile soils varied from 0.37 to 0.81 mg kg^{-1} (Table 5) and its highest value 0.81 was observed of pedon P1 and lowest value 0.37 in pedon p1. These soils were low to medium in available boron. Data from the present study on available boron indicated that-similar as reported by Bendale *et al.*, (1951) [2] for soils of

Bombay State and by Mahabari (1970) [16] and Chavan (1974) [6] for Maharashtra soils.

Available Molybdenum

The available molybdenum content of the profile soils varied from 0.04 to 0.29 mg kg^{-1} Table 5 and its highest value 0.29 was observed of pedon 4 and lowest value 0.04 was observed in pedon 3. And these soils were low to medium in available molybdenum. It can be observed that there is a positive correlation between pH and available molybdenum. The available soil molybdenum increases with soil pH. Gupta and Dabas (1980) [11] observed that available molybdenum had highly significantly correlated with pH.

Conclusion

It can be concluded from the above results that the soils of Nagpur districts were found neutral to moderately alkaline in reaction, low EC, low in organic carbon content, moderately calcareous in nature. These Pedon soils were Low to medium in available N, medium to high available P, medium to high level in available K, low to medium in available Sulphur status, whereas deficient in available Zn and sufficient in available Cu, available Fe, available Mn, available B and deficient in available Mo.

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