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Survey of Soil Profile Characteristics and Variability at Mulegaon Research Farm, ZARS, Solapur

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Abstract

Knowledge of soil morphological and physicochemical properties is vital in the decision making regarding which research project should be implemented in which kind of soil. From a total of three typifying profiles, nine representative samples were collected at varying depths according to the presence of subordinate horizon from the Mulegaon Research Farm of the Zonal Agricultural Research Station, Solapur.Taxonomically, the profiles were *Lithic Ustorthent* (*Entisols*), *Typic Haplustept* (*Inceptisols*), and *Vertic Haplustept* (*Inceptisols*). The textural class varied from silty clay loam for the Entisols to clay for the remaining two Inceptisols.The physical properties indicated heavy soils throughout the study area. The pH was varied from neutral to moderately alkaline. All profiles soils were nonsaline. Macronutrients showed a general decreasing trend with increasing soil depth. The available N ranged between the low and very low categories. Available phosphorus varied between very low to moderately high class. Available potassium was found to be very high in all profiles, whereas available sulphur was deficient. DTPA manganese and copper were sufficient while DTPA iron was deficient throughout all 3 profiles. DTPA zinc was sufficient in all pedons except pedon3.

Key words : Profile,medium soil, deep soil, *Ustorthent*, *Haplustept*.

A soil profile study involves the examination and analysis of vertical sections of soil layers or horizons in a specific location. These layers, from the surface down to the bedrock or other parent material, provide valuable information about the composition, structure, and properties of the soil. The goal of studying soil profiles is to help in decision-making regarding fertilization, irrigation, and crop selection. Different soil horizons have varying nutrient levels and water-holding capacities, which influence the crop growth. They also aid in assessing soil contamination, erosion potential, and groundwater quality. This information is essential for land-use planning and conservation. The bearing capacity and stability of the soil are vital for ensuring the longevity and safety of the structure to be built on it.

Soil profiles typically consist of distinct horizons labelled as O (organic), A (topsoil), B (subsoil), and C (parent material). Morphological analysis involves the identification and characterization of each horizon based on colour, texture, structure, and composition. For example, information on soil texture is crucial for understanding drainage, fertility, and nutrient-holding capacity, whereas structure and consistency affect water infiltration, root penetration, and overall soil stability. A soil profile study is important for various applications, including agriculture, environmental assessment, and engineering. The morphological aspects provide a comprehensive understanding of the properties and behaviour of soil. Therefore, a study had been conducted at the Mulegaon Research farm of Zonal Agriculture Research Station, Solapur to gain insights for the implementation of future projects.

Materials and methods

Experimental details : The profile study was one of the objectives of the assessment of soil fertility of the Mulegaon Research Farm, ZARS, Solapur. Based on the soil type, three locations were selected for determining the profiles using GPS technology. The location of the profiles is given Figure 1. The dug-out profile was then studied for its morphological properties as per the USDA soil survey manual. Soil samples representing a sub-horizon each were collected viz., between 0-30cm from the shallow profile, 0-15cm, 15-30cm, 30-45cm and 45-60 cm from the medium profile and 0-15cm, 15-30cm, 30-60cm and 60-90cm from the deep profile. A total of nine soil samples, one from Entisols and four samples each from the two Inceptisols, were collected. These soil profiles were then analyzed for physico-chemical properties, viz., pH using the potentiometric method, EC determined by the conductometric method, organic carbon determined by the wet oxidation method, and calcium carbonate determined by the rapid titration method. These

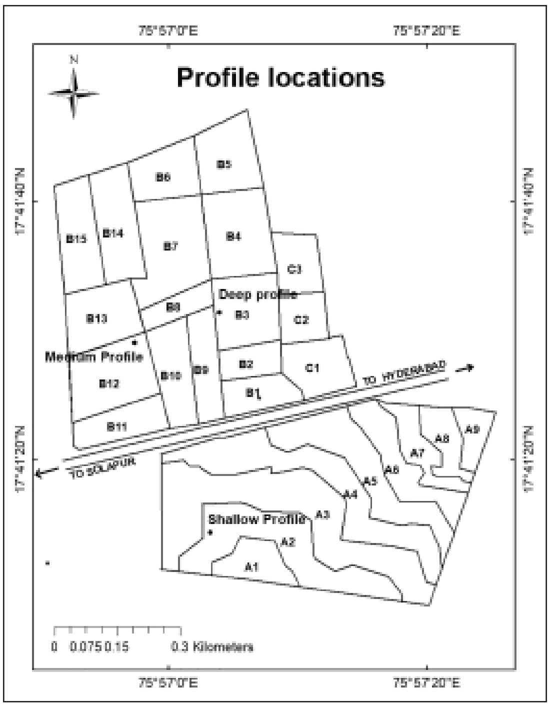

Fig. 1. Image showing locations of profile taken at the Mulegaon Research Farm, ZARS, Solapur

soil samples were also analyzed for available nitrogen using the alkaline permanganate method, phosphorus using Olsen's method, potassium using the neutral normal ammonium acetate method, sulphur using the $CaCl_2$ extractable method, micronutrients by DTPA extract of soil (pH 7.3) using Atomic Absorption Spectrophotometer, texture by International pipette method and bulk density, porosity, particle density, maximum water holding capacity and volume expansion using the Hilgard dish method as given by the methods and formulae by Keen and Rackowski (1921).

Results and discussion

Morphological properties

Pedon 1: *Lithic Ustorthent* (Entisols)

Ap (0-30 cm) The soils in this sub horizon were dark brown (10YR4/3) in colour. The texture was gravelly silty clay loam and the structure was weak fine subangular blocky. The consistency of the soil was slightly hard under dry conditions, very friable under moist conditions, and sticky and plastic under wet conditions. There were many coarse and fine roots present, and the soil exhibited very slight effervescence on dilute HCl application. The soil contained 20-25% fine gravels, and a clear smooth boundary was observed.

Pedon 2: *Typic Haplustept* (Inceptisols)

Ap (0-15 cm) The soils in this sub horizon were very dark greyish brown (10YR3/2) in colour. The texture wasclay and the structure wasstrong coarse subangular blocky.Consistency of the soil was hard under dry conditions, friable under moist conditions and sticky and plastic under wet conditions.Generated very slight effervensces on dil. HCl application. 1-2 cm cracks and a clear smooth boundary was observed.

Bw1 (15-30 cm) The soils in this sub horizon were very dark greyish brown (10YR3/2) in color. The texture was clay and the structure was medium moderate subangular blocky. The consistency of the soil was hard under dry conditions, friable under moist conditions, and very sticky and plastic under wet conditions. There were many fine roots present, and the soil exhibited very slight effervescence on dilute HCl application. A clear smooth boundary was observed.

Bw2 (30-45 cm) The soils in this sub horizon were very dark greyish brown (10YR3/2) in colour. The texture was clay and the structure was medium moderate subangular blocky. The consistency of the soil was hard under dry conditions, friable under moist conditions, and very sticky and plastic under wet conditions. There were many very fine roots present, and the soil exhibited slight effervescence on dilute HCl application. A clear smooth boundary was observed.

BC (45-60 cm) The soils in this sub horizon were very dark greyish brown (10YR3/2) in colour. The texture was gravelly clay and the structure was fine weak subangular blocky. The consistency of the soil was hard under dry conditions, friable under moist conditions, and sticky and plastic under wet conditions. The soil exhibited slight effervescence on dilute HCl application. There were 62 % fine gravels present, and a diffuse wavy boundary was observed.

Pedon 3: *Vertic Haplustept* (Inceptisols)

Ap (0-15 cm) The soils in this sub horizon were very dark greyish brown (10YR3/2) in color. The texture was clay and the structure was strong coarse subangular blocky. The consistency of the soil was hard under dry conditions, firm under moist conditions, and very sticky and plastic under wet conditions. There were many coarse and fine roots present, and the soil exhibited very slight effervescence on dilute HCl application. 5-6 cm cracks and a clear smooth boundary were observed.

Bw1 (15-30 cm) Very dark greyish brown (10YR3/2); Clay; Moderate medium subangular blocky structure; Dry - hard; Moist - firm; wet - very sticky and plastic; 2-3 cm wide cracks, very slight effervensces, few coarse and frequent fine roots; clear smooth boundary.

Bw2 (30-60 cm) The soils in this sub horizon were very dark greyish brown (10YR3/2) in color. The texture was clay and the structure was moderate medium subangular blocky. The consistency of the soil was hard under dry conditions, firm under moist conditions, and very sticky and plastic under wet conditions. There were few coarse and frequent fine roots present, and the soil exhibited very slight effervescence on dilute HCl application. 2-3 cm wide cracks and a clear smooth boundary were observed.

BC (60-90 cm) The soils in this sub horizon were very dark greyish brown (10YR3/2) in color. The texture was clay and the structure was medium moderate angular blocky. The consistency of the soil was very hard under dry conditions, firm under moist conditions, and very sticky and very plastic under wet conditions. The soil had well-developed pressure faces, 0.5 to 1 cm wide cracks, and weakly developing non-intersecting slickensides. Many very fine roots were present, and the boundary was gradual wavy.

Physical properties : Details of data regarding the physical properties arepresented in Table 1.The resultsreveal that the bulk density ranged from 1.12-1.33 Mg m^{-3}. Pedon 2 (*Typic Haplustept*) exhibited both: the highest bulk density and the lowest density. The results indicated a trend of increasing bulk density with depth. This finding aligns with observations reported by Rajagopal *et al*. (2013) for soils in the Waranga district of central Telangana state. Porosity of the soil samples ranged from 45.73-58.04% with highest value in pedon 2 (*Typic Haplustept*) and lowest value in pedon 1 (*Lithic Ustorthent*). The particle density ranged from 2.14Mg m^{-3} in pedon 1 (*Lithic Ustorthent*) to 3.01Mg m^{-3} in pedon 2 (*Typic Haplustept*). Maximum water holding capacity of the profile samples varied from 46.11% in pedon 1 (*Lithic Ustorthent*) to 62.81% in pedon 2 (*Typic Haplustept*). The volume expansion of the profile soil samples ranged from 7.09 in pedon 1 (*Lithic Ustorthent*) to 8.94 in pedon 2 (*Typic Haplustept*).

The particle size distribution (Table 1) showed that the highest mean clay content (72.45%), and the lowest mean silt content (15.99%) was reported in pedon 2 (*Typic Haplustept*) and in pedon 3 (Vertic Haplustept) the lowest sand per cent (8.94%) was recorded. The highest silt content was recorded in pedon 1 (*Lithic Ustorthent*), resulting in the textural class of silty clay loam. The textural class of pedon 2 and 3 was clay. Similar trend of observations was recorded by Nagaraju and Gajbhiye (2014) in soils of Kukadi command area in Ahmednagar district

Chemical properties : pH: An analysis of soil samples from the Mulegaon Research Farm, ZARS, Solapur revealed a range of soil reactions, including neutral, slightly alkaline, and moderately alkaline (Table 2). The pH value of 7.6 was measured in Pedon 1 (*Lithic Ustorthent*). Pedon 2 (*Typic Haplustept*) exhibited a range of 7.08-7.82 while, Pedon 3 (*Vertic Haplustept*) had the range of 7.68-8.10. This pattern of increasing pH aligns with the observations of Patil *et al*. (2019), Das *et al*. (2022), and Tiwari *et al.* (2023).

Electrical conductivity : Electrical conductivitymeasurements of soil samples collected (Table 2) revealed values ranging from 0.22 dS m^{-1}, 0.10-0.15 dS m^{-1} and 0.08-0.17 dS m^{-1} for Pedon 1, 2 and 3, respectively. These values fall well within the safe limit for normal soils, indicating a non-saline classification. This observation aligns with the findings reported by Tiwari *et al*. (2023).

Organic carbon : Analysis of soil organic

Table 1. Physical properties of typifying pedons

Horizons	Depth cm	Bulk density Mg m-3	Porosity %	Particle density Mg m-3	Max. water holding capacity %	Volume expansion %	Particle size analysis %			Textural class
							Sand	Silt	Clay	
Pedon 1: *Lithic Ustorthent (Entisols)*										
Ap	0-30	1.16	45.73	2.14	46.11	7.09	14.75	46.58	38.67	Silty clay loam
Pedon 2: *Typic Haplustept (Inceptisols)*										
Ap	0-15	1.16	57.23	2.71	59.26	7.89	11.56	15.99	72.45	Clay
Bw1	15-30	1.12	52.18	2.34	62.81	8.94	10.64	21.91	67.45	Clay
Bw2	30-45	1.23	58.04	2.93	55.28	7.71	9.46	30.55	59.99	Clay
BC	45-60	1.33	55.76	3.01	55.86	6.84	12.45	26.99	60.56	Clay
Pedon 3: *Vertic Haplustept (Inceptisols)*										
Ap	0-15	1.18	55.45	2.65	58.12	7.85	9.45	23.32	67.23	Clay
Bw1	15-30	1.22	55.98	2.77	59.17	8.56	10.50	25.96	63.54	Clay
Bw2	30-60	1.26	52.00	2.63	56.44	7.70	8.94	22.71	68.35	Clay
BC	60-90	1.32	55.32	2.95	53.63	6.70	10.45	32.21	57.34	Clay

carbon content from the Mulegaon Research Farm, ZARS, Solapur (Table 2) revealed a decreasing trend with depth. Furthermore, organic carbon content in Lithic Ustorthent (Pedon 1) was 0.30%, while Pedon 3 (*Vertic Haplustept*) ranged from 0.24% to 0.41%, and Typic Haplustept (Pedon 2) ranged from 0.27% to 0.33%. This observed decrease in organic carbon with increasing depth aligns with findings reported by Titirmare *et al.* (2019), Shinde (2022), and Sushma *et al.* (2023).

Calcium carbonate : Calcium carbonate ($CaCO_3$) content in soils from the Mulegaon Research Farm, ZARS, Solapur (Table 2) exhibited a trend of increasing values with depth (ranging from 6.00% to 12.25% across all pedons). Lithic Ustorthent (Pedon 1) had the lowest $CaCO_3$ content (6.00%), followed by Typic Haplustept (Pedon 2) with a range of 8.00% to 8.25%, and Vertic Haplustept (Pedon 3) showing the highest range (8.75% to 12.25%). These observations align with previous studies by Chadar *et al.* (2018) in Latur, and Patil *et al.* (2019). The increasing trend suggests potential leaching of calcium salts from upper horizons with subsequent deposition at lower depths, possibly facilitated by the high soil pH levels.

Available nitrogen : Analysis of available nitrogen content in soils from the Mulegaon Research Farm, ZARS, Solapur revealed a range of values between 66-119 kg ha^{-1} (Table 2). Pedon 2 (*Typic Haplustept*) exhibited the lowest available nitrogen content (66 kg ha^{-1}). These observations are consistent with findings reported by Bhoyar *et al.* (2023), who also documented a trend of higher nitrogen content in surface soils compared to subsurface layers. This pattern likely reflects the influence of agricultural practices, such as nitrogen fertilizer applicationduring crop cultivation, and the accumulation of organic matter at the soil surface.

Available phosphorus : Data reveals low to moderately high levels of available phosphorus in profile samples of the Mulegaon Research Farm, ZARS, Solapur, ranging from 1.10 to 21.68 kg ha^{-1}. A consistent trend of decreasing available phosphorus with depth was

Table 2. Chemical properties of typifying pedons

Pedon no.	Depth cm	Chemical properties				Available macronutrients				Available micronutrients			
		pH 1:2.5	EC dSm^{-1}	OC %	$CaCO_3$ %	N	P	K	S	Fe	Mn	Zn	Cu
						kg ha^{-1}			mg kg^{-1}	mg kg^{-1}			
Pedon 1: *Lithic Ustorthent: Entisols*													
Ap	0-30	7.60	0.22	0.30	6.00	119	8.23	529	1.07	2.74	22.53	1.23	4.78
Pedon 2: *Typic Haplustept:Inceptisols*													
Ap	0-15	7.08	0.12	0.33	8.00	85	21.68	750	1.52	4.33	39.48	1.63	5.20
Bw1	15-30	7.28	0.10	0.29	8.00	69	17.29	683	0.36	3.72	43.49	1.45	4.84
Bw2	30-45	7.57	0.15	0.27	8.00	66	13.17	617	0.36	3.22	39.7	1.19	4.64
BC	45-60	7.82	0.10	0.30	8.25	88	8.51	441	0.27	2.58	32.87	0.95	4.33
Pedon 3: Vertic Haplustept:Inceptisols													
Ap	0-15	7.68	0.17	0.39	8.75	97	5.76	661	1.88	2.52	37.61	1.13	4.89
Bw1	15-30	8.10	0.11	0.41	12.25	88	2.74	562	2.68	1.95	34.38	0.86	4.76
Bw2	30-60	7.96	0.08	0.38	8.75	94	6.86	353	0.45	1.94	29.98	0.50	3.98
BC	60-90	8.00	0.13	0.24	10.00	75	1.10	342	0.27	1.54	11.84	1.12	1.79

observed across all pedons. Pedon 2 (Typic Haplustept) exhibited the highest value of available phosphorus. These findings align with observations reported by Meena *et al.* (2010) and Bhoyar *et al.* (2023), who documented similar patterns of decreasing available phosphorus content with increasing soil depth. Surface soils possess higher available phosphorus content compared to subsurface layers, this may bedue to increased phosphorus fixation by clay minerals and free calcium carbonates at lower depths.

Available potassium : Available potassium content in soils from the Mulegaon Research Farm, ZARS, Solapur exhibited a wide range, spanning from 342 kg ha^{-1} to 750 kg ha^{-1} (Table 2). This indicates that the soils are very high in available potassium overall. However, a general trend of decreasing available potassium with depth was observed across all pedons. Pedon 3 (Vertic Haplustept) exhibited the lowest available potassium content (342 kg ha^{-1}) which still fell in the very high category. These findings are consistent with previous studies by Meena *et al*. (2010) and Bhoyar *et al*. (2023) conducted in Saoner tehsil, Nagpur district.

Available sulphur: Analysis of available sulphur content in soils from the Mulegaon Research Farm, ZARS, Solapur (Table 2) revealed a range of values of 1.07 mg kg^{-1}, 0.27-1.52 mg kg^{-1} and 0.27-2.68 mg kg^{-1} for Pedon 1, 2 and 3 respectively. Pedon 3 (*Vertic Haplustept*) exhibited both the highest (2.68 mg kg^{-1}) and lowest (0.27 mg kg^{-1}) available sulfur contents across various depths.

DTPA micronutrients : Analysis of micronutrient availability in Mulegaon Research Farm, ZARS, Solapur soils (Table 2) revealed that iron (Fe) content is deficient across all the pedons. Pedon 1 (Lithic Ustorthent) exhibited a single value of 2.74 mg kg^{-1}. In Pedon 2 (*Typic Haplustept*), Fe content ranged from 2.58 mg kg^{-1} to a maximum of 4.33 mg kg^{-1} as observed in the surface layer. Pedon 3 (*Vertic Haplustept*) showed the lowest Fe content, ranging from 1.54 mg kg^{-1} at 90 cm depth to a 2.52 mg kg^{-1} at the surface layer. These findings are consistent with observations reported by Aich *et al*. (2017). Pedon 1 (*Lithic Ustorthent*) had the lowest Mn content, with a value of 22.53 mg kg^{-1}. Pedon 2 (*Typic Haplustept*) showed a wider range, with Mn content varying from 32.87 mg kg^{-1} and 43.49 mg kg^{-1}. Pedon 3 (Vertic Haplustept) displayed Mn content ranging from 11.84 mg kg^{-1} to 37.6 mg kg^{-1}. These findings align with observations reported by Thangasamy *et al*. (2005) who documented higher Mn content in surface horizons, generally decreasing with depth. Pedon 2 (*Typic Haplustept*) exhibited the highest Zn content (1.63 mg kg^{-1}) within the surface layer. In contrast, Pedon 3 (Vertic Haplustept) showed the lowest Zn content (0.50 mg kg^{-1}) measured at a depth of 60 cm. These observations align with trends reported by Wagh *et al*. (2016), Aich *et al*. (2017) and Naphade *et al.* (2022), where Zn availability generally decreased with soil depth.The available Cu content ranged from 1.79-5.20 mg kg^{-1} in the profiles of Mulegaon Research Farm, ZARS, Solapur. All the profiles contain sufficient copper throughout the whole profile with decreasing trend with increase in depth. This must be due to decrease in organic matter with increase of soil depth as it acts as chelating agent for copper. It was observed that the highest available copper content occurred in pedon 2. Typic Haplustept (Pedon 3). Kaygude *et al*. (2020), observed similar trends of copper variation.

Conclusions

The study concludes that the profile studied were taxonomically, *Lithic Ustorthent, Typic Haplustept* and *Vertic Haplustept* with textural class of slity clay loam and clay for the remaining, respectively. Soils coming under *Lithic Ustorthent* have nonsaline neutral pH with low amounts of organic carbon, medium amount of $CaCO_3$, very low amounts of available nitrogen, low amounts of phosphorus and very high amount of potassium. It is also sufficient in DTPA Mn, Zn and Cu but deficient in available sulphur and DTPA Fe. Soils coming under *Typic Haplustept* have nonsaline neutral to slightly alkaline pH with low amounts of organic carbon, medium amount of $CaCO_3$, very low amounts of nitrogen, low to moderately high amounts of phosphorus and very high amounts of potassium. It is also sufficient in DTPA Mn, Zn and Cu but deficient in available sulphur and DTPA Fe. Soils coming under *Vertic Haplustept* have nonsaline slightly to moderately alkaline pH with low to moderate amounts of organic carbon, medium to high amounts of $CaCO_3$, very low amounts of nitrogen and phosphorus and very high amounts of potassium. It is also sufficient in DTPA Mn and Cu but deficient in available sulphur and DTPA Fe. DTPA Zn is deficient at the depth of 30-60cm but is sufficient in rest of the profile.

References

Aich, V., More, N. B., Udayana, S. K. and Patil, G. D. 2017. GPS-GIS Based Soil Maps of Micronutrients Status in Organic Farms at College of Agriculture, Pune (MS), India. International Journal of Current Microbiology and Applied Sciences, 6(8), 855-861.

Bhoyar, K. D., Raut, M. M., Dhemre, U. S. and Bagmare, R. R. 2023. Assessment of nutrient status of soybean growing soils in Saoner tehsil, district Nagpur. The Pharma Innovation Journal, 12(1), 1101-1105.

Chadar, B. R., Vaidya, P. H., Kachave, R. R. and Aundhakar, A.V. 2018. Characterizations, classifications and soil site suitability of farm College of Agriculture, Latur, Maharashtra. Journal of Pharmacognosy and Phytochemistry. 1: 166-170.

Das, B. M., Raut, M., Badge, S., Mareddy, N. and Bhoyar, K. 2022. Fertility status of rice growing soils of Gadchiroli tehsil of Maharashtra, India in relation to available macronutrients and soil chemical properties. International J. of Plant and Soil Sci., 34(24), 283-289.

Kaygude, G. A., More, N. B., Wankhede, S. Y., Shinde, S. T. and Patil, G. D. 2020. GIS-GPS based soil fertility maps of micronutrients of village Harnas of Bhor tehsil in Pune district. International Journal of Current Science. 8(2), 1922-1928.

Keen, B. A., and Raczkowski, H. 1921. The relation between the clay content and certain physical properties of a soil. The Journal of Agricultural Science, 11(4), 441-449.

Meena, H. B., Giri, J. D., and Mishra, H. K. 2010. Nutrient availability in soils as affected by physiography in Chittorgarh district, Rajasthan. Agropedology, 20(1), 85-87.

Nagaraju, M. S. and Gajbhiye, K. S. 2014. Characterization and evaluation of soils from Kukadi command area in Ahmednagar district of Maharashtra for land resource management. Agropedology. 24(2), 157-165

Naphade, M., Shinde, R., Mendhe, A. and Suryavanshi, R. T. 2022. Micronutrient status and its correlation with chemical properties of soils of Jalgaon district, Maharashtra.

Patil, P. B., Jatkar, P. R., and Adsul, P. B. 2019. Physico-chemical properties in soils from Washi tahsil of Osmanabad district. Journal of Pharmacognosy and Phytochemistry, 8(4), 149-151

Rajagopal, V., Prasadini, P. P., Pazanivelan, S. and Balakrishnan, N. 2013. Characterization and classification of soils in Warangal district of central Telangana zone. Madras Agric. J. 100(4), 432-437.

Shinde S. K. 2022.Physico-chemical properties and nutrient availability of soils of Latur and Renapur tahsils of Latur district, M.Sc. (Agri.) Thesis submitted to Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. (India).

Sushma, A. T., Gawde, N., Paul, R., and Pattanaik, I. 2023. Depth-wise distribution of chemical properties of the soils from different sites of the Northern Hill Zone of Chattisgarh. The Pharma Innovation Journal, 12(3), 3460-3465.

Thangasamy, A., Naidu, M.V.S., Ramavatharam, N. and Raghava Reddy, C. 2005. Characterisation, Classification and Evaluation of Soil Resources in Sivagiri Micro-watershed of Chittoor District in Andhra Pradesh for Sustainable Land Use Planning. Journal of the Indian Society of Soil Science, 53(1), 11-21.

Titirmare, N. S., Takankhar, V. G., Vaidya, P. H., Nawkhare, A. D., and Landge, R. B. 2019. Characterization and classification of red soils from Hasegaonwadi of Latur district. International Journal of Current Science, 7(5), 1104-1108.

Tiwari, R., Dwivedi, B. S., and Sharma, Y. M. 2023. Soil properties and soybean yield as influenced by long term fertilizer and organic manure application in a Vertisols under Soybean-Wheat Cropping Sequence. Legume Research-An International Journal, 1, 7.