Soil Profile Studies under Different Orchard Management System in Chhindwara District of Madhya Pradesh

Abstract

The investigation conducted at the laboratory of Rajiv Gandhi South Campus, Banaras Hindu University, Barkachha; Mirzapur during the year 2021-22. The objective of this study was to characterize the physicochemical properties and macro-nutrient availability of orchard soil depth under (0–15, 15-30, 30-60, 60-90 cm) of different blocks of Chhindwara District, Madhya Pradesh. By using GPS camera, 52 soil samples was collected from different orchard of different blocks of district. The physical and chemical properties of soil were critically analyzed. The pH of orchard soil was found slightly acidic to alkaline in nature. Total soluble salts were found less than 1dSm^{-1} . Organic carbon was observed high in upper surface (0-15 cm) and decreased with the increasing depth of the profile. Bulk density (1.28 – 1.97 Mg m^{3}) and particle densities (2.49 – 2.65 Mg m^{3}) were found in normal ranged for all the layers. The samples were found under low water holding capacity (30.87-65.24%) of all the orchards. Nitrogen was observed in low (110.30 kg ha^{-1}) to medium (468.28 kg ha^{-1}) range in the different layers (0-15, 15-30, 30-60, 60-90cm). Phosphorus and sulphur content were found medium (8.56-11.78 kg ha^{-1} and 10.6-13.9 kg ha^{-1}) in surface layer and low (7.10 – 10.65 and 8.4-12.7 kg ha^{-1}) for sub-surface layers. Available potassium was determined in high range (224.0-378.8 kg ha^{-1}) for all the layers (0-15, 15-30, 30-60, 60-90 cm).

Keywords: *Nutrients, Orchards, Physico-chemical properties, Soil fertility.*

Introduction

Orchard soil health or soil quality is the capacity of soil to support productive trees over time without negatively affecting the surrounding environment. Soil health is influenced by interacting biological, physical, and chemical properties of soil. Active soil biological communities mineralize nitrogen, create soil structure, and compete with plant pathogens. Madhya Pradesh is the central state of India. Bhopal is the capital of Madhya Pradesh. "Chhindwara" district is one of the major districts of Madhya pradhesh in India. Chhindwara is the largest district in Madhya Pradesh with an area of 11,815 sq km. Soil health is influenced by interacting biological, physical, and chemical properties of soil. Active soil biological communities mineralize nitrogen, create soil structure, and compete with plant pathogens.

Soil profile is an essential tool for managing nutrients. We can learn a lot about soil fertility by looking at a soil profile. The soil profile varies as a result of weathering and/or organic matter decay. Harvests grown on well-managed soils yield healthier, higher-yielding crops. Because organic matter affects practically all facets of soil quality, managing soil organic matter is crucial.

Soil profile study on orchards in Chindwara district of Madhya Pradesh was not found in the literature, therefore this study was carried out. Some work has been done on the soil profile of Shivpuri district of Madhya Pradesh where available sulphur content varied from 11.25 to 13.25 and 9.87 to 16.25 with the mean of 12.27 and 12.40 $mg\ kg^{-1}$ in Inceptisol and Vertisol, respectively, Bhatnagar *et al.* (2003). This study will support to the orchards management by

using balance fertilization on the basis of depth wise nutrient status and establishment of new orchards in the study area.

Material and Methods

Study site: The geographical location of Chhindwara is within 21.28' to 22.49' North logititude and 78.40 to 79.23' East latitude, The total area of Chhindwara is 11,815 sq. km. with total cultivated area 555.5 ha. The average maximum temperature in May was approximately 44'C and the average maximum was 5'C, Chhindwara district receives 1,183 mm of rainfall on average per year, maximum rainfall in the district occurred from October to March during the southwest monsoon, while minimal rainfall occurred from January to May, Soil Sampling was done from the different blocks of chhindwara district of Madhya Pradesh. The experimental sites were selected based on Agri – Horticulture system Orange *(Citrus sinensis)*, Mango *(MangiferaIndica)*, Papaya *(Carica papaya)*, Custard apple *(Annona squamosa)*, Dragon fruit *(Hylocerusundantus)*.

Soil sampling and analysis:

Samples were collected from different orchard at different depths, depth of sampling [0-15, 15-30, 30-60, 60-90] cm were kept with the help of auger from different blocks of chhindwara district. The soil samples kept into properly labeled samples bags. Soil samples were brought to the laboratory and air dried, crushed with wooden roller, sieved through 2 mm sieve and used for determination of various soil physico-chemical characteristics. The physical parameters include bulk density, particle density, porosity, water holding capacity, whereas chemical parameters include pH, Electrical conductivity, Organic Carbon, Macro-Nutrients (N, P, K, S).

The processed soil samples were analyzed for different nutrients using specific standard procedures for macro and micro nutrients. Soil pH was determined by pH meter, EC by conductivity meter, bulk density and particle density by pycnometer (Black *et al.* (1965), water holding capacity was measured by keen box, Piper (1966). The organic matter content was determined by wet digestion method (Walkley and Black's rapid titration method 1934), Available nitrogen was estimated by alkaline $KMnO_4$ method (Subbiah and Asija 1956), Available phosphorus was extracted by 0.5M $NaHCO_3$ solution pH 8.5 (Olsen *et al.*1954) and colour developed by ascorbic acid method (Watanabe and Olsen 1965). Available potassium was determined by neutral normal ammonium acetate method (Hanway and Heidal, 1952) with the help of flame photometer. Sulphur was estimated by turbidimetrically method (Chesnin and Yien,1950). The available major nutrient content and various physico-chemical characteristics of the soils were estimated for the correlation analysis of the data.

Results and Discussion

The data shows that the bulk density of orchard soil depth under [0-15, 15-30, 30-60 and 60-90cm] ranged between 1.28-1.40, 1.24-1.47, 1.63-1.87 and 1.81-1.97 Mg m^3, The mean difference of soil bulk density with comparing soil depth of 0-15cm and 60-90cm was -36.77%. Bulk density was negative due to increasing with increase depth. The particle density of orchard soil depth under [0-15, 15-30, 30-60 and 60-90cm] ranged between 2.49-2.65, 2.47-2.61, 2.43-2.59 and 2.30-2.61 Mg m^3, the mean difference of soil particle density with comparing soil depth of 0-15cm and 60-90cm was 2.72% which was non-significant. The highest particle density (2.65 Mg m^3) was reported in sample 1 in the orange-1 orchard. Porosity of orchard soil depth under [0-15, 15-30, 30-60 and 60-90cm] ranged 45.24-50.96, 40.89-51.37, 26.95-41.71 and 19.26-29.12% respectively. The mean difference of soil porosity with comparing soil depth of 0-15cm

and 60-90cm was 40.52%. and highest porosity was reported in sample number 30 in guava-2, The water holding capacity of orchard soil depth under [0-15, 15-30, 30-60 and 60-90cm] ranged 30.87-65.24, 40.36-64.00, 42.92-59.34 and 35.89-59.96% respectively and highest water holding capacity was reported in sample number 40 in banana-2 orchard. The mean difference of soil WHC with comparing soil depth of 0-15 and 60-90cm was 1.99%. Similar findings were reported by Kuchanwar *et al*. (2017). The pH of orchard soil depth under [0-15, 15-30, 30-60, 60-90cm] ranged 7.2-8.7, 6.9-8.6, 6.8-8.5 and 6.4-8.3 respectively with slightly acidic to alkaline and mean value of soil pH comparing soil depth of 0-15cm and 60-90cm was varied 6.17%.

Table 1: Status of physical properties of depth wise soil samples of different orchards.

		Depth (cm)			
		0-15	15-30	30-60	60-90
Bulk density (Mg m^3)	Range	1.28-1.40	1.24-1.47	1.63-1.87	1.81-1.97
	Mean	1.36	1.4	1.74	1.86
	S.D.	0.02	0.05	0.06	0.04
Particle density (Mg m^3)	Range	2.49-2.65	2.47-2.61	2.43-2.59	2.30-2.61
	Mean	2.58	2.55	2.53	2.51
	S.D.	0.04	0.04	0.04	0.05
Porosity (%)	Range	45.24-50.96	40.89-51.37	26.95-41.71	19.26-29.12
	Mean	47.36	45.22	31.59	25.55
	S.D.	1.25	2.34	2.87	2.08
WHC (%)	Range	30.87-65.24	40.36-64.00	42.92-59.34	35.89-59.96
	Mean	52.25	52.1	51.89	51.24
	S.D.	6.73	4.29	3.95	5.49

The highest pH (8.7) was reported in sample 1 of orange-1 and sample 5 from orange-2 and sample 29 of guava-1, similar trend was found by Surwase *et al*., (2016). The electrical conductivity of orchard soil depth under [0-15, 15-30, 30-60, 60-90cm] ranged 0.31-0.39, 0.21-

0.39, 0.21-0.37 and 0.12-0.35 dSm^{-1}. The mean difference of soil EC was compared between soil depth of 0-15 and 60-90cm and found 19.44% variation. The highest EC (0.39) dSm^{-1} was reported in sample number 18 of papaya-1, parallel findings were studied by Singh *et al*., (2016). The organic carbon of orchard soil depth under [0-15, 15-30, 30-60, 60-90cm] ranged between 0.39-1.66, 0.30-1.38, 0.15-1.06 and 0.03-0.73%. The mean difference of soil OC was compared between soil depth of 0-15 and 60-90cm and found 58.82% variation between upper and lowest layers. The highest O.C (1.66%) was found in sample 1 of orange-1 (Surwase *et al*., 2016**)**.

Table 2 : Status of pH, EC and organic carbon of depth wise soil samples of different orchards.

		Depth (cm)			
		0-15	15-30	30-60	60-90
pH	Range	7.2-8.7	6.9-8.6	6.8-8.5	6.4-8.3
	Mean	8.1	7.9	7.8	7.6
	S.D.	0.44	0.48	0.51	0.59
EC (dSm^{-1})	Range	0.31-0.39	0.21-0.39	0.21-0.37	0.12-0.35
	Mean	0.36	0.34	0.32	0.29
	S.D.	0.02	0.04	0.044	0.06
OC (%)	Range	0.39-1.66	0.30-1.38	0.15-1.06	0.03-0.73
	Mean	0.68	0.55	0.41	0.28
	S.D.	0.3	0.26	0.217	0.17

The available nitrogen of orchard soil depth under [0-15, 15-30, 30-60 and 60-90cm] ranged 225.79-468.28, 201.56-387.12, 137.98-273.63 and 110.31-210.39 kg ha^{-1}. The highest nitrogen content (468.28 kg ha^{-1}) was found in sample number 5 of orange-2 orchard and related findings were reported by Amara *et al.* (2017). The mean difference of soil nitrogen content was compared with soil depth of 0-15 and 60-90cm and found 58.91% variation between 0-90 cm depth. The available phosphorus content of orchard soil depth under [0-15, 15-30. 30-60 and 60-90cm] ranged from 8.56-11.78, 8.43-10.65, 7.53-9.86 and 7.10-9.45 kg ha^{-1}. The highest (11.78

kg ha^{-1}) was observed in sample number 23 in papaya-2 orchard likely results were reported by Motsara (2002). The mean difference of available P compared between soil depth of 0-15 and 60-90cm and shown 23.82% difference between upper and lower layers. The available potassium content of orchard soil depth under [0-15, 15-30, 30-60, 60-90cm] ranged between 351.2-378.8, 315.8-345.4, 266.8-278.1, 224.0-281.6 kg ha^{-1}. The highest K (378.8 kg ha^{-1}) was found in sample number 5 of orange-2 orchard, like wise report given by Pal, (1985). The mean difference of exchangeable potassium compared between soil depth of 0-15 and 60-90cm was 30.01%. The available sulphur content of orchard soil depth under [0-15, 15-30, 30-60, 60-90cm] ranged was 10.6-13.9, 10.2-12.7, 9.3-11.6, 8.4-10.6 kg ha^{-1}. The highest S (13.9 kg ha^{-1}) was found in sample number 4 of orange-1 orchard, results were confined with Balanagoudar, (1989). The mean difference of sulphur was compared between soil depth of 0-15 and 60-90cm and it was 21.66% between surface layer and lower layer (90 cm depth).

Table 3: Status of available N, P, K and S in depth wise soil samples of different orchards.

		Depth (cm)			
		0-15	15-30	30-60	60-90
Nitrogen (kg ha^{-1})	Range	225.79-468.28	201.56-387.12	137.98-273.63	110.31-210.39
	Mean	324.07	264.62	189.97	133.15
	S.D.	68.24	50.27	36.86	18.05
Phosphorus (kg ha^{-1})	Range	8.56-11.78	8.43-10.65	7.53-9.86	7.10-9.45
	Mean	9.99	9.21	8.23	7.61
	S.D.	0.731	0.5	0.62	0.55
Potassium (kg ha^{-1})	Range	351.2-378.8	315.8-345.4	266.8-278.1	224.0-281.6
	Mean	363.6	329.4	283.3	259
	S.D.	5.58	5.88	15.98	17.68
Sulphur (kg ha^{-1})	Range	10.6-13.9	10.2-12.7	9.3-11.6	8.4-10.6
	Mean	12	11.3	10.4	9.4
	S.D.	0.83	0.64	0.58	0.42

Correlation studies reveal (table-2) that 0-15 cm depth of soil of orchards pH, EC, organic carbon, bulk density has negative correlation with nitrogen and positive correlation with particle density water holding capacity. Available phosphorus has positive correlation with pH, organic carbon, particle density and water holding capacity except EC and bulk density. The exchangeable potassium was positively correlated with all the parameters. Available sulphur content was found negative correlation with pH, electrical conductivity, bulk density and particle density while positive correlation with organic carbon and water holding capacity. Correlation studies reveal (table-5) that 15-30 cm depth of soil of orchards pH, organic carbon, bulk density and particle density has negative correlation with nitrogen and positive correlation with EC and water holding capacity. Available phosphorus has positive correlation with pH, organic carbon, bulk density and particle density while negative correlation with EC and water holding capacity. The exchangeable potassium was negatively correlated with pH, EC, organic carbon and positive correlation with bulk density, particle density and water holding capacity. Available sulphur content has negative correlation with bulk density and particle density while positive correlation was found with pH, EC, organic carbon and water holding capacity. According to correlation studies (table-6) the EC, organic carbon and water holding capacity of the soil of orchards at depth of 30-60 cm positively correlate with nitrogen while pH, bulk density and particle density was negatively correlated. Available phosphorus has positive association with pH, EC, bulk, particle density whereas organic carbon and water holding capacity has negative correlation with phosphorus. Exchangeable potassium has negative correlation with pH and organic carbon whereas positively correlation with EC, bulk density, particle density and water holding capacity. Water holding capacity has positively connect with the available sulphur while negative correlation was shown with EC, organic carbon, bulk density and particle density. Correlation

study revel(table-4) that 60-90 cm depth of soil of orchards pH, bulk density, particle density were found negatively correlated with nitrogen while positive correlation with EC, organic carbon and water holding capacity. Available phosphorus has positively correlated with pH, EC, particle density and water holding capacity whereas negative correlation with organic carbon and bulk density. Exchangeable potassium has negatively correlated with pH, EC, organic carbon, particle density and water holding capacity while positive correlated with bulk density only. Available sulphur content has positively correlated with bulk density and water holding capacity whereas negative correlation with pH, EC, organic carbon and particle density.

Table 4 : Correlation between available soil nutrients and physico-chemical characteristics at 0 to 15 cm depth in soils of different orchards.

0-15 (cm)	N	P	K	S
PH	-0.161	0.525	0.083	-0.179
EC	-0.199	-0.007	0.150	-0.125
OC	-0.010	0.414	0.247	0.033
BD	-0.083	-0.079	0.170	-0.136
PD	0.212	0.223	0.255	-0.135
WHC	0.084	0.042	0.298	0.122

Table 5 : Correlation between soil nutrients availability and physico-chemical characteristics at 15 to 30 cm depth in different orchards.

15-30 (cm)	N	P	K	S
PH	-0.260	0.456	-0.046	0.003
EC	0.225	-0.008	-0.043	0.106
OC	-0.028	0.161	-0.133	0.112
BD	-0.220	0.009	0.018	-0.385
PD	-0.013	0.114	0.440	-0.169
WHC	0.277	-0.137	0.007	0.241

Table 6 : Correlation between soil nutrients availability and physico-chemical characteristics at 30 to 60 cm depth of different orchards.

30-60 (cm)	N	P	K	S
PH	-0.137	0.275	-0.052	-0.285
EC	0.308	0.059	0.154	-0.041
OC	0.157	-0.008	-0.072	-0.045
BD	-0.111	0.028	0.063	-0.125
PD	-0.026	0.077	0.325	-0.066
WHC	0.141	-0.122	0.119	0.341

Table 7 : Correlation between soil nutrients availability and physico-chemical characteristics at 60 to 90 cm depth of different orchard.

60-90 (cm)	N	P	K	S
PH	-0.018	0.426	-0.452	-0.337
EC	0.076	0.195	-0.229	-0.051
OC	0.036	-0.066	-0.140	-0.072
BD	-0.177	-0.092	0.144	0.141
PD	-0.176	0.148	-0.128	-0.028
WHC	0.076	0.131	-0.155	0.100

Conclusion

This study representation the analysis of physico-chemical properties and available nutrients of the samples taken from soil profiles depth wise (0-15, 15-30, 30-60, 60-90 cm) and establish a correlation between soil properties and available nutrients. On the basis of results the soil samples were found slightly acidic to alkaline in nature. Total soluble salts were found less than 1dSm^{-1} which indicates that soil was safe for the orchard plants. Organic carbon observed high in upper surface (0-15 cm) whereas decreased with the increasing depth of the profile. Bulk density and particle density were found in normal range for all the layers. The studied samples were found under low water holding capacity (30-65%) of all the orchards. Nitrogen was found in low to medium range in the layer of 0-15, 15-30, 30-60, 60-90cm whereas phosphorus and sulphur contents were found medium in surface layer while lower range under sub-surface layers. Available potassium was set up in high range for all the layers (0-15, 15-30, 30-60, 60-90 cm). Finally, it can be concluded that, the available nutrients were found higher in upper surface in

comparison to lower layers of the orchards soil profile therefore, proper attention should be given on nutrient management up to optimum depth.

Application of good quality and more amount of locally available organic matter or compost to the areas of orchard where low soil fertility would improve the soil quality and preserve sustainable farming. To give a realistic approach to managing soil quality and fertility that enables the adoption of measures for sustainable farming, assessment of soil characteristics and quality of orchards area should be linked to the farmer's views and conditions. This study will support to the orchards management and establishment of new orchards in the study area.

References

Amara, D. M. K., L. Patil, A. M. Kamara and D. H. Saidu (2017). Assessment of soil fertility status using nutrient index approach. Academia Journal of Agricultural Research, 5(2): 28-38.

Balanagoudar, A. B. (1989). Investigation on status and forms of sulphur in soils of North Karnataka. M. Sc. (Agri.) Thesis, Universityof Agriculture Science, Dharwad (India).

Bhatnagar, R. K., Bansal, K. N., & Trivedi, S. K. (2003). Distribution of sulphur in some profiles of Shivpuri district of Madhya Pradesh. *Journal of the Indian Society of Soil Science*, ***51***(1), 74-76.

Black, G. R. (1965). Bulk Density. Methods of soil Analysis, Ed. CA Black Part 1. *Am. Soc. Agron.: Madison, Wis*, 375-7.

Chesnin, L. and Yien, C. H. (1950). Turbidimetric determination of available sulphur. Proceeding of Soil Science. American. 14 : 149-151.

Hanway, J. J., and Heidel, H.(1952). Soil analysis methods as used in Iowa state college soil testing laboratory. Iowa agriculture, 57, 1-31.

Jackson, M. L. (2005). Soil chemical analysis: advanced course. UW-Madison Libraries parallel press.

Kuchanwar, O. D.,Ghagare, R. B., Deotale, P. P., andDeshmukh, S. (2017). Effect of soil Fertility and nutrients availability in rhizosphere on citrus (Citrus reticulata) yield. *Current Horticulture*, *5*(1), 58-60.

Motsar a, M. R. (2002). Available nitrogen, phosphorus and potassium status of Indian soils as depicted by soil fertility maps. *Fertiliser News*, *47*(8), 15-22.

Olsen, S. R. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. US Department of Agriculture. (No. 939)

Pal, D. K. (1985). Potassium release from muscovite and biotite under alkaline conditions. Pedologie (Ghent) 35,133-146.

Piper, C. S. (1966). Soil and plant analysis, Hans. *Pub. Bombay. Asian Ed, 1966*, 368-74.

Subbaiah, B. V. and Asija, G. L. (1956). A rapid procedure for the determination of available nitrogen in soils. Current Science. 25 : 259-260.

Surwase, S. A., Kadu, P. R., &Patil, D. S. (2016). Soil micronutrient status and fruit quality of orange orchards in KalmeshwarTahsil, District Nagpur (MS). *Journal of Global Biosciences*, *5*(1), 3523-3533.

Walkley, A., and Black, I. A. (1934). An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. *Soil science*, 37(1), 29-38.