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 and particle densities were found in normal ranged for all the layers. The samples were found under low water holding capacity (30-65%) of all the orchards. Nitrogen was observed in low to medium range in the layer (0-15, 15-30, 30-60, 60-90cm). Phosphorus and sulphur content were found medium in surface layer and low for sub-surface layer. Available potassium was determined in high range for all the layers (0-15, 15-30, 30-60,60-90 cm).

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

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. Physical properties of soil determine its ability to store and release nutrients; accommodate water entry, storage, and movement; provide sufficient oxygen for roots and microbes; and moderate environmental stress. Chemical aspects of soil health include nutrient presence and availability, pH, cation exchange capacity (CEC), salinity, and the presence of any contaminants, such as heavy metals or persistent pesticide residues. Madhya Pradesh is the central state of India. Bhopal is the capital of Madhya Pradesh. The economy of Madhya Pradesh is the 10^{th} largest in India. “Chhindwara” district is one of the major districts of Madhya pradhesh state of India and Chhindwara town is the district headquarters. Chhindwara is the largest district in Madhya Pradesh with an area of 11,815 sq km. The district is part of Jabalpur division.

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).

Bulk density and Particle density were determined by pycnometer. Porosity was calculated by using bulk density and particle density measurement (Black et al. 1965). Water holding capacity was determined by Keen‘s box (Piper, 1966). The pH was determined by pH meter (Jackson 2005) after making 1:2.5 soil water suspension. Electrical conductivity was determined by electrical conductivity meter (Jackson 2005).Percent Organic Carbon was estimated by Wet Oxidation method (Walkley and Black, 1934).Available Nitrogen was estimated by Alkaline Potassium Permanganate method, using Kjeltech semi auto analyzer (Subbiah and Asija, 1956). Available phosphorus was determined by Spectrophotometric method as described by (Olsen et al., 1954). Available Potassium was estimated by Neutral normal Ammonium Acetate extraction followed by Flame photometric method (Hanway and Heidal, 1952). Available Sulphur was estimated by calcium chloride method followed by

Spectrophotometric analysis (Chesnin and Yien, 1951). 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/m3, 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/m3, 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) 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 between 45.24-50.96, 40.89-51.37, 26.95-41.71 and 19.26-29.12%, 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 30 in guava-2, The water holding capacity of orchard soil depth under [0-15, 15-30, 30-60 and 60-90cm] ranged between 30.87-65.24, 40.36-64.00, 42.92-59.34 and 35.89-59.96%, And highest water holding capacity was reported in sample 40 in banana-2 orchard. The mean difference of soil WHC with comparing soil depth of 0-15 and 60-90cm was 1.99% Kuchanwar et al. (2017). The pH of orchard soil depth under [0-15, 15-30, 30-60, 60-90cm] ranged between 7.2-8.7, 6.9-8.6, 6.8-8.5 and 6.4-8.3 with slightly acidic to alkaline and mean value of soil pH with 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 equally by Surwase *et al*., (2016). The electrical conductivity of orchard soil depth under [0-15, 15-30, 30-60, 60-90cm] ranged between 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 with comparing soil depth of 0-15 and 60-90cm was 19.44%. The highest EC (0.39) dSm^{-1} was reported in sample 18 of papaya-1 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 with comparing soil depth of 0-15 and 60-90cm was 58.82%. 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 between 225.79-468.28, 201.56-387.12, 137.98-273.63 and 110.31-210.39 kg/ha. The highest nitrogen content (468.28 kg/ha) was found in sample 5 on orange-2 orchard by Amara *et al.* (2017). The mean difference of soil nitrogen content with comparing soil depth of 0-15 and 60-90cm was 58.91%**.** The available phosphorus content of orchard soil depth under [0-15, 15-30. 30-60 and 60-90cm] ranged between8.56-11.78, 8.43-10.65, 7.53-9.86 and 7.10-9.45 kg/ ha. The highest (11.78 kg/ha) was observed in sample 23 in papaya-2 orchard by Motsara (2002). The mean difference of available P with comparing soil depth of 0-15 and 60-90cm was 23.82%. 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. The highest K (378.8 kg/ha) was found in sample 5 of orange-2 orchard by Pal, (1985). The mean difference of Exchangeable K with comparing 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 between 10.6-13.9, 10.2-12.7, 9.3-11.6, 8.4-10.6 kg/ ha. The highest S (13.9 kg/ha) was found in sample 4 of

orange-1 orchard by Balanagoudar, (1989). The mean difference of S with comparing soil depth of 0-15 and 60-90cm was 21.66%,

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 were non-significant correlation with Nitrogen and positive significant correlation with particle density water holding capacity, Available Phosphorus positive significant correlation with pH organic carbon particle density and water holding capacity. The exchangeable K was positively significant correlated with all the parameters. Available sulphur content was non- significant correlation with pH electrical conductivity bulk density. Positive correlation with Organic carbon particle density and water holding capacity.Correlation studies reveal (table-5) that 15-30 cm depth of soil of orchards pH organic carbon bulk density particle density were non-significant correlation with Nitrogen and positive significant correlation with EC water holding capacity, Available Phosphorus positive significant correlation with pH organic carbon bulk density and particle density. The exchangeable K was positively significant

correlated with pH, EC, organic carbon and non-significant correlation with bulk density, particle density and water holding capacity. Available sulphur content was non- significant correlation with bulk density and particle density. Positive correlation was found with pH, EC, organic carbon and water holding capacity. According to correlation studies (table-6) the EC organic carbon bulk density and water holding capacity of the soil in orchards at a depth of 30-60 cm significantly positively correlate with the amount of nitrogen that is available, pH and particle density were not significantly correlated. Available phosphorus has a significant positive association with pH, EC, bulk, particle density, organic carbon and water holding capacity has non-sufficient correlation with phosphorus. Exchangeable potassium has a non-significant positive significant correlation with pH and organic carbon and positively correlation with EC bulk density particle density and water holding capacity, pH and water holding capacity significantly positively connect with the available sulphur content and non-significant correlation 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 non-significant correlation with Nitrogen and positive significant correlation with EC organic carbon and water holding capacity, Available phosphorus has positively correlated with pH EC particle density and water holding capacity, And non-significant with organic carbon and bulk density, Exchangeable potassium has non-significant correlated with pH, EC, organic carbon and particle density and significant positive correlate with and water holding capacity, Available sulphur content has positively significant with bulk density and water holding capacity and non-significant 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 expose the analysis of physico-chemical properties and available nutrient 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 with available nutrients. On the basis of results the soil samples were found in slightly acidic to alkaline in nature. Total soluble salts were found less than $1dSm^{-1}$ which indicates that soil was safe for the crops. Organic carbon was observed high in upper surface (0-15 cm) and decreased with the increasing depth of the profile. Bulk density and particle densities were found in normal ranged for all the layers. The samples were found under low water holding capacity (30-65%) of all the orchards. Nitrogen was observed in low to medium range in the layer (0-15, 15-30, 30-60, 60-90cm). Phosphorus and sulphur content were found medium in surface layer and low for sub-surface layer. Available potassium was determined 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 profile. 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).

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.