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# Impact of Long-term Nutrient Management Practices on Physical Properties of a *Vertisol* in Central India

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

Health of any soil is influenced by its physical properties to greater extent which has been more prominent in Vertisols due to their self-till behavior. Differential application of nutrients in long-term may alter the soil properties at temporal and spatial scales. Inventory on effect of different long-term nutrient management practices on physical properties across the soil depths, especially on *Vertisols* of central India, is insufficient. Present study examined the long-term (48 years) effect of different combinations of organic and inorganic nutrient management practices under soybean-wheat cropping system on various physical properties (Bulk density, Particle density, Porosity and Water

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holding capacity) of a *Vertisol* in of central India. In the present study, soil sample were collected at four depths (0-15, 15-30, 30-45 and 45-60 cm) in triplicate from seven treatments (Control, 100% NP, 100% NPK, 100% NPK+FYM, 100% N, 50% NPK and 150% NPK) of permanent plots of AICRP on LTFE (initiated in 1972), Jabalpur. By differential nutrient management practices the bulk density and porosity affected significantly up to 30 cm soil depth and beyond that up to 60 cm non-significantly. At all selected soil depths, water holding capacity were significantly affected. On contrary, a non-significant effect was observed on particle density by various nutrient managements. This study indicated a positive impact of balance fertilizer application and integrated approach of nutrient management on physical properties of soil.

*Keywords: LTFE; physical properties; bulk density; particle density; porosity; water holding capacity; vertisol.*

## 1. INTRODUCTION

Clay-dominant *Vertisols* occupy approximately 2.5 percent of the world's total land area. Vertisols together with soils having vertic features cover about 72.9 million hectares in India [1]. These soils are known for their swell- shrink property as a well as for becoming very hard when dry and sticky in wet conditions enhances the role of physical properties in crop production process. Maintaining balanced physical properties is must for good soil health. Fertilizer application in agricultural fields has increased in a rapid manner as they are playing an unprecedented role in enhancing crop production in India as well as Madhya Pradesh. On one side use of high nutrient responsive cultivars increased the consumption of inorganic fertilizer, other side it has replaced on-farm beneficial practices like use of manures or FYM and recycling of crop residues [2]. Continuous application of nutrient sources alter the physical properties of soils, organic sources like FYM or manure enhances the porosity and water holding capacity etc. In central India, soybean-wheat is a dominant cropping system practiced on 4.5 million hectare area of *Vertisol*. Imbalanced use of fertilizer in this region is predominant cause of declining yield and deterioration of soil health [3]. The impact of continuous cropping and intensive fertilizer application on the yield of different crops and the characteristics of the soil are effectively shown by long-term fertilizer trials. However, only few studies are available describing the temporal and special effect of nutrient practices on physical properties of *Vertisol*. Considering these points, the present study was planned with the objective to evaluate the effects of different nutrient management on physical properties of soil under soybean-wheat cropping system in a *Vertisol* at various depth.

## 2. MATERIALS AND METHODS

A long-term fertilizer experiment (AICRP-LTFE) started during 1972–73 at the experimental farm of the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, India (23°10´N, 79°57´E) 393 m above mean sea level by Indian Council of Agricultural Research (ICAR) was selected for this study. The climate of experimental site is semi-arid and subtropical with average annual mean rainfall of the area is 1274 mm. Recommended rates of N-P-K through fertilizer application for soybean and wheat were 20:80:20 kg/ha and 120:80:40 kg/ha, respectively. Farmyard manure (FYM) (15 Mg/ha/year up to 2012-13; 5 Mg/ ha/year from 2013-14) was applied to soybean crop only during kharif season. The soil of experimental field was a clayey *Vertisol* (Haplustert), characterized as a medium-deep black soil. It is classified as very fine, belonging to Kheri series of fine montmorillonitic hyperthermic family of *Typic* Haplustert. Soil samples were collected after the harvest of *Rabi* crop (wheat) in April 2021 in triplicates from seven treatments (Control, 100% NP, 100% NPK, 100% NPK+FYM, 100% N, 50% NPK and 150% NPK) at four depths (0-15 cm, 15-30 cm, 30-45 cm and 45-60 cm) with the help of screw auger and kept in separate polythene bags after processing.

The bulk density of soil was estimated by core method [4], particle density by pycnometer method, water holding capacity by keen box method and the porosity was calculated from bulk density and particle density [5] using equation:

$$\text{Porosity (f)} = \left(1 - \frac{\rho b}{\rho s}\right) x100$$

Porosity (f) = Porosity of soil expressed in percent.
$\rho b$ = Bulk Density of soil expressed in $Mg/m^3$
$\rho s$ = Particle Density of soil expressed in $Mg/m^3$

The data were analyzed by carrying out Analysis of Variance (ANOVA) using randomized block design (RBD). To test the differences between means of different treatments critical difference (C.D.) were computed at *P=0.05* [6].

## 3. RESULTS AND DISCUSSION

### 3.1 Bulk Density (BD)

Bulk density of soils from different treatments belonging to long-term fertilizer experiment were analyzed (Table 1 and Fig. 1). In topsoil (0-15 cm), BD varied from 1.31 Mg $m^{-3}$ to 1.38 Mg $m^{-3}$ and at lower depths (15-30, 30-45, and 45-60 cm) from 1.34 to 1.40, 1.40 to 1.42, and 1.42 to 1.43 Mg $m^{-3}$ respectively. Lower values of BD was evident in surface soil (0–15 cm) than in the deeper layers (15-30, 30-45, and 45-60 cm). Mean value of bulk density from surface to 60 cm deep soil layer followed a trend as: Control >100% N = 50% NPK >100% NPK =150% NPK > 100% NP = 100% NPK+FYM.

Among the treatments, significantly lower values of BD observed in 100% NPK+FYM and higher values in control at all depths. At the surface and subsurface soil, application of 100% NPK along with FYM has resulted significantly lower bulk density (1.31 Mg $m^{-3}$ and 1.34 Mg $m^{-3}$) compared to control (1.38 Mg $m^{-3}$ and 1.40 Mg $m^{-3}$) and was at par to 150% NPK (1.32 Mg $m^{-3}$) and 100% NPK (1.33 Mg $m^{-3}$). At the depth of 30-45 cm and 45-60 cm, different nutrient management practices had similar bulk density with no significant difference.

The lower value of soil bulk density in treatments with FYM application might be attributed to the higher quantity of soil organic matter contributed by continuous application of FYM that improves the soil aggregation [7] and in treatments receiving only NPK or sole use balanced inorganic fertilizer might be due to high biomass production subsequently leads to increase in organic matter in soil [8]. Increase in bulk density with increase in depth might be due to continuous tillage operations loose the soil at surface and subsurface depth, ut more compaction at deep layer (30-60 cm) resulted increased bulk density [9]. Similar findings were observed by Tadesse et al. [10], Sharma et al. [11] and Dhillon et al. [12].

### 3.2 Particle Density (PD)

Data pertaining to particle density of soil influenced by long-term application of integrated nutrients is given in Table 1. indicated that long-term application of different nutrient management practices had no significant effect on particle density of soil, however heading towards deeper soil layers it slightly increased. In surface soil (0-15 cm), particle density ranged between 2.56 Mg $m^{-3}$ to 5.58 Mg $m^{-3}$ and at 15-30, 30-45, and 45-60 cm depths, it varied from 2.57 to 2.59, 2.58 to 2.59, and 2.59 to 2.60 Mg $m^{-3}$ respectively. Mean value of particle density across 0-60 cm did not show any noticeable change under different nutrient management practices (Fig. 1).

Particle density is a static property of any soil, also known as true density of soil. However, a meagerly less value of particle density in treatment with FYM application was may be due to inclusion of low mass-high volume particle by FYM into the soil Chattoo et al. [13] and Neupane et al. [14]. A non-significant change in particle density were also reported by Nandapure et al. [15] in a *Vertisol* and Gite et al. [16] in a lateritic soil.

### 3.3 Porosity

Porosity is a physical property of soil that controls the activity of soil biota, nutrients availability, aeration and impact the soil health directly. Data related to porosity of soil under different nutrient management practices has been revealed the significant differences among various treatments in surface and sub-surface soil, on contrary no significant difference found in the deeper layers (30-45 and 45-60 cm) (Table 1). A noticeable change in mean porosity was observed across the soil depth 0-60 cm with a maximum (46.93%) in 100% NPK+FYM and a minimum (45.34%) in control (Fig. 1.). In surface and sub-surface soil, the maximum porosity observed in 100% NPK+FYM (48.82% and 47.75%) and the minimum in Control (46.28% and 45.64%). Pore spaces in 150% NPK, 100% NPK and 100% NP found at par to 100% NPK+FYM and control was found at par to 100% N, 50% NPK at both soil depth. Furthermore, in deeper soil layers (30-45 cm and 45-60 cm), the maximum porosity recorded in 100% NPK+FYM (45.76% and 45.38%) and the minimum in Control (44.87% and 44.58%).

A higher value of porosity in treatment with integrated approach of nutrient application (100% NPK+FYM) over the other treatments might be due to binding agents (polysaccharides and bacterial gums) produced by microbial breakdown of FYM, which in turn promotes soil aggregation ad results increase in porosity Arya et al. [17] found similar results as an effect of integrated nutrient management (INM) on physico-chemical properties. Thangasamy et al. [18] and Dhaliwal et al. [19] also reported decrease trend in porosity across the soil depth along with higher value of porosity in FYM treated treatments.

**Table 1. Effect of different long-term nutrient management practices on physical properties of a *Vertisol* across 0-60 cm**

| Soil Depth (cm) / Treatment | Particle Density (Mg m$^{-3}$) | | | | Bulk Density (Mg m$^{-3}$) | | | |
|---|---|---|---|---|---|---|---|---|
| | 0-15 | 15-30 | 30-45 | 45-60 | 0-15 | 15-30 | 30-45 | 45-60 |
| CONTROL | 2.58 | 2.58 | 2.58 | 2.59 | 1.38 | 1.40 | 1.42 | 1.43 |
| 100% NP | 2.57 | 2.58 | 2.59 | 2.60 | 1.34 | 1.35 | 1.41 | 1.43 |
| 100% NPK | 2.58 | 2.59 | 2.59 | 2.59 | 1.33 | 1.35 | 1.41 | 1.42 |
| 100% NPK + FYM | 2.56 | 2.57 | 2.58 | 2.60 | 1.31 | 1.34 | 1.40 | 1.42 |
| 100% N | 2.57 | 2.57 | 2.58 | 2.59 | 1.37 | 1.38 | 1.42 | 1.43 |
| 50% NPK | 2.57 | 2.58 | 2.59 | 2.59 | 1.36 | 1.37 | 1.42 | 1.43 |
| 150% NPK | 2.58 | 2.58 | 2.59 | 2.60 | 1.32 | 1.35 | 1.41 | 1.43 |
| SEm± | 0.010 | 0.009 | 0.005 | 0.006 | 0.009 | 0.006 | 0.010 | 0.007 |
| C.D. (*p=0.05*) | NS | NS | NS | NS | 0.028 | 0.019 | NS | NS |
| **Soil Depth (cm) / Treatment** | **Porosity (%)** | | | | **Water holding capacity (%)** | | | |
| | **0-15** | **15-30** | **30-45** | **45-60** | **0-15** | **15-30** | **30-45** | **45-60** |
| CONTROL | 46.28 | 45.64 | 44.87 | 44.58 | 43.03 | 40.09 | 39.22 | 38.70 |
| 100% NP | 47.92 | 47.54 | 45.35 | 44.89 | 44.23 | 42.53 | 41.10 | 40.85 |
| 100% NPK | 48.44 | 47.67 | 45.61 | 44.96 | 44.47 | 43.40 | 41.27 | 38.72 |
| 100% NPK + FYM | 48.82 | 47.75 | 45.76 | 45.38 | 47.68 | 46.34 | 44.10 | 41.71 |
| 100% N | 46.79 | 46.19 | 45.03 | 44.88 | 43.25 | 42.62 | 39.04 | 38.75 |
| 50% NPK | 47.07 | 46.90 | 45.00 | 44.62 | 43.55 | 42.30 | 40.42 | 39.07 |
| 150% NPK | 48.66 | 47.75 | 45.61 | 45.17 | 45.22 | 43.28 | 41.34 | 40.97 |
| SEm± | 0.352 | 0.239 | 0.401 | 0.264 | 0.866 | 0.852 | 0.612 | 0.672 |
| C.D. (*p=0.05*) | 1.086 | 0.736 | NS | NS | 2.668 | 2.625 | 1.884 | 2.069 |

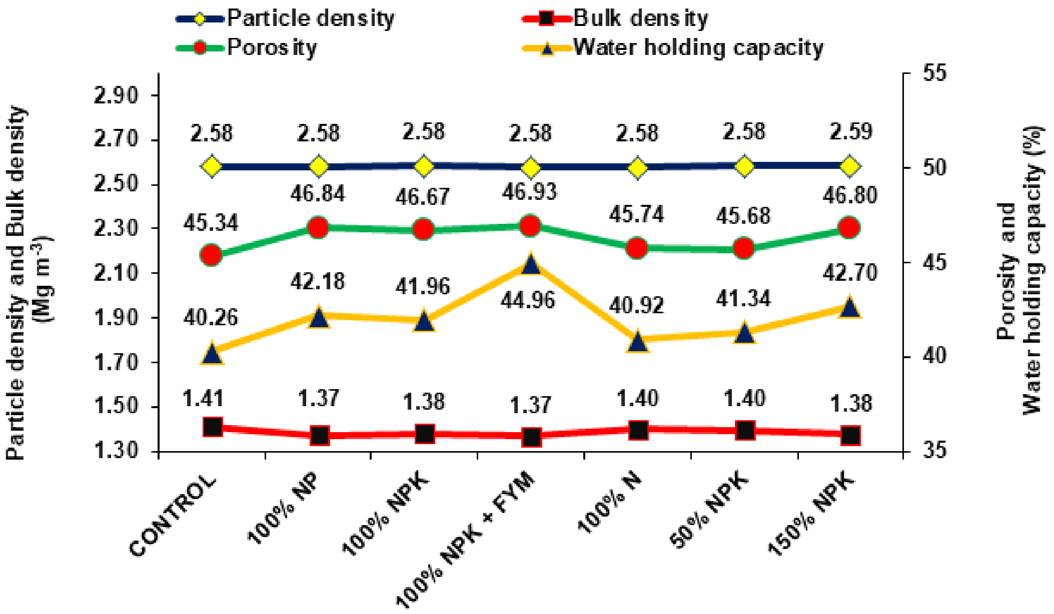


**Fig. 1. Trend of physical properties under different long-term nutrient management practices across 0-60 cm soil depth**

### 3.4 Water Holding Capacity (WHC)

The effect of different treatments on water holding capacity in soil at different depths are illustrated in Table 1 and depicted in Fig. 1. Data clearly expressed the significant effect of different nutrient sources on water holding capacity of soil.

Water holding capacity of soil at depth 0-15, 15-30, 30-45, and 45-60 cm varied from their minimum values of 43.03, 40.09, 39.22 and 38.70 per cent under control to maximum values of 47.68, 46.34, 44.10 and 41.71 per cent under treatment receiving combined application of inorganic and organic manures (100% NPK+FYM). In surface soil (0-15 cm) the maximum water holding capacity obtained in 100% NPK+ FYM was at par to 150% NPK and minimum value obtained under Control treatment at depth 30-45 cm was at par to imbalance nutrient management practices (50% NPK, 100% N, and 100% NP). From surface soil to 60 cm deep soil, control treatment had a noticeable mean lower (40.26 %) water holding capacity and a mean higher (44.96%) were found in 100% NPK+FYM. When compared to control, long-term 100% NPK+FYM application improved WHC by 11.67%. Similarly, application of 100% N, 50% NPK, 100% NPK, 100% NP, and 150% NPK were found improving water holding capacity respectively by 1.46, 2.63, 4.23, 4.77, and 5.91 per cent.

Higher value of water holding capacity in 100% NPK+FYM compared to other treatments and at surface soil (0-15 cm) as compared to other soil depths may be ascribed to higher organic matter, better aggregation and higher porosity [20]. Continuous application of organic matter increases macro and micro pores, which retains more water in soil and decrease in WHC with increase in soil depth might be due to more compaction of deeper layers and less clay content [21] Similar results were obtained by Hati et al. [2], Pareek et al. [22] and Pandey and Srivastava [23], [24-26].

## 4. CONCLUSION

Present study concluded that the long-term application of organic and inorganic sources had significant effect on the physical properties like bulk density, porosity, and water holding capacity of soil. Use of FYM with balance fertilizer application found as a good nutrient practices to be followed for good crop production and better soil health.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Hati KM, Mandal KG, Misra AK, Ghosh PK, Bandyopadhyay KK. Effect of inorganic fertilizer and farmyard manure on soil physical properties, root distribution, and water-use efficiency of soybean in vertisols of central India. Bioresour Technol. 2006;97(16):2182-8. DOI: 10.1016/j.biortech.2005.09.033, PMID 16289791.
2. Hati KM, Swarup A, Mishra B, Manna MC, Wanjari RH, Mandal KG, et al. Impact of long-term application of fertilizer, manure and lime under intensive cropping on physical properties and organic carbon content of an alfisol. Geoderma. 2008; 148(2):173-9. DOI: 10.1016/j.geoderma.2008.09.015
3. Behera UK, Sharma AR, Pandey HN. Sustaining productivity of wheat–soybean cropping system through integrated nutrient management practices on the vertisols of central India. Plant Soil. 2007;297(1-2):185-99. DOI: 10.1007/s11104-007-9332-3
4. Jamison VC, Weaver HA, Reed IF. A hammer-driven soil-core sampler. Soil Sci. 1950;69(6):487-96. DOI: 10.1097/00010694-195006000-00005
5. Mujumdar SP, Singh RA. Analysis soil physical properties. Jodhpur: Agrobias (India) Publishers; 2005;50-1, 117-8.
6. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd ed. New York: Wiley Interscience. 1984;680.
7. Kusro PS, Singh DP, Paikra MS, Kumar D, Viashwavidyalaya IGK. Effect of organic and inorganic additions on physico-chemical properties in vertisol. Am Int J Res Formal Appl Natl Sci. 2014;5(1):51-3.
8. Mishra KN, Patra AK, Garnayak LM, Mohanty AK, Swain SK. Long-term effects of integrated nutrient management on productivity and soil properties of rice (*Oryza sativa*)-rice cropping system in

coastal Odisha. Indian J Agron. 2017; 62(3):239-46.

9. Meena HM, Sharma SK, Meena MC. Soil physical properties of vertisol affected due to different tillage and mulch practices under wheat (*Triticum aestivum* L.). Indian J Dryland Agric Res Dev. 2011;26(1):90-5.
10. Tadesse T, Dechassa N, Bayu W, Gebeyehu S. Effects of farmyard manure and inorganic fertilizer application on soil physico-chemical properties and nutrient balance in rain-fed lowland rice ecosystem. AJPS. 2013;04(2):309-16. DOI: 10.4236/ajps.2013.42041
11. Sharma KL, Ramachandrappa BK, Chandrika DS, Sathish A, Dhanpal GN, Rao CS, et al. Effect of organic manure and crop residue based long-term nutrient management systems on soil quality changes under sole finger millet (*Eleusine coracana* (L.) Gaertn.) and groundnut (*Arachis hypogaea* L.)-finger millet rotation in rainfed alfisol. Commun Soil Sci Plant Anal. 2016;47(7):899-914. DOI: 10.1080/00103624.2016.1147045
12. Dhillon IS, Singh D, Chahal HS. Physico-chemical properties of soil as influenced by integrated nutrient management in onion (Allium cepa L.) crop. Indian J Agric Res. 2020;54(5):671-5.
13. Chattoo MA, Ahmed N, Najar GR, Ali A, Dar ZM, Dar QAH. Direct and residual effect of integrated nutrient management on crop productivity and physico-chemical characteristics of allfisols in okra-pea cropping system. J Appl Hortic. 2014;16(2):149-53. DOI: 10.37855/jah.2014.v16i02.26
14. Neupane B, Aryal K, Chhetri LB, Regmi S. Effects of integrated nutrient management in early season cauliflower production and its residual effects on soil properties. J Agric Nat Resour. 2020;3(2):353-65. DOI: 10.3126/janr.v3i2.32548
15. Nandapure SP, Sonune BA, Gabhane VV, Katkar RN, Patil RT. Long term effects of integrated nutrient management on soil physical properties and crop productivity in sorghum-wheat cropping sequence in a vertisol. Indian J Agric Res. 2011;45(4):336-40.
16. Gite V, Vaidya KP, Kapse, V. D. D, AA, More SS. Effect of integrated nutrient management on physico-chemical properties of lateritic soil of Konkan region of Maharashtra. Agric International. 2019;6(1):4-10.
17. Arya V, Trivedi SK, Tomar PS, Singh M, Dhakad H. Effect of Integrated Nutrient Management (INM) on physico-chemical Properties of Soils under Pearl Millet-mustard Cropping Sequence in Typic Ustochrepts. Int J Plant Soil Sci. 2022; 34(19):183-93. DOI: 10.9734/ijpss/2022/v34i1931101
18. Thangasamy A, Singh D, Dwivedi BS, Chakraborty D, Tomar RK, Meena MC. Soil organic carbon, hydraulic properties and yield of maize and wheat under long-term fertilization in an inceptisol. J Indian Soc Soil Sci. 2017;65(2):189-98. DOI: 10.5958/0974-0228.2017.00022.6
19. Dhaliwal SS, Sharma S, Sharma V, Shukla AK, Walia SS, Alhomrani M et al. Long-term integrated nutrient management in the maize–wheat cropping system in alluvial soils of North-Western India: Influence on soil organic carbon, microbial activity and nutrient status. Agronomy. 2021;11(11):2258. DOI: 10.3390/agronomy11112258
20. Bamboriya JS, Purohit HS, Jat G, Bamboriya SD, Shekhawat AS, Meena AK. Impact of integrated nutrient management in maize on physico-chemical properties of soil. The Pharm Innov J. 2022;11(2): 475-8.
21. Bhavya VP, Anil Kumar S, Ashok A, Shivanna M, Shiva KM. Changes in soil physical properties as a result of different land use systems with depth. Int J Curr Microbiol Appl Sci. 2018;7(1):2319-7706.
22. Pareek PK, Yadav PK, Kumar S, Yadav SR, Sharma BD. Effect of integrated nutrient management on soil physico-chemical properties of date palm orchard under alkaline soil condition. J Pharmacogn Phytochem. 2018;7(4): 1009-12.
23. Pandey V, Srivastava A. Effect of integrated use of organic manures and chemical fertilizers under soil test crop response approach on soil properties and yield of maize (*Zea mays* L.). Int J Plant Soil Sci. 2021;33(10):40-7. DOI: 10.9734/ijpss/2021/v33i1030471
24. Karikatti P, Bhat SN, Balanagoudar SR, Mastanareddy BG, Veeresh H, Rao S. Long term effect of Organic, Integrated and Inorganic Nutrient Management Practises on Soil Properties in a vertisol. Int J Curr Microbiol Appl Sci. 2020; 9(1):2317-26. DOI: 10.20546/ijcmas.2020.901.263

25. Richards LA. Diagnosis and Improvement of Saline- alkali Soils. Agric Handb. 1954;60.
26. Selvi D, Santhy P, Dhakshinamoorthy M. Effect of inorganics alone and in combination with farmyard manure on physical properties and productivity of vertic Haplustepts under long-term fertilization. J Indian Soc Soil Sci. 2005;53(3):302-7.



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