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Physical Characteristics of Soil as Influenced by Integrated Organic Nutrient Management Practices - A Review

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Authors' contributions

This work was carried out in collaboration among all authors. Author AS designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors AKP and US managed the analyses of the study. Author US managed the literature searches. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Sustaining the productivity at higher level to meet the increasing demand of food, fuel and fiber for the growing population is the key issue in Indian agriculture. Among the factors, continuous use of imbalanced fertilizers and decline in soil physical productivity and organic matter are considered responsible. To improve soil physical condition and improve organic matter status of soil, incorporation of organic sources of nutrient in combination with chemical fertilizers are recommended. This review pertinent to the present investigation has been reviewed.

Keywords: Integrated nutrient management; physical properties; fertilizers; plant; agriculture.

1. INTRODUCTION

The use of chemical fertilizers and organic manure has both positive and negative effects on plant growth and the soil chemical fertilizers are restively inexpensive, have high nutrient contents and are rapidly taken up by plants. However the use of excess fertilizer can result in a number of

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problems such as nutrient loss, surface water and groundwater contamination, soil acidification or basification, reduction in useful microbial communities and increased sensitivity to harmful insect [10]. Organic manure has a number of shortcomings including low nutrient content, slow decomposition. However, organic manure has multiple benefits due to balanced supply of nutrient availability due to increased soil microbial activity, the decomposition of harmful elements, soil structure improvement and increased soil water availability. In agriculture, soil quality refers to the soils ability to sustain production [21]. Soil physical properties can be used as indicates for making soil quality assessment and for determining the sustainability of farming system. Judicious use of organic manure along with chemical fertilizers improves soil physical properties. Long term studies established that balanced application of fertilizers, farm yard manure, compost and crop residues improve organic carbon as well as microbial biomass carbon in addition to others available nutrients [37]. Number of studies from different part of country has shown that integrated nutrient management not only restores maintains but also improves physical attributes of soil quality [36]. The organic source of nutrients in the INM system act as slow release fertilizers as it synchronizes the nutrient demand set by plants both in time and space [1].

Attempts are therefore made to present the brief summary of work carried out in India and abroad in the different aspects of integrated nutrient management practices which directly or indirectly relates soil physical properties.

Therefore, literature reviews were collected on the effect of integrated nutrient management on some important soil physical properties.

2. AGGREGATE STABILITY

Soil aggregates as represented by mean weight diameter, aggregate stability and percentage of water stable aggregates was significantly applied by integrated nutrient management practices. The mean weight diameter results from 0.70 to 1.02 mm among the integrated treatment with the lowest being in the control (0.69 mm) [32].

The water stable macro aggregates ranged from 54.60% under control to 71.27% under Sesbania green leaf manuring + FYM + BGA treatment. Differences in aggregation between the treatments might be due to the differences in C input returned to the soil [19]. Positive effect of manure and straw application on aggregates stability has also been reported by Singh *et al.,* [35] and Tripathi and Singh, [38]. Hati *et al.,* [15] reported that application of 10 mg farm yard manure and recommended NPK to soybean for three consecutive years had larger mean weight diameters and a higher percentage of water stable aggregates (55%). Pant and Ram [27] observed that application of FYM and inorganic fertilizers improved the mean weight diameters. The increase in organic carbon content might be responsible for stabilization of aggregates and hence higher mean weight diameter.

Haynes and Naidu [16] reviewed that addition of organic manure into soil resulted in increase in water stable aggregates. Under all integrated nutrient management treatments water stable aggregates > 1.0 mm of soil generally increased and those under inorganic treatment [12]. The application of balanced dose of NPK showed significantly high amount of soil aggregates compared to the plot with N alone. The response of FYM addition in increasing the size of water stable aggregates was not dependent of inorganic fertilizers [8]. Increase in percentage of macro aggregates and reducing in percentage of micro aggregates with FYM application was likely due to conversion of some of the micro pores to macro pores as a result of cementing action of organic and polysaccharides formed during the decomposition of organic residues (Mishra and Sharma, 1997). Sharma *et al.,* [34] observed an increase in percentage of water stable aggregates of size fraction > 0.25 mm as a result of continuous application of FYM with chemical fertilizer and lime.

3. BULK DENSITY

Report of the experiment conducted on acid clay loam soil with a maize mustard crop system by Saha *et al. [32]*, revealed a reduction in bulk density of soil with integrated nutrient management practices. Aziz et al. [3] reported that bulk density increased with increase in recommended dose of chemical fertilizer but does not vary significantly and addition of FYM @ 10 t ha^{-1} significantly decrease the bulk density. Incorporation of organic manure and biofertilizers reduced bulk density of soil which is an important soil characteristic for successful root development [19]. Kafle *et al.,* [17] observed minimum bulk density in the treatments integrated with farm yard manure and chemical fertilizers. significant lower bulk density was

recorded under 50% nitrogen through poultry manure + 25% nitrogen through urea + biofertilizers + Zn applied plot [20]. Parewa *et al. [28]* reported that the bulk density of soil decreased significantly with incorporation of FYM @ 10 t ha^{-1} which may be due to increase in organic carbon content in soil. This finding is corroborated with the finding of Dadhich *et al. [11]*.

Das and Patel [12] reported that integrated nutrient management treatments generally decreased the bulk density of soil as compared to these under inorganic treatments and the reason might be due to the higher soil organic carbon in these treatments. Bajpai *et al.,* [4] found that incorporation of organic sources considerably decreased the bulk density if the soil. Bellakki and Badanur [7] reported that in situ incorporation of sunnhemp for ten years reduced the bulk density as compared with fertilizers application.

4. POROSITY

Hyanes and Naidu (1998) reviewed that addition of organic manure into soil resulted in soil increase in porosity of soil. The vermicompost treated plots which were on par with poultry manure treated recorded the highest soil porosity. Rabindra *et al. [30]* observed an increase in porosity in case of farm yard manure alone while working on combined application of inorganic fertilizer and organic manure. Application of various organic materials either to meet 50 per cent or 25 per cent nitrogen along with fertilizer had better influence on the porosity of NPK fertilizers.

Soil porosity was significantly greater in pots where NPK was applied in combination with lime, FYM and biofertilizers than the unmanured control treatments [32]. This may be due to more organic matter content, better aggregation and changing pore size distribution of the soil [2]. Mahimairaja *et al.,*[22] also found that total porosity of soil increase with inorganic chemical fertilizers and compost application.

5. HYDRAULIC CONDUCTIVITY

Conjoint use of recommended dose of fertilizer and farm yard manure resulted in significant increase in hydraulic conductivity of soil [5]. Hati *et al.,* [15] reported that saturated hydraulic conductivity (13.32 x 10^{-6}) ms^{-1} of the NPK + FYM treatment was significantly greater than that of NPK (10.53 x 10^{-6}) ms^{-1} treatments.

Maximum value of hydraulic conductivity was observed with 100% NPK + FYM treatment followed by 100% NPK + Zn treatment and the lowest was under control treatment [27]. Khuspure *et al.,* [18] also reported an improvement of hydraulic conductivity with the application of 10 t FYM ha^{-1} followed by castor cake @ 500 kg^{-1}. Haynes and Naidu [16] reviewed that addition of organic manure into soil resulted in increase in hydraulic conductivity of soil. The hydraulic conductivity was highest in treatment having 75% NPK + 5 t ha^{-1} FYM + lime [29]. Mean saturated hydraulic conductivity was more under manure amended plots than with no manure. Application of N had significant effect in increasing saturated hydraulic conductivity over no N in all soil layer [8]. Mishra and Sharma (1997) also found that application of FYM improved saturated hydraulic conductivity and use of organic sources might have increased the stability of aggregates, which could have improved pore size distribution along with total porosity resulting in greater saturated hydraulic conductivity. Combined application of FYM and NPK resulted in significantly highest hydraulic conductivity than NPK application. [33].

6. INFILTRATION RATE

Addition of NPK fertilizers along with FYM, lime and biofertilizers, resulted in an increase in infiltration rate of the soil [32], Malik *et al.,* [23] reported an improvement in infiltration rate with the incorporation of vermicompost and chopped crop residue and this may be due to improvement of soil aggregation with addition of organic matter in the soil. The vermicompost treated plots were on par with poultry manure treated plots reduced the highest infiltration rate [31]. The infiltration rate was highest in 75% NPK 9 2.5 t ha-1 goat manure + lime owing to high humus content in soil due to addition of manure [29].

Application of manure increased initial infiltration rate, steady infiltration rate and cumulative infiltration over no manure treated plots [8]. The application of FYM over the year not only increased total porosity but also might have lead better pore size distribution and ultimately resulting in higher infiltration rate [16]. Thus, FYM modified soil structure and improved soil aggregation and infiltration characteristics [14]. Marathe and Bharombe (2005) reported that

application of recommended dose of fertilizers had higher infiltration rate over control. Integrated nutrient management in rice wheat system had marked influence on infiltration rate [4]. Sesbania green manure and mungbean residue incorporation resulted in soil aggregation which in turn increased the infiltration rate in rice-wheat cropping system [26].

7. MOISTURE RETENTION CAPACITY

A five year field experiment was carried out on acidic clay loam soil with a maize-mustard crop sequence to study the effect of continuous application of nitrogen, phosphors and potassium fertilizers alone or incombination with lime, FYM and biofertilizers on physical properties of soil. The result of the experiment revealed an increase in water retention capacity of soil with integrated nutrient management [32].

The higher value of maximum water holding capacity in the treatment receiving vermicompost and crop residue than RDF received treatment may be attributed to the fact these organics indirectly contributes to soil texture via increased fauna activity leading to improve soil aggregation and porosity which ultimately increased the macro pores [23]. Integrated use of NPK fertilizers with FYM resulted in improvement in soil water holding capacity and this may be due to better environment for root growth, which accumulate more root stables in the soil [28]. The results are in accordance with the findings of Datt *et al., [13]*. Soil water holding capacity was maximum in treatments where balanced fertilizations with FYM amended treatment was practiced [27]. Haynes and Naidu [16] reviewed that addition of organic manure into soil resulted in water holding capacity of soil. Addition of fertilizer levels significantly increased water holding capacity and this may be due to enhanced root growth leading to accumulation of more rot stables. The improvement of water holding capacity in response to the addition of FYM causes better environment for root development [28].

8. SOIL PENETRATION RESISTANCE

Bandyopadhyay et al. [6] reported that conjoint use of recommended dose of fertilizers and farm yard manure (NPK + FYM) resulted in significant decrease in soil penetration resistance. Celik *et al.[9]* reported that the use of organic fertilizers such as manure and compost decrease the soil penetration resistance. Uses of fertilizers more than the recommended amount cause formation, accumulation and concentration of mineral salts of fertilizers which leads to compaction layer and soil degradation in the long term. High compaction increase soil penetration resistance [24]. Bandyopadhay *et al.,* 2010 reported that conjunctive use of recommended dose of fertilizer and farm yard manure (NPK + FYM) resulted in significant ($P < 0.05$) decrease of soil penetration resistance.

9. CONCLUSION

The study present the brief summary of work carried out in India and abroad in the different aspects of integrated nutrient management practices which directly or indirectly relates soil physical properties. Soil aggregates as represented by mean weight diameter, aggregate stability and percentage of water stable aggregates was significantly applied by integrated nutrient management practices.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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