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Effect of Integrated Nutrient Management on Physical and Physico-chemical Properties of Soil

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Authors' contributions

This work was carried out by PM under the guidance of remaining all authors. All authors read and approved the final manuscript.

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ABSTRACT

Increasing food production while reducing environmental impact and resource use is the main challenge in agriculture. The usage of inorganic fertilizers in agriculture for increasing food production does not guarantee a sustainable future. In Integrated Nutrient Management (INM) we make conjunctive use of organic manures and inorganic fertilizers for improving soil productivity while also protecting soil properties from being destructed. In this research, the effect of INM on various soil properties is been investigated. The field experiment was carried out in India, during the *rabi* season of 2020 in a sandy loam soil of *ustic Inceptisols* under maize (*Zea mays* L.) variety *Pioneer* - 3396 as the Test crop. Application of Farm Yard Manure (FYM) @ 10 t/ha, biofertilizers namely *Azospirillum and Phosphorus Solubilizing Bacteria* (*Pseudomonas sp.*) @ 5 kg/ha each, was followed. The inorganic fertilizers @ 200:60:50 N-P_2O_5-K_2O kg ha^{-1} were followed as

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recommended dose and applied in three splits. The experiment is conducted in Randomised Complete Block Design (RCBD) comprising eight treatments and three replications *viz.,* T_1: Control, T_2: 100% RDN, T_3: 125% RDN, T_4: 75% RDN+ 25% N through FYM, T_5: 75% RDN + 25% N through FYM + Biofertilizers, T_6: 100% RDN+ 25% N through FYM, T_7: 100% RDN+ Biofertilizers and T_8: 100% RDN+ 25% N through FYM + Biofertilizers. Statistical significance was tested by applying F-test at a 0.05 level of probability. There was observed a non-significant effect on the Bulk Density (BD), Porosity, Water Holding Capacity (WHC), Cation Exchange Capacity (CEC), Soil reaction (pH), and Electrical Conductivity (EC), Organic Carbon (OC) of the experimental soil, which might be due to the short duration of the study.

Keywords: Manures; fertilizers; soil properties; maize.

1. INTRODUCTION

Physical and physico-chemical properties of soil play a crucial role in determining the productivity of soil and these properties are affected by the management practices that we adopt for cultivation [1]. Integrated nutrient management is the art of sensible utilization of the benefits of organic manures, inorganic fertilizers and biofertilizers for improving agricultural productivity by creating a balanced nutrition strategy that can maintain soil fertility and reduce the deterioration of soil. In INM we use organic manures such as farm yard manure, pig manure, sheep manure, etc., that improve the organic carbon status [2] of the soil after their decomposition. The organic component in INM improves soil physical properties, such as soil structure [3], aeration, infiltration rate [4], porosity [5], water-holding capacity [6] and decreases soil crusting [7]. But since the improvement in physical and physico-chemical properties of soil require long-term treatment [8, 9] with organic manures, their application for a short period can have a positive impact [10]. Farmyard manure increases soil microbial activity and contains all macro and micronutrients, FYM is regarded as a viable option to improve soil health [11] and also maintains soil productivity for a long time. Whereas, biofertilizers play role in the decomposition process and solubilization of nutrients [12]. *Azospirillum* is a popular microbial inoculant that can fix atmospheric nitrogen and also aids in the physiological and developmental aspects of maize [13]. Phosphorus Solubilising Bacteria (PSB) improve the availability of soluble phosphate and enhances growth of maize [14]. By following integrated nutrient management strategy, we can answer many challenges related to sustainable agriculture by reducing the negative impacts of long-term and disproportionate usage of chemical fertilizers on the soil.This paper presents the effect of the integrated use of inorganic fertilizers, FYM, and biofertilizers on the physical and physico-chemical properties of soil.

2. MATERIALS AND METHODS

Field research was conducted during the *rabi* season of the year 2020 at Agricultural College Farm, Bapatla. The soil is sandy loam in texture which belongs to the order *Inceptisols* and sub-order *ustepts*. The previous cropping history of the experimental plot was mostly with sorghum and pearl millet. The recommended dose of fertilizer was followed as 200:60:50 N-P_2O_5-K_2O kg ha^{-1} applied through Urea, Single Super Phosphate (SSP) & Morphate of Potash (MOP), respectively. The biofertilizers namely *Azospirillum* + PSB {*Phosphorus Solubilizing Bacteria* (*Pseudomonas* sp.)} @5 kg ha^{-1} each. The experiment consisted of eight treatments and three replications. The treatments are as follows : T_1: Control, T_2: 100% RDN, T_3: 125% RDN, T_4: 75% RDN+ 25% N through FYM, T_5: 75% RDN + 25% N through FYM + Biofertilizers, T_6: 100% RDN+ 25% N through FYM, T_7: 100% RDN+ Biofertilizers and T_8: 100% RDN+ 25% N through FYM + Biofertilizers. The control treatment is devoid of any fertilization and all remaining treatments were equally supplied with inorganic P and K doses at their recommended level whereas, the Recommended Dose of Nitrogen (RDN) is varied among the treatments which is often been substituted with Farm Yard Manure (FYM) and/or biofertilizers. The data on various parameters were statistically analysed by using Fisher's method of analysis of variance as suggested by [15] for the Randomized Complete Block Design (RCBD) adopted in this study. Statistical significance was tested by applying F-test at a 0.05 level of probability. Critical differences at 0.05 levels were worked out for the significant effects. The experimental field was ploughed twice by a tractor-drawn cultivator and FYM is applied and left for 15 days for decomposition and the field was given a little

Table 1. Initial soil characteristics (0-15cm) of the experimental soil

Particulars	Readings
Physical properties	
I. Mechanical analysis	
1. Sand (%)	72 %
2. Silt (%)	13 %
3. Clay (%)	15 %
Textural class	Sandy loam
Bulk density (t m^{-3})	1.44
Water holding capacity (%)	13.92
Porosity (%)	38
Physico- chemical properties	
pH	7.2
EC (dS m^{-1})	0.25
CEC [C mol (p+) kg^{-1}]	13.73
Organic carbon (%)	0.21

tillage with a disc harrow to chop up unwanted weeds and to churn the soil to obtain required tilth and perfect incorporation of soil with FYM. The seeds of maize (*Zea mays* L.) cultivar, *Pioneer* 3396 were hand dibbled @ 25 kg ha^{-1} by following a spacing of 60 cm X 20 cm. The seeds were pre-treated with thiram 1.5 g kg^{-1} to avoid fungal infections and are inoculated with *Azospirillum* and *Phosphorus Solubilizing Bacteria* (PSB) before sowing. Inorganic fertilizers were applied in three splits, the first split at the time of sowing, the second and third at 30 and 45 days after sowing respectively. The crop was irrigated as and when required. The soil analysis was performed before the experiment and also during the harvest stage of the crop, to know the effect of different treatments imposed. The initial characteristics of the soil (0-15 cm depth) are enlisted in Table 1.

The texture analysis was carried out by the bouyoucos hydrometer method given by [16]. Bulk density (t m^{-3}) was estimated by core method as per the procedure given by [17]. Water holding capacity (%) was estimated by the method described by [18]. Porosity(%) was calculated by using the formula proposed by [19]. The Physico-chemical properties of soil namely soil reaction (pH) was measured by using a glass electrode pH meter in a 1 : 2.5 ratio of soil water suspension [20]. Electrical conductivity (EC) (dSm^{-1}) of soil samples was determined in 1: 2.5 soil water suspension using an electrical conductivity bridge [20]. Organic carbon (%) was estimated by Walkley and Black's method as described by [21]. The Cation exchange capacity (CEC) (C mol (P^+) kg^{-1}) was measured by the method described by [22].

3. RESULTS AND DISCUSSION

3.1 Bulk Density (B.D), Porosity, Water Holding Capacity (WHC)

Bulk density of soil at harvest of the crop was not significantly influenced by the various treatments imposed. But a comparatively lower BD, higher porosity and higher WHC was recorded in treatment 100% RDN + 25% FYM + Biofertilizers (T_8) than in all other treatments, which might be due to the effect of FYM, Biofertilizers [11,23]. The non-significant effect on bulk density of soil even after applying organic manures and inorganic fertilizers was also reported by [10] who revealed that reduction in bulk density is due to higher organic carbon, more pore space and good soil aggregation which was a long-term change. Hence the non-significant effect of manures on bulk density, WHC and porosity of the present experiment might be because of the shorter period of study. It has also been well-documented by several scientists that a greater quantity of organic material is needed to improve soil properties.

Soil Reaction (pH): The data presented in Table 3 reveals that there was no significant effect on soil reaction and electrical conductivity of soil, by the imposed treatments. In this case, the pH decreased in all treatments as compared to the initial pH of experimental soil and the decline was more pronounced in the treatments which

Table 2. Effect of integrated nutrient management on soil's physical properties at harvest stage of maize crop

Treatments	B.D (t m^{-3})	Porosity (%)	WHC (%)
T_1: Control	1.43	40.56	13.92
T_2: 100% RDN	1.44	40.90	14.02
T_3: 125% RDN	1.44	41.47	14.33
T_4: 75% RDN + 25% FYM	1.42	42.46	16.71
T_5: 75% RDN + 25% FYM + Biofertilizers	1.41	42.78	17.12
T_6: 100% RDN + 25% FYM	1.42	42.53	16.76
T_7: 100% RDN + Biofertilizers	1.42	42.11	14.78
T_8: 100% RDN + 25% FYM + Biofertilizers	1.41	42.91	17.14
SEm (±)	0.01	0.79	1.08
CD (P=0.05)	NS	NS	NS
CV (%)	7.31	7.69	12.53

Table 3. Effect of Integrated nutrient management on soil physico-chemical properties

Treatments	pH	EC (dSm^{-1})	OC (%)	CEC (C mol (p^+) kg^{-1})
T_1: Control	7.20	0.23	0.21	13.75
T_2: 100% RDN	7.10	0.24	0.22	14.33
T_3: 125% RDN	7.08	0.24	0.22	14.69
T_4: 75% RDN + 25% FYM	6.98	0.26	0.23	16.07
T_5: 75% RDN + 25% FYM + Biofertilizers	6.97	0.27	0.24	16.47
T_6: 100% RDN + 25% FYM	6.98	0.26	0.23	15.39
T_7: 100% RDN + Biofertilizers	7.09	0.25	0.22	15.03
T_8: 100% RDN + 25% FYM + Biofertilizers	6.96	0.27	0.25	17.13
SEm (±)	0.09	0.03	0.03	1.13
CD (P=0.05)	NS	NS	NS	NS
CV (%)	7.09	7.23	7.24	8.26

received organic and inorganic dose of nutrients in combination. The decrease in soil pH due to INM was also confirmed by the findings of [24,25].The addition of organic manure results in organic matter oxidation and the release of carbon dioxide in the soil. The release of organic acids during the decomposition of manure will in turn causes a slight decline in pH [26]. However, the effect was not significant because of the short duration of the present study.

Electrical Conductivity (EC): The perusal of data in Table 3 indicates that there was no significant effect on the EC of soil. However, a numerically higher EC was recorded in the treatment 100% RDN + 25% FYM + Biofertilizers (T_8) and lower in the control treatment, this might be due to the release of electrolyte during decomposition that causes slight increase in soil EC. This was in line with the research findings of [10,27] who also reported no significant change and a slight increase in the electrical conductivity of soil under INM.The total salt concentration is not highly altered because the doses of fertilizers added in different treatments were quite small and salts added through fertilizers might have been leached down due to the good number of irrigations received during the crop growth period.

Organic Carbon (OC): The organic carbon content was found non significantly influenced by different treatments imposed and it ranged from 0.21 to 0.25 %. The slight increase in organic carbon content in all the treatments with integrated use of nutrient sources, could be partly attributed due to the the fact that microbial activity in the soil gets stimulated in the presence of available organic matter, and also due to enhancement of root growth which leads to the accumulation of organic residues. These findings are in agreement with that of [3, 28, 29] who also reported an improvement in organic carbon status to increased organic manure and biomass production.Since the improvement in O.C of soil cannot be occurred within a short treatment with organic manures, there was no noticeable effect.

Cation Exchange Capacity (CEC): The CEC of soils was not significantly influenced by different treatments and it ranged from 13.75 to 17.13 C mol (p^+) kg^{-1}. Among the treatments, a better CEC was observed in treatment 100% RDN + 25% FYM + Biofertilizers (T_8) which was followed by treatment 75% RDN + 25% FYM + Biofertilizers (T_5) i.e 16.47 C mol (p+) kg^{-1}. It was inferred that the CEC of the soil was slightly increased at harvest as compared to that of the initial soil and the improvement was noticeable in the treatments which received higher levels of organic manure through FYM. Applied organic manures decompose in soils to form humus and humic substances, which play a dominant role along with clay micelle in the complex soil reactions that enhances the CEC of soil [30]. A similar influence of integrated nutrient supply systems on CEC of soil was earlier reported by [25,31].

4. CONCLUSION

Even though integrated nutrition management treatments have been found beneficial over sole inorganic nutrition and no nutrition treatments, the effect was found to be non-significant in this study. The decomposition of organic manures is a slow process and cannot bring remarkable changes in the physical and physico-chemical properties of soil within a short period of manure application. However, to reduce the usage of inorganic fertilizers, the Integrated Nutrient Management (INM) strategy is a viable option.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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