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Role of Fermented Organic Manure and Mycorrhiza on Physio Chemical Properties of Soil of Prayagraj, 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

The integrated use of fermented organic manure and mycorrhiza has been employed to enhance crop productivity and maintain soil health and fertility. The research titled "Role of fermented organic manure and mycorrhiza on physio-chemical properties of soil" was conducted during the Zaid season of 2023 at the Central Research Farm, Department of Soil Science and Agricultural Chemistry, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology, and

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Sciences, Prayagraj, Uttar Pradesh, India. The plot was designed in 3X3 RBD having 3 levels of fermented organic manure @ 0, 50, 100 %, Mycorrhiza @ 0, 50, 100 % and N, P, K at RDF respectively. The Variety selected was PDM- 139 released by SVRC, Uttar Pradesh in the year 1974. The average yield recorded was 6-9 q ha^{-1}. Results indicated non-significant with the highest values observed in the control treatment in case of bulk density (Mg m^{-3}) and particle density (Mg m^{-3}) of soil was recorded maximum in T1 (Absolute control) and minimum was recorded at T9 (NPK@RDF + M2@ 10Kg ha^{-1} 50% + F2@ 50 l ha^{-1} 100%). The maximum Pore space (%) and Water holding capacity (%) of soil was recorded at T9 (NPK@RDF + M2@ 10Kg ha^{-1} 50% + F2@ 50 l ha^{-1} 100%) and the minimum was found in T1 (control). The slight decrease of pH and EC was observed on application of the treatments, the maximum pH of soil was recorded at T9 (NPK@RDF + M2@ 10Kg ha^{-1} 50% + F2@ 50 l ha^{-1} 100%) and the minimum in T1 (Absolute control. The maximum organic carbon (%) and increase of N, P, K of soil was recorded at T9 (NPK@RDF + M2@ 10Kg ha^{-1} 50% + F2@ 50 l ha^{-1} 100%) and the minimum was found in T1 (Absolute control).

Keywords: Fermented organic manures; mycorrhiza; green gram; soil health; physio-chemical properties, etc.

1. INTRODUCTION

Soil is generally defined as the fine earth that covers the land surface, formed through various weathering processes either in place or by the accumulation of materials transported by wind, water, or ice. A distinctive feature of soil is the addition of organic material to this weathered substance. This organic matter can be both living and dead. Therefore, soil can be described as a mixture of mineral material and organic matter, which imparts its unique characteristics [1]. Agricultural soil is a type of soil that is used for productive activities of various crops, considered of great importance in terms of environmental decontamination since plants apart from absorbing nutrients such as CO_2, also absorb different polluting compounds from soil [2,3,4].

Mycorrhiza are among the most widespread forms of symbiosis on Earth, involving a mutualistic relationship between plants and fungi that enhances nutrient and water uptake by plants [5-10]. Operating at the interface of biological, chemical, and physical processes that underpin soil fertility, mycorrhizal fungi thrive in heterogeneous environments with highly variable conditions in soil and plant roots [11-14]. The persistent use of chemical fertilizers can render soil unfit for crop cultivation by diminishing microbial activity and reducing microbial populations. In contrast, organic fertilizers play a crucial role in revitalizing soil health. Among these, biofertilizers are significant for maintaining soil health, with Arbuscular Mycorrhizal (AM) fungi forming associations with about 80% of plant species. The symbiotic relationship between AM fungi and plants has been extensively studied by researchers [15].

AM fungi, also known as Vesicular Arbuscular Mycorrhizal (VAM) fungi, are particularly effective at enhancing the absorption of micronutrients like zinc (Zn) and copper (Cu) and increasing plant resilience to various stresses, including drought, salinity, heavy metals, and water scarcity [16]. This symbiotic relationship boosts plant development by supplying essential nutrients such as nitrogen (N), phosphorus (P), potassium (K), and zinc. Mycorrhizal associations also help reduce plant susceptibility to certain soil-borne diseases, and the application of AM fungi has been shown to enhance nitrogenase activity [17].

Fermented organic manure over the past century, the evolution of agriculture has significantly increased agricultural output, with chemical fertilization playing a pivotal role. However, the increased use of fertilizers and intensive land use have led to numerous environmental issues, such as nitrogen runoff contributing to watershed pollution. Fermented organic manure has garnered attention for its environmental benefits [18-20]. This type of microbial organic fertilizer not only supplies crops with essential nutrients but also enhances crop growth conditions and activates intrinsic soil nutrients through numerous enzymatic activities (Wang et al. 2018).

The composition of N-Carb, a type of fermented organic manure, includes a fermented organic extract that provides abundant organic nitrogen, phosphorus, potassium, and micronutrients. This enriches soil organic matter by rapidly enhancing organic carbon in the soil structure. Consequently, soil is protected from degradation and erosion, and soil aeration is improved. This environment promotes the activity of beneficial carbon-fixing microbes, which enrich soil organic carbon and support adequate photosynthesis in plants. The organic extracts of hydrolyzed material in N-Carb enable crop plants to absorb essential nutrients through their roots, even under adverse soil conditions. It also optimizes soil moisture retention at the root zone, helping plants withstand various biotic and abiotic stresses, including salinity, drought, and nutrient deficiency, making it suitable for both organic and conventional farming [21].

2. MATERIALS AND METHODS

The field trial was conducted during the Zaid season of 2023 at the Central Research Farm of the Department of Soil Science and Agricultural Chemistry at Sam Higginbottom University of Agriculture, Technology and Sciences (U.P.), located at 25°24'30'' N latitude, 81°51'10'' E longitude, and 98m above mean sea level. This location is part of the Agro-Ecological Sub Region [North Alluvium Plain Zone (0-1% slope)] and the Agro-Climatic Zone (Upper Gangetic Plain Region). Agro-climatically, Prayagraj District falls within the subtropical belt of Southeast Uttar Pradesh, experiencing extremely hot summers and cold winters. The maximum temperature ranges up to 46°C, rarely dropping below 4- 5°C, with relative humidity between 20-94%. The area receives an average annual rainfall of about 1100mm, primarily from July to the end of September, though occasional winter precipitation is not uncommon. During the crop season, temperatures ranged from a minimum of 21.38℃ to a maximum of 37.82℃, while humidity varied from 46.42% to 96.85%

2.1 Experimental Design

The experimental design was a 3x3 Randomized Block Design with three levels of fermented organic manure (0, 50, 100%), mycorrhiza (0, 50, 100%), and NPK at recommended doses (RDF). Each plot measured 2m x 2m, and the green gram variety used was PDM-139, aimed at evaluating soil properties and health.

2.2 Methodology

The soil in the experimental area was primarily sandy loam, classified as Inceptisol and part of the alluvium soil near the Ganga-Yamuna Basin. Before tillage operations, soil samples were collected randomly from five distinct locations within the experimental plot at a depth of 0-15cm. These samples were prepared for physical and chemical analysis by air-drying, coning, and quartering, sieving through a 2mm sieve, and storing in polythene bags. Post-harvest, soil samples were again collected according to different treatment combinations and analyzed for various parameters listed in Table 1.

Table 1. Soil Parameter Analysis

i. Physical Properties

Sl. no.	Parameter	Method	Method
1.	Bulk Density	Graduated measuring cylinder	Muthuval et al. [22]
2.	Particle density	Graduated measuring cylinder	Muthuval et al. [22]
3.	Pore space	Graduated measuring cylinder	Muthuval et al. [22]
4.	Water retention capacity	Graduated measuring cylinder	Muthuval et al. [22]

ii. Chemical properties

Sl. no.	Parameter	Unit	Method
1.	Soil pH	Digital pH meter	Jackson,[23]
2.	Soil EC	Digital EC meter	Wilcox, 1950
3.	Organic Carbon	Wet Oxidation Method	Walkley and Black, 1947
4.	Available Nitrogen	Kjeldahl method	Subbiah and Asija, [24]
5.	Available Phosphorus	Colorimetric method	Olsen et al. [25]
6.	Available Potassium	Flame Photometer method	Toth and Prince, [26]

Table 2. Treatment combination

Treatments	Treatment Combination	Symbol
T1	Absolute control	L0M0F0
T2	NPK@RDF + M0 + F1 @ 50%	LM0F1
T3	NPK@RDF + M0 + F2 @ 100%	LM0F2
T4	NPK@RDF + M1@ 50% + F0	LM1F0
T5	NPK@RDF + M1@ 50% + F1@ 50%	LM1F1
T6	NPK@RDF + M1@ 50% + F2@ 100%	LM1F2

Treatments	Treatment Combination	Symbol
T7	NPK@RDF + M2@ 100% + F0	LM2F0
T8	NPK@RDF + M2@ 100% + F1@ 50%	LM2F1
T9	NPK@RDF + M2@ 100% + F2@ 100%	LM2F2

Note: RDF = Recommended dose of fertilizer, M= Mycorrhiza and F= Fermented organic manure

The detailed about treatment combination of the conducted research wise given in Table 2.

3. RESULT SAND DISCUSSION

The study found that using fermented organic manure and mycorrhiza significantly enhances various soil physical parameters, such as particle density, water holding capacity, and porosity, thereby maintaining good soil health. Additionally, soil chemical properties improved with increased nutrient levels, including soil electrical conductivity (EC), organic carbon, available nitrogen, phosphorus, and potassium [27-31].

The field experiment revealed that soil bulk density and pH decreased with higher levels of fermented organic manure and mycorrhiza [32-34]. The maximum bulk density (1.341 Mg m^{-3}) and pH (7.06) were observed in the control treatment T1[Absolute control], while the minimum pH (6.95) and bulk density (1.224 Mg m^{-3}) were found in the T9- [NPK@RDF + M2@ 10Kg ha^{-1} 100% + F2@ 50 l ha^{-1} 100%].

The T9- [NPK@RDF + M2@ 10Kg ha^{-1} 100% + F2@ 50 l ha^{-1} 100%] treatment also resulted in the highest values for electrical conductivity (0.42 dS m^{-1}), particle density (2.41), pore space (48.72 %), water holding capacity (48.53 %), organic carbon (0.65 %), available nitrogen (297.67 kg ha^{-1}), available phosphorus (26.03 kg ha^{-1}), available potassium (211.07 kg ha^{-1}). In contrast, the control treatment T1[Absolute control] had the lowest values for these parameters: minimum electrical conductivity (0.30 dS m^{-1}), pore space (45.43 %), water holding capacity (43.42 %), organic carbon (0.45 %), available nitrogen (274.67 kg ha^{-1}),available phosphorus (18.83 kg ha^{-1}), available potassium (178.30 kg ha^{-1}). This indicates that the T9 treatment has the greatest potential to improve soil health and productivity.

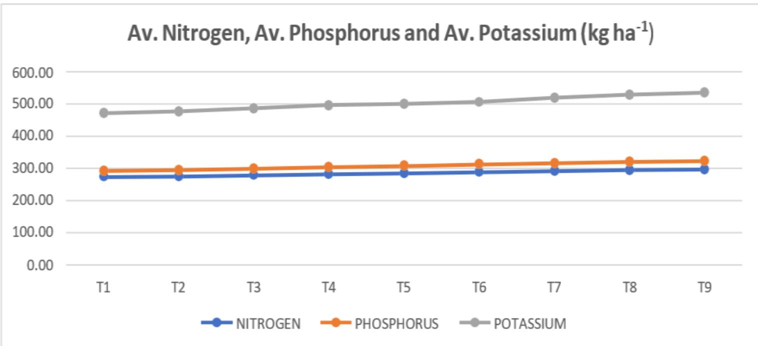

Fig. 1. Graphical representation of Av. nitrogen, Av. phosphorus and Av. potassium vs treatment combination

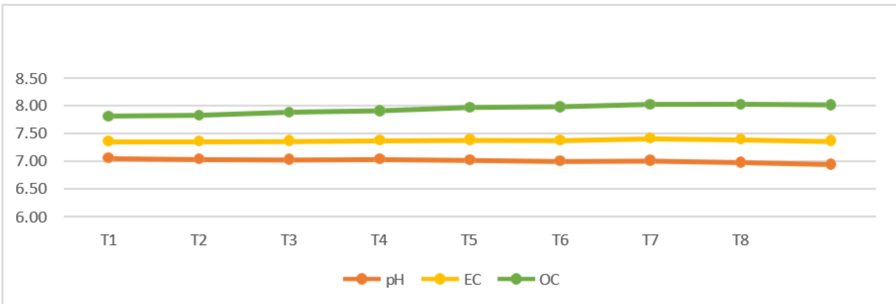

Fig. 2. Graphical representation of treatment combination vs EC, pH and OC (%)

Table 3. Effect of different levels of NPK fermented organic manure and mycorrhizal inoculation on bulk density (Mg m^{-3}), particle density (Mg m^{-3}) water holding capacity (%) and pore space (%)

Treatments	Bulk Density (Mg m^{-3})	Particle Density (Mg m^{-3})	Water Holding Capacity (%)	Pore Space (%)
	0-15 cm	0-15 cm	0-15 cm	0-15 cm
T1	1.341	2.424	43.52	44.68
T2	1.334	2.434	44.79	45.20
T3	1.325	2.446	45.20	45.83
T4	1.294	2.449	45.47	47.17
T5	1.281	2.490	46.12	48.56
T6	1.271	2.513	46.56	49.43
T7	1.261	2.514	47.52	49.85
T8	1.244	2.564	47.95	51.49
T9	1.224	2.597	48.53	52.87
F-Test	NS	NS	S	S
S.Em. (±)	0.02	0.02	0.21	0.14
C.D.@5%	0.05	0.05	0.45	0.29

Table 4. Effect of different levels of NPK fermented organic manure and mycorrhizal inoculation on pH, EC, organic carbon, Av. Nitrogen, Av. Phosphorus and Av. Potassium (kg ha^{-1})

Treatments	pH	EC (dSm^{-1})	OC (%)	Av. Nitrogen (kg ha^{-1})	Av. P_2O_5 (kg ha^{-1})	Av. K_2O (kg ha^{-1})
	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm	0-15 cm
T1	7.06	0.30	0.45	274.67	18.83	178.30
T2	7.05	0.32	0.46	276.33	19.60	181.52
T3	7.04	0.34	0.51	279.33	20.88	187.12
T4	7.05	0.34	0.53	283.33	21.48	192.18
T5	7.03	0.36	0.58	286.00	22.60	191.87
T6	7.01	0.38	0.60	289.33	23.56	193.91
T7	7.02	0.40	0.61	292.67	24.60	202.80
T8	6.99	0.41	0.63	296.33	25.08	207.68
T9	6.95	0.42	0.65	297.67	26.03	211.65
F-Test	S	S	S	S	S	S
S.Em. (±)	0.08	0.02	0.03	0.54	0.16	0.85
C.D.@5%	0.21	0.03	0.05	1.15	0.35	1.80

4. CONCLUSION

It is revealed from trial that the various level of NPK fermented organic manure and mycorrhizal inoculation used from in the experiment, the treatment combination T9 – [NPK@RDF + M2@ 10Kg ha^{-1} 50% + F2@ 50 l ha^{-1} 100%] for green gram it could be recommended for profitable production of green gram (*Vigna radiata* L.) var. PDM-139 and treatment T9 is best in terms of soil physical and chemical properties. Further it increased soil fertility and nutrient uptake by the plant. The major challenges faced during the research trial was infestation of white flies and yellow mosaic virus attack due to dry condition around the field. Overall, it proved to be beneficial both respect to soil health properties by application of fermented organic manures and inoculation of mycorrhiza in cultivation and growth of green gram.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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