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Evaluation of Green Gram (*Vigna radiata* L. var PDM 139) Cultivated and Harvested Soils Supplemented with Nano Urea, Rhizobium and Farm Yard Manure

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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

A study was conducted to investigate the "Evaluation of varying levels of Nano urea, FYM, and rhizobium on soil properties and yield characteristics of green gram (*Vigna radiata*. L) var. PDM 139" at the research farm of soil science and agricultural chemistry. The experiment followed a

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randomized block design (RBD) with three replications. Treatment T_9 (NU at 100% + RZ at 100% + FYM at 100%) showed a slight decrease in pH (6.96 P^H), bulk density (1.27 mg m^{-3}), particle density (2.46 mg m^{-3}), there was a significant increase in pore space (48.90%), water holding capacity (46.51%), EC (0.20 ds m^{-3}), organic carbon (0.58%), available nitrogen (320 kg ha^{-1}), phosphorus (21.4 kg ha^{-1}), potassium (195.12 kg ha^{-1}), and plant growth. Among all the treatment joint use of T_9 (NU at 100% + RZ at 100% + FYM at 100%) showed the most significant impact on green gram growth through healthy soil.

Keywords: Greengram; soil; nano urea; rhizobium; FYM.

1. INTRODUCTION

Soil serves as the primary medium for plant growth and is fundamental to crop production. Various soil properties affect plant growth, including texture (whether coarse or fine), aggregate size, porosity, permeability (aeration), water holding capacity, pH level, bulk density, and particle density. The rate at which water moves into the soil (infiltration) is influenced by soil texture, physical structure (soil structure and tilth), and the amount of vegetation covering the soil surface. Organic matter plays a role in enhancing water retention in all types of soils and can also improve infiltration rates in fine-textured soils. Bulk density indicates the soil's ability to support plant structure, facilitate water and solute movement, and maintain soil aeration [1] Soil pH significantly impacts the solubility of essential nutrients required for optimal plant growth and development [2,3,4]. Monitoring soil pH is valuable as it predicts various chemical processes in the soil. It aids in decisions related to plant suitability for specific locations, potential pH adjustments, and provides a rough estimate of nutrient availability to plants in the soil. Plants primarily obtain carbon, oxygen, and hydrogen from air and water, while other essential nutrients, termed plant nutrients, are sourced from soil or supplemented through fertilizers and absorbed predominantly through roots [5] Green gram, also known as mung bean, ranks as the third most significant pulse crop among thirteen food legumes cultivated in India. The functional properties of proteins are influenced by various physical and chemical factors such as soil pH, ionic strength, temperature, and pressure, contributing to their variability and potential in food production [6]. Proteins are typically expensive to produce industrially. With a growing global population and improved standards of living, there is increasing pressure on protein availability for food consumption. This underscores the importance of maximizing the use of green gram, particularly its nutritious germinated form [7]. Green gram enhances soil physical properties. The productivity of moong bean is hindered by its cultivation on marginal and submarginal lands with inadequate fertilization and suboptimal management practices. Poor yields of moong bean in farmer fields stem from insufficient awareness among farmers regarding optimal sowing dates, effective weed control, balanced fertilizer application, pest management strategies, and proper planting methods. Delayed planting of moong bean results in decreased pod or plant numbers, reduced grain weight, and ultimately lower grain yield. Sowing time is identified as the foremost agronomic factor crucial for realizing the yield potential of improved moong bean varieties. Optimal sowing time ensures synchronization between the vegetative and reproductive stages of the crop, thereby playing a pivotal role in achieving high seed yields [8].

Liquid Nano-urea, when applied as a foliar spray, penetrates through stomata and other openings on leaves and is readily absorbed by plant cells. Nano-urea in liquid form efficiently moves through the plant's phloem from source to sink as required. Unused nitrogen is stored in plant vacuoles and released gradually to support proper growth and development. Unlike subsidized urea, liquid Nano-urea is offered to farmers at a 10% lower cost per unit and is easier to transport, with one 500-ml bottle equating to one bag of regular urea. It is safe for humans, animals, birds, rhizosphere organisms, and the environment at recommended application levels. Compared to conventional urea, Nano-urea's uptake efficiency exceeds 80%, reducing the quantity needed to meet plant nitrogen requirements. Foliar application of Nano-urea at critical crop growth stages effectively meets nitrogen needs, enhancing fertilizer efficiency, crop productivity, and quality. Nano-urea can potentially reduce reliance on conventional urea by up to 50% [9]. Rhizobium, a genus of gram-negative soil bacteria, participates in nitrogen fixation. It forms an endosymbiotic relationship with the roots of legumes and various flowering plants. Farmyard manure (FYM) contributes significantly to enhancing soil fertility and productivity by positively impacting soil physical, chemical, and biological properties, as well as ensuring balanced plant nutrition [10]. Fertilizers are crucial for sustaining and enhancing soil fertility by providing plants with readily available nutrients. Therefore, it is important to assess the impact of combining farmyard manure (FYM) with chemical fertilizers on the growth and yield of post-rainy season green gram [11]. Applying nano urea through foliar methods alongside organic and inorganic fertilizers enhanced the growth and yield of green gram [12]. The current study aims to assess soil health and fertility through the application of nano urea (NU), rhizobium (RZ), and farmyard manure (FYM), examining their impact on crop growth and yield.

2. MATERIALS AND METHODS

2.1 Experimental Site

The experiment took place at the Research Farm of Soil Science and Agricultural Chemistry, located approximately 6 km from Prayagraj city. The farm is situated at latitudes 23°52’ N to 31°28 N and longitudes 77°3’ to 84°28’ E, with an altitude of 98 meters above sea level.

2.2 Climatic Conditions in the Experimental Area

Prayagraj district lies within the subtropical belt of southeast Uttar Pradesh, characterized by hot summers and cold winters. Maximum temperatures can soar to 46-48°C, while occasionally dropping to 4-5°C. Relative humidity ranges from 20% to 94%, and the average annual rainfall is approximately 1100 mm.

3. RESULTS AND DISCUSSION

3.1 Effect of Nano Urea, FYM, and Rhizobium on the Physical Soil properties post-green gram harvest

The data showed that the treatment T1 (absolute control) non-significantly influenced the bulk density of soil (1.31), particle density of soil (2.50) at 0–15 cm depth and significantly influenced percentage pore space (48.90), and water holding capacity (46.51) of soil were found to be optimal in treatment T9 (NU @ 100% + RZ @ 100% + FYM @ 100%) over T1 (absolute control) treatment at 0–15 cm and 15–30 cm depth.

Table 1. Physical parameters

Particulars	Method employed
Sand (%)	Bouyoucos (1927) [13]
Silt (%)	Bouyoucos (1927) [13]
Clay (%)	Bouyoucos (1927) [13]
Textural class	Bouyoucos (1927) [13]
Bulk density (Mg m^{-3}	Muthuval (1992) [14]
Particle density (Mg m^{-3})	Muthuval (1992) [14]
Pore space (%)	Muthuval (1992) [14]
Water holding capacity (%)	Black (1965) [15]

Table 2. Chemical parameters

Parameters	Method employed	Range
Soil P^H (1:2)	(Jackson 1958) [16]	(0-14 pH)
Soil EC (ds m^{-1})	(Wilcox 1950) [17]	(< 0.75 ds m^{-1})
Organic Carbon (%)	(Walkley and Black, 1947) [18]	(0.5-0.75 %)
Available Nitrogen (kg ha^{-1})	(Subbiah and Asija, 1956) [19]	(240-480 kg ha^{-1})
Available Phosphorus (kg ha^{-1})	(Olsen et al., 1954) [20]	(11.0 -22 kg ha^{-1})
Available Potassium (kg ha^{-1})	(Toth and Prince., 1949) [21]	(110 -280 kg ha^{-1})

Table 3. Treatment combinations

Treatment	Treatment combination
T1	(Absolute control)
T2	NU @ 0% + RZ @ 50% + FYM @ 50%
T3	NU @ 0% + RZ @ 100% + FYM @ 100%
T4	NU @ 50% + RZ @ 0% + FYM @ 0%
T5	NU @ 50% + RZ @ 50% + FYM @ 50%
T6	NU @ 50% + RZ @ 100% + FYM @ 100%
T7	NU @ 100% +RZ @ 0% + FYM @ 0%
T8	NU @ 100% +RZ @ 50% + FYM @ 50%
T9	NU @ 100% +RZ @ 100% + FYM @ 100%

Table 4. Effect of Nano Urea, FYM, and Rhizobium on Bulk Density, Particle Density, Pore Space, and Water Holding Capacity

S.No.	TREATMENT	B.D (Mg m^{-3})	P.D (Mg m^{-3})	Pore Space (%)	WHC (%)
T1	(Absolut control)	1.31	2.50	46.21	43.30
T2	NU @ 0% + RZ @ 50% + FYM @ 50%	1.30	2.50	47.35	44.38
T3	NU @ 0% + RZ @ 100% + FYM @ 100%	1.28	2.48	48.71	45.18
T4	NU @ 50% + RZ @ 0% + FYM @ 0%	1.31	2.49	46.38	43.40
T5	NU @ 50% + RZ @ 50% + FYM @ 50%	1.29	2.49	47.50	44.58
T6	NU @ 50% + RZ @ 100% + FYM @ 100%	1.28	2.47	48.82	45.61
T7	NU @ 100% +RZ @ 0% + FYM @ 0%	1.31	2.49	47.22	44.21
T8	NU @ 100% +RZ @ 50% + FYM @ 50%	1.29	2.48	47.65	45.11
T9	NU @ 100% +RZ @ 100% + FYM @ 100%	1.27	2.46	48.90	46.51
	F TEST	**NS**	**NS**	**S**	**S**
	S. Em. (±)	**0.015**	**0.029**	**1.13**	**0.54**
	C.D (P =0.05)	**0.047**	**0.087**	**3.39**	**1.62**

Where, NU- Nano urea, RZ- Rhizobium, FYM- Farm yard manure B.D- Bulk density, P.D- Particle density, WHC- Water holding capacity

Table 5. Effect of Nano Urea, FYM, and Rhizobium on EC, Organic Carbon, Available Nitrogen, Phosphorus, and Potassium

S.N.	TREATMENT	pH	EC (ds m^{-3})	OC (%)	Nitrogen (Kg ha^{-1})	Phosphorus (Kg ha^{-1})	Potassium (Kg ha^{-1})
T1	(Absolut Control)	7.05	0.17	0.38	282	17.2	180.21
T2	NU @ 0% + RZ @ 50% + FYM @50%	7.03	0.16	0.42	292	18.7	182.41
T3	NU @ 0% + RZ @ 100% + FYM @100%	6.99	0.18	0.54	298	19.3	189.26
T4	NU @ 50% + RZ @ 0% + FYM @0%	7.04	0.15	0.39	283	16.3	180.31
T5	NU @ 50% + RZ @ 50% + FYM @50%	7.03	0.17	0.46	294	18.6	183.61
T6	NU @ 50% + RZ @ 100%+FYM @100%	6.97	0.19	0.56	310	20.2	190.11
T7	NU @ 100% +RZ @ 0% + FYM @0%	7.04	0.15	0.40	284	16.4	181.11
T8	NU @ 100% +RZ @ 50% + FYM @50%	7.02	0.17	0.48	296	18.5	186.16
T9	NU @100% +RZ @100% +FYM @100%	6.96	0.20	0.58	320	21.4	195.12
	F TEST	**NS**	**S**	**S**	**S**	**S**	**S**
	S. Em. (±)	**0.12**	**0.013**	**0.042**	**4.9**	**0.30**	**3.02**
	C.D (P =0.05)	**0.37**	**0.25**	**0.126**	**14.8**	**0.92**	**9.06**

Where, NU- Nano urea, RZ- Rhizobium, FYM- Farm yard manure, EC- Electrical Conductivity, OC- Organic carb

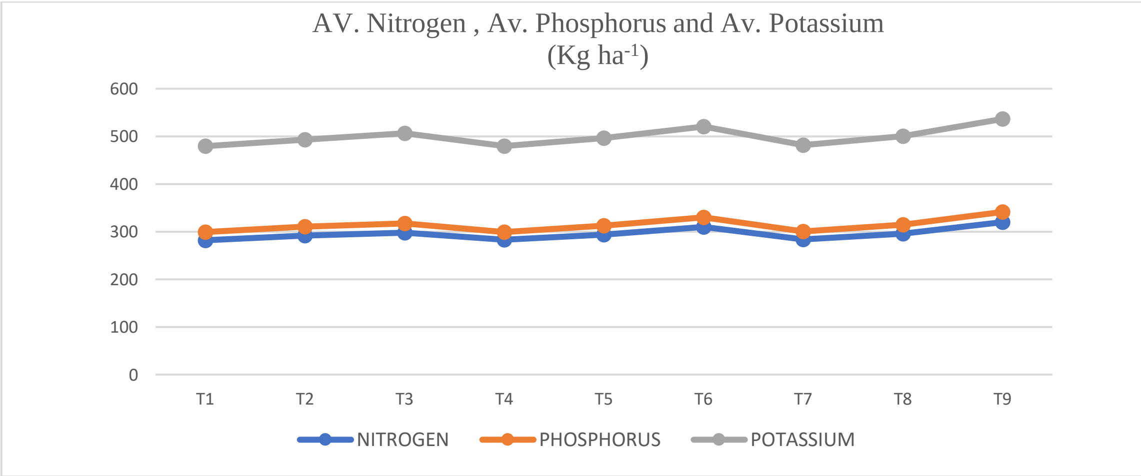

Fig. 1. Graph representation of Av Nitrogen, Av. Phosphorus, Av. Potassium vs Treatment combination

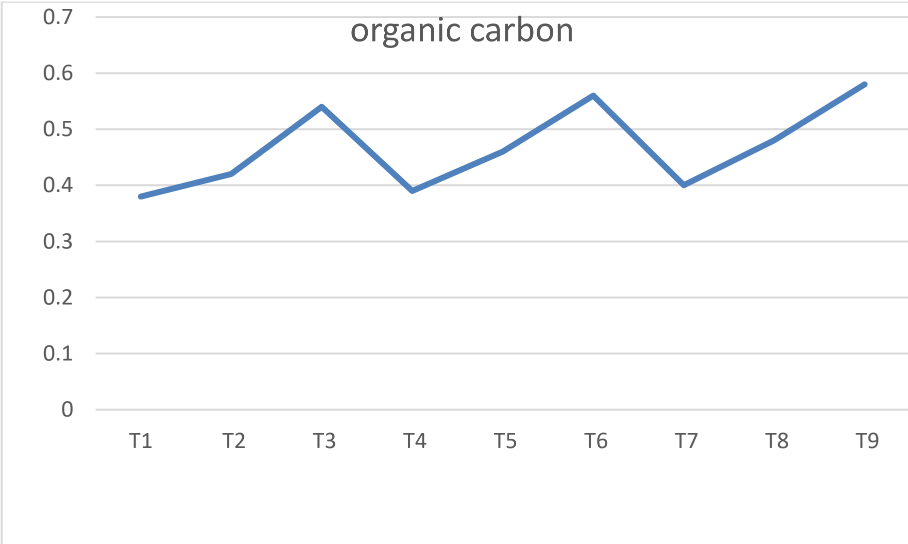

Fig. 2. Graph of representation of organic carbon

3.2 Effect of Nano Urea, FYM, and Rhizobium on Chemical characteristics of soil following green gram harvest

The data indicated that the treatment T1 (absolute control) non-significantly influenced the soil P^H at its maximum (7.05) at 0–15 cm depth, respectively (Table 5). There was a significantly influenced maximum build-up of electrical conductivity (0.20), percentage organic carbon (0.58), available N (320), available phosphorus (21.4), and available potassium (195.12) observed under the treatment T_9 (NU @ 100% + RZ @ 100% + FYM @ 100%) content in soil; however, minimum values were detected in the treatment T_1 (absolute control) at 0–15 cm depth and at 15–30 cm depth.

4. CONCLUSION

The conclusion based on the result. The use of liquid inorganic fertilizer and organic fertilizer significantly influenced soil health in relation to green gram cultivation. It can be concluded that application of T_9 (@100% NU + @100% RZ+ @100% FYM) was found to improve soil structure and microbial activity. Consequently, soil properties are positively impacted. nano urea provides efficient nitrogen delivery, FYM improves organic matter content and soil texture, while rhizobium inoculation boosts nitrogen fixation, collectively leading to a soil health. It can be concluded that foliar application of NU to green gram var. PDM 139 treatment (T9) enhanced soil structure and health by increasing water holding capacity and available N,P,K in the soil.

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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