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# Influence of inorganic fertilizers, neem cake and rhizobium on soil health and yield attributes of green gram (*Vigna radiata* L.) Var. PDM-139 (Samrat)

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## Abstract
In the Zaid season of 2023, researchers at Sam Higginbottom University of Agriculture, Technology, and Sciences, Prayagraj, conducted a field experiment titled "Influence of Inorganic Fertilizers, Neem Cake, And Rhizobium on Soil Health and Yield Attributes of Green Gram (*Vigna Radiata* L.)." Experiment$_9$ treatments [$T_1$ = Absolute Control, $T_2$ = @ 0% NPK + @ 50% RZ (Seed inoculants) + @ 50% NC, $T_3$ = @ 0% NPK + @ 100% RZ + @ 100% NC, $T_4$ = @ 50% NPK + @ 0% RZ + @ 50% NC, $T_5$ = @ 50% NPK + 50% RZ + 50% NC, $T_6$ = @ 50% NPK + @ 100% RZ + @ 100% NC, $T_7$ = @ 100% NPK + @ 0% RZ + @ 0% NC, $T_8$ = @ 100% NPK + @ 50% RZ + @ 50% NC, and $T_9$ = @ 100% NPK + @ 100% RZ + @ 100% NC], were arranged using three replications in a Randomized Block Design (R.B.D.). The findings indicate significant variations among the treatments, with Treatment $T_9$ consistently outperforming the others. $T_9$ exhibited improved soil structure, characterized by a high organic carbon content of 0.436%, a pore space of 44.55%, and a water retention capacity of 41.43%. There was a slight change in bulk density (1.299 Mg m-3), particle density (2.461 Mg m-3), pH (7.22), and E.C. (0.251 dS m-1) in $T_9$. The nutritional availability was also higher in $T_9$, with increased amounts of available nitrogen (284.61 kg $ha^{-1}$), phosphorus (17.05 kg $ha^{-1}$), and potassium (158.13 kg $ha^{-1}$). Furthermore, $T_9$ significantly improved crop yield attributes, including a pod length of 10.19 cm, a pod yield of 11.98 q $ha^{-1}$, and a seed count per pod of 8.19. These results underscore the effectiveness of integrated nutrient approaches in improving soil fertility and promoting sustainable crop yield.

**Keywords:** Green gram, soil health, soil parameters, yield attributes, macro-nutrients, inorganic fertilizers, neem cake and rhizobium

## Introduction
In Indian diets, pulses play a crucial role as an important source of protein and are often used as a substitute for meat because of their low dairy and animal intake. They also have the benefit of improving soil health as they serve as green manure. The nitrogen-fixing properties of pulses make them ideal for achieving food and nutritional security, reducing poverty and hunger, and contributing to agriculture (Varma, 2022) [19]. People in India have cultivated green gram, scientifically known as Vigna radiata, since ancient times, and it is considered a native crop (Vavilov, 1926) [20]. It is an annual crop that grows to a height of about 60-76 cm (Oplinger *et al*., 1990) [15]. The cultivation area for mung beans in India is around 4.9 million hectares, with a yield of 2.6 million tonnes. Since 2016-17, there has been rapid growth in mung bean cultivation, with Rajasthan being the leading contributor, accounting for 48% of the land and 42% of the total output. Other major contributing states include Madhya Pradesh, Maharashtra, Karnataka, Bihar, Odisha, Gujarat, Andhra Pradesh, and Tamil Nadu, collectively contributing over$_9$0% of the overall mung bean production (Anonymous, 2024). Green gram is a nutritious crop, providing protein, carbohydrates, calcium, iron, zinc, sodium, potassium, fiber, vitamins, and fat. However, it also contains compounds such as tannins, phytic acid, hemagglutinin, trypsin inhibitors, proteinase inhibitors, and polyphenols, which can affect nutrient absorption (Kumar and Pandey, 2020; Mubarak, 2005) [7, 10]. Globally, the mung bean cultivation area is 7.3 million hectares, with an average yield of 721 kg/ha.

India and Myanmar are responsible for 30% of the global output, while China, Indonesia, Thailand, Kenya, and Tanzania are also major producers. Dry grains, sprouts, noodles/starch, and paste are the divisions of the mung bean market. In South Asia and Kenya, people commonly use green gram in cooking, while in East and Southeast Asia, it is used in various dishes. Kenya, Mozambique, and Tanzania are top importers, and major export destinations include the United States, Nepal, and the United Kingdom (Nair and Schreinemachers, 2020; Noble *et al.*, 2020) [12, 13]. Green gram is a nutritious plant-based meat alternative that is rich in proteins, vitamins, and minerals. It offers potential health benefits, including antioxidant and anti-inflammatory properties, and can promote gut health. It finds application in functional foods and cosmetics (Mekkara and Bukkan, 2021) [9].

Nitrogen is an essential ingredient for all crops. It boosts nutrition while also increasing protein content. Plants that are deficient may have stunted development and develop a yellow-green tint. It hastens the photosynthetic behavior of green plants and the growth and development of living tissues, particularly the tiller count in grains (Azadi *et al.,* 2013) [2].

Phosphorus is a necessary component of the growth and development of green gram (*Vigna radiata*), often known as mung bean. It is essential for various physiological functions, including photosynthesis, energy transmission, root formation, and cell division. Phosphorus is also involved in the creation of DNA and RNA, which are required for plant growth and reproduction. A phosphorus deficit can cause stunted growth, poor root development, and lower production (Khan *et al.,* 2022) [6].

Potassium is vital for plant growth and functions, including protein synthesis, glucose metabolism, enzyme activation, stomatal control, and photosynthesis. It enhances stress tolerance by maintaining ion balance, supporting antioxidant defense, and aiding cellular signaling and phytohormones. However, the specific mechanisms of K-induced stress tolerance are still unclear (Hasanuzzaman *et al.,* 2018) [4].

Neem cake is an organic manure that enhances soil health and plant growth without harming the environment. Farmers can use neem cake alone or in combination with other organic manures to maximize its benefits. Neem cake contains essential nutrients like nitrogen, phosphorus, potassium, calcium, magnesium, and micro-nutrients such as zinc, copper, iron, and manganese (Gupta, 2022) [3].

Rhizobium is an environmentally friendly bacteria that aids in nitrogen fixation. They are valuable bio fertilizers in India, particularly for leguminous crops. The symbiotic relationship between legumes and Rhizobium is crucial for nitrogen fixation in agriculture. Inoculating mung beans with Rhizobium species resulted in improved plant growth, photosynthesis, and production of dry matter (Meena *et al*., 2016; Thakur and Panwar, 1995) [8, 17].

## Materials and Methods

At the Research Farm of Soil Science and Agricultural Chemistry at Sam Higginbottom University of Agriculture Technology and Sciences, the researchers conducted the experiment. The farm is located six kilometers away from Prayagraj city on the right bank of the Yamuna River. The experimental site falls within the sub-tropical region, positioned at 25º24'23"N latitude, 81º52'E longitude, and an altitude of98 meters above mean sea level. Prayagraj district is located in the southeast of Uttar Pradesh and falls within the subtropical belt. It experiences scorching summers and fairly cold winters. It is possible for the area to experience temperatures as high as 46 °C–48 °C, while the minimum temperature rarely falls below 4 °C–5 °C. Relative humidity varies from 20 to 94 percent, with an average annual rainfall of around 1100 mm. The experiment classifies the soils as Inceptisols, which are mostly alluvial in nature. Before any tillage operations, we collected soil samples from three different sites within the experimental plot randomly, at depths of 0–15 cm and 15–30 cm. Researchers reduced the size of the soil samples through coning and quartering method, air-dried, and passed them through a 2 mm sieve to prepare for physical and chemical analysis.

**Table 1:** Treatment combinations of green gram

| Treatment | Treatment Description |
|---|---|
| $T_1$ | Absolute Control |
| $T_2$ | @ 0% NPK + 50% RZ (Seed inoculants) + 50% NC |
| $T_3$ | @ 0% NPK + 100% RZ + 100% NC |
| $T_4$ | @ 50% NPK + 0% RZ + 0% NC |
| $T_5$ | @ 50% NPK + 50% RZ + 50% NC |
| $T_6$ | @ 50% NPK + 100% RZ + 100% NC |
| $T_7$ | @ 100% NPK + 0% RZ + 0% NC |
| $T_8$ | @ 100% NPK + 50% RZ + 50% NC |
| $T_9$ | @ 100% NPK + 100% RZ + 100% NC |

## Results and Discussion

### Soil parameters

The combination of Inorganic fertilizer, Neem cake, and Rhizobium significantly improved the soil parameters. Improvements in the soil's properties result in an increase in pore space, water retaining capacity, organic carbon, accessible nitrogen, phosphorus, and potassium.

Table 2. showed that, application of various NPK levels, Neem cake, and Rhizobium had the following effects on the soil that Treatment $T_9$ exhibited the highest bulk density at 0–15 cm depth (1.299 Mg m-3) and at 15–30 cm depth (1.304 Mg m-3). At the 0-15 cm depth, the minimum value of 1.263 Mg m-3 was found in treatment $T_1$, while at the 15–30 cm depth, it was 1.271 Mg m-3. Treatment $T_9$ showed the highest particle density of 2.461 Mg m-3 at a depth of 0–15 cm and 2.471 Mg m-3 at a depth of 15–30 cm, while treatment $T_1$ had the minimum particle density.

Table 3. showed that treatment $T_9$ had the highest pore space (44.55% at 0–15 cm and 44.18% at 15–30 cm). Treatment $T_1$ had the lowest pore space (41.25% at 0–15 cm and 40.55% at 15–30 cm). Treatment $T_9$ also had the highest water retaining capacity (41.43% at 0–15 cm and 41.05% at 15–30 cm), while treatment $T_1$ had the lowest water retaining capacity (38.01% at 0–15 cm and 37.34% at 15–30 cm).

Table 4. indicated that, at 0–15 cm depth, treatment $T_1$ (Absolute Control) exhibited the highest pH level of 7.29, while at 15–30 cm depth, it recorded a pH level of 7.32. On the other hand, the lowest pH levels were found in treatment $T_9$, with values of 7.22 at 0–15 cm depth and 7.23 at 15–30 cm depth. The highest E.C. values of 0.251 at 0–15 cm depth and 0.253 at 15–30 cm depth indicated that treatment $T_9$ had the lowest

E.C. levels. Treatment $T_1$ exhibited the lowest pH levels, with values of 0.215 at 0–15 cm depth and 0.221 at 15–30 cm depth. The values of 0.436% at 0–15 cm depth and 0.433% at 15–30 cm depth indicated that treatment $T_9$ had the highest organic carbon levels. Treatment $T_1$, on the other hand, showed the lowest organic carbon levels with values of 0.395% at 0–15 cm depth and 0.389% at 15–30 cm depth.

Table 5. revealed that, treatment $T_9$ had the highest available nitrogen (284.61 kg $ha^{-1}$) at 0–15 cm depth, and (284.02 kg $ha^{-1}$) at 15–30 cm depth, using 100% NPK, 100% RZ, and 100% NC.

Treatment $T_1$ had the lowest available nitrogen (267.56 kg $ha^{-1}$) at 0–15 cm depth, and (263.56 kg $ha^{-1}$) at 15–30 cm depth. For phosphorus, treatment $T_9$ had the highest available phosphorus (17.05 kg $ha^{-1}$) at 0–15 cm depth, and (16.69 kg $ha^{-1}$) at 15–30 cm depth. Treatment $T_1$ had the lowest available phosphorus (13.76 kg $ha^{-1}$) at 0–15 cm depth, and (12.26 kg $ha^{-1}$) at 15–30 cm depth. Finally, treatment $T_9$ had the highest available potassium
(159.45 kg $ha^{-1}$) at 0–15 cm depth, and (158.83 kg $ha^{-1}$) at 15–30 cm depth. Treatment $T_1$ had the lowest available potassium (145.63 kg $ha^{-1}$) at 0–15 cm depth, and (142.34 kg $ha^{-1}$) at 15–30 cm depth.

**Yield Attributes**

Table 6. indicated that, longest pod length per plant was 10.19 cm in $T_9$, achieved with the application of (@ 100% NPK+ @ 100% RZ+ @ 100% NC). The shortest pod length was 6.67 cm in $T_1$ (Absolute Control). In terms of pods per plant, the maximum count was 26.23 in $T_9$ (@ 100% NPK+ @ 100% RZ+ @ 100% NC), while the minimum was in $T_1$ (Absolute Control). $T_9$ also had the highest number of seeds per pod at 8.19, again with the same application. The maximum pod yield was 11.98 q $ha^{-1}$ in $T_9$, while the minimum was
7.03 q $ha^{-1}$ in $T_1$ (absolute control).

**Table 2:** Effect of Inorganic fertilizers, Neem cake and Rhizobium on bulk density and particle density (Mgm-3)

| Sr. no. | Treatments | Bulk density (Mgm- 3) | | Particle density (Mgm-3) | |
|---|---|---|---|---|---|
| | | 0-15 cm | 15-30 cm | 0-15 cm | 15-30 cm |
| $T_1$ | Absolute Control | 1.263 | 1.271 | 2.431 | 2.437 |
| $T_2$ | @ 0% NPK + 50% RZ (Seed inoculants) + 50% NC | 1.268 | 1.274 | 2.435 | 2.442 |
| $T_3$ | @ 0% NPK + 100% RZ + 100% NC | 1.274 | 1.279 | 2.441 | 2.449 |
| $T_4$ | @ 50% NPK + 0% RZ + 0% NC | 1.265 | 1.273 | 2.433 | 2.439 |
| $T_5$ | @ 50% NPK + 50% RZ + 50% NC | 1.281 | 1.287 | 2.445 | 2.452 |
| $T_6$ | @ 50% NPK + 100% RZ + 100% NC | 1.288 | 1.293 | 2.451 | 2.459 |
| $T_7$ | @ 100% NPK + 0% RZ + 0% NC | 1.274 | 1.282 | 2.437 | 2.444 |
| $T_8$ | @ 100% NPK + 50% RZ + 50% NC | 1.294 | 1.299 | 2.455 | 2.463 |
| $T_9$ | @ 100% NPK + 100% RZ + 100% NC | 1.299 | 1.304 | 2.461 | 2.471 |
| F- test | | NS | NS | NS | NS |
| S. Em. (±) | | - | - | - | - |
| C. D. (P = 0.05) | | - | - | - | - |

**Table 3:** Effect of Inorganic fertilizers, Neem cake and Rhizobium on Pore space and Water Retaining Capacity (%) of soil

| Sr. no. | | Pore space (%) | | Water retaining capacity (%) | |
|---|---|---|---|---|---|
| | | 0-15 cm | 15-30 cm | 0-15 cm | 15-30 cm |
| $T_1$ | Absolute Control | 41.25 | 40.55 | 38.01 | 37.34 |
| $T_2$ | @ 0% NPK + 50% RZ (Seed inoculants) + 50% NC | 41.65 | 41.05 | 38.55 | 37.95 |
| $T_3$ | @ 0% NPK + 100% RZ + 100% NC | 42.25 | 41.73 | 39.05 | 38.50 |
| $T_4$ | @ 50% NPK + 0% RZ + 0% NC | 41.45 | 40.80 | 38.27 | 37.65 |
| $T_5$ | @ 50% NPK + 50% RZ + 50% NC | 42.70 | 42.15 | 39.95 | 39.39 |
| $T_6$ | @ 50% NPK + 100% RZ + 100% NC | 43.35 | 42.85 | 40.03 | 39.49 |
| $T_7$ | @ 100% NPK + 0% RZ + 0% NC | 42.20 | 41.47 | 39.55 | 39.00 |
| $T_8$ | @ 100% NPK + 50% RZ + 50% NC | 43.85 | 43.45 | 40.75 | 40.30 |
| $T_9$ | @ 100% NPK + 100% RZ + 100% NC | 44.55 | 44.18 | 41.43 | 41.05 |
| | F- test | S | S | S | S |
| | S. Em. (±) | 0.60 | 0.70 | 0.59 | 0.56 |
| | C. D. (P = 0.05) | 1.83 | 2.11 | 1.77 | 1.69 |

**Table 4:** Effect of Inorganic fertilizers, Neem cake and Rhizobium on pH of soil (1:2.5) w/v, Electrical Conductivity (dSm-1), and Organic carbon (%) of soil

| Sr.no. | Treatments | pH (1:2.5) w/v | | E.C (dSm-1) | | Organic Carbon (%) | |
|---|---|---|---|---|---|---|---|
| | | 0-15 cm | 15-30 cm | 0-15 cm | 15-30 cm | 0-15 cm | 15-30 cm |
| $T_1$ | Absolute Control | 7.29 | 7.32 | 0.215 | 0.221 | 0.395 | 0.389 |
| $T_2$ | @ 0% NPK + 50% RZ (Seed inoculants) + 50% NC | 7.28 | 7.30 | 0.221 | 0.225 | 0.400 | 0.393 |
| $T_3$ | @ 0% NPK + 100% RZ + 100% NC | 7.26 | 7.27 | 0.226 | 0.229 | 0.406 | 0.402 |
| $T_4$ | @ 50% NPK + 0% RZ + 0% NC | 7.28 | 7.31 | 0.218 | 0.223 | 0.397 | 0.391 |
| $T_5$ | @ 50% NPK + 50% RZ + 50% NC | 7.25 | 7.27 | 0.231 | 0.234 | 0.413 | 0.408 |
| $T_6$ | @ 50% NPK + 100% RZ + 100% NC | 7.24 | 7.25 | 0.236 | 0.24 | 0.418 | 0.414 |
| $T_7$ | @ 100% NPK + 0% RZ + 0% NC | 7.27 | 7.3 | 0.228 | 0.232 | 0.402 | 0.396 |
| $T_8$ | @ 100% NPK + 50% RZ + 50% NC | 7.23 | 7.25 | 0.241 | 0.244 | 0.428 | 0.423 |
| $T_9$ | @ 100% NPK + 100% RZ + 100% NC | 7.22 | 7.23 | 0.251 | 0.253 | 0.436 | 0.433 |
| F- test | | NS | NS | S | S | S | S |
| S. Em. (±) | | - | - | 0.003 | 0.004 | 0.006 | 0.007 |
| C. D. (P = 0.05) | | - | - | 0.010 | 0.012 | 0.019 | 0.021 |

**Table 5:** Effect of Inorganic fertilizers, Neem cake and Rhizobium on Available Nitrogen, Phosphorus, And Potassium (kg ha$^{-1}$)

| Sr.no. | Treatments | Av. Nitrogen (kg ha$^{-1}$) | | Phosphorus (kg ha$^{-1}$) | | Potassium (kg ha$^{-1}$) | |
|---|---|---|---|---|---|---|---|
| | | 0-15 cm | 15-30 cm | 0-15 cm | 15-30 cm | 0-15 cm | 15-30 cm |
| $T_1$ | Absolute Control | 267.56 | 263.56 | 13.76 | 12.26 | 145.63 | 142.34 |
| $T_2$ | @ 0% NPK + 50% RZ (Seed inoculants) + 50% NC | 268.94 | 264.94 | 13.96 | 12.46 | 146.37 | 143.28 |
| $T_3$ | @ 0% NPK + 100% RZ + 100% NC | 269.95 | 265.99 | 14.36 | 12.86 | 147.23 | 144.34 |
| $T_4$ | @ 50% NPK + 0% RZ + 0% NC | 271.88 | 268.7 | 15.01 | 14.26 | 149.93 | 147.34 |
| $T_5$ | @ 50% NPK + 50% RZ + 50% NC | 273.85 | 271.15 | 15.46 | 14.8 | 151.25 | 149.21 |
| $T_6$ | @ 50% NPK + 100% RZ + 100% NC | 275.95 | 273.95 | 15.86 | 15.25 | 153.43 | 151.45 |
| $T_7$ | @ 100% NPK + 0% RZ + 0% NC | 278.85 | 277.05 | 16.26 | 15.76 | 155.93 | 154.01 |
| $T_8$ | @ 100% NPK + 50% RZ + 50% NC | 281.93 | 280.47 | 16.66 | 16.26 | 157.45 | 156.09 |
| $T_9$ | @ 100% NPK + 100% RZ + 100% NC | 284.61 | 284.02 | 17.05 | 16.69 | 159.45 | 158.23 |
| | F- test | S | S | S | S | S | S |
| | S. Em. (±) | 3.61 | 4.05 | 0.22 | 0.23 | 1.99 | 2.05 |
| | C. D. (P = 0.05) | 10.89 | 12.20 | 0.66 | 0.71 | 5.99 | 6.19 |

**Table 6:** Effect of Inorganic fertilizers, Neem cake and Rhizobium on Pod length (cm), pods per plant, Seeds per plant, and Pod yield (qha$^{-1}$)

| Sr. no. | Treatments | Pod length (cm) | Pods per plant | Seeds per pod | Pod yield (q ha$^{-1}$) |
|---|---|---|---|---|---|
| $T_1$ | Absolute Control | 6.67 | 18.43 | 4.67 | 7.03 |
| $T_2$ | @ 0% NPK + 50% RZ (Seed inoculants) + 50% NC | 6.96 | 19.17 | 4.96 | 7.95 |
| $T_3$ | @ 0% NPK + 100% RZ + 100% NC | 7.34 | 20.22 | 5.34 | 8.96 |
| $T_4$ | @ 50% NPK + 0% RZ + 0% NC | 7.79 | 19.63 | 5.79 | 7.49 |
| $T_5$ | @ 50% NPK + 50% RZ + 50% NC | 8.59 | 20.71 | 6.59 | 8.42 |
| $T_6$ | @ 50% NPK + 100% RZ + 100% NC | 8.93 | 24.46 | 6.93 | 8.79 |
| $T_7$ | @ 100% NPK + 0% RZ + 0% NC | 7.97 | 22.49 | 5.97 | 9.35 |
| $T_8$ | @ 100% NPK + 50% RZ + 50% NC | 9.67 | 25.57 | 7.67 | 10.65 |
| $T_9$ | @ 100% NPK + 100% RZ + 100% NC | 10.19 | 26.23 | 8.19 | 11.98 |
| F- test | | S | S | S | S |
| S. Em. (±) | | 0.15 | 0.21 | 0.10 | 0.12 |
| C. D. (P = 0.05) | | 0.45 | 0.63 | 0.32 | 0.38 |

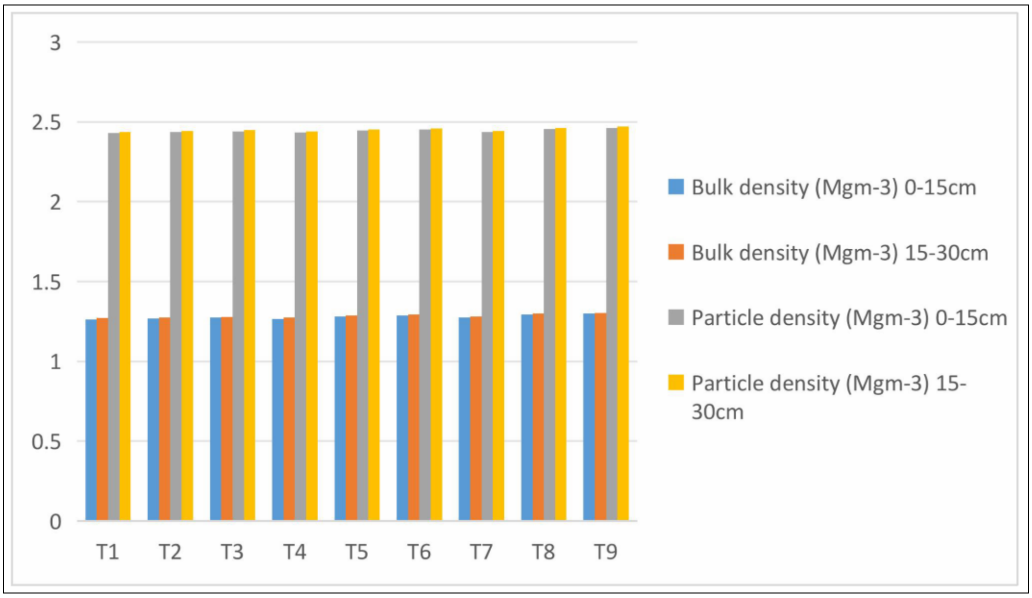


**Fig 1:** Effect of Inorganic fertilizers, Neem cake and Rhizobium on bulk density and particle density (Mgm-3)

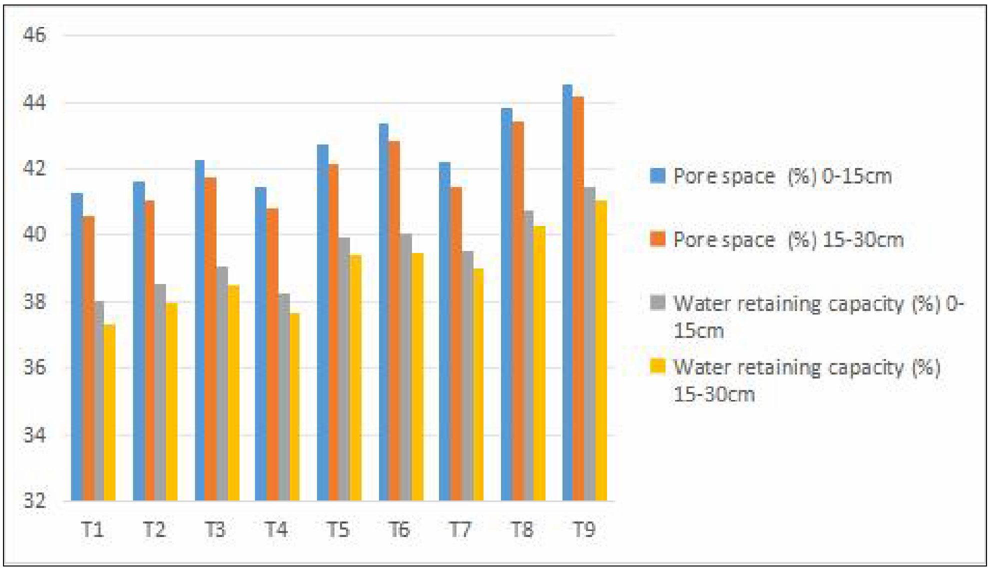


**Fig 2:** Effect of Inorganic fertilizers, Neem cake and Rhizobium on Pore space and Water Retaining Capacity (%) of soil.

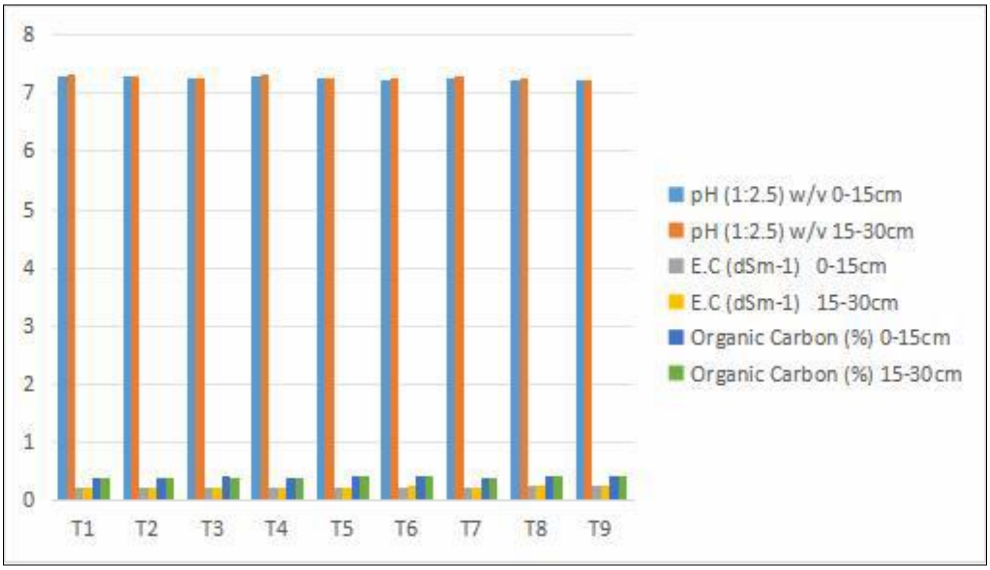


**Fig 3:** Effect of Inorganic fertilizers, Neem cake and Rhizobium on pH of soil (1:2.5) w/v, Electrical conductivity (dSm-1) and Organic carbon (%) of soil

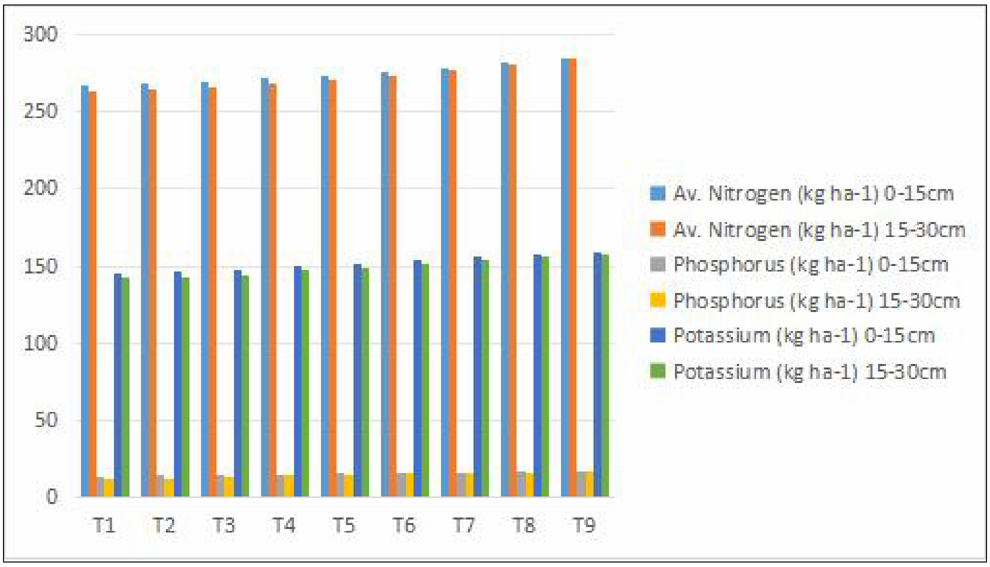


**Fig 4:** Effect of Inorganic fertilizers, Neem cake and Rhizobium on Available Nitrogen, Phosphorus and Potassium (kg $ha^{-1}$).

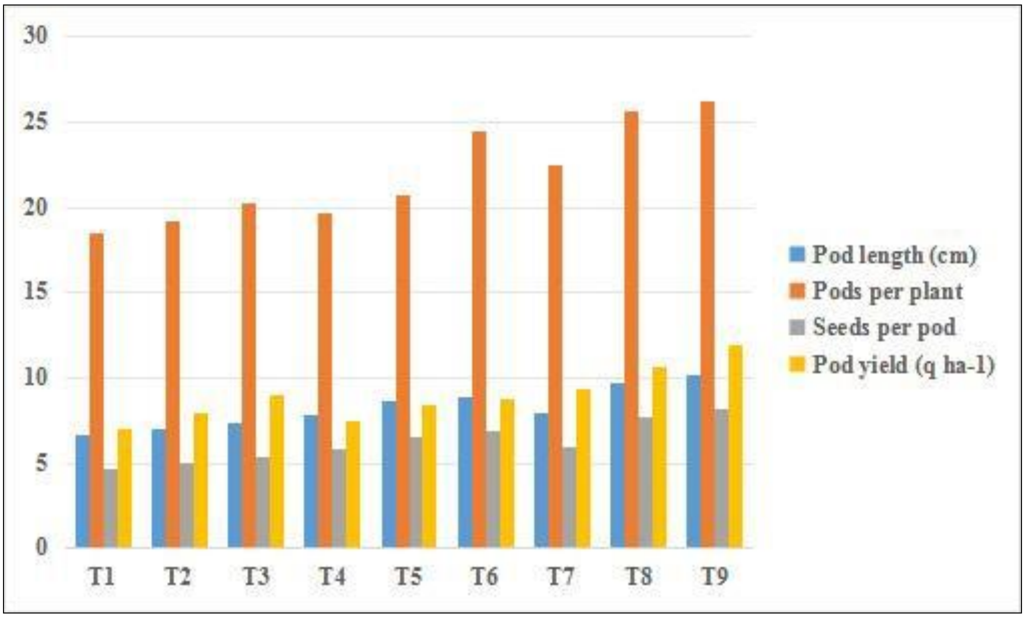


**Fig 5:** Effect of Inorganic fertilizers, Neem cake and Rhizobium on Pod length (cm), pods per plant, Seeds per plant, and Pod yield (qha$^{-1}$).

## Conclusion

The utilization of treatment $T_9$, which involves the use of 100% NPK, Neem cakes, and Rhizobium, has resulted in enhanced soil fertility, improved nutritional supply, and increased crop productivity. The implementation of integrated nutrient management technology has significantly improved soil health, pore space, and water retention capacity, leading to substantial crop growth and profitability. This approach demonstrates the effectiveness of integrated nutrient management in supporting sustainable agriculture.

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## References

1. Anonymous. Pulses In India: Retrospect And Prospects, Annual Report 2022-23; Directorate of Pulse Development, Bhopal; c2024.
2. Azadi E, Rafiee M, Hadis N. The effect of different nitrogen levels on seed yield and morphological characteristic of mung bean in the climate condition of Khorramabad. Annals of Biological Research. 2013;4(2):51-55.
3. Gupta AK. Use of neem and neem-based products in organic farming. Indian Farming. 2022;72(1).
4. Hasanuzzaman M, Bhuyan MB, Nahar K, Hossain MS, Mahmud JA, Hossen MS, Fujita M. Potassium: a vital regulator of plant responses and tolerance to abiotic stresses. Agronomy. 2018;8(3):31.
5. Jackson M. Soil chemical analysis. Prentice Hall, Inc., Englewood Cliffs, NJ. 1958;498(1958):183-204.
6. Khan A, Nawaz H, Rab A, Asim M, Khan I, Munsif F. Impact of Phosphorous and Zinc Levels on the Productivity of Green Gram (*Vigna radiate* L.). Journal of Soil, Plant and Environment. 2022;1(1):38-49.
7. Kumar S, Pandey G. Biofortification of pulses and legumes to enhance nutrition. Heliyon. 2020;6(3).
8. Meena S, Swaroop N, Dawson J. Effect of integrated nutrient management on growth and yield of green gram (*Vigna radiata* L.). Agricultural Science Digest-A Research Journal. 2016;36(1):63-65.
9. Mekkara NS, Bukkan DS. A review on nutritional composition, antinutritional components and health benefits of green gram (*Vigna radiata* (L.) Wilczek). Journal of Food Biochemistry. 2021;45(6):e13743.
10. Mubarak AE. Nutritional composition and antinutritional factors of mung bean seeds (*Phaseolus aureus*) as affected by some home traditional processes. Food Chemistry. 2005;89(4):489–495.
11. Muthuvel P, Udayasoorian C, Natesan R, Ramaswami PR. Introduction to Soil Analysis. Tamil Nadu Agricultural University, Coimbatore; c1992.
12. Nair R, Schreinemachers P. Global Status and Economic Importance of Mungbean. 2020. doi:10.1007/978-3-030-20008-4_1.
13. Noble TJ, Williams B, Hoang TML, Das Bhowmik SS, Tan GZH, Mundree S. Genomic Approaches to Abiotic Stresses in Mungbean. In: The Mungbean Genome; c2020. p. 169-179.
14. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate (NaHCO3). U.S.D.A. Circular. 1954;939:1-19.
15. Oplinger ES, Hardman LL, Kaminski AR, *et al*. Mungbean. In: Alternative feed crop manual. Madison, WI: University of Wisconsin; c1990.
16. Subbiah BV, Asija GL. Rapid procedure for the estimation of available nitrogen in soil. Current Science. 1956;25:259-260.
17. Thakur AK, Panwar JDS. Effect of Rhizobium VAM interactions on growth and yield in mungbean (Vigna radiata L.) under field conditions. Indian J. Pl. Pathol. 1995;38:62-65.
18. Toth SJ, Prince AL. Estimation of cation exchange capacity and exchangeable Ca, K and Na content of soil by flame

photometer technique. Soil Sci. 1949;67:439-445.
19. Varma P. Introduction. In: Pulses for Food and Nutritional Security of India. India Studies in Business and Economics. Springer, Singapore; c2022.
20. Vavilov NI. Centers of origin of cultivated plants. Bull. Appl. Bot. 1926;26:1-248.
21. Walkley A, Black IA. Estimation of soil organic carbon by the chromic acid titration method. Soil Science. 1947;47:29-38.
22. Wilcox LV. Electrical conductivity. Journal-American Water Works Association. 1950;42(8):775-776.