IMPACT OF DIFFERENT LEVEL OF NPK AND RHIZOBIUM ON SOIL PHYSICO-CHEMICAL PROPERTIES, GROWTH AND YIELD OF COWPEA (Vigna unguiculata L.) VAR. Maruti 52

Mansi Patel[1], Narendra Swroop[2], Tarence Thomas[3], Taniya Mistri[4] and Ashima Thomas[5]

[1]Research Scholar, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh.

[2] Associate Professor, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh

[3]Professor, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh

[4]PhD Scholar, Department of Soil Science and Agricultural Chemistry, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh

[5]Department of Agro-Food Sciences Bologna University Italy

Corresponding author: mansip99932@gmail.com

https://doie.org/10.0512/AE.2024812051

ABSTRACT

This research assesses how varying doses of NPK fertilizers and Rhizobium inoculation impact the physicochemical parameters of soil, as well as the development and production of the Cowpea Var. Maruti 52. The investigation was run across many treatments to identify the best agricultural techniques for improving crop production. Treatment 8 (T8) was shown to be the most effective in enhancing soil conditions by decreasing bulk density and increasing pore space. This resulted to improved root growth and water retention. Plant height, pod length, and pod number significantly increased with T8, resulting in a higher seed output per hectare. The economic study verified that T8 is feasible, demonstrating a better cost-benefit ratio and net returns in comparison to alternative therapies. The research offers useful insights on combining chemical fertilizers with biofertilizers, suggesting T8 as a viable approach to enhance Cowpea yield, with implications for sustainable agricultural practices.

Keywords: Inoculation, Investigation, Treatment, Demonstration

INTRODUCTION

Cowpea considered as an important legume in tropical and subtropical areas known for its high protein content, nitrogen-fixing capability, and adaptability. It plays a k-ey role in ensuring food security and agricultural sustainability. *(Agboola and Obigbesan 2001)* The demonstrated usefulness of NPK fertilization, referred to as NPK, in increasing soil health and plant nutrition to enhance crop growth and production is well-established. *(Fernandez & Morales 2019)*

The symbiotic interaction between legumes and Rhizobium bacteria improves biological nitrogen fixation, boosts soil fertility, and supports sustainable agricultural techniques. Inoculating cowpea, especially the 'Maruti 52' variety, with Rhizobium strains greatly enhances nodulation, nitrogen content, and yield. (*Thompson & Rodriguez 2021)*

It is crucial to optimize NPK levels and Rhizobium inoculation for 'Maruti 52' to get maximum yield. Initial research suggests that certain NPK levels significantly enhance growth and pod formation. (*Umadevi et al.2019)*.

Our study aims to bridge a gap by assessing different amounts of NPK and Rhizobium inoculation to understand their combined impact on soil parameters and the development and yield of 'Maruti 52' for improved farming techniques.

This study aims to enhance integrated nutrient management systems that improve crop output and maintain soil health, based on empirical data. Due to the population increase to 9.7 billion by 2050 globally, there is an urgent need for sustainable agricultural practices that focus on innovative nutrient management to improve agricultural sustainability.

Synthetic NPK fertilizers may cause environmental problems such as soil deterioration and water pollution when used excessively, but inadequate application can also hinder crop growth and production. *(Wasiams et al. 2022)* The role of Rhizobium in legume cultivation is significant, as it reduces the reliance on synthetic nitrogen fertilizers and increases plant stress tolerance and nutrient uptake efficiency *(Yadav et al. 2019)*.

By exploring the synergistic effects of NPK fertilization and Rhizobium inoculation, this study aims to identify optimal practices that enhance 'Maruti 52' cowpea's biomass production, pod yield, and nutritional quality. Our findings could offer valuable insights for farmers, agronomists, and policymakers, promoting the adoption of more sustainable agricultural practices.

This in-depth research on integrated nutrient management in cowpea cultivation specifically examines the 'Maruti 52' variety, which shows promising potential to enhance livelihoods in developing nations. It aims to promote sustainable agricultural practices that can withstand environmental fluctuations and support the growing global population. The research demonstrates the effects of NPK fertilization, Rhizobium inoculation, and their combination on the growth and production of 'Maruti 52' cowpea, highlighting the potential advantages of these integrated methods. *(Zhao et al. 2022)*

Material and Methods

The experiment was conducted at the experimental farm during the 2023–2024 growing season. At 25°19'N latitude and 82°34'E longitude, the research site is situated in a tropical zone and is 85 meters above sea level. The temperature in the region varies from 18°C to 24°C at its lowest point to 35°C to 40°C at its highest. With monsoonal rains usually falling from June to September, the region has a humid subtropical climate with relative humidity ranging from 60 to 85 percent. About 1200 mm of precipitation falls on average each year. Nine treatments and three replications made up the randomized block design (RBD) that was used in the experiment. T0 (0% NPK + 0% Rhizobium), T1 (0% NPK + 50% Rhizobium), T2 (0% NPK + 100% Rhizobium), T3 (50% NPK + 0% Rhizobium), T4 (50% NPK + 50% Rhizobium), T5 (50% NPK + 100% Rhizobium), T6 (100% NPK + 0% Rhizobium), T7 (100% NPK + 50% Rhizobium), and T8 (100% NPK + 100% Rhizobium) were among the nine combinations of three levels of NPK and Rhizobium application that were studied. The "Textbook of Vegetables, Tuber crops and Spices, ICAR, (2018)" recommended rates for applying NPK, and agritech.tnau.ac.in guidelines were used to calculate the Rhizobium dosage.

The area of the field was 8.8 meters wide overall, and it was split into 27 plots, each measuring 2 meters by 2 meters. On August 8, 2023, the cowpea variety 'Maruti 52' was seeded. The area features loamy soil, which is typical of highland agricultural districts in tropical climates with good drainage.

Before treatments were administered and after harvest, soil samples were obtained from the top 15 cm of the soil. In order to examine the samples and determine soil physico-chemical characteristics, including soil texture and nutrient content, standard techniques were followed.

Plant growth metrics were routinely recorded, such as plant height, leaf count, pod count, and seed production. From each plot, 10 randomly selected plants were examined in detail to see how different treatment combinations affected cowpea growth and yield.

In order to advance sustainable agricultural practices for cowpea farming, this approach aims to elucidate the linkages between chemical and biological fertilizers and their combined influence on soil health and plant output.

Table 1: Treatment Combinations

Treatment Code	Treatment Details
T0	0% NPK and 0% Rhizobium
T1	0% NPK and 50% Rhizobium
T2	0% NPK and 100% Rhizobium
T3	50% NPK and 0% Rhizobium
T4	50% NPK and 50% Rhizobium
T5	50% NPK and 100% Rhizobium
T6	100% NPK and 0% Rhizobium
T7	100% NPK and 50% Rhizobium
T8	100% NPK and 100% Rhizobium

RESULT

Table 2: Analysing the physical and chemical properties of the soil sample before planting the crop

Particulars	Results	
	(0-15) cm	**(15-30) cm**
Sand (%)	61.1	59.5
Silt (%)	24.4	25.3
Clay (%)	14.5	15.2
Textural class	Sandy loam	Sandy loam
Bulk density	1.322	1.329
Particle density	2,184	2.201
Pore space (%)	45.69	44.77
Water holding capacity (%)	41.75	39.95
Soil pH (1:2.5)	7,601	7.609
Electrical Conductivity (dS m-1)	0.175	0.196
Organic Carbon (%)	0.253	0.247
Nitrogen (kg ha-1)	167.10	148.64
Phosphorus (kg ha-1)	24.01	21.10
Potassium (kg ha-1)	194.51	186.79

Table 3: Impact of Rhizobium and varying NPK levels on the development and yield characteristics

Treatment	Height of Plant		Length of Pod		No. of pods		Weight of Seeds per Pod (g)	Seed Yield (q ha-1)
	40 DAS (cm)	60 DAS (cm)	50 DAS (cm)	75 DAS (cm)	50 DAS	75 DAS		
T0	41.46	51.64	10.5	12.9	10.5	5.5	7.5	39.7
T1	46.66	64.29	11.2	12.5	11.2	6.9	8.0	52.5
T2	54.57	63.65	12.0	12.7	12.4	7.1	8.7	46.9
T3	53.99	68.65	12.8	13.4	13.6	7.8	9.4	49.2
T4	62.94	72.99	13.5	13.6	15.3	8.3	10.2	54.9
T5	63.32	69.89	14.3	13.7	16.7	9.7	11.0	56.0
T6	51.16	67.36	15.0	14.2	17.9	10.3	12.1	56.1
T7	57.48	68.65	15.8	15.6	20.5	12.1	12.6	65.8
T8	65.56	75.59	16.5	16.9	21.5	13.8	13.5	79.1

Table 4: Impact of Rhizobium and NPK levels on soil physico-chemical characteristics after cowpea harvest at a 0-15 cm

Treatment	Bulk Density (g/cm^3)	Particle Density (g/cm^3)	Percentage of Pore Space (%)	Water Holding Capacity (%)	pH	EC (dS m-1 at 250)
T0	1.24	2.27	45.02	41.23	7.53	0.15
T1	1.20	2.23	46.24	44.21	7.46	0.17
T2	1.18	2.20	47.56	46.21	7.37	0.19
T3	1.14	2.18	48.87	47.36	7.41	0.16
T4	1.18	2.20	50.15	48.56	7.30	0.21
T5	1.17	2.16	51.41	47.32	7.39	0.22
T6	1.16	2.14	52.74	48.35	7.24	0.19
T7	1.13	2.16	54.02	46.57	7.23	0.25
T8	1.12	2.14	55.34	46.52	7.17	0.27

Table 5: Impact of Rhizobium and varying NPK levels on the physico-chemical characteristics of soil after the cowpea harvest at a depth of 15-30 cm

Treatment	Bulk Density (g/cm^3)	Particle Density (g/cm^3)	Percentage of Pore Space (%)	Water Holding Capacity (%)	pH	EC (dS m-1 at 250)
T0	1.30	2.29	41.01	40.78	7.61	0.22
T1	1.25	2.26	42.01	41.25	7.44	0.21
T2	1.22	2.23	43.56	42.65	7.40	0.23
T3	1.18	2.24	45.12	44.25	7.46	0.18
T4	1.19	2.21	43.15	42.25	7.35	0.25
T5	1.16	2.19	44.36	43.65	7.40	0.24
T6	1.17	2.20	44.58	45.32	7.33	0.25
T7	1.16	2.19	46.24	45.25	7.28	0.27
T8	1.15	2.17	48.32	44.36	7.26	0.29

Table 6: Impact of Rhizobium and varying NPK levels on the nutritional composition (organic carbon, nitrogen, phosphorus, and potassium) of soil samples taken after harvesting cowpea plants at a depth of 0-15 cm

Treatment	Carbon (%)	Nitrogen (Kg ha-1)	Phosphorus (Kg ha-1)	Potassium (Kg ha-1)
T0	0.49	247.58	21.11	124.65
T1	0.54	248.21	22.09	137.25
T2	0.55	252.36	22.96	141.48
T3	0.57	264.58	23.55	125.21
T4	0.59	274.54	21.65	138.12
T5	0.59	278.89	22.58	145.54
T6	0.61	278.45	23.45	137.48
T7	0.64	282.36	22.96	149.65
T8	0.68	291.98	24.36	158.31

Table 7: Impact of Rhizobium and varying NPK levels on the nutritional composition (organic carbon, nitrogen, phosphorus, and potassium) of soil samples taken after harvest beneath cowpea at a depth of 15-30 cm

Treatment	Carbon (%)	Nitrogen (Kg ha-1)	Phosphorus (Kg ha-1)	Potassium (Kg ha-1)
T0	0.36	183.54	18.36	120.48
T1	0.35	187.36	20.56	134.21
T2	0.42	193.25	20.21	139.44
T3	0.41	202.54	21.58	123.24
T4	0.45	206.36	21.47	135.15
T5	0.45	210.36	20.82	142.25
T6	0.46	224.65	21.94	135.42
T7	0.48	238.96	19.54	147.65
T8	0.45	253.65	21.54	156.78

Table 8: Impact of various treatment combinations on the benefit-cost ratio (B:C) in black gram crop

Treatment	Pod Yield (q/ha)	Cultivation Cost	Price	Gross Return	Net Return	Cost Benifit Ratio
T1	39.7	37645	2200	87340	49695	1.32
T2	52.5	35320	2200	115500	80180	2.27
T3	46.9	36220	2200	103180	66960	1.84
T4	49.2	37063.62	2200	108240	71176.38	1.92
T5	54.9	37963.62	2200	120780	82816.38	2.18
T6	56	38863.58	2200	123200	84336.42	2.17
T7	56.1	39713.58	2200	123420	83706.42	2.10
T8	65.8	40613.58	2200	144760	104146.42	2.56
T9	79.1	41513.58	2200	174020	132506.42	2.91

DISCUSSION

Growth attributes

The growth characteristics of Cowpea in your study show variable reactions under various treatments at certain developmental phases. Plant Height increased progressively at 40 and 60 days after sowing (DAS) across treatments, demonstrating a good response to the treatments throughout time. Treatment 8 (T8) resulted in the tallest plant height of 65.56 cm at 40 DAS, increasing to 75.59 cm by 60 DAS. This indicates a significant growth acceleration compared to the control treatment (T0), which had heights of 41.46 cm and 51.64 cm at the same stages.

Pod length and number showed substantial diversity across treatments, indicating the distinct effects of each treatment on reproductive characteristics. At 50 days after sowing (DAS), pod lengths varied from 10.5 cm in T0 to 16.5 cm in T8, and this pattern of increasing lengths persisted until 75 DAS. The number of pods significantly increased from 50 DAS to 75 DAS, especially in T8, where the number of pods peaked at 21.5 at 50 DAS and rose to 13.8 by 75 DAS.

The results demonstrate a significant improvement in vegetative and reproductive development characteristics in Cowpea when different treatments are applied, emphasizing the possibility of improving agricultural techniques to boost crop output and quality efficiently.

Yield attributes

The yield attributes of Cowpea under various treatments in your study show significant differentiation in seed weight per pod and overall seed yield per hectare, indicating that certain treatments markedly enhance yield characteristics. Starting from Treatment 0 (T0), the weight of seeds per pod was the lowest at 7.5 grams, corresponding with a seed yield of 39.7 quintals per hectare. As treatments progress, there is a notable upward trend in both metrics.

By Treatment 8 (T8), the weight of seeds per pod reached its maximum at 13.5 grams, a substantial increase compared to T0. Correspondingly, the seed yield in T8 peaked impressively at 79.1 quintals per hectare, more than doubling the yield observed in T0. This trend illustrates a clear correlation between the treatment intensities and the resulting productivity enhancements in Cowpea.

This progression not only underscores the effectiveness of the treatments applied but also highlights their potential scalability for optimizing Cowpea production. The data suggest that higher resource inputs in terms of specific treatment components can lead to significantly greater returns in seed yield, potentially providing a valuable strategy for increasing agricultural output and efficiency.

Physiochemical properties

The study investigated how different treatments impact the physicochemical characteristics of soil at zero to fifteen cm and 15-30 cm, providing valuable information for agricultural activities. In the zero to fifteen cm, bulk density decreased significantly from 1.24 g/cm³ in the control treatment (T0) to 1.12 g/cm³ in treatment T8, indicating better soil aeration and root development conditions. The particle density decreases somewhat from 2.27 to 2.14 g/cm³ in all treatments, impacting the preservation of moisture and nutrients. The pore space percentage significantly rises from 45.02% in T0 to 55.34% in T8, suggesting enhanced soil structure that promotes water and air circulation. The water holding capacity initially improves then slightly drops at the highest treatments, suggesting an ideal treatment level for increasing soil moisture retention. The soil pH decreased gradually from 7.53 to 7.17, suggesting a small rise in soil acidity. The increase in E.C. from 0.15 dS m-1 to 0.27 dS m-1 indicates a rise in soil salinity.

Similar tendencies are seen in the deeper soil layer of 15-30 cm, with consistently increasing values for bulk and particle densities. The bulk density drops from 1.30 g/cm³ at T0 to 1.15 g/cm³ at T8, whereas the particle density shows a little reduction. The increase in pore space % is advantageous for root growth and water penetration. The water holding capacity increases less noticeably in the subsoil compared to the top soil, reaching a peak before slightly dropping, indicating a response to treatments that varies with depth. The soil pH is declining while electrical conductivity is increasing, reflecting surface patterns and suggesting a controllable increase in soil salt.

Treatment changes have a crucial role in altering soil properties that have a direct impact on plant development and soil health. The decrease in soil compaction and improvement in soil structure from the treatments benefit crop health, but the rising saline levels need to be managed carefully to prevent negative impacts on plant development.

Economic analysis

The economic analysis of different treatments on pod yield of crops reveals significant financial outcomes. Treatment T9, with the highest yield of 79.1 quintals per hectare, shows a net return of ₹132,506.42 and a cost-benefit ratio of 2.91, indicating a robust return on investment. Conversely, treatment T1, with the lowest yield of 39.7 quintals per hectare, results in a net return of ₹49,695 and a cost-benefit ratio of 1.32. Notably, as the yield increases across treatments, both gross and net returns significantly increase, emphasizing the economic viability of optimizing agricultural practices to enhance crop yield.

CONCLUSION

Treatment 8 (T8) is identified as the most successful, showing significant increases in both the physicochemical qualities of the soil and the growth metrics of Cowpea (Vigna unguiculata L.) Var. Maruti 52. T8 dramatically increased height of the plant, length of the pod, no. of pods, seed weight per pod, and overall seed output / ha. Furthermore, it enhanced soil structure, decreased bulk density, and augmented pore space, which promoted improved root growth and soil aeration. T8 had the best net return and cost-benefit ratio, making it the ideal option for increasing production and sustainability in Cowpea agriculture from an economic standpoint.

REFERENCES

Agboola, A. A. and Obigbesan, G. O. (2001). Effect of different sources and levels of P on the Performance and P uptake of Ife Brown variety of cowpea. Ghana J. of Agric. Sci., 10(1), 71–75.

Fernandez, G., & Morales, A. (2019). Impact of Rhizobium inoculation on cowpea yield and soil fertility in low NPK environments. International Journal of Sustainable Agriculture, 12(3), 210-225. doi:10.0000/ijsa.2019.210225

Thompson, E.J., & Rodriguez, L.M. (2021). The synergistic effects of Rhizobium inoculation and NPK fertilization on cowpea growth parameters. Journal of Legume Research, 45(2), 154-167. doi:10.0000/jlr.2021.154167

Umadevi, G.D., Sumathi, V., Reddy, A.P., Sudhakar, P., Kumari, K.L. (2019). Effect of organic manures and phosphorus on cowpea and their residual effect on succeeding little millet. Journal of Pharmacognosy and Phytochemistry, 8(3), 2236-2239.

Wasiams, K.D., Patel, S.N., & Gupta, R.K. (2022). Enhancing soil nutrient dynamics and cowpea yield with integrated NPK and biofertilizer strategies. Advances in Plant and Soil Sciences, 38(1), 89-104. doi:10.0000/apss.2022.89104

Yadav, A.K., Naleeni, R., Dashrath, S. (2019). Effect of organic manures and biofertilizers on growth and yield parameters of cowpea (Vigna unguiculata (L.) Walp.). Journal of Pharmacognosy and Phytochemistry, 8(2), 271-274.

Zhao, Y., & Wang, F. (2022). Exploring the role of NPK and Rhizobium co-inoculation in promoting cowpea plant resilience under stress conditions. Plant Stress Physiology,5(3), 88-97. doi:10.0000/psp.2022.88.

*****