

Effect of Different Levels of NPK, Biochar and *Azotobacter* on Physico-Chemical Properties of Soil on Cowpea (*Vigna unguiculata*)

ABSTRACT

In light of this, the following goals are present in the experiment "Effect of Different Levels of NPK and Biochar, Azotobacter on Physico-chemical Properties of Soil and Yield Attributes of Cowpea to calculate the impact of various NPK, Biochar, and *Azotobacter* dosages on the physical-chemical characteristics of soil. ~~Before conducting research,~~ An excavated soil sample from the experimental site revealed that the land topography ranged from nearly level to sloped by 1% to 6%, with soil area falling into the Inceptisol order. The soil texture was sandy loam, with sand percentages of 62.65%, silt percentages of 21.09, and clay percentages of 16.26. The soil's pH of soil was 6.89, and its electrical conductivity (EC) was non-saline (0.42 ds m⁻¹). Organic carbon content was low to medium, available nitrogen was low to medium (280.78 kg-ha⁻¹), available phosphorus was 17.34 kg-ha⁻¹, and available potassium was 168.16 kg-ha⁻¹. Two factors with three levels of @NPK 0, 50, and 100% ha⁻¹, three levels of @Biochar 0, 50, and 100% ha⁻¹, and a randomized block design were used in the statistical analysis. During field testing, nine different treatments were used; the best outcomes were significant. The results indicate that the physical and chemical parameters of the soil, including the cumulative mean values for bulk density (1.39 and 1.41 mg-m⁻³), particle density (2.46 and 2.47 mg-m⁻³), and soil pH (6.89 and 6.91), attained their maximum in T1 (Absolute control) at depths of 0-15 cm and 15-30 cm, respectively. Additionally, the percentage pore space was found to be 48.22% and 47.39%, and the water holding capacity was found to be 44.14% and 45.34%, electrical conductivity (EC) was measured at 0.49 ds-m⁻¹ and 0.52 ds-m⁻¹, the percentage of organic carbon was determined to be 0.40%, and the available nitrogen was found to be (299.78 kg-ha⁻¹ and 295.76 kg-ha⁻¹, available phosphorus was (23.78 kg-ha⁻¹ and 21.98 kg-ha⁻¹), and the available potassium was (179.25 kg-ha⁻¹ and 176.56 kg-ha⁻¹).

Key word: Biochar, Azotobacter, cowpea, NPK.

INTRODUCTION –

According to Singh *et al.*, (2008) One of the most important natural resources for maintaining life on Earth is soil. It is an intricate, dynamic, living system that is vital to many

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different ecological processes. Soil is made up of minerals, organic matter, water, and air. It is formed over thousands of years by the weathering of rocks and the decomposition of organic matter. A medium for plant growth is soil. A major factor in crop productivity is soil quality. The coarseness and fineness of the soil, aggregate size, porosity, aeration (permeability), water-holding capacity, pH, bulk density, and particle density are some of the soil characteristics that influence plant growth. The texture, physical state (soil structure and tilth), and amount of vegetation cover on the soil all affect the rate of water moving into the soil (infiltration).

In their investigation of the quality and yield of cowpea at different NPK levels, Prasad and Kumar (2021) found that while increasing nitrogen levels significantly increased yield, there remained a threshold beyond which further yield benefits were not discernible. This highlights how important it is to minimize misuse by maximizing N application. This discovery has two ramifications. It highlights the significance of precise nutrient management in the first place in order to maximize agricultural output while reducing resource loss and environmental damage. To accomplish sustainable agricultural practices, farmers must adjust their fertilizer application tactics based on crop requirements, soil nutrient levels, and environmental factors. Secondly, it emphasizes the necessity of doing research and extending efforts to teach farmers about proper nutrient management techniques. By spreading information regarding

According to Asai *et al.*, (2009) Biochar refers to biomass-derived charcoal, obtained when biomass is —baked under low or no oxygen conditions (pyrolysis). It holds good as a tool for improving soil fertility and sequestering carbon (C) in soil among other potential benefits. The conversion of organic waste to produce biochar by pyrolysis process is one of the viable options that can enhance natural rates of carbon sequestration in the soil, reduce farm waste and improve soil quality.

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Azotobacter is among one of them with very promising future *Azotobacter* spp. are non-symbiotic heterotrophic bacteria capable of fixing an average 20 kg N/ha/per year. Rajae *et al* .. (2007) Found that *Azotobacter* have the ability to fix atmospheric nitrogen (N₂) and convert it into nitrogenous forms that can be assimilated by plants and are considered Rhizo-bacteria that promote plant growth . They are bacteria that stimulate growth improving nitrogen fixation and phosphate solubilization.

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According to Deepa *et al.*, (2016) Cowpea is one of the most important legume vegetable grown in India. It is also known as black eye pea, southern pea and Crowder pea, well adapted to many areas of the humid tropics and sub-tropical zones. It is grown throughout India for its long, green vegetable pods, seeds and foliage for fodder. cowpea bean seeds contain 54.5%

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carbohydrates, 24.1% protein, and 0.1% fat. Similarly, [Aramendiz-Tatis et al., \(2016\)](#) mention that *V. unguiculata* L. Walp has a high protein content between 21.2 and 27.9% carbohydrates 52 g per 100 g and iron 68 mg per 100 g, among other compounds of nutritional value. It is grown for fodder, vegetable and green manuring purposes. It has protein content about 24.6% and rich source of calcium and iron.

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2. MATERIAL AND METHODS

2.1. Experimental site and soil location

The investigation site of the crop research farm is situated 5 kilometers distant on the right bank of the Yamuna River and is located at 25° 58' N latitude and 81° 52' E longitude. It has an elevation of 98 meters above mean sea level. Representative of the Agro-Climatic Zone (Upper Gangetic Plain Region) and the Agro-Ecological Sub-region (North Alluvial Plain Zone, 0–1% slope).

2.2. Climatic condition

The area of Prayagraj district comes under sub-tropical belt in the Southeast of Uttar Pradesh, which experiences extremely hot summers and fairly cold winters. The maximum temperature of the location reaches up to 45°C – 48°C and seldom falls as low as 3°C – 5°C. The relative humidity ranged between 25 to 95 percent. The average rainfall in this area is around 1000-1200 mm annually.

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2.3 Treatment combination

Table 1: Treatment combination

| Treatment | Treatment Combination | Symbol |
|----------------|---|--------|
| T ₁ | [Absolute Control] | R0B0A0 |
| T ₂ | @N10P30K20 kg ha ⁻¹ +@BC0 t ha ⁻¹ +@AZ 1.25 kg ha ⁻¹ | R1B0A1 |
| T ₃ | @N20P60K40 kg ha ⁻¹ +@BC0 t ha ⁻¹ +@AZ 2.5 kg ha ⁻¹ | R2B0A2 |
| T ₄ | @NOP0K0 kg ha ⁻¹ +@BC2.5 t ha ⁻¹ +@AZ0 kg ha ⁻¹ | R0B1A0 |
| T ₅ | @N10P30K20 kg ha ⁻¹ +@BC2.5 t ha ⁻¹ +@AZ 1.25 kg ha ⁻¹ | R1B1A1 |
| T ₆ | @N20P60K40 kg ha ⁻¹ +@BC2.5 t ha ⁻¹ +@AZ 2.5 kg ha ⁻¹ | R2B1A2 |
| T ₇ | @NOP0K0 kg ha ⁻¹ +@BC5 t ha ⁻¹ +@AZ 0 kg ha ⁻¹ | R0B2A0 |
| T ₈ | @N10P30K20 kg ha ⁻¹ +@BC5 t ha ⁻¹ +@AZ 1.25 kg ha ⁻¹ | R1B2A1 |
| T ₉ | @N20P60K40 kg ha ⁻¹ +@BC5 t ha ⁻¹ +@AZ 2.5 kg ha ⁻¹ | R2B2A2 |

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NOTE: Recommended Dose of Fertilizers (RDF) [NPK]: -20:60:40, Biochar: -5 t ha⁻¹, *Azotobacter*: -

2.5 kg ha⁻¹

2.4 Experimental Details

A randomized block design (RBD), comprising nine treatment combinations reproduced three times with distinct treatment allocations in each replication, was used to set up the current investigation. At the research site, this results in twenty-seven plots. In this study, three different doses of biochar and an *Azotobacter* seed treatment were applied in addition to

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inorganic fertilizers such as potassium, phosphorus, and nitrogen as RDF. As suitable, the cowpea crop was manually seeded on August 1st, 2023. The seed variety Maruti-52 was planted at a rate of 25 kg per hectare, with a row-to-row spacing of 45 cm and a plant-to-plant spacing of 15 cm.

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2.5 Fertilizer Application

The recommended doses of NPK 20:60:40 (100%) were applied to the crop: N (44 kg ha⁻¹), P₂O₅ (375 kg ha⁻¹), and K₂O (66.67 kg ha⁻¹). The 100% application of N, P, and K was used as the basal dose at the time of sowing. In addition to these applications Biochar 5t ha⁻¹ and seed treatment with *Azotobacter* 2.5 kg ha⁻¹. The sources of NPK fertilizers were nitrogen through urea (N₂O 46%). Phosphorus through single superphosphate (P₂O₅ 16%) and potassium through muriate of potassium (K₂O 60%) were applied earlier to sowing in regards to treatments just before the seed sowing. Nitrogen and urea (N 46%) were applied in two different doses.

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2.6 statistical Analysis

The statistical analysis of the data was carried out using STATISTICA software [2].

3. RESULT AND DISCUSSION

3.1 Effect of Different levels of NPK Biochar and *Azotobacter* physical properties of soil (Post Harvest) on cowpea.

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The data showed that the treatment T1 (Absolute control) non-significantly influenced the Bulk density of soil (1.39 Mg m⁻³ and 1.41 Mg m⁻³), Particle density of soil (2.46 Mg m⁻³ and 2.47 Mg m⁻³) at 0-15 cm and 15-30 cm depth and significantly influenced Percentage pore space(48.22% and 47.39%), Water holding capacity (44.14% and 45.34%) of soil were found maximum in treatment T9 (@N20P60K40 kg ha⁻¹ + @BC5 t ha⁻¹ + @AZ2.5 Kg ha⁻¹) over T1 (Absolute control) treatment at 0-15 cm and 15-30 cm depth, respectively.

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TABLE 2: Effect of Different levels of NPK Biochar and Azotobacter on physical properties of soil (post-harvest) on Cowpea.

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| Treatments | Bulk Density (Mgm-3) | | Particle Density (Mg m ⁻³) | | Pore space (%) | | Water holding capacity (%) | | |
|---------------------|---|-----------|--|-----------|----------------|----------|----------------------------|----------|----------|
| | 0-15 cm | 15-30 cm | 0-15 cm | 15-30 cm | 0-15 cm | 15-30 cm | 0-15 cm | 15-30 cm | |
| T1 | [Absolute Control] | 1.39 | 1.41 | 2.46 | 2.47 | 42.55 | 42.29 | 39.26 | 40.12 |
| T2 | @N10P30K20 kg ha ⁻¹ +@BC0 t ha ⁻¹ +@AZ 1.25 kg ha ⁻¹ | 1.37 | 1.39 | 2.45 | 2.45 | 44.44 | 43.30 | 40.11 | 40.78 |
| T3 | @N20P60K40 kg ha ⁻¹ +@BC0 t ha ⁻¹ +@AZ 2.5 kg ha ⁻¹ | 1.38 | 1.40 | 2.45 | 2.46 | 43.36 | 42.75 | 39.80 | 40.57 |
| T4 | @N0P0K0 kg ha ⁻¹ +@BC2.5 t ha ⁻¹ +@AZ0 kg ha ⁻¹ | 1.34 | 1.36 | 2.43 | 2.44 | 45.85 | 45.53 | 41.67 | 41.83 |
| T5 | @N10P30K20 kg ha ⁻¹ +@BC2.5 t ha ⁻¹ +@AZ 1.25 kg ha ⁻¹ | 1.35 | 1.37 | 2.43 | 2.44 | 45.73 | 44.98 | 41.13 | 42.32 |
| T6 | @N20P60K40 kg ha ⁻¹ +@BC2.5 t ha ⁻¹ +@AZ 2.5 kg ha ⁻¹ | 1.36 | 1.38 | 2.44 | 2.45 | 45.67 | 44.85 | 41.33 | 42.91 |
| T7 | @N0P0K0 kg ha ⁻¹ +@BC5 t ha ⁻¹ +@AZ 0 kg ha ⁻¹ | 1.33 | 1.35 | 2.42 | 2.43 | 46.85 | 45.83 | 42.56 | 43.47 |
| T8 | @N10P30K20 kg ha ⁻¹ +@BC5 t ha ⁻¹ +@AZ 1.25 kg ha ⁻¹ | 1.32 | 1.34 | 2.41 | 2.42 | 47.01 | 46.21 | 43.33 | 43.87 |
| T9 | @N20P60K40 kg ha ⁻¹ +@BC5 t ha ⁻¹ +@AZ 2.5 kg ha ⁻¹ | 1.31 | 1.33 | 2.40 | 2.41 | 48.22 | 47.39 | 44.14 | 45.34 |
| F- test | | NS | NS | NS | NS | S | S | S | S |
| S.Em. (±) | | - | - | - | - | 0.768 | 0.760 | 0.683 | 0.546 |
| C.D (P=0.05) | | - | - | - | - | 2.30 | 2.27 | 2.048 | 1.638 |

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3.2 Effect of Different levels of NPK Biochar and *Azotobacter* on chemical properties of soil (post-harvest) on Cowpea.

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The data showed that the treatment T1 (Absolute control) non-significantly influenced the soil pH is maximum (6.89 and 6.91) at 0-15 cm and 15- 30 cm depth, respectively and Electrical Conductivity (0.42 and 0.44 dS m⁻¹), There was significantly influenced maximum build-up of Percentage Organic Carbon (0.41% and 0.40%) Available Nitrogen (299.48 kg ha⁻¹ and 295.76 kg ha⁻¹), Available Phosphorus (23.78 kg ha⁻¹ and 21.98 kg ha⁻¹) and

Available Potassium (179.25 kg ha⁻¹ and 176.56 kg ha⁻¹) were observed under the treatment T9 (@N20P60K40 kg ha⁻¹+@BC5 t ha⁻¹+@AZ 2.5 kg ha⁻¹) content in soil, however minimum values were detected in the treatments T1 (Absolute control) at 0-15 cm depth and at 15- 30 cm depth, respectively.

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| Treatments | | pH | | Electrical conductivity (dS m ⁻¹) | | Organic carbon (%) | |
|---------------------|---|-----------|-----------|---|-----------|--------------------|----------|
| | | 0-15 cm | 15-30 cm | 0-15 cm | 15-30 cm | 0-15 cm | 15-30 cm |
| T1 | [Absolute Control] | 6.89 | 6.91 | 0.42 | 0.44 | 0.34 | 0.33 |
| T2 | @N10P30K20 kg ha ⁻¹ +@BC0 t ha ⁻¹ +@AZ 1.25 kg ha ⁻¹ | 6.87 | 6.89 | 0.44 | 0.46 | 0.35 | 0.34 |
| T3 | @N20P60K40 kg ha ⁻¹ +@BC0 t ha ⁻¹ +@AZ 2.5 kg ha ⁻¹ | 6.88 | 6.90 | 0.43 | 0.45 | 0.35 | 0.34 |
| T4 | @N0P0K0 kg ha ⁻¹ +@BC2.5 t ha ⁻¹ +@AZ0 kg ha ⁻¹ | 6.84 | 6.86 | 0.47 | 0.49 | 0.36 | 0.35 |
| T5 | @N10P30K20 kg ha ⁻¹ +@BC2.5 t ha ⁻¹ +@AZ 1.25 kg ha ⁻¹ | 6.85 | 6.87 | 0.46 | 0.48 | 0.37 | 0.35 |
| T6 | @N20P60K40 kg ha ⁻¹ +@BC2.5 t ha ⁻¹ +@AZ 2.5 kg ha ⁻¹ | 6.86 | 6.88 | 0.45 | 0.47 | 0.38 | 0.36 |
| T7 | @N0P0K0 kg ha ⁻¹ +@BC5 t ha ⁻¹ +@AZ 0 kg ha ⁻¹ | 6.83 | 6.84 | 0.47 | 0.50 | 0.39 | 0.37 |
| T8 | @N10P30K20 kg ha ⁻¹ +@BC5 t ha ⁻¹ +@AZ 1.25 kg ha ⁻¹ | 6.82 | 6.83 | 0.48 | 0.51 | 0.40 | 0.38 |
| T9 | @N20P60K40 kg ha ⁻¹ +@BC5 t ha ⁻¹ +@AZ 2.5 kg ha ⁻¹ | 6.81 | 6.82 | 0.49 | 0.52 | 0.41 | 0.40 |
| F- test | | NS | NS | NS | NS | S | S |
| S.Em. (±) | | - | - | - | - | 0.0046 | 0.0043 |
| C.D (P=0.05) | | - | - | - | - | 0.0140 | 0.0131 |

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TABLE 3: Effect of Different levels of NPK Biochar and Azotobacter on chemical properties (pH, EC, Organic carbon) of soil (post-harvest) on Cowpea.

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| Treatments | Available Nitrogen (kg ha ⁻¹) | | Available Phosphorus (kg ha ⁻¹) | | Available Potassium (kg ha ⁻¹) | |
|---|---|----------|---|----------|--|----------|
| | 0-15 cm | 15-30 cm | 0-15 cm | 15-30 cm | 0-15 cm | 15-30 cm |
| T1 [Absolute Control] | 280.04 | 273.04 | 17.34 | 15.56 | 168.16 | 165.23 |
| T2 @N10P30K20 kg ha ⁻¹ +@BC0 t ha ⁻¹ +@AZ 1.25 kg ha ⁻¹ | 283.87 | 275.17 | 18.69 | 16.77 | 169.78 | 166.76 |
| T3 @N20P60K40 kg ha ⁻¹ +@BC0 t ha ⁻¹ +@AZ 2.5 kg ha ⁻¹ | 285.28 | 276.28 | 19.19 | 17.24 | 171.26 | 168.65 |
| T4 @N0P0K0 kg ha ⁻¹ +@BC2.5 t ha ⁻¹ +@AZ0 kg ha ⁻¹ | 286.48 | 287.98 | 17.68 | 15.17 | 170.76 | 169.34 |
| T5 @N10P30K20 kg ha ⁻¹ +@BC2.5 t ha ⁻¹ +@AZ 1.25 kg ha ⁻¹ | 288.14 | 288.64 | 19.49 | 17.19 | 173.24 | 171.67 |
| T6 @N20P60K40 kg ha ⁻¹ +@BC2.5 t ha ⁻¹ +@AZ 2.5 kg ha ⁻¹ | 290.87 | 290.87 | 20.18 | 18.98 | 175.65 | 172.59 |
| T7 @N0P0K0 kg ha ⁻¹ +@BC5 t ha ⁻¹ +@AZ 0 kg ha ⁻¹ | 294.56 | 292.16 | 20.48 | 17.45 | 177.85 | 174.67 |
| T8 @N10P30K20 kg ha ⁻¹ +@BC5 t ha ⁻¹ +@AZ 1.25 kg ha ⁻¹ | 296.76 | 290.76 | 21.42 | 19.65 | 178.12 | 175.15 |
| T9 @N20P60K40 kg ha ⁻¹ +@BC5 t ha ⁻¹ +@AZ 2.5 kg ha ⁻¹ | 299.43 | 293.36 | 23.78 | 21.98 | 179.25 | 176.56 |
| F- test | S | S | S | S | S | S |
| S.Em. (±) | 3.835 | 3.336 | 0.326 | 0.213 | 2.687 | 2.006 |
| C.D (P=0.05) | 11.498 | 10.001 | 0.977 | 0.639 | 8.075 | 6.015 |

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TABLE 4: Effect of Different levels of NPK Biochar and Azotobacter chemical properties (Available Nitrogen, Available Phosphorus, Available Potassium) of soil (post-Harvest) on Cowpea.

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4. CONCLUSION

Based on the findings, the combined application of organic manure and inorganic fertilizer significantly enhanced soil health in relation to cowpea cultivation. Specifically, the application of T9 (comprising 100% NPK, 100% Biochar, and 100% Azotobacter) emerged as the most effective treatment for improving key soil properties. These enhancements included increased pore space, enhanced water holding capacity, elevated levels of organic carbon, and greater availability of nitrogen, phosphorus, and potassium. This integrated approach not only optimized soil conditions but also potentially enhanced crop productivity and sustainability in cowpea farming systems.

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