

Influence of Different Levels of NPK, Biochar and *Azotobacter* on PhysicoChemical Properties of Soil on Cowpea (*Vigna unguiculata*)

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ABSTRACT

The excavated soil sample from The soil of experimental site before conducting research operation, mentioned that the land topography range was nearly leveled with a 1-3% slope and soil area falls in order *Inceptisol* and soil texture was sandy loam (sand % 62.65%, silt % 21.09% and clay % 16.26%) with neutral to alkaline in reaction pH (6.89), electrical conductivity (EC) was non saline (0.42 ds-m^{-1}) in nature organic carbon have low content (0.34%), available nitrogen was low to medium ($280.78 \text{ kg-ha}^{-1}$), available phosphorus was (17.34 kg-ha^{-1}) and available potassium ($168.16 \text{ kg-ha}^{-1}$). the design applied for statistical analysis was carried out with a randomized block design having two factors with three levels of NPK 0, 50, and $100\% \text{ ha}^{-1}$, three levels of Biochar 0, 50 and $100\% \text{ ha}^{-1}$ and three levels of *Azotobacter* 0, 50 and $100\% \text{ ha}^{-1}$ respectively. Among nine treatments during field experimentation, the best results significantly. However, the physical and chemical soil parameters, the cumulative mean value for Bulk density (1.39 Mg-m^{-3} and 1.41 Mg-m^{-3}), particle density (2.46 Mg-m^{-3} and 2.47 Mg-m^{-3}) and soil pH (6.89 and 6.91) was found maximum in T₁(Absolute control) at depth 0-15 cm and 15-30 cm, respectively percentage pore space (48.22% and 47.39%) and water holding capacity was (44.14% and 45.34%) and electrical conductivity (EC) was (0.49 ds-m^{-1} and 0.52 ds-m^{-1}) and organic carbon percentage (0.41% and 0.40%) and available nitrogen was ($299.78 \text{ kg-ha}^{-1}$ and $295.76 \text{ kg-ha}^{-1}$), Available phosphorus was (23.78 kg-ha^{-1} and 21.98 kg-ha^{-1}) and available potassium was ($179.25 \text{ kg-ha}^{-1}$ and $176.56 \text{ kg-ha}^{-1}$) were found maximum in T₉ consisting of ($\text{N}_{20}\text{P}_{60}\text{K}_{40} \text{ kg-ha}^{-1} + \text{BC}_5 \text{ t ha}^{-1} + \text{AZ}_{2.5} \text{ kg-ha}^{-1}$) in comparison to other NPK and biochar, *Azotobacter* levels of application.

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Key word: Biochar, *Azotobacter*, cowpea, NPK, kharif season.

INTRODUCTION –

Soil is a fundamental natural resource, essential for the sustenance of life on Earth. It is a complex, dynamic, and living system that plays a crucial role in various ecological processes. Formed through the weathering of rocks and the decomposition of organic matter over thousands of years, soil is composed of minerals, organic matter, water, and air. Soil is a medium for plant growth. Crop production is based largely on soils. Some of the soil properties affecting plant growth include: soil texture (coarse fine), aggregate size, porosity, aeration (permeability), and water holding capacity, pH, bulk density, particle density. The rate of water movement into the soil (infiltration) is influenced by its texture, physical condition (soil structure and tilth), and the amount of vegetative cover on the soil surface. Organic matter tends to increase the ability of all soils to retain water, and also increases infiltration rates of fine textured soils. Bulk density reflects the soil's ability to function for structural support, water and solute movement, and soil aeration. [11]

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NPK fertilizers, encompassing the essential nutrients nitrogen (N), phosphorus (P), and potassium (K), are fundamental to modern agricultural practices. These three macronutrients play critical roles in plant growth and development, each contributing uniquely to physiological processes and overall plant health. The balanced supply of NPK fertilizers is vital for maximizing crop yields and ensuring sustainable agricultural productivity.

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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 a very promising future. *Azotobacter* spp. are non-symbiotic heterotrophic bacteria capable of fixing an average 20 kg N/ha/per year. *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 (PGPR). They are bacteria that stimulate growth improving nitrogen fixation and phosphate solubilization. [2,4].

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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% 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. [12]

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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 250 58' N latitude and 810 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 ~~South-east~~Southeast of Uttar Pradesh, which ~~experience~~experiences extremely hot ~~summer~~summers and fairly cold ~~winter~~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
T1	[Absolute Control]	R0B0A0
T2	@N10P30K20 kg ha ⁻¹ +@BC0 t ha ⁻¹ +@AZ 1.25 kg ha ⁻¹	R1B0A1
T3	@N20P60K40 kg ha ⁻¹ +@BC0 t ha ⁻¹ +@AZ 2.5 kg ha ⁻¹	R2B0A2
T4	@N0P0K0 kg ha ⁻¹ +@BC2.5 t ha ⁻¹ +@AZ0 kg ha ⁻¹	R0B1A0
T5	@N10P30K20 kg ha ⁻¹ +@BC2.5 t ha ⁻¹ +@AZ 1.25 kg ha ⁻¹	R1B1A1
T6	@N20P60K40 kg ha ⁻¹ +@BC2.5 t ha ⁻¹ +@AZ 2.5 kg ha ⁻¹	R2B1A2
T7	@N0P0K0 kg ha ⁻¹ +@BC5 t ha ⁻¹ +@AZ 0 kg ha ⁻¹	R0B2A0
T8	@N10P30K20 kg ha ⁻¹ +@BC5 t ha ⁻¹ +@AZ 1.25 kg ha ⁻¹	R1B2A1
T9	@N20P60K40 kg ha ⁻¹ +@BC5 t ha ⁻¹ +@AZ 2.5 kg ha ⁻¹	R2B2A2

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NOTE: RDF[NPK]: -20:60:40, Biochar: -5 t ha⁻¹; *Azotobacter*: - 2.5 kg ha⁻¹

2.4 Experimental Details

The current study was set up using a randomized block design (RBD), which consists of nine treatment combinations that are replicated three times with different treatment allocations in each replication. This creates twenty-seven plots at the research site. In this study, biochar and seed treatment with *Azotobacter* was applied in three different doses along with inorganic

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fertilizers such as Nitrogen, Phosphorous and Potassium as RDF. The cowpea crop was manually sown on August 1st, 2023, as appropriate. At a pace of 25 kg per hectare, with a row-to-row distance of 45 cm and a plant-to-plant distance of 15 cm, the seed variety Maruti-52 was planted.

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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 5 t-ha⁻¹ and seed treatment with *Azotobacter* 2.5 kg-ha⁻¹. The sources of NPK fertilizers were nitrogen through urea (~~46%~~ N₂O ~~46%~~). Phosphorus through single superphosphate (~~16%~~ P₂O₅ ~~16%~~) and potassium through muriate of potassium (~~60%~~ K₂O ~~60%~~) were applied earlier to sowing in regards to treatments just before the seed sowing. Nitrogen and urea (~~46%~~ N~~46%~~) were applied in two different doses.

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2.6 Soil Analysis

For laboratory examination, the soils from each plot were taken apart, air dried, powdered, and put through a 2-mm-size sieve. Soil samples were analyzed for Bulk density, Particle density, Percentage pore space and Water holding capacity (WHC) using a 100-ml measuring cylinder (Muthuvel *et al.*, 1992) [7], pH [5], EC (Wilcox, 1950) [17], Organic carbon percentage (Walkley and Black, 1934) [16], Available Nitrogen (Subbiah and Asijja, 1956) [14], Available Phosphorus (Olsen *et al.*, 1954) [9] and Available Potassium (Toth and Prince, 1949) [15] before sowing the experimental crop and after harvest of the crop.

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2.7 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.

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 + @AZ_{2.5} Kg ha⁻¹) over T₁ (Absolute control) treatment at 0-15 cm and 15-30 cm depth, respectively (Table 2 and fig. 1). This corroborates with the findings of [8,10,12].

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 (Mg-m ⁻³)		Particle Density (Mg-m ⁻³)		Pore space (%)		Water holding capacity (%)	
T ₁ [Absolute Control]	1.39	1.41	2.46	2.47	42.55	42.29	39.26	40.12
T ₂ @N ₁₀ P ₃₀ K ₂₀ kg ha ⁻¹ +@BC ₀ 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
T ₃ @N ₂₀ P ₆₀ K ₄₀ kg ha ⁻¹ +@BC ₀ 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
T ₄ @N ₀ P ₀ K ₀ kg ha ⁻¹ +@BC _{2.5} t ha ⁻¹ +@AZ ₀ kg ha ⁻¹	1.34	1.36	2.43	2.44	45.85	45.53	41.67	41.83
T ₅ @N ₁₀ P ₃₀ K ₂₀ kg ha ⁻¹ +@BC _{2.5} 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
T ₆ @N ₂₀ P ₆₀ K ₄₀ kg ha ⁻¹ +@BC _{2.5} 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
T ₇ @N ₀ P ₀ K ₀ kg ha ⁻¹ +@BC ₅ t ha ⁻¹ +@AZ ₀ kg ha ⁻¹	1.33	1.35	2.42	2.43	46.85	45.83	42.56	43.47
T ₈ @N ₁₀ P ₃₀ K ₂₀ kg ha ⁻¹ +@BC ₅ 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
T ₉ @N ₂₀ P ₆₀ K ₄₀ kg ha ⁻¹ +@BC ₅ 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)	-	-	-	-	2.302	2.278	2.048	1.638

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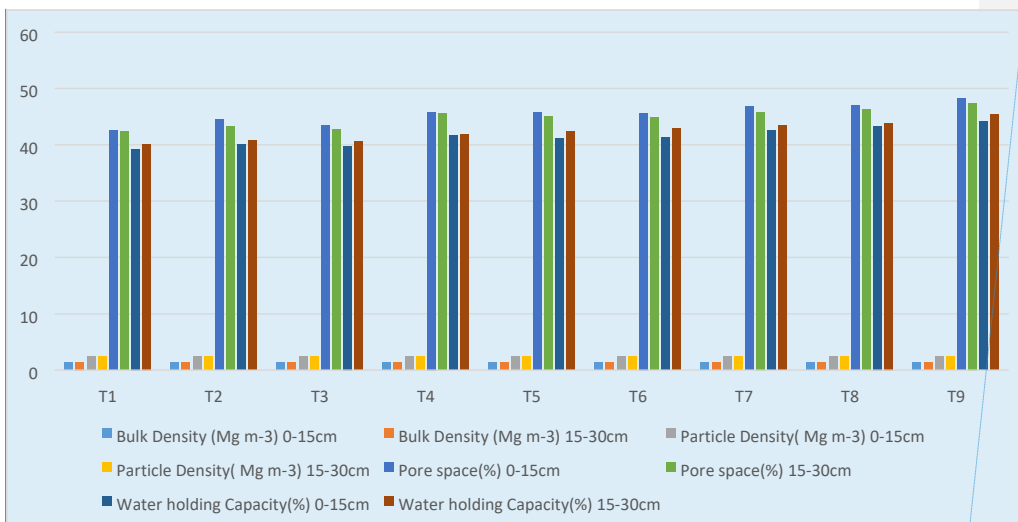
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Fig. 1. Effect of Different Levels of NPK, Biochar and *Azotobacter* on Bulk density and Particle density, pore space and water holding capacity of the post-harvest soil sample.

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

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%), (Table 3 and fig.3) 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 (Table 3 and 4 and fig.2,3). This corroborates with the findings of [8,10,12].

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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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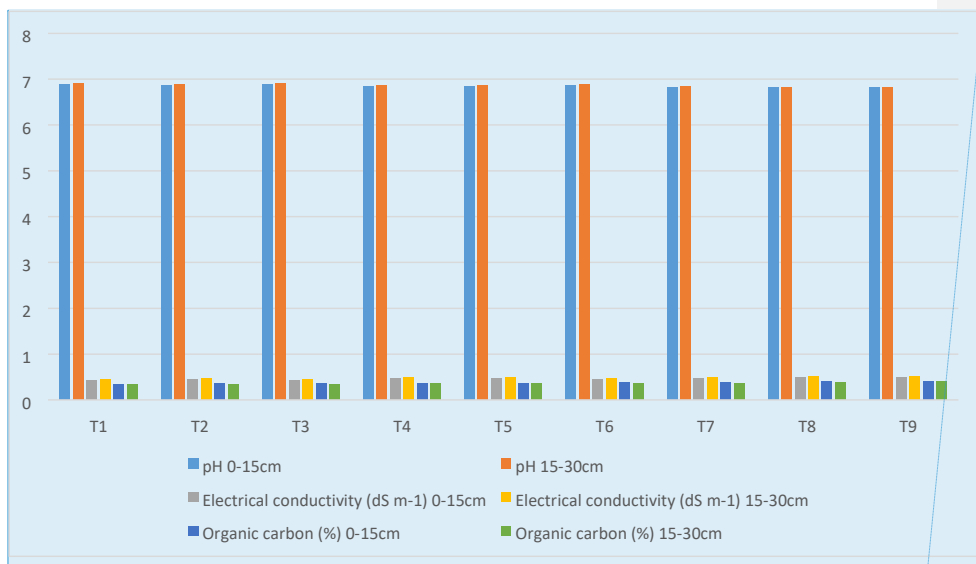
Treatments	pH		Electrical conductivity (dS m ⁻¹)		Organic carbon (%)	
T ₁ [Absolute Control]	6.89	6.91	0.42	0.44	0.34	0.33
T ₂ @N ₁₀ P ₃₀ K ₂₀ kg ha ⁻¹ +@BC ₀ t ha ⁻¹ +@AZ _{1.25} kg ha ⁻¹	6.87	6.89	0.44	0.46	0.35	0.34
T ₃ @N ₂₀ P ₆₀ K ₄₀ kg ha ⁻¹ +@BC ₀ t ha ⁻¹ +@AZ _{2.5} kg ha ⁻¹	6.88	6.90	0.43	0.45	0.35	0.34
T ₄ @N ₀ P ₀ K ₀ kg ha ⁻¹ +@BC _{2.5} t ha ⁻¹ +@AZ ₀ kg ha ⁻¹	6.84	6.86	0.47	0.49	0.36	0.35
T ₅ @N ₁₀ P ₃₀ K ₂₀ kg ha ⁻¹ +@BC _{2.5} t ha ⁻¹ +@AZ _{1.25} kg ha ⁻¹	6.85	6.87	0.46	0.48	0.37	0.35
T ₆ @N ₂₀ P ₆₀ K ₄₀ kg ha ⁻¹ +@BC _{2.5} t ha ⁻¹ +@AZ _{2.5} kg ha ⁻¹	6.86	6.88	0.45	0.47	0.38	0.36
T ₇ @N ₀ P ₀ K ₀ kg ha ⁻¹ +@BC ₅ t ha ⁻¹ +@AZ ₀ kg ha ⁻¹	6.83	6.84	0.47	0.50	0.39	0.37
T ₈ @N ₁₀ P ₃₀ K ₂₀ kg ha ⁻¹ +@BC ₅ t ha ⁻¹ +@AZ _{1.25} kg ha ⁻¹	6.82	6.83	0.48	0.51	0.40	0.38
T ₉ @N ₂₀ P ₆₀ K ₄₀ kg ha ⁻¹ +@BC ₅ 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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Fig. 2. Effect of Different Levels of NPK Biochar and *Azotobacter* on pH, EC and Organic carbon of the post-harvest soil sample.

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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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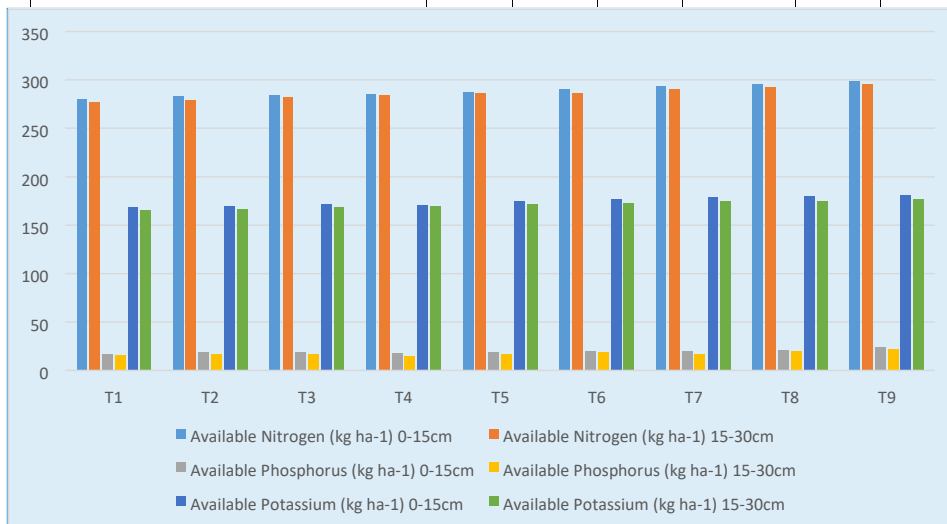
Treatments	Available N (Kg ha ⁻¹)	Available P (Kg ha ⁻¹)	Available K (Kg ha ⁻¹)
T1 [Absolute Control]	280.04	276.73	168.58
T2 @N ₁₀ P ₃₀ K ₂₀ kg ha ⁻¹ +@BC ₀ t ha ¹ +@AZ _{1.25} kg ha ⁻¹	282.87	279.35	169.87
T3 @N ₂₀ P ₆₀ K ₄₀ kg ha ⁻¹ +@BC ₀ t ha ¹ +@AZ _{2.5} kg ha ⁻¹	284.28	282.58	171.46
T4 @N ₀ P ₀ K ₀ kg ha ⁻¹ +@BC _{2.5} t ha ¹ +@AZ ₀ kg ha ⁻¹	285.47	284.12	170.78
T5 @N ₁₀ P ₃₀ K ₂₀ kg ha ⁻¹ +@BC _{2.5} t ha ¹ +@AZ _{1.25} kg ha ⁻¹	287.36	285.89	174.65
T6 @N ₂₀ P ₆₀ K ₄₀ kg ha ⁻¹ +@BC _{2.5} t ha ¹ +@AZ _{2.5} kg ha ⁻¹	290.59	286.39	176.78
T7 @N ₀ P ₀ K ₀ kg ha ⁻¹ +@BC ₅ t ha ⁻¹ +@AZ ₀ kg ha ⁻¹	293.67	290.93	178.86
T8 @N ₁₀ P ₃₀ K ₂₀ kg ha ⁻¹ +@BC ₅ t ha ¹ +@AZ _{1.25} kg ha ⁻¹	295.89	292.42	175.15

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T ₉	@N ₂₀ P ₆₀ K ₄₀ kg ha ⁻¹ +@BC ₅ t ha ¹ +@AZ _{2.5} kg ha ⁻¹	298.88	295.76	23.78	21.98	181.32	176.56
F-test		S	S	S	S	S	S
S.Em. (±)		3.835	3.336	0.326	0.275	2.687	2.006
C.D (P=0.05)		11.498	10.001	0.977	2.686	8.057	6.015



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Fig. 3. Effect of Different Levels of NPK Biochar and Azotobacter on Available Nitrogen, Available Phosphorus and Available Potassium of the post-harvest soil sample.

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4. CONCLUSION

Conclusion Based on the results, the application of organic manure and inorganic fertilizer was found to improve the soil's health in references to cowpea. Application of T₉ (@ 100% NPK + @ 100% Biochar + 100% Azotobacter) was found optimal for improving Soil Properties like Pore space, Water holding capacity, Organic Carbon and Available Nitrogen, Phosphorus, Potassium.

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