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Influence of NPK and poultry manure on physico-chemical properties of soil in cowpea

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Abstract
The research was lead at the Soil Science Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P. during the *Rabi* season in 2023-2024. The experiment was laid out in Randomized Block Design with eighteen treatments and three replications with four levels of NPK and poultry manure and one level of *rhizobium* respectively that leads to the Nitrogen, Phosphorus and Potassium (kg ha^{-1}), OC%,% pore space and water holding capacity (%) of soil after crop harvest was found significant except on bulk density (Mg m^{-3}), particle density (Mg m^{-3}), pH and EC (dSm^{-1}) of soil after harvest. The treatment T_{16} (@ 105% NPK + @ 30% Poultry Manure + *Rhizobium* Inoculation) in soil have significant findings which comprises yellowish brown and sandy loam textured neutral to alkaline soil that is non- saline in nature. Physico-chemical properties of soil was found best in treatment T_{16} (@ 105% NPK + @ 30% Poultry Manure + *Rhizobium* Inoculation) as compare with in treatment T_1 (@ 0% NPK + @ 0% Poultry Manure + *Rhizobium* Inoculation).

Keywords: NPK, poultry manure, cowpea, rhizobium, etc.

Introduction
Healthy soils are the foundation of a healthy life. Soil health refers to the ability of soil, as a living system, to sustain biological productivity, animal and plant health, and environmental quality. Maintaining soil health requires conservation and intentional management of soil health principles (Rautaray *et al*., 2003) [25]. It's worth it, though. Life, dependent on soil, cannot thrive in unhealthy soils creating major downstream impacts on human, animal, and plant health (Bethlenfalvay *et al*., 1992) [5]. Healthy soil performs five functions that enable clean air and water and healthy plants and organisms. Those five functions are regulating water, sustaining plant and animal life, filtering and buffering potential pollutants, cycling nutrients, and providing physical stability and support (Kachroo, 1970) [15].

Cowpea grows predominantly in peninsular and central India. In northern India, it is grown in, Punjab, Rajasthan Haryana, Madhya Pradesh and Uttar Pradesh. During 2017 – 2018 the total coverage under cowpea in Uttar Pradesh is 23.61 lakh hectare with a production around 22.34 lakh tones (Anonymous, 2018) [2]. Phosphorus availability in Indian soils is poor to medium, however application of adequate amount of phosphorus has been recorded for higher formation of good quality nodules led to enhances growth and yield in legumes (Sammauria *et al*., 2009) [28].

In India, cowpea is grown as vegetable mainly in semi-arid and arid regions of Haryana, Punjab, West U.P. and Delhi with significant area in Rajasthan, Kerala, Karnataka, Tamil Nadu, Gujarat and Maharashtra and area covered under cowpea is 654 lakh hectares along with productivity of 916 kg per hectare and production of 599 lakh tones (Joshi *et al*., 2018) [14]. Cowpea is rich in protein, minerals and vitamins, generally preferred for its tender pods and fresh seeds but in some parts of the country dry seeds are also consumed [Nielsen *et al*., 1997; Ahenkora *et al*., 1998; Timko and Singh, 2008] [22, 1, 33]. Cowpea leaves contain 34.91% protein, 31.11% carbohydrates, 5.42% fat, 19.46% prebiotics, 65.21 mg iron, 1.62 g calcium, 1.66 g magnesium, 0.56 g phosphorus and 2.22 g sodium (Enyiukwu *et al*., 2018) [8]. Cowpea crop can provide up to 88 kg nitrogen per hectare whereas in an effective crop of cowpea inoculated with *Rhizobium*, it could provide more than 150 kg per hectare of nitrogen which is enough for fulfilling 80-90 per cent of total requirement in plants (Kormata *et al.*, 2000) [16]. Nitrogen is vitally important for plant nutrient. Nitrogen is essential constituent of protein and is present in many other compounds of great physiological importance in plant metabolism. Nitrogen is called a basic constituent of life (Choudhary and Yadav, 2017) [7].

Phosphorus is an essential constituent of majority of enzymes, which are of great importance in the transformation of energy, in carbohydrate metabolism, fat metabolism, in respiration, photosynthesis, energy storage, cell elongation and improves the quality of crops of plants. It enhances the activity of rhizobium and increased the formation of root nodules (Sudharani *et al.*, 2020) [32].

Potassium also plays a vital role in carbon sequestration in soil. It helps in cell osmo-regulation, turgor maintenance and cell expansion. It imparts increased vigour and disease resistance to plant and function as an activator of numerous enzymes, regulates water conduction within the plant cell and water loss from the plant by maintaining the balance between anabolism, respiration and transpiration (Salem and Salam, 2012) [27].

Poultry manure can improve soil fertility by adding microbes, nutrients and organic matter to the soil. It improves soil fertility and enhances the development of the roots system and the vigor of the plants and makes them less susceptible to diseases and pest attacks. Poultry manure with high proportion of organic carbon content improves organic matter of the soil and retains substantial amounts of soil water and this subsequently increases the water content of soil upon application of the manure.

Rhizobium inoculation increased the root nodulation through better root development and more nutrient availability, resulting in vigorous plant growth and dry matter production which resulted in better flowering, fruiting and pod formation and ultimately there was beneficial effect on seed yield (Sardana *et al.*, 2006) [29].

Materials and Methods

A field experiment conducted at the Soil Science Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, during the *Rabi* season of years (2023-2024) growing cowpea *Var*. Super Gomati applied four levels of NPK and poultry manure and one level of *rhizobium* respectively NPK = 0%, 35%, 70%, 105% and Poultry manure = 0%, 10%, 20%, 30% including *Rhizobium* = 100% experiment is lead to observe the physical and chemical parameters. In physical parameters like that bulk density, particle density, pore space and water holding capacity through method by 100 ml graduated measuring cylinder and process by Muthuvel *et al.*, 1992 [20].

In chemical parameters through method by-

a) Soil pH – method given by (Jackson, M. L. 1958) [15] through using digital pH meter.
b) Soil EC (dSm^{-1})-method given by (Wilcox, 1950) [36] through using digital EC meter.
c) Organic Carbon (%) - Wet oxidation method given by (Walkley and Black, 1947) [35]
d) Available Nitrogen (kg ha^{-1})-Kjeldhal Method (Subbiah and Asija, 1956) [31]
e) Available Phosphorus (kg ha^{-1})- Colorimetric method by using Jasper single beam U.V. Spectrophotometer at 660 nm wavelength given by (Olsen *et al.*, 1954) [24]
f) Available Potassium (kg ha^{-1})- Flame photometric method by using Metzer Flame Photometer given by (Toth and Prince, 1949) [34].

Results and Discussion

Physical Properties of Soil

The data presented in table 1 and depicted in fig. 1 clearly shows the bulk density (Mg m^{-3}) of soil as influenced by NPK and poultry manure. The maximum bulk density of soil 1.28 and 1.30 Mg m^{-3} at 0-15 and 15-30 cm was recorded in treatment T_{16} (@ 105% NPK + @ 30% Poultry Manure + *Rhizobium* Inoculation) followed by 1.25 and 1.27 Mg m^{-3} at 0-15 and 15-30 cm in treatment T_{15} (@ 105% NPK + @ 20% Poultry Manure + *Rhizobium* Inoculation) and minimum bulk density of soil 1.18 and 1.21 Mg m^{-3} at 0-15 and 15-30 cm was recorded in treatment T_1 (@ 0% NPK + @ 0% Poultry Manure + *Rhizobium* Inoculation) respectively (Gaden *et al.*, 2023; Kumari *et al.*, 2022 and Nadeem *et al.*, 2018) [10, 17, 21].

The maximum particle density of soil 2.55 and 2.59 Mg m^{-3} at 0-15 and 15-30 cm was recorded in treatment T_{16} (@ 105% NPK + @ 30% Poultry Manure + *Rhizobium* Inoculation) followed by 2.52 and 2.56 Mg m^{-3} at 0-15 and 15-30 cm in treatment T_{15} (@ 105% NPK + @ 20% Poultry Manure + *Rhizobium* Inoculation) and minimum particle density of soil 2.36 and 2.38 Mg m^{-3} at 0-15 and 15-30 cm was recorded in treatment T_1 (@ 0% NPK + @ 0% Poultry Manure + *Rhizobium* Inoculation) respectively (Gaden *et al.*, 2023; Kumari *et al.*, 2022 and Nadeem *et al.*, 2018) [10, 17, 21].

The maximum pore space of soil 49.89 and 46.68% at 0-15 and 15-30 cm was recorded in treatment T_{16} (@ 105% NPK + @ 30% Poultry Manure + *Rhizobium* Inoculation) followed by 48.47 and 46.12% at 0-15 and 15-30 cm in treatment T_{15} (@ 105% NPK + @ 20% Poultry Manure + *Rhizobium* Inoculation) and minimum pore space of soil 42.05 and 40.02% at 0-15 and 15-30 cm was recorded in treatment T_1 (@ 0% NPK + @ 0% Poultry Manure + *Rhizobium* Inoculation) respectively (Revathi *et al.*, 2022; Bartwal *et al.*, 2021 and Yadav *et al.*, 2019) [26, 4, 37].

The maximum water holding capacity of soil 39.32 and 37.07% at 0-15 and 15-30 cm was recorded in treatment T_{16} (@ 105% NPK + @ 30% Poultry Manure + *Rhizobium* Inoculation) followed by 38.83 and 36.50% at 0-15 and 15-30 cm in treatment T_{15} (@ 105% NPK + @ 20% Poultry Manure + *Rhizobium* Inoculation) and minimum water holding capacity of soil 32.13 and 30.90% at 0-15 and 15-30 cm was recorded in treatment T_1 (@ 0% NPK + @ 0% Poultry Manure + *Rhizobium* Inoculation) respectively (Revathi *et al.*, 2022; Bartwal *et al.*, 2021 and Yadav *et al.*, 2019) [26, 4, 37}.

Chemical Properties of Soil

The data presented in table 2 and depicted in fig. 2 clearly shows the pH of soil as influenced by NPK and poultry manure. The response of pH of soil was found to be non-significant in levels of NPK and poultry manure. The maximum pH of soil 7.36 and 7.48 at 0-15 and 15-30 cm was recorded in treatment T_1 (@ 0% NPK + @ 0% Poultry Manure + *Rhizobium* Inoculation) followed by 7.33 and 7.41 at 0-15 and 15-30 cm in treatment T_2 (@ 0% NPK + @ 20% Poultry Manure + *Rhizobium* Inoculation) and minimum pH of soil 6.42 and 6.58 at 0-15 and 15-30 cm was recorded in treatment T_{16} (@ 105% NPK + @ 30% Poultry Manure +

Rhizobium Inoculation) respectively (Hussein *et al*., 2014 and Nkaa *et al*., 2014) [12, 23].

The maximum EC of soil 0.61 and 0.69 dSm^{-1} at 0-15 and 15-30 cm was recorded in treatment T_{16} (@ 105% NPK + @ 30% Poultry Manure + *Rhizobium* Inoculation) followed by 0.57 and 0.66 dSm^{-1} at 0-15 and 15-30 cm in treatment T_{15} (@ 105% NPK + @ 20% Poultry Manure + *Rhizobium* Inoculation) and minimum EC of soil 0.35 and 0.41 dSm^{-1} at 0-15 and 15-30 cm was recorded in treatment T_1 (@ 0% NPK + @ 0% Poultry Manure + *Rhizobium* Inoculation) respectively (Hussein *et al*., 2014 and Nkaa *et al*., 2014) [12, 23].

The maximum organic carbon of soil 0.58 and 0.54% at 0-15 and 15-30 cm was recorded in treatment T_{16} (@ 105% NPK + @ 30% Poultry Manure + *Rhizobium* Inoculation) followed by 0.55 and 0.51% at 0-15 and 15-30 cm in treatment T_{15} (@ 105% NPK + @ 20% Poultry Manure + *Rhizobium* Inoculation) and minimum organic carbon of soil 0.42 and 0.35% at 0-15 and 15-30 cm was recorded in treatment T_1 (@ 0% NPK + @ 0% Poultry Manure + *Rhizobium* Inoculation) respectively (Banstola *et al*., 2018 and Singh *et al*., 2018) [3, 30].

The maximum available nitrogen of soil 277.53 and 271.32 kg ha^{-1} at 0-15 and 15-30 cm was recorded in treatment T_{16} (@ 105% NPK + @ 30% Poultry Manure + *Rhizobium* Inoculation) followed by 274.35 and 267.45 kg ha^{-1} at 0-15 and 15-30 cm in treatment T_{15} (@ 105% NPK + @ 20% Poultry Manure + *Rhizobium* Inoculation) and minimum available nitrogen of soil 248.07 and 241.52 kg ha^{-1} at 0-15 and 15-30 cm was recorded in treatment T_1 (@ 0% NPK + @ 0% Poultry Manure + *Rhizobium* Inoculation) respectively (Miheretu, A. and Addo, J. S., 2017; Mawo *et al*., 2016 and George *et al*., 2014) [19, 18, 11].

The maximum available phosphorus of soil 35.03 and 30.79 kg ha^{-1} at 0-15 and 15-30 cm was recorded in treatment T_{16} (@ 105% NPK + @ 30% Poultry Manure + *Rhizobium* Inoculation) followed by 33.71 and 28.56 kg ha^{-1} at 0-15 and 15-30 cm in treatment T_{15} (@ 105% NPK + @ 20% Poultry Manure + *Rhizobium* Inoculation) and minimum available phosphorus of soil 21.08 and 17.06 kg ha^{-1} at 0-15 and 15-30 cm was recorded in treatment T_1 (@ 0% NPK + @ 0% Poultry Manure + *Rhizobium* Inoculation) respectively (Miheretu, A. and Addo, J. S., 2017; Mawo *et al*., 2016 and George *et al*., 2014) [19, 18, 11].

The maximum available potassium of soil 218.22 and 213.51 kg ha^{-1} at 0-15 and 15-30 cm was recorded in treatment T_{16} (@ 105% NPK + @ 30% Poultry Manure + *Rhizobium* Inoculation) followed by 214.54 and 210.79 kg ha^{-1} at 0-15 and 15-30 cm in treatment T_{15} (@ 105% NPK + @ 20% Poultry Manure + *Rhizobium* Inoculation) and minimum available potassium of soil 192.84 and 189.36 kg ha^{-1} at 0-15 and 15-30 cm was recorded in treatment T_1 (@ 0% NPK + @ 0% Poultry Manure + *Rhizobium* Inoculation) respectively (Miheretu, A. and Addo, J. S., 2017; Mawo *et al*., 2016 and George *et al*., 2014) [19, 18, 11].

Table 1: Influence of NPK and poultry manure on bulk density (Mg m^{-3}), particle density (Mg m^{-3}), pore space (%) and Water holding capacity (%) of soil.

Treatments	Bulk density (Mg m^{-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
T_1	1.18	1.21	2.36	2.38	42.05	40.02	32.13	30.90
T_2	1.16	1.19	2.39	2.42	42.73	40.46	32.74	31.12
T_3	1.17	1.20	2.37	2.40	43.18	40.84	33.07	31.55
T_4	1.19	1.22	2.38	2.41	43.60	40.98	33.69	31.98
T_5	1.17	1.20	2.40	2.44	44.02	41.15	34.15	32.32
T_6	1.16	1.19	2.43	2.46	44.63	41.59	34.83	32.73
T_7	1.18	1.21	2.41	2.43	45.15	42.08	35.20	33.05
T_8	1.20	1.23	2.42	2.44	45.43	42.49	35.54	33.40
T_9	1.21	1.24	2.45	2.47	45.82	42.96	35.93	33.87
T_{10}	1.19	1.22	2.48	2.50	46.06	43.22	36.09	34.10
T_{11}	1.22	1.25	2.46	2.48	46.24	43.63	36.46	34.62
T_{12}	1.23	1.24	2.47	2.51	47.60	44.07	36.28	34.94
T_{13}	1.21	1.23	2.49	2.52	47.88	44.50	36.75	35.37
T_{14}	1.23	1.25	2.51	2.54	48.16	44.93	37.27	35.85
T_{15}	1.25	1.27	2.52	2.56	48.47	45.12	38.83	36.50
T_{16}	1.28	1.30	2.55	2.59	49.89	46.68	39.32	37.07
F-Test	NS	NS	NS	NS	S	S	S	S
S.Ed. (±)	-	-	-	-	0.80	0.92	0.67	0.83
C.D. at 0.5%	-	-	-	-	1.68	1.90	1.41	1.72

Table 2: Influence of NPK and poultry manure on pH, EC (dSm^{-1}), organic carbon (%), available nitrogen (kg ha^{-1}), available phosphorus (kg ha^{-1}) and available potassium (kg ha^{-1}) of soil.

Treatments	pH		EC (dSm^{-1})		Organic carbon (%)		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	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1	7.36	7.48	0.35	0.41	0.42	0.35	248.07	241.52	21.08	17.06	192.84	189.36
T_2	7.33	7.41	0.37	0.42	0.43	0.38	250.36	243.80	21.49	17.63	194.64	192.81
T_3	7.28	7.35	0.38	0.45	0.41	0.36	249.19	242.10	22.75	18.28	193.80	188.14
T_4	7.23	7.31	0.40	0.46	0.44	0.39	251.35	245.62	22.87	18.59	193.10	190.77
T_5	7.17	7.27	0.39	0.47	0.45	0.42	252.09	247.18	24.06	19.23	195.39	193.41
T_6	7.14	7.21	0.42	0.49	0.47	0.41	255.51	250.47	24.71	19.56	195.57	194.07
T_7	7.08	7.15	0.43	0.51	0.46	0.43	254.56	249.52	26.03	19.79	200.47	196.61
T_8	7.03	7.09	0.46	0.54	0.48	0.40	258.09	253.20	26.41	20.37	202.20	195.77
T_9	6.96	7.02	0.48	0.55	0.49	0.44	256.89	251.38	28.64	21.86	199.21	198.17
T_{10}	6.90	6.97	0.47	0.58	0.47	0.42	260.77	255.78	29.08	22.06	203.36	201.44
T_{11}	6.78	6.94	0.49	0.59	0.50	0.45	259.09	254.21	29.49	22.63	206.22	203.75
T_{12}	6.70	6.86	0.50	0.61	0.53	0.48	263.37	259.54	29.75	23.28	205.69	200.36
T_{13}	6.64	6.79	0.51	0.63	0.51	0.46	266.63	260.78	30.87	24.59	208.78	206.51
T_{14}	6.55	6.72	0.54	0.64	0.54	0.49	270.96	264.18	32.06	26.23	212.84	208.95
T_{15}	6.49	6.64	0.57	0.66	0.55	0.51	274.35	267.45	33.71	28.56	214.54	210.79
T_{16}	6.42	6.58	0.61	0.69	0.58	0.54	277.53	271.32	35.03	30.79	218.22	213.51
F-Test	NS	NS	NS	NS	S	S	S	S	S	S	S	S
S.Ed. (±)	-	-	-	-	0.07	0.09	2.26	2.87	1.52	1.20	2.40	2.70
C.D. at 0.5%	-	-	-	-	0.18	0.23	4.60	5.92	3.10	2.45	4.86	5.47

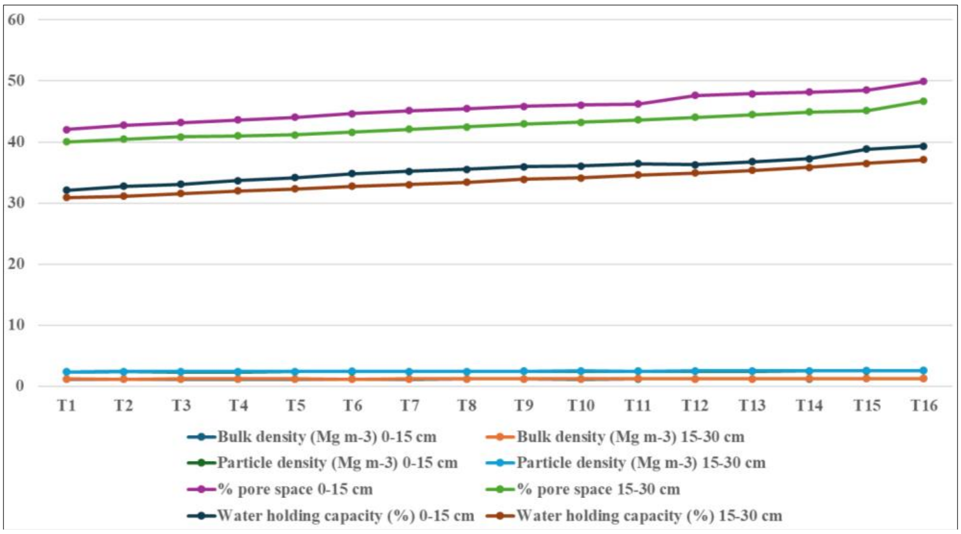

Fig 1: Influence of NPK and poultry manure on bulk density (Mg m^{-3}), particle density (Mg m^{-3}), pore space (%) and Water holding capacity (%) of soil.

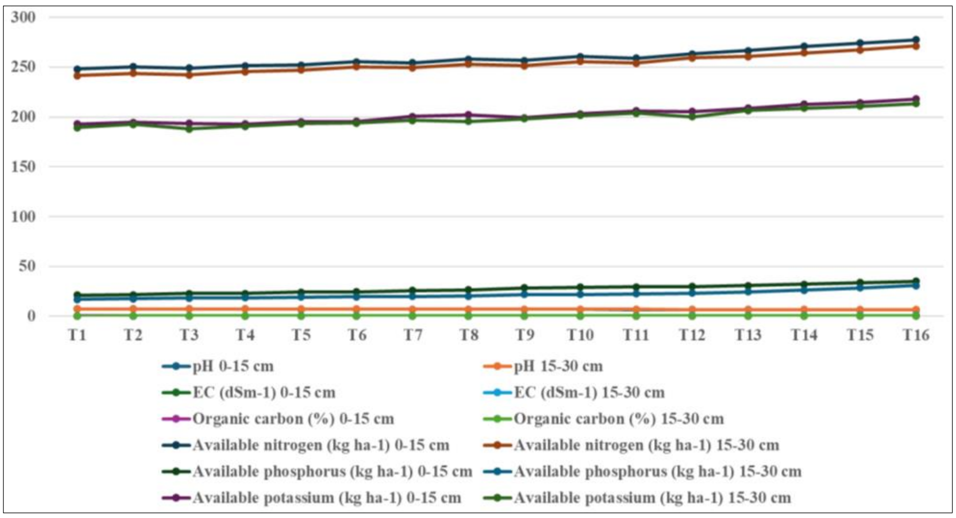

Fig 2: Influence of NPK and poultry manure on pH, EC (dSm^{-1}), organic carbon (%), available nitrogen (kg ha^{-1}), available phosphorus (kg ha^{-1}) and available potassium (kg ha^{-1}) of soil.

Conclusion

According to the results revealed the treatment T_{16} (@ 105% NPK + @ 30% Poultry Manure + *Rhizobium* Inoculation) was seen to be best for all the physico-chemical parameters which is followed by treatment T_{15} (@ 105% NPK + @ 20% Poultry Manure + *Rhizobium* Inoculation) and the lowest treatment was T_1 (@ 0% NPK + @ 0% Poultry Manure + *Rhizobium* Inoculation). Which proved that full dose of NPK, poultry manure, FYM and PSB are recommendable to the farmers.

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