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B Pavani
Research Scholar, Department of Soil Science and Agricultural Chemistry, Naini Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Narendra Swaroop
Associate Professor, Department of Soil Science and Agricultural Chemistry, Naini Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Dr. Arun A David
Professor, Department of Soil Science and Agricultural Chemistry, Naini Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Akshita Barthwal
Ph.D., Scholar, Department of Soil Science and Agricultural Chemistry, Naini Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Akshita Barthwal
Ph.D., Scholar, Department of Soil Science and Agricultural Chemistry, Naini Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj, Uttar Pradesh, India

Effect of different levels of FYM, Neem cake and *Rhizobium* on physico-chemical properties of soil Prayagraj region

B Pavani, Narendra Swaroop, Dr. Arun A David and Akshita Barthwal

Abstract
A field experiment was conducted during Kharif season 2020 at the research farm of department Soil Science and Agricultural Chemistry, SHUATS, The experiment consisted of 9 treatments combinations which were replicated thrice and laid out in simple RBD of three levels of FYM, Neem cake and *Rhizobium* To achieve higher growth and yield of rainy cowpea variety GOWMATI, it was found application of T_9 (100% treatment FYM + 100% Neem Cake + *Rhizobium*) it has shown effective growth under Prayagraj climatic conditions. It was observed that for physical and chemical properties of soil in treatment T_9 treatment (100% FYM + 100% Neem cake + *Rhizobium*) were improved significantly due to FYM, Neem cake and *Rhizobium* use of inputs. Bulk density (Mgm^{-3}), Particle density (Mgm^{-3}), Pore space (%), Water Retention Capacity (%), pH, Electrical conductivity (dS m^{-1}), Organic Carbon (%), Available Nitrogen ($kgha^{-1}$), Available Phosphorous ($kgha^{-1}$), Available Potassium ($kgha^{-1}$). The Soil Organic carbon content, Water holding capacity and available NPK significantly increased in most of the treatments after harvest of cowpea, it was observed that treatment T_9 (100% FYM + 100% Neem cake + *Rhizobium*) was best in terms of growth, yield and economic parameters.

Keywords: Physical-chemical properties of soil, FYM, neem cake, *Rhizobium* and cowpea

Introduction
Cowpea [*Vigna unguiculata* (L.)] commonly known in India as labia is one of the important kharif pulse crops grown for vegetable, grain, forage and green manuring. Pulse crops leave behind reasonable quantity of nitrogen in soil to the extent of 30 $kgha^{-1}$. Cowpea is an important legume vegetable crop grown commercially in summer season and rainy season. In India pulses are grown nearly in 25.43 m ha^{-1} with an annual production of 17.28 million tonne and an average productivity of 679 kg ha^{-1}. The per capita availability of pulses in India is 35.5 g/day as against the minimum requirement of 70 g/day/capita as advocated by Indian Council of Medical Research (Anonymous, 2009).

Cowpea is a good source of food, fodder, vegetables and certain snacks. It is a crop that can be used as catch crop, mulch crop, intercrop, mixed crop and green crop. With the growing population of the world in general and the developing countries in particular, demands are overwhelmed for enhanced food production. Various pulses play an important role to satisfy the growing human food demands and nutritional security. India is the largest producer of pulses, accounts for about 25 percent of the global share. Being an inseparable ingredient in the diet of the vast majority of vegetarian population and mainstay of sustainable crop production, pulses continue to be an important component of the rainfed agriculture, since time immemorial. Pulses are second most important group of crops after cereals. Among the pulse crops, cowpea is more cosmopolite and grown in most of the regions of India which showed very encouraging results and promises to have a far-reaching significant in achieving a breakthrough in the pulse production. It is grown for its long green pods as vegetables, seeds and pulses, as green manure, as well as green fodder. (Anon 2015)

Neem cake is a product derived from *Azadirachta indica* (the Neem tree). With over 140 chemical compounds isolated from the Neem tree, uses for Neem have been numerous (everything from an analgesic to an anti-fungal and insecticidal agent). The Neem cake obtained from the expeller contains 8-10% oil, which is recovered by solvent extraction. The residual oil and the limonoids in the cake cause insect repellence and solvents or water extracts make the product a good antifeedant and growth inhibitor. The octanortriterpenoids α and β-nimolactones isolated from seed cake and fruit coat are moderately antifeedant.

The seed cake is rich in plant nutrients (crude protein 13-18%, carbohydrate 24-50%, crude fiber 8-26%, fat 2-13%, ash 5-18% and acid insoluble ash 1-17%, with nitrogen, phosphorous, calcium, and magnesium) and is used as manure for soil amendment and for urea coating (Manoj Kumar 2018) [9].

Farm yard manure; The organic Materials most commonly used to improve soil conditions and fertility include Farmyard manure (FYM), animal wastes, crop residues, urban organic wastes (either as such or composted), green manures, bio-gas spent slurry, microbial Preparations, vermicompost and biodynamic preparations Farm yard manure made from cattle dung, excreta of other animals, animal tissues and excretory products, and compost from rural and urban wastes, crop residues and green-manure are collectively designated as bulky organic manures because of their low contents of major nutrients, while materials like oil cakes, fish meal, animal meal, poultry manures, slaughter house wastes containing comparatively higher contents of plant nutrients are grouped under concentrated organic manures. In general organic manures containing up to two percent nitrogen are included in zinc (Deepa 2016).

Rhizobium are diverse Gram-negative members of the Proteobacteria that fix nitrogen inside root and stem nodules, which they incite on leguminous plants. All are facultative symbionts, and as a group they are successful soil bacteria. They have diverse metabolic capabilities, but most often couple versatile heterotrophy with aerobic and anaerobic respiration. As rhizobia are metabolically versatile, they are widely used as plant growth promoters of multiple legumes and cereals. Rhizobia utilizes C4 acids in preference to sugars and the sugar utilization is reserved as long as C4 acids are present. This is apparent as a diauxie when rhizobia are grown in the presence of a sugar and a C4 acid together. Several reports have shown succinate to repress the enzymes required Intransport and utilization of sugars, sugar alcohols, hydrocarbons (Deepa 2016).

Materials and Methods

Experimental site

The experiment has conducted at the Soil Science Research Farm of SHUATS, Prayagraj, which is located at 25024’30” N latitude, 810 51’10” E longitude and 98 m above the mean sea level and is situated 6 km away on the right bank of Yamuna river. Representing the Agro-Ecological Sub Region [North Alluvium plain zone (0-1% slope)] and Agro-Climatic Zone (Upper Gangetic Plain Region).

Agro-climatic conditions

Allahabad has sub-tropical climate with extremes of summer and winter. During the winter months, especially December and January, temperature may drop down to as low as 35 ºC, while in the summer months (May-June) temperature reaches above 45-48 ºC. Hot scorching winds are a regular feature during the summer whereas there may be an occasional frost during the winter. The annual rainfall is about 850-1100 mm, mostly during the monsoon i.e., July to September, with a few occasional showers during the winter months. The average monthly rainfall, maximum and minimum temperature and relative humidity was recorded.

Soil analysis and soil sampling

The soil experimental area falls in the order (Inceptisol) Azonal soils of great group. The soil of experimental field is alluvial with neutral to alkaline reaction. The soil samples were randomly collected from one site in the experiment plot prior to tillage operation and after crop harvest of the experimental crop with the help of soil auger and Khurpi from a depth of 0-15 cm and 15-30 cm. These soil samples were grinded and mixed with the help of mallet. Then volume of the soil sample was reduced by conning and quartering and passed through a 2 mm sieve by way of preparing the sample for mechanical, physical and chemical analysis.

Mechanical analysis of soil

Mechanical analysis of soil sample was done to determine the soil texture with the help of Bouyoucos hydrometer (Bouyoucos, 1927).

Experimental details

The experiment was conducted at the research farm of Soil Science and Agricultural Chemistry, Naini, SHAUTS during kharif season. The experiment is conducted in a randomized block design (RBD) where three levels of FYM, Neem cake and *Rhizobium* (0, 50, 100%) the treatments are replicated into three time dividing the experimental area into twenty-seven plots.

Physical analysis

The physical analysis of soil was done to determine Bulk density (Mg m^{-3}), Particle density (Mg m^{-3}) Pore space (%), Water holding capacity (%). Bulk density, Particle density, Pore space was determined by using Graduated Measuring Cylinder (Muthuval *et al.*, 1992).

Chemical analysis of soil

The chemical analysis of soil was done to determine Nitrogen, Phosphorus, Potassium, Organic carbon, pH and electrical conductivity (EC). Nitrogen content was estimated by Kjeldahl’s method (Subbaih and Asijia, 1956). The Phosphorus and Potassium contents were determined by “Olsen colorimetric method” (Olsen *et al.*, 1954) and flame Photometer (Toth and Prince, 1949) [15] respectively. The soil organic matter was estimated by “hydrochloric and oxidation method” as suggested by (Wakley and Black, 1947) [17]. The pH of soil was determined by Digital Electric pH meter and the EC was determined by electrical Conductivity meter (Jackson 1958).

Statistical analysis

The recorded data during the course of investigation on growth, yield and quality components were subjected to two-way classification analysis of variance (ANOVA) as outline by Fisher (1960) where the ‘F’ test was significant for comparison of the treatment means, CD values were worked out at 5% probability level.

Results and Discussion

Physical analysis of soil bulk density (Mg m^{-3}) of soil

The Bulk density (Mg m^{-3}) of soil recorded in the plots under different levels of FYM, Neem cake and *Rhizobium*. Table 1 and graphically illustrated in Fig 1. The data shows significant effect on different levels of FYM, Neem cake and *Rhizobium* on bulk density of soil properties. The maximum bulk density of soil at depth 0-15 and 15-30 was 1.31, 1.34 recorded at T1 Control whereas the minimum bulk density of soil at depth 0-15 and 15-30 1.16, 1.04 was found in T9 @100% FYM + @100% Neem cake + *Rhizobium*. The mean of Bulk density of soil was found significant at the result of the data depicted in Table 4.1. This was due to the compaction of the soil, compaction increases bulk density and reduces crop yields. Similar results have also been recorded by Pradeepa *et al.*, (2011) [11].

Particle density (Mg m^{-3}) of soil

The mean of Particle density of soil was found significant at FYM, Neem cake and *Rhizobium*. The result of the data depicted in table 1 the maximum Particle density of soil at depth 0-15 and 15-30 cowpea found in T1 (control) which was 2.44, 2.45. the minimum Particle density of soil at depth 0-15 and 15-30 was found in T9 @100% FYM + @100% Neem cake + *Rhizobium* which was 2.27,2.28. It was found that due to the application of FYM, Neem cake and *Rhizobium* of the soil is decreased. Similar results have also been recorded by Pradeepa *et al.*, (2011) [11].

Pore space (%) of soil

The mean of Pore space of soil was found significant at FYM, Neem cake and *Rhizobium*. The result of the data depicted in table 1 the maximum Pore space of soil at depth 0-15 and 15-30 found in T9 @100% FYM + @100% Neem cake + *Rhizobium* which was 57.50, 40.85. The minimum Pore space of soil at depth 0-15 and 15-30 was 41.63, 35.45, found in T1 (control). It contains higher amount of organic materials and indicated an enrichment of fine fractions i.e. leading to change in physical properties of soil. From above findings it was found that high pore space due to increase in organic matter. The result are corroborated by Manoj Kumar *et al.*, (2018) [9].

Water holding capacity (%) of soil

The mean of Water holding capacity of soil was found significant at FYM, Neem cake and *Rhizobium*. The result of the data depicted in table 1 the maximum Water Holding Capacity of soil at depth 0-15 and 15-30 was 51.33, 42.75, found in T9 @100% FYM + @100% Neem cake + *Rhizobium* the minimum Water holding capacity of soil at depth 0-15 and 1530 was 45.33, 37.00, found in T1 Control. Water Holding Capacity increases with increase in organic matter. Similar findings also reported by Babaji *et al.*, (2011) [3].

Chemical analysis effect of FYM, Neem cake and *Rhizobium* on soil pH

The mean of Soil pH was found significant at FYM, Neem cake and *Rhizobium*. The result of the data depicted in Table 2 and in Figure 2 the maximum pH of soil at depth 0-15 and 15-30 was found in T1 Control which was 7.52, 7.54, the minimum pH 7.10, 7.20 was found in T9 @100% FYM + @100% Neem cake + *Rhizobium*. Similar findings also reported by Khandelwal *et al.*, (2012) [7].

Electrical conductivity of soil (dS m^{-1})

The mean of Electrical conductivity of soil was found significant at FYM, Neem cake and *Rhizobium*. The result of the data depicted in Table 2 the maximum Electrical conductivity of soil at depth 0-15 and 15-30 was found in T9 @100% FYM + @100% Neem cake + *Rhizobium*, which was 0.24, 0.21, the minimum Electrical conductivity of soil at depth 0-15 and 15-30 was found in T1 (control) was 0.15, 0.11. It was found that ECs value of <1.0 dS m^{-1} is normal and good for the germination of seeds. Similar findings also reported by Khandelwal *et al.*, (2012) [7].

Organic carbon content (%) in soil

The mean of Organic Carbon content in soil was found significant with FYM, Neem cake and *Rhizobium*. The result of the data depicted in Table 2 the maximum Organic carbon of soil at depth 0-15 and 15-30 was 0.64, 0.58 found in T9 @100% FYM + @100% Neem cake + *Rhizobium*, the minimum Organic carbon content of soil at depth 0-15 and 15-30 was found in T1 (control) which was 0.47, 0.44, Similar findings also reported by Khandelwal *et al.*, (2012) [7].

Available Nitrogen (kg ha^{-1}) in soil

The mean of Available Nitrogen in soil was found significant at FYM, Neem cake and *Rhizobium*. The result of the data depicted in table 2 the maximum Available Nitrogen in soil at depth 0-15 and 15-30 found in T9 @100% FYM + @100% Neem cake + *Rhizobium* which was 298.95, 234.21 the minimum available Nitrogen in soil at depth 0-15 and 15-30 was found in T1 Control was 245.52, 189.18. The results from above findings shows that the increase in available Nitrogen in soil after crop harvest by application of balanced fertilizers increased efficiency of Nitrogen fixing capacity and nodule formation. Legumes have potential to improve soil nutrients status through biological nitrogen fixation and incorporation of biomass in to the soil as green manure. Similar finding also reported by Manoj Kumar *et al.*, (2018) [9].

Available Phosphorus (kg ha^{-1}) in soil

The mean of available Phosphorus in soil was found significant at. FYM, Neem cake and *Rhizobium*. The result of the data depicted in Table 2 the maximum available Phosphorus in soil at depth 0-15 and 15-30 found in T9@100% FYM + @100% Neem cake + *Rhizobium* which was 30.77, 29.28, the minimum available Phosphorus in soil at depth 0-15 and 15-30 was found in T1 (control) was 20.18,21.48, From above findings deficiency of Phosphorus causes significant yield reduction in leguminous crops. These results are in close conformity with the findings of Manoj Kumar *et al.*, (2018) [9].

Available potassium (kg ha^{-1}) in soil

The mean of Available Potassium in soil was found significant at FYM, Neem cake and *Rhizobium*. The result of the data depicted in Table 2 the maximum available Potassium in soil at depth 0-15 and 15-30 in T9 @100% FYM + @100% Neem cake + *Rhizobium* which was 205.25, 186.75, the minimum available Potassium in soil at depth 0-15 and 15-30 was found in T1 (control) was 128.62, 128.48, It was found that application of potassium seems to have a beneficial effect in overcoming soil moisture stress and increasing physiological parameters and carbon partitioning in food legumes. Similarly finding also reported by Khandelwal *et al.*, (2012) [7].

Table 1: Effect of nitrogen, phosphorus, potassium, boron and zinc on physical analysis of soil.

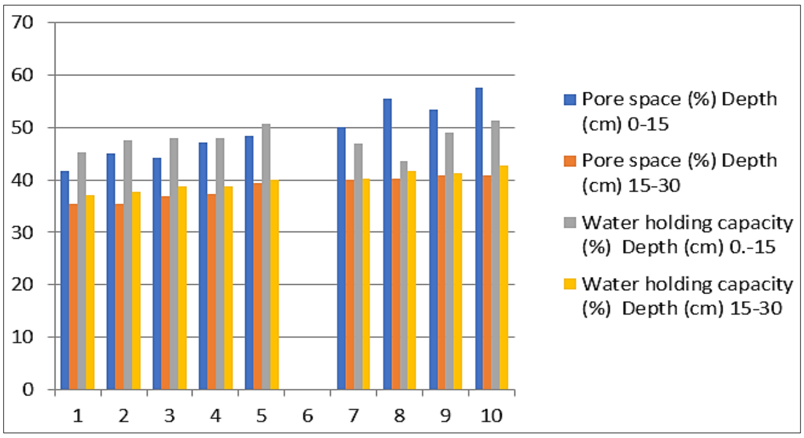
Symbols	Treatments	Bulk density ($Mg\ m^{-3}$)		Particle density ($Mg\ m^{-3}$)		Pore space (%)		Water holding capacity (%)	
		Depth (cm)		Depth (cm)		Depth (cm)		Depth (cm)	
		0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
T_1	Control	1.31	1.34	2.44	2.45	41.63	35.45	45.33	37.00
T_2	@0% FYM + @ 2t/ha Neem cake	1.27	1.33	2.36	2.42	45.09	35.42	47.60	37.65
T_3	@0% FYM + @ 4t/ha Neem cake + *Rhizobium*	1.27	1.32	2.35	2.42	44.18	36.88	48.00	38.67
T_4	@3t/ha FYM + @0% Neem cake	1.26	1.30	2.40	2.41	47.20	37.22	48.00	38.68
T_5	@3t/ha FYM + @2t/ha Neem cake	1.23	1.24	2.41	2.40	48.47	39.35	50.65	40.00
T_6	@3t/h FYM + @4t/ha Neem cake + *Rhizobium*	1.22	1.17	2.42	2.36	50.09	39.92	47.00	40.15
T_7	@6t/ha FYM + @0% Neem cake	1.19	1.14	2.38	2.35	55.52	40.18	43.68	41.67
T_8	@6t/ha FYM + @2t/ha Neem cake	1.17	1.09	2.42	2.42	53.33	40.87	49.00	41.33
T_9	@6t/ha FYM + @4t/ha Neem cake + *Rhizobium*	1.16	1.04	2.28	2.28	57.50	40.85	51.33	42.75
	F- test	S	S	S	S	S	S	S	S
	S.Ed. (±)	0.02	0.04	0.02	0.02	1.14	0.72	2.17	0.80
	C.D. (P = 0.05)	0.04	0.08	0.05	0.04	2.42	1.52	4.59	1.70

Table 2: Effect of nitrogen, phosphorus, potassium, boron and zinc on chemical analysis of soil.

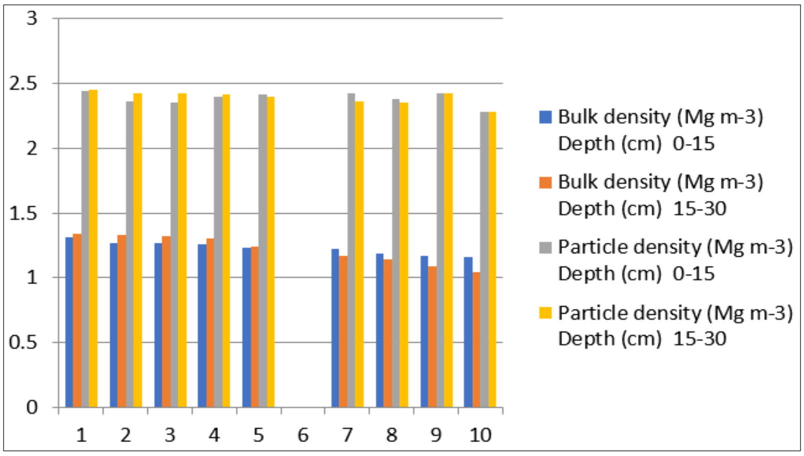
Symbols	Treatments	Soil pH		Electrical conductivity ($dS\ m^{-1}$)		Organic Carbon (%)		Available Nitrogen ($kg\ ha^{-1}$)	
		Depth (cm)		Depth (cm)		Depth (cm)		Depth (cm)	
		0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
T_1	Control	7.52	7.54	0.15	0.11	0.47	0.44	245.88	183.18
T_2	@0% FYM + @ 2t/ha Neem cake	7.52	7.50	0.16	0.13	0.50	0.47	249.52	189.03
T_3	@0% FYM + @ 4t/ha Neem cake + *Rhizobium*	7.48	7.45	0.17	0.14	0.51	0.47	253.72	191.58
T_4	@3t/ha FYM + @0% Neem cake	7.48	7.49	0.17	0.15	0.53	0.49	265.52	200.24
T_5	@3t/ha FYM + @2t/ha Neem cake	7.42	7.43	0.18	0.17	0.55	0.51	273.80	205.71
T_6	@3t/h FYM + @4t/ha Neem cake + *Rhizobium*	7.42	7.39	0.19	0.19	0.57	0.52	278.99	211.67
T_7	@6t/ha FYM + @0% Neem cake	7.35	7.33	0.21	0.17	0.61	0.55	285.45	215.84
T_8	@6t/ha FYM + @2t/ha Neem cake	7.28	7.32	0.23	0.19	0.62	0.57	294.28	222.13
T_9	@6t/ha FYM + @4t/ha Neem cake + *Rhizobium*	7.10	7.20	0.24	0.21	0.64	0.58	298.95	234.21
	F-test	S	S	S	S	S	S	S	S
	S.Ed.(±)	0.08	0.07	0.01	0.03	0.01	0.01	7.47	1.47
	C.D. (P = 0.05)	0.018	0.15	0.02	0.03	0.03	0.03	15.83	2.56

Table 3: Effect of Treatments Available Phosphorus (kg ha-1) Available Potassium (kg ha-1)

Symbols	Treatments	Available Phosphorus ($kg\ ha^{-1}$)		Available Potassium ($kg\ ha^{-1}$)	
		Depth (cm)		Depth (cm)	
		0-15	15-30	0-15	15-30
T_1	Control	20.38	21.48	128.62	128.48
T_2	@0% FYM + @ 2t/ha Neem cake	22.02	22.85	132.61	124.78
T_3	@0% FYM + @ 4t/ha Neem cake + *Rhizobium*	23.40	25.35	138.77	130.30
T_4	@3t/ha FYM + @0% Neem cake	23.55	26.50	148.88	137.05
T_5	@3t/ha FYM + @2t/ha Neem cake	24.34	27.58	158.33	138.62
T_6	@3t/h FYM + @4t/ha Neem cake + *Rhizobium*	25.48	28.50	166.72	156.11
T_7	@6t/ha FYM + @0% Neem cake	26.09	28.60	177.17	162.02
T_8	@6t/ha FYM + @2t/ha Neem cake	25.52	29.10	190.30	168.88
T_9	@6t/ha FYM + @4t/ha Neem cake + *Rhizobium*	30.77	29.28	205.25	186.75
	F-test	S	S	S	S
	S.Ed.(±)	1.41	1.09	5.12	1.78
	C.D. (P = 0.05)	2.98	2.30	10.85	2.98

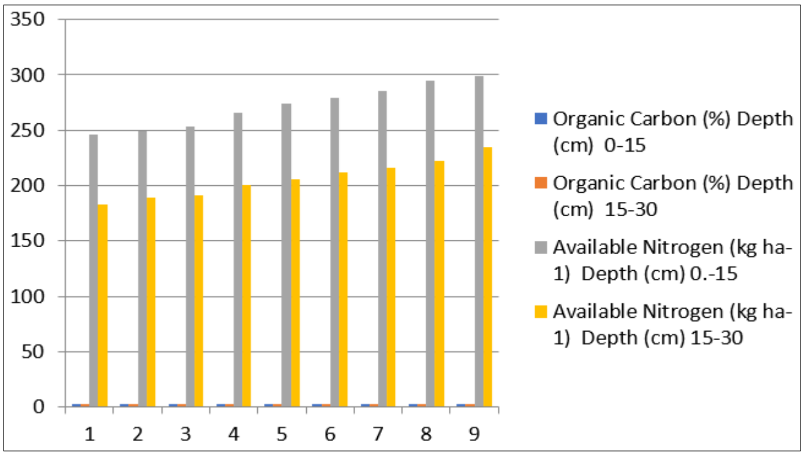


A)

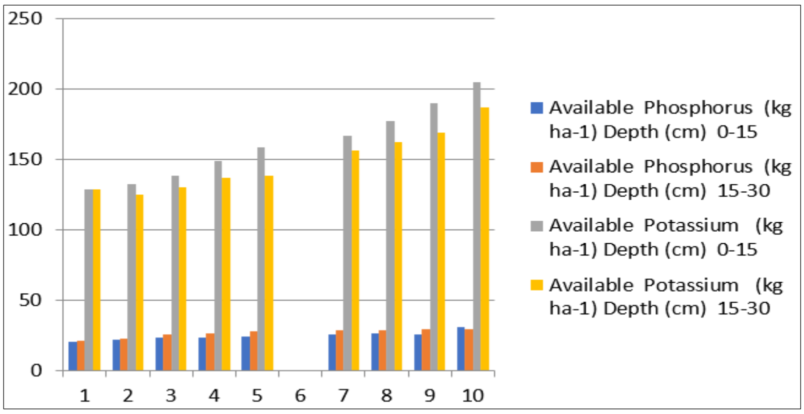


B)

Fig 1: Shows the figure of A and B Effect of FYM, Neem cake and *Rhizobium* on Physical analysis of soil.



A)



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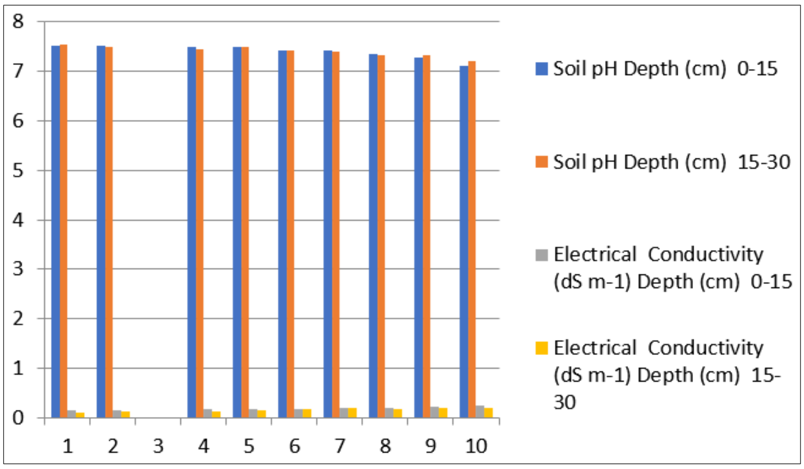

C)

Fig 2: Shows the figure of A B and C Effect of FYM, Neem cake and *Rhizobium* on Chemical analysis of soil.

Conclusion

It was concluded from the trial that the effect levels in the experiment. The best treatment combination was T_9 @100% FYM = @100% Neem cake + *Rhizobium* found to be appropriate for cowpea (*Vigna unguiculata* L.) var. Gomati in Prayagraj. Based on above findings. In post soil the important parameter on chemical properties on cowpea crop different treatment of FYM Neem cake and *Rhizobium*, the highest EC was found in treatment T_9 (0.24, 0.19), at depth of 0 to 15 cm and 15 to 30 cm respectively. In T_9 pH was found minimum (7.10, 7.20) highest organic Carbon (%), and available Nitrogen, Phosphorous, Potassium was found (0.64, 0.58), (298.95, 234.21), (30.77, 29.28), (205.25, 186.78), respectively at depth 0 to 15 cm and 15 to 30 cm for getting maximum growth, yield, Cost benefit ratio of the crop and Physico-chemical properties of soil. Therefore, here it's a need for further investigation to confirm the results at various locations in Prayagraj.

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Competing interests

Authors have declared that no competing interests exist.

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