

Response of NPK and Neem Cake on Soil Properties, Growth and Yield of Cluster Bean

ABSTRACT

An experiment was conducted on "Response of NPK and Neem cake on Soil health, Growth and Yield of Cluster Bean (*Cyamopsis tetragonoloba* L.)" at research farm of soil science and agricultural chemistry, during zaid season of 2023-24. In the present investigations experiment 9 treatments, were laid out in randomized block design with three replications. Cluster bean was taken for study and the pre sowing soil sample analysis and soil is sandy loam in texture, cluster bean responds significantly with the different treatment combination. The maximum nitrogen was recorded 304.67 kg ha⁻¹ in 0-15 cm depth and 258.6 kg ha⁻¹ in 15-30 cm depth under treatment T9 - [N20P40K40+Neem Cake@ 5 q ha⁻¹] and minimum nitrogen was recorded 175.1 kg ha⁻¹ in 0-15 cm depth and 142.33 kg ha⁻¹ in 15-30 cm depth in treatment T1 - [N0P0K0+Neem Cake@ 0 q ha⁻¹]. The maximum phosphorus was recorded 30.43 kg ha⁻¹ in 0-15 cm depth and 27.65 kg ha⁻¹ in 15-30 cm depth under treatment T9 - and minimum phosphorus was recorded 18.81 kg ha⁻¹ in 0-15 cm depth and 15.74 kg ha⁻¹ in 15-30 cm depth in treatment T1. The maximum potassium was recorded 252.9 kg ha⁻¹ in 0-15 cm depth and 186.7 kg ha⁻¹ in 15-30 cm depth under treatment T9 and minimum potassium was recorded 199.7 kg ha⁻¹ in 0-15 cm depth and 166.8 kg ha⁻¹ in 15-30 cm depth in treatment T1.

Keywords: Cluster bean; yield attributes; soil; nitrogen; phosphorus; potassium; Neem cake.

1. INTRODUCTION

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. Soil pH directly affects the solubility of many of the nutrients in the soil needed for proper plant growth and development. Soil pH measurement is useful because it is a predictor of various chemical activities within the soil. As such, it is also a useful tool in making management decisions concerning the type of plants suitable for location, the possible need to modify soil pH (either up or down), and a rough indicator of the plant availability of nutrients in the soil. Three elements, carbon, oxygen and hydrogen, are essential to plant growth and are supplied by air and water. The other essential elements are referred to as plant nutrients, and are provided by the soil, or are added as fertilizers, and enter plants almost exclusively through the roots (Singh *et al.*, 2008).

Nutrient balance is the key component to increase crop yields. Excess and imbalanced use of nutrients has caused nutrient mining from the soil, deteriorated crop productivity and ultimately soil health. Replenishment of these nutrients through organic and combination with organic and

inorganic has a direct impact on soil health and crop productivity. By keeping in view all the factors related to soil fertility and productivity fertilizers are applied to soil to maintain soil status and crop productivity. Greengram highly responsive to fertilizer application. The dose of fertilizer depends on the initial soil fertility status and moisture availability conditions. Application of N, P and K to pulses and oilseeds showed greater response than to cereals. Sulphur not only improved grain yield but also improved the quality of crops (Hedge and Babu, 2004).

Nitrogen is an important nutrient for all crops. It increases yield nutrition also increases the protein content. Deficient plants may have stunted growth and develop yellow-green colour. It accelerates photosynthetic behavior of green plants as well as growth and development of living tissues specially tiller count in cereals (Azadi *et al.*, 2013).

Phosphorus is the second most important nutrient that must be added to the soil to maintain plant growth and sustain crop yield. It stimulates early root development and growth and thereby helps to establish seedlings quickly. Large quantities of Phosphorus are found in seed and fruit and it is considered essential for seed formation. It enhances the activity of rhizobia and increased the formation of root nodules. Thus, it helps in fixing more of atmosphere nitrogen in root nodules (Patil *et al.*, 2011).

Potassium is one of the seventeen elements which are essential for growth and development of plants. Potassium is required for improving the yield and quality of different crops because of its effect on photosynthesis, water use efficiency and plant tolerance to diseases, drought and cold as well for making the balance between protein and carbohydrates (Singh *et al.*, 2008).

Neem cake organic manure protects plant roots from nematodes, soil grubs and termites, probably due to its residual limonoid content. It also acts as a natural fertilizer with pesticidal properties. Neem cake is widely used in India to fertilize paddy, cotton and sugarcane and almost all vegetables. Neem cake improves the organic matter content of the soil, helps improve soil texture, water holding capacity, and soil aeration for better root development.

Neem cake has an adequate quantity of NPK in organic form for plant growth. Being a totally botanical product it contains 100% natural NPK content and other nutrients as N (Nitrogen 2.0% to 5.0%), P (Phosphorus 0.5% to 1.0%), K (Potassium 1.0% to 2.0%), Ca (Calcium 0.5% to 3.0%), Mg (Magnesium 0.3% to 1.0%), S (Sulphur 0.2% to 3.0%), Zn (Zinc 15 ppm to 60 ppm), Cu (Copper 4 ppm to 20 ppm), Fe (Iron 500 ppm to 1200 ppm), Mn (Manganese 20 ppm to 60 ppm). It is rich in both sulphur compounds.

Cluster bean (*Cyamopsis tetragonoloba* L.) is an important kharif crop that belongs to leguminaceae family. It has been emerged in North western India through trans-domestication of *Cyamopsis senegalensis* and was separated into three species, viz. *C. tetragonoloba*, *C. senegalensis* and *C. serrata*. Among these three species, *Cyamopsis tetragonoloba* is widely grown. It is a self-pollinated, diploid plant with 14 number of chromosomes ($2n = 14$). Cluster bean is also being widely known as guar, guwar, gavar or guwar bean and is the source of guar gum having a wide range of industrial applications. It is a drought sufferance leguminous crop because of tap rooting system and has high capacity to recover from water stress. The root "Guar" represents its originated from Sanskrit word "Gauaahar" which mean cow fodder of the livestock. It is a drought tolerant crop mainly cultivated in arid and semi-arid regions of the world. It is grown mainly in countries like India, Pakistan, Morocco, USA, Germany, Italy, Greece, and Spain.

India alone accounts for 80% of the world's total production of cluster bean which ranged from 14.24 lakh tonnes to 16.76 lakh tones for year 2017-18 (Anonymous, 2018).

In India, vegetable cluster bean is widely cultivated throughout India in both of Zaid and rainy. It is generally cultivated in of urban, rural areas and also in kitchen gardens. India is the world largest producer of guar, contributing about 80 per cent of world production. In India, it is mainly cultivated area under Uttar Pradesh and Maharashtra. The cultivated area under beans in India during 2018-19 was 229 lakh ha with the production of 2324 MT. The cultivated area of gaur in Gujrat is 35.82 thousand

ha with a production 365.11 thousand. In Rajasthan, cluster bean is commonly grown in Barmer, Churu, Sriganganagar, Nagaur, Jalore, Sikar, Jaisalmer, Bikaner, Jaipur and Alwar districts. Rajasthan occupies first position in India both in area and production. It accounts nearly 82.1 per cent area and 70 per cent production in India. Haryana and Gujarat have second and third position, respectively. Rajasthan has an area of 30.33 lakh hectare, with production of 17.16 metric tonnes with a productivity of 566 kg ha⁻¹ (Butt *et al.* 2007).

Cluster bean is an important summer annual legume that grows upward that reaches a maximum height of 18 to 40 inches. It develops tap roots that can reach moisture deep below the soil surface and has a single main stem. Cluster bean flowers are of purple to pink colour having a length of about 8 mm and are formed in axillary racemes. Pods of cluster bean are 1.5 to 4 inches long containing 5 to 12 seeds each and seeds are dull-white to pink to light gray or black colored. Guar is a short growing season crop. Its growing season is from July to August and harvesting season lasts from October to November. It grows well on fertile and sandy loam soils with medium texture. Like other legumes, guar is a wonderful soil- building crop with respect to available nitrogen. A large endosperm is found in guar beans that contain galactomannan gum (guar gum) which forms gel when come in contact with water. Guar gum is soluble polysaccharide in cold water, extracted from cluster beans. Guar gum consists of (1→4)-linked β-D- manna units with (1→6)-linked α-D-galactose residues as side chains. Guar gum is composed of galactomannan (75-85%), moisture (8-14%), protein (5-6%), fiber (2-3%) and ash (0.5-1%) (Mudgil *et al.*, 2014).

2. MATERIALS AND METHODS

2.1 Geographical Location of the Experimental Site

The experimental site is located at a latitude of 25.41° North and longitude of 81.84 ° East, with an altitude of 98 meters above the mean sea level (MSL).

2.2 Climatic Conditions of the Experimental Area

The area of Prayagraj comes under humid sub-tropical climate, which experiences warm humid monsoon, hot dry summer and cold dry winter. The annual mean temperature is 26.1°C while monthly mean temperatures are 18-29°C. The daily average maximum temperature is about 22°C and the minimum temperature is 9°C. The average annual rainfall received is 1042.2 mm. At this location, the temperature reaches upto 46°C-48°C and the minimum temperature recorded is 4°C-5°C. The relative humidity ranges in this location ranges between 20-94%.

3. RESULTS AND DISCUSSION

3.1 Effect of NPK, and Neem cake on Physical Properties of Post-Harvest Soil of Cluster Bean

The maximum bulk density was recorded 1.35 Mg m⁻³ in 0-15 cm depth and 1.39 Mg m⁻³ in 15-30 cm depth under treatment T1 and minimum bulk density was recorded 1.17 Mg m⁻³ in 0-15 cm depth and 1.21 Mg m⁻³ in 15-30 cm depth in treatment T9. The maximum particle density was recorded 2.40 Mg m⁻³ in 0-15 cm depth and 2.54 Mg m⁻³ in 15-30 cm depth under treatment T1 and minimum particle density was recorded 2.23 Mg m⁻³ in 0-15 cm depth and 2.35 Mg m⁻³ in 15-30cm depth in treatment T9. The application of treatment T9 recorded the highest porosity (48.78 %) among all the treatments, while lowest porosity was found in control in 0-15 cm depth. Application of T9 recorded the highest porosity (46.20 %) in 15- 30 cm soil, which was significantly superior to other treatments. Minimum porosity content in soil was recorded under control (41.57 %).

Table 1. Treatment combination

Treatment	Treatment Combination	Symbol
T1	@Absolute control	R0N0
T2	@[0% NPK + 50% Neem cake]	R0N1

T3	@[0% NPK + 100% Neem cake]	R0N2
T4	@[50% NPK + 0% Neem cake]	R1V0
T5	@[50% NPK + 50% Neem cake]	R1V1
T6	@[50% NPK + 100% Neem cake]	R1V2
T7	@[100% NPK + 0% Neem cake]	R2V0
T8	@[100% NPK + 50% Neem cake]	R2V1
T9	@[100% NPK + 100% Neem cake]	R2V2

The maximum water holding capacity was recorded 45.18 % in 0-15 cm depth and 42.97% in 15-30 cm depth in treatment T9 - and minimum water holding capacity was recorded 42.79 % in 0-15 cm depth and 40.33 % in 15-30 cm depth in treatment T1. Soil pH of this experiment ranged from 7.15 to 7.55 and it was maximum for T9 and minimum under T1 i.e. for 0-15 cm depth. In case of 15-30 cm depth it was maximum for T9 and minimum under T1 7.44 and 7.0 respectively. The application of NPK fertilizers can increase soil organic matter and improve soil structure, leading to a decrease in soil bulk density. This is because the organic matter helps to bind soil particles together, creating pore spaces that allow for better water and air movement. Additionally, the improved soil structure can lead to better root development and plant growth (Bhattacharyya *et al.*, 2008), Kumar *et al.* (2008). Increased organic matter can improve soil structure and increase soil pore space the retention of dissolved O.M. leading to change in physical properties of soil. Similar results were also reported by (Awad *et al.* (2014). Increasing the rate of organic fertilizers increases the soil organic carbon these organic carbon releases organic acid and organic acid increases the soil pH. When increases soil depth soil pH increases due to increase in alkalinity. These results indicated that the soil pH was decreased by N application at different stages. N application could increase the N contents of leaf and stem. Similar findings were recorded by Verma and Baigh, (2012) and Takase *et al.* (2011).

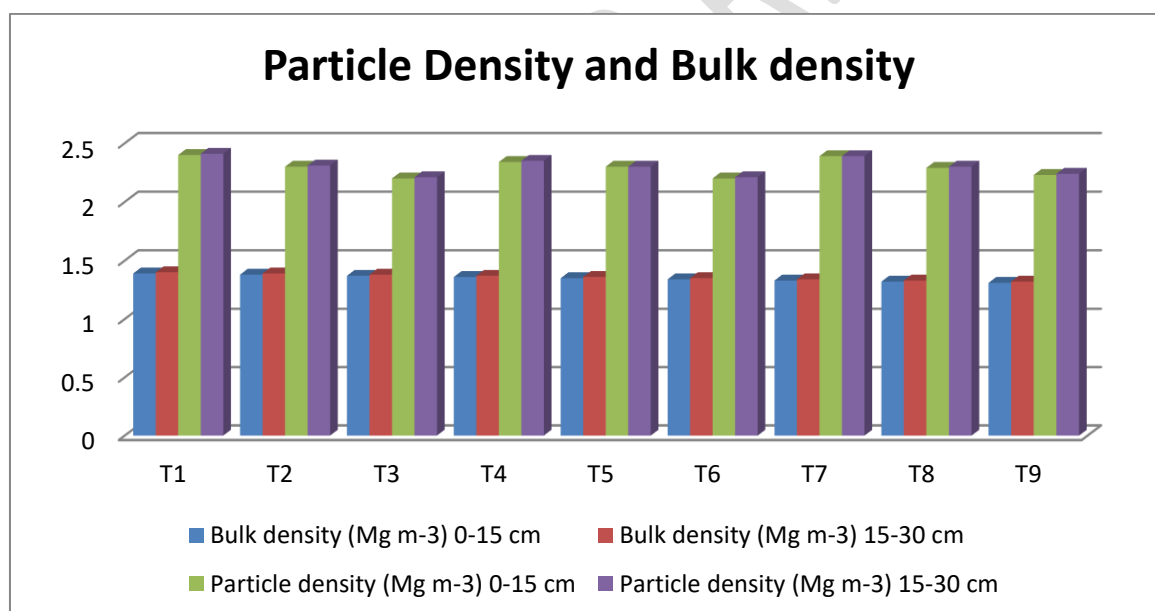


Fig. 1. Effect of NPK, and Neem cake on physical properties of post-harvest soil of cluster bean

Table 2. Effect of NPK, and Neem cake on physical properties of post-harvest soil of cluster bean

Treatment	Bulk density (Mg m ⁻³)		Particle density (Mg m ⁻³)		Pore space (%)		Water retaining capacity (%)		pH (1:2.5) w/v		Electrical conductivity (ds m ⁻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
T1	1.39	1.40	2.40	2.41	43.56	43.85	40.3	42.79	6.87	6.89	0.24	0.20
T2	1.38	1.39	2.30	2.31	44.45	43.65	43.0	44.14	6.85	6.87	0.26	0.22
T3	1.37	1.38	2.20	2.21	45.67	43.26	43.8	46.93	6.83	6.85	0.26	0.23
T4	1.36	1.37	2.34	2.35	43.65	41.25	40.7	42.15	6.84	6.86	0.24	0.21
T5	1.35	1.36	2.30	2.30	45.03	43.61	41.1	43.96	6.82	6.84	0.26	0.23
T6	1.34	1.35	2.20	2.21	44.66	42.60	43.2	45.16	6.81	6.83	0.27	0.23
T7	1.33	1.34	2.39	2.39	43.98	41.69	41.3	43.00	6.80	6.82	0.25	0.21
T8	1.32	1.33	2.29	2.30	44.66	42.61	41.6	43.16	6.79	6.81	0.25	0.22
T9	1.31	1.32	2.23	2.24	46.01	45.69	42.4	45.18	6.78	6.80	0.28	0.24
C.D. at 5%	-	-	-	-	0.064	0.050	0.7	0.555	-	-	-	-
S.Em. (±)	-	-	-	-	0.021	0.017	2.1	1.67	-	-	-	-
F-Test	NS	NS	NS	NS	S	S	S	S	NS	NS	NS	NS

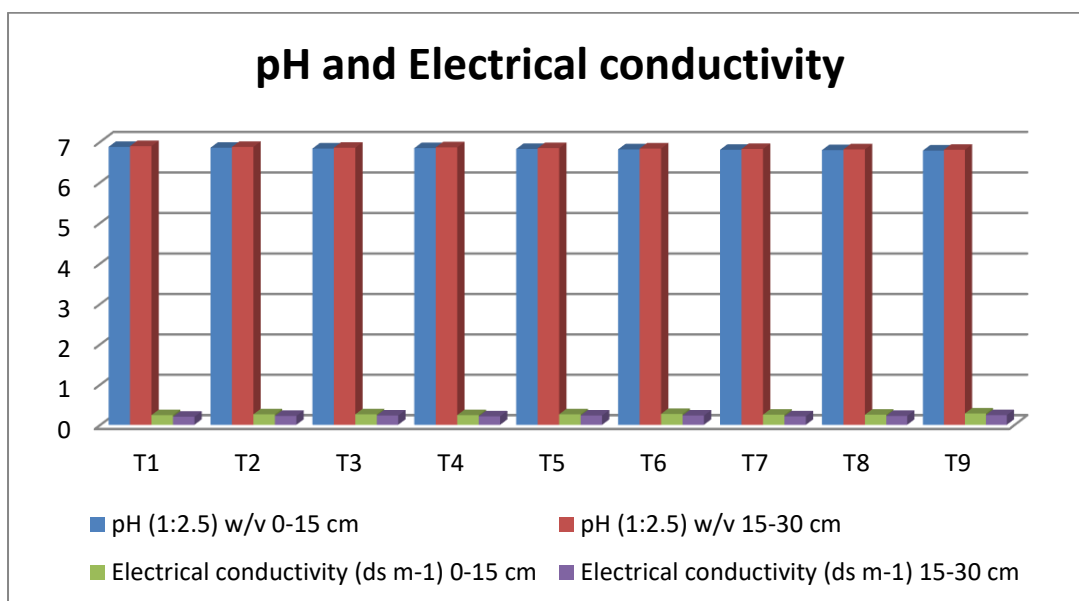


Fig. 2. Effect of NPK, and Neem cake on physical properties of post-harvest soil of cluster bean

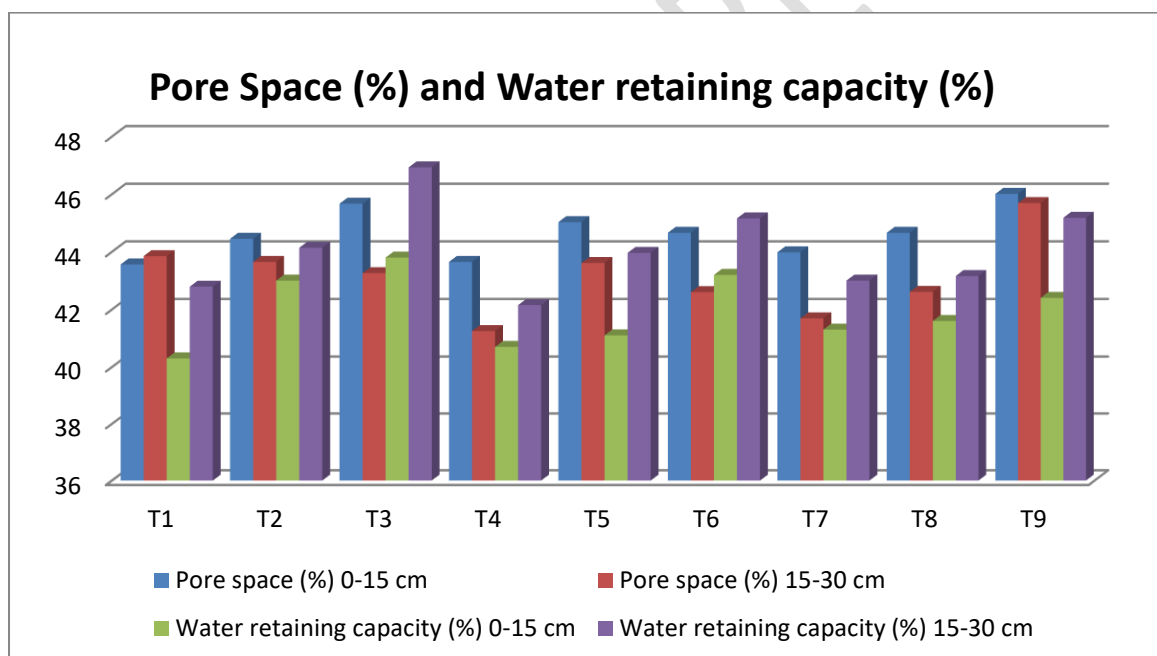


Fig. 3. Effect of NPK, and Neem cake on physical properties of post-harvest soil of cluster bean

3.2 Effect of NPK, and Neem Cake on Chemical Properties of Post-Harvest Soil of Cluster Bean

The treatment T9 - recorded the highest organic carbon is 0.530 % in 0-15 cm soil, which was significantly superior to other treatments. Minimum organic carbon content in soil was recorded under in T1 (0.470 %). Significantly higher O.C attributed to bulk posting of organic matter. Available Nitrogen of soil as influenced by N, P, K, The maximum nitrogen was recorded 182 kg ha⁻¹ in 0-15 cm depth and 168 kg ha⁻¹ in 15-30 cm depth under treatment T9 and minimum nitrogen was recorded

113 kg ha⁻¹ in 0-15 cm depth and 92.5 kg ha⁻¹ in 15-30 cm depth in treatment T1. The maximum phosphorus was recorded 19.8kg ha⁻¹ in 0-15 cm depth and 17.7kg ha⁻¹ in 15-30 cm depth under treatment and minimum phosphorus was recorded 14.3 kg ha⁻¹ in 0-15 cm depth and 11.2 kg ha⁻¹ in 15-30 cm depth in treatment T₁. The maximum potassium was recorded 140 kg ha⁻¹ in 0-15 cm depth and 133 kg ha⁻¹ in 15-30 cm depth under treatment T₉ and minimum potassium was recorded 126 kg ha⁻¹ in 0-15 cm depth and 125 kg ha⁻¹ in 15-30 cm depth in treatment T₁. Similar findings were reported by Moharana *et al.* (2012), Katkar *et al.* (2011), Patel *et al.* (2018) and Rathore *et al.* (2007).

Table 3. Effect of NPK, and Neem cake on Chemical properties of post-harvest soil of cluster bean

Treatment	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
T1	0.35	0.33	264.04	262.04	17.3	15.99	166.3	164.5
T2	0.36	0.34	266.87	264.17	17.9	16.59	167.4	165.6
T3	0.38	0.36	269.28	267.28	18.4	17.09	169.1	167.3
T4	0.36	0.34	271.48	269.98	17.6	16.29	168.6	166.8
T5	0.38	0.36	273.14	271.64	18.1	16.79	171.1	169.3
T6	0.39	0.37	275.87	273.87	18.9	17.59	174.3	172.5
T7	0.37	0.35	277.56	275.16	17.9	16.59	176.7	174.9
T8	0.39	0.37	281.76	279.76	20.4	19.09	181.1	179.3
T9	0.41	0.39	283.43	281.36	22.8	21.49	183.2	181.4
C.D. at 5%	0.014	0.003	10.01	4.01	0.99	0.733	0.947	0.56
S.Em. (±)	0.005	0.001	3.27	4.01	1.294	1.044	1.247	1.119
F-Test	S	S	S	S	S	S	S	S

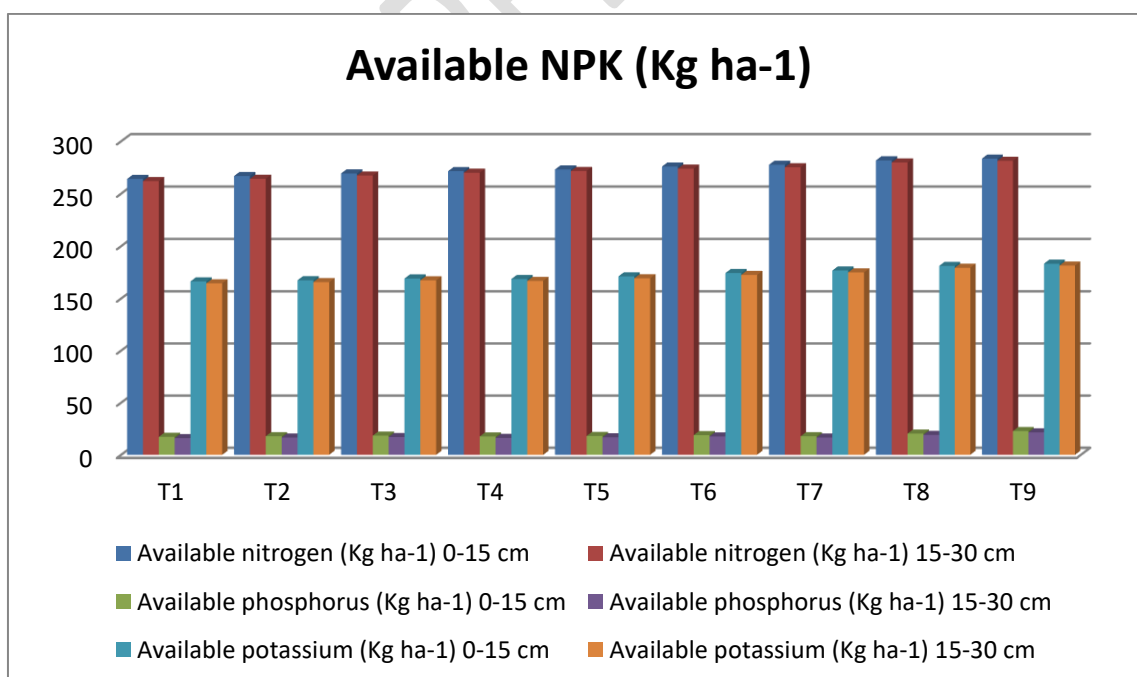


Fig. 4. Effect of NPK, and Neem cake on Chemical properties of post-harvest soil of cluster bean

3.3 Effect of NPK, and Neem Cake on Plant Growth and Yield Parameter of Cluster Bean

Treatment T9 attained the maximum plant height as 26.43 cm, 69.09 cm and 69.71 cm at 30, 60 and 90 DAS at harvest stage, respectively. Among the various treatments, control plot recorded the minimum plant height to the tune 13.5 cm, 41.2 cm and 48.5 cm at 30, 60 and 90 DAS at harvest stage, respectively. The maximum number of leaves per plant 8.31, 18.60 and 25.11 at 30, 60 and 90 DAS was found in T9 and minimum number of leaves plant⁻¹ 7.61, 16.22 and 21.11 at 30, 60 and 90 DAS was found in T1 respectively. The maximum number of pod plant⁻¹ was recorded 77.2 in treatment T9 - and minimum 39.06 in T1 respectively which was higher than number of pod plant⁻¹ any other treatment combination. The maximum pod yield was recorded 48.22 q ha⁻¹ in treatment T9 and minimum 29.25 q ha⁻¹ in T1 respectively which was higher than pod yield any other treatment. Similar finding was observed by Ali *et al.*, 2011, Chaudhari *et al.* (2013), Deshmukh *et al.* (2014), Biswas *et al.* (2014) and Masih *et al.* (2020).

Table 4 Effect of NPK, and Neem cake on plant growth and yield parameter of cluster bean

Treatment	Plant height (cm)			No. of Branches plant ⁻¹	Number of leaves			No. of pod plant ⁻¹	Pod yield (qha ⁻¹)
	30 DAS	60 DAS	90 DAS		30 DAS	60 DAS	90 DAS		
T1	13.56	41.22	48.5	4.100	7.61	16.22	21.11	39.06	29.25
T2	16.56	53.74	58.44	5.033	7.78	17.47	21.98	41.50	31.74
T3	17.86	55.15	60.04	5.267	7.91	17.62	23.11	43.60	33.44
T4	19.46	58.89	65.61	6.167	8.09	17.78	23.6	46.80	36.12
T5	21.03	58.30	66.36	6.433	8.13	18.04	23.85	59.13	38.58
T6	22.13	61.53	71.28	6.233	8.16	18.14	23.91	61.76	40.33
T7	24.03	68.49	77.22	6.233	8.20	18.31	24.44	73.63	43.11
T8	24.96	67.38	78.02	6.633	8.22	18.53	24.91	75.80	45.23
T9	26.43	69.09	79.71	6.733	8.31	18.6	25.11	77.20	48.22
C.D. at 5%	0.15	0.269	0.279	0.054	S	S	S	0.58	1.395
S.Em. (±)	0.05	0.089	0.091	0.018	0.13	0.24	0.41	0.193	0.461
F-Test	S	S	S	S	0.39	0.72	1.22	S	S

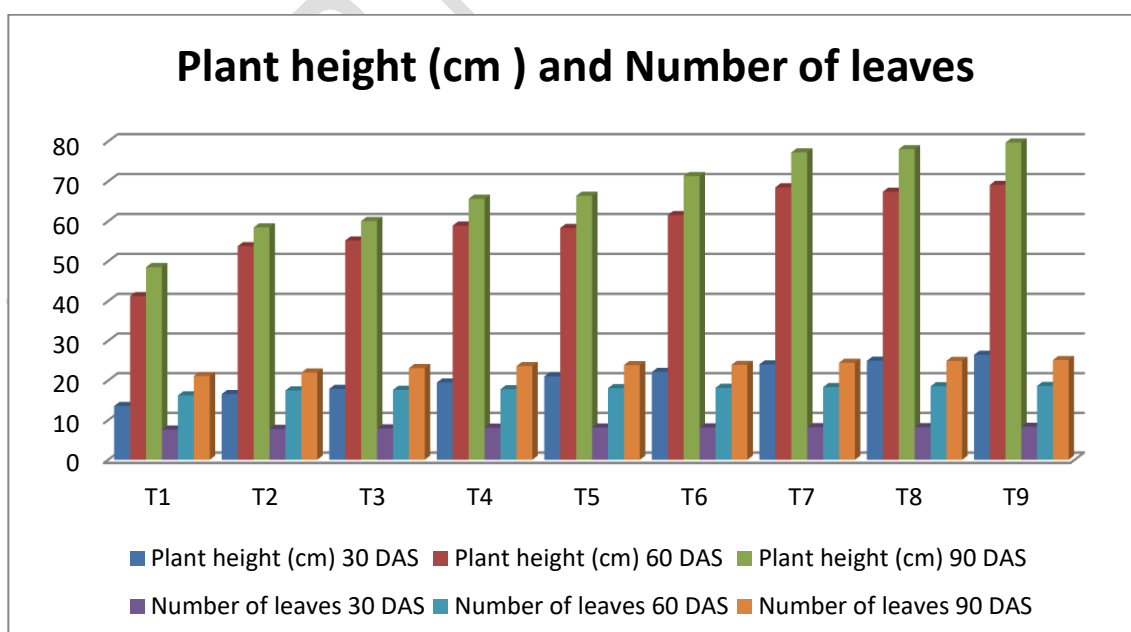


Fig. 5. Effect of NPK, and Neem cake on plant growth parameter of cluster bean

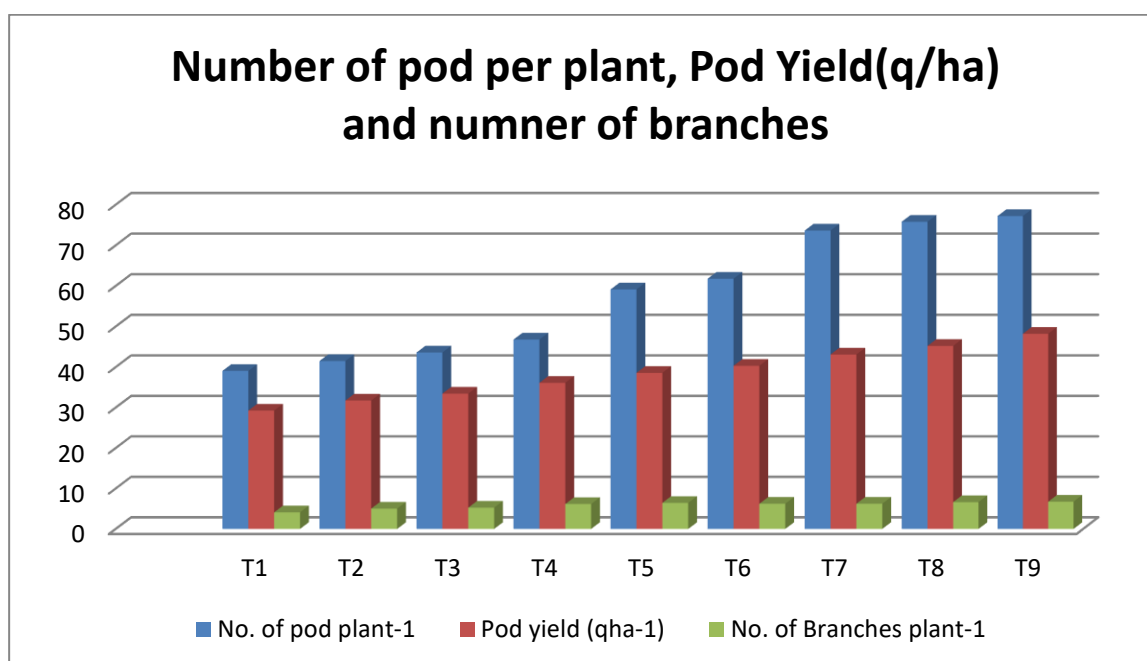


Fig. 6. Effect of NPK, and Neem cake on yield parameter of cluster bean

3.4 Economics of Cluster Bean

Among the various treatments, treatment T₉ provided the highest net return of Rs. 83710 ha⁻¹ that excelled rest of the treatments. Treatment T₈ was observed as the next superior and best treatment by fetching the net returns of Rs. 33900 ha⁻¹. However, the control plot treatment showed lowest net returns of Rs. 18350 ha⁻¹. The highest mean B: C ratio of 2.37 was recorded with the application of over other treatments for cluster bean cultivation.

Table 5. Economics of different treatment combination of Cluster bean

Treatment	Pod yield (qha ⁻¹)	Selling price (Rs/q)	Cost of Cultivation (Rs/ha)	Gross return (Rs)	Net return (Rs.)	C:B Ratio
T1	29.25	3000	53850	87750	33900	1.62
T2	31.74	3000	55850	95220	39370	1.7
T3	33.44	3000	57850	100320	42470	1.73
T4	36.12	3000	55400	108360	52960	1.95
T5	38.58	3000	57400	115740	58340	2.01
T6	40.33	3000	59400	120990	61590	2.03
T7	43.11	3000	56950	129330	72380	2.27
T8	45.23	3000	58950	135690	76659	2.3
T9	48.22	3000	60950	144660	83710	2.37

4. CONCLUSION

Findings of present study conclude that that treatment T₉ - [N₂₀P₄₀K₄₀+Neem Cake@ 5 q ha⁻¹] was best in all soil health parameters. T₉ also provide significantly highest vegetative growth as well as yield attributes and positive effect on net return up to ₹83710 ha⁻¹ with B: C ratio of 1:2.37 of cluster bean therefore, it is suggested that T₉ found most suitable for sustainable soil health parameters, cluster bean to obtain higher yield and economic of the farmers, the trail was based on one season, so that the findings can be substantiate before recommendation.

REFERENCES

- Anonymous (2018). Indian institute of maize research.
- Awad, N., Gagnon, M. and Messier, C. (2004) The relationship between impaired glucose tolerance, type2 diabetes, and cognitive function. *Journal of clinical and experimental neuropsychology*,26(8), 1044-1080.
- Azadi, E., Rafiee, M. and Hadis, N. (2013) the effect of different nitrogen levels on seed yield and morphological characteristic of mung bean in the climate condition of Khorramabad. *Annals of Biological Research*, 4(2):51-55
- Bhattacharya, C. B., Sen, S. and Koscho, D. (2008). Using corporate social responsibility to win the war for talent. MIT Sloan management review, 49(2).
- Butt, M. S., Shahzadi, N., Kamran, M., Sharif and Nasir, M. (2007) Guar Gum: A Miracle Therapyfor Hypercholesterolemia, Hyperglycemia and Obesity, Critical reviews in food science and nutrition, 47(4): 389-396.
- Dash, S.K., Ansaba, V., Tripathy, L. and Pathak, M. (2019). Effect of integrated nutrient management on growth, yield and yield attributing parameters of french bean (*Phaseolus vulgaris* L.). *The Pharma Innovation Journal*, 8(11), 98-100.
- Hedge, D. M. and Babu, S. N. (2004) Role of balanced fertilization in improving crop yield and quality. *Fertilizers News*, 4(9): 03-31.
- Kumar, J. (2008) Physio-chemical properties of the soil, under the two-forest plantation standsaround Varanasi (U.P.), India. influenced by integrated nutrient management under alley cropping system. *Indian Journal of Agricultural Sciences*; 89 (11): 1876– 80.
- Kumar, V., and Singh, C. (2018) Cluster bean: A novel alternative for commercial Guar Gum production. *Indian Farmer*, 383-387.
- Mudgil, D., Barak, S., and Khatkar, B.S. (2014) Guar gum: processing, properties and food applications. *Journal of food science and technology*, 51, 409-418.
- Patil, S.C., Jagtap, D.N. and Bhale, V.M. (2011) Effect of phosphorus and sulphur on growth and yield of moong bean. *Internet J. agric.Sci.*,7 (2): 348-351.
- Singh R.S. and Yadav M.K. (2008) Effect of phosphorus and biofertilizers on growth, yield and nutrient uptake of long duration mung under rainfed condition. *Journal of Food Legumes*.21 (1):46-48.
- Singh, R.N., Surendra Singh, Prasad, S.S., Singh, V.K and Pramod kumar. (2011) Effect of integrated nutrient management on soil fertility, nutrient uptake and yield of rice- pea cropping system on an upland acid soil of Jharkhand. *Journal of the Indian Society of Soil Science*. 59(2): 158-163.
- Takas e, M., Sam-Amoah, Owusu, L. K., Sekyere, J. D. (2011) the effects of four sources of irrigation water on soil chemical and physical properties. *Asian Journal of Plant Sciences* 10: 1, pp 92-96.18.
- Tosan Sahu, T. K., Kumar, M., Kumar, N., Chandrakar, T. and Singh, D. P. (2022). Effect of Nano urea application on growth and productivity of rice (*Oryza sativa* L.) under mid land situation of Bastar region. *Pharma Innov*, 11, 185-87.