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Effect of nitrogen, phosphorus, potassium, sulphur and zinc on soil health parameters of cluster bean (*Cyamopsis tetragonoloba* L.)

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Abstract
Inorganic fertilizers and micronutrient are important for crop productivity and soil health. A field experiment was conducted on cluster bean crop during August-November (Late *kharif*) 2020 at the research farm of Department of Soil Science and Agricultural Chemistry, NAI, SHUATS. The experiment was laid out in Randomized Block Design with 9 treatment combinations Nitrogen, Phosphorus, Potassium, Sulphur and Zinc (0% NPK S Zn, 50% NPK S Zn, 100% NPK S Zn) with 3 replications respectively. It was observed that for physical and chemical properties of soil and growth, yield and economic parameters in treatment T_9 @100% NPK, @100% S, @100% Zn were improved significantly due to application of Nitrogen, Phosphorus, Potassium, Sulphur and Zinc. The results showed that progressive increase of bulk density (Mg m^{-3}), Particle density (Mg m^{-3}), Pore space (%), Water Retaining Capacity(%), Soil pH, Electrical Conductivity (dS m^{-1}) of soil is increased as the depth of soil increased, Organic Carbon, Available Nitrogen (kg ha^{-1}), Available Phosphorus (kg ha^{-1}), Available Potassium (kg ha^{-1}), Available Sulphur (kg ha^{-1}) and Available Zinc (ppm) in soil is decreased with increase in soil depth.

Keywords: Physical, chemical properties of soil, nitrogen, phosphorus, potassium, sulphur, zinc and cluster bean

Introduction
Cluster bean (*Cyamopsis tetragonoloba* L.) popularly known as guar, is a drought hardy and deep-rooted legume crop grown for feed, fodder, green manure and vegetable purpose. The term guar has been evolved from the common use of the crop and its residue as cattle feed Gowahaar (Gow means cow and Ahaar mean feed). It is a drought resistant plant which belongs to the family Leguminaceae and subfamily Papilinaceae and is known to improve soil fertility. Root nodules contain nitrogen-fixing bacteria and incorporation of crop residues improves soil fertility and productivity. (Aykroyd, 1963) [5].

The origin of crop has been suggested in India and tropical Africa. India leads among the major guar producing countries of the world, contributing around 75 to 80% to the world's total production (7.5 to 10 lakhs tonnes). The composition of clusterbean is 8.10 g moisture, 10.8 g carbohydrate, 23% protein, 1.4 g fat, 1.4 g minerals, 0.09 mg thiamine, 0.03 mg riboflavin, 47 I.U. vitamin C, 316 I.U, vitamin A (per 100 g of edible portion) (Aykroyd, 1963) [5].

Guar is also cultivated as cash crop in Australia, Brazil, South Africa and Pakistan. Besides the traditional use of guar as feed and fodder, it has gained special industrial significance on account of increasing use of guar gum (galactomannan), which is mainly present in seed endosperm. Green pods of clusterbean are rich source of protein, minerals and vitamins. Its seeds are mainly used for extraction of endospermic gum (30-35%) (Ayub *et al*., 2012) [1].

Cluster bean being a legume crop which has the capacity to fix atmospheric nitrogen by its effective root nodules the major part of nitrogen is met through *rhizobium* present in the root nodules hence, crop does not require additional nitrogen for its initial growth and development stage. The nitrogen application increased crude protein, crude fibre contents, ash percentage, carbohydrates, and leaf area per plant, dry matter and green fodder yield of cluster bean cultivars (Ayub *et al*., 2010) [2].

Phosphorus plays a vital role in photosynthesis, respiration, energy storage, cell elongation and improves the quality of crops, transformation of energy, in carbohydrate metabolism, in fat metabolism and also in respiration of plants. It stimulates early root development and growth and there by helps to establish seedlings quickly. It enhances the activity of *rhizobium* and increased the formation of root nodules. Thus, it helps in fixing more of atmosphere nitrogen in root nodules.

The potassium activates more than 60 enzymes and enzymatically catalyzes the system involved in photosynthesis, metabolism and translocation of carbohydrates and proteins. Other benefits ascribed to Potassium include resistance of plants against pests, disease and stresses caused by drought, frost, salinity, sodicity and in assuring improved crop quality characteristics (Kherawat *et al.*, 2013) [19].

Zinc is required for plant growth's as an activator of several enzymes and is directly involved in the biosynthesis of growth regulators such as auxin, which promotes production of more plant cells and biomass that will be stored in the plant organs especially in seeds and their deficiencies may be one of the important reasons of poor yields. (Alloway, 2008.) [3].

Sulphur plays an important role in many plant physiological processes like synthesis of sulphur containing amino acids (cystine, cysteine and methionine), synthesis of certain vitamins (biotine and thiamine), coenzyme-A, metabolism of carbohydrates, proteins and fats. Sulphur also promotes nodulation in legumes. Although not a constituent, sulphur is required for the synthesis of chlorophyll. (Baviskar *et al.*, 2012).

Materials and Methods

Experimental site

The experiment has conducted at the Soil Science Research Farm of SHUATS, Prayagraj, which is located at $25^0$24'30" N latitude, 81^0 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 3-5 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 reduce 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) [11].

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 inorganic fertilizers Nitrogen, Phosphorus, Potassium, Sulphur and Zinc (0%, 50%, 100%) respectively, the treatments are replicated into three times dividing the experimental area into twenty-seven plots.

Physical analysis of soil

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

Chemical analysis of soil

The chemical analysis of soil was done to determine Organic carbon, pH and electrical conductivity (EC), available Nitrogen, available Phosphorus, available Potassium, available Sulphur and available Zinc. The soil organic matter was estimated by "hydrochloric and oxidation method" as suggested by (Wakley and Black, 1947). The pH of soil was determined by Digital Electric pH meter (Jackson 1958) and the EC was determined by electrical Conductivity meter (Wilcox, 1950) [33]. Available Nitrogen content was estimated by Kjeldahl's method (Subbaih and Asijia, 1956). The available Phosphorus and available Potassium contents were determined by "Olsen colorimetric method" (Olsen *et al.*, 1954) [23] and flame Photometer (Toth and Prince, 1949) [31] respectively. Sulphur is determined with the help of UV Spectrophotometer Bardsley and Lancaster (1960) [10]. Zinc in soil determined with the help of atomic absorption spectrophotometer Lindsay and Norvell (1978) [20].

Treatment combinations

T_1 (Absolute Control),
T_2 (@0% NPK + @50% S + @50% Zn),
T_3(@0% NPK + @100% S + @100% Zn),
T_4 (@50% NPK + @0% S + @0% Zn),
T_5(@50% NPK + @50% S + @50% Zn),
T_6 (@50% NPK + @100% S + @100% Zn),
T_7(@100% NPK + @0% S + @0% Zn),
T_8 (@100% NPK + @50% S + @50% Zn),
T_9(@100% NPK + @100% S + @100% Zn)

Statistical analysis

The data recorded during the course of investigation is subjected to Statistical analysis by Randomized Block Design for drawing conclusion. The significant and non-significant effect was judged with the help of 'F' (variance ratio) table. The significant difference between the means was tested against the critical difference of 5% level. For testing the hypothesis, the ANOVA table was used. (Fisher, 1960) [15].

Results and Discussion

Physical analysis of soil

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

The Bulk density (Mg m^{-3}) of soil influenced in various treatment combinations were subjected. There is a significant difference among the treatments. The maximum bulk density of soil was recorded at T_9 @100% NPK, @100% S, @ 100% Zn (1.29) and (1.37) at depth 0-15 cm and 15-30 cm and the minimum Bulk density of soil was recorded at T_1 (Control) (1.12) and (1.20) at depth 0-15 cm and 15-30 cm respectively. As the usage level of inorganic fertilizer increases the bulk density of the soil also increases. This was due to the compaction of the soil, compaction increases bulk density of the soil. Similar results have also been recorded by Bhattacharya *et al.*, (2004) [9], Thomson *et al.*, (2008) and Bhattacharya *et al.*, (2017) [6].

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

The particle density (Mg m^{-3}) of soil influenced in various treatment combinations were subjected. The particle density of soil was found to be significant difference among the treatments. The maximum particle density of soil was recorded at T_9 @100% NPK, @ 100% S, @ 100% Zn (2.67) and (2.70) at depth 0-15 cm and 15-30cm and minimum particle density of soil was recorded was recorded at T_1 (Control) (2.46) and (2.47) at a depth 0-15cm and 15-30 cm respectively. The above findings showed that the optimum dose of inorganic fertilizers increased the particle density significantly. This shows that increasing application of inorganic fertilizer significantly improves the rate of compaction there by, increase the soil particle density Similar findings also reported by Walia (2010) [32], Bhattacharya *et al*., (2004) [9] and Chaudhary *et al*., (1997) [14].

Pore space (%) of soil

The pore space (%) of soil after crop harvest influenced in various treatment combinations were subjected. The maximum pore space was recorded at T_9 @100% NPK, @100% S, @100% Zn (63.42) and (58.49) at depth 0-15 cm and 15-30 cm respectively and the minimum pore space was recorded at T_1 (Control) (48.20) and (44.67) at depth 0-15 cm and 15-30 cm. There is a significant difference among the treatments. The above findings showed that the optimum dose of inorganic fertilizers increased the pore space significantly. This is due to the increasing application of inorganic fertilizer significantly improves the soil pore space. Similar findings also reported by Chauhan *et al*., (2014) [13], Walia (2010) [32] and Chaudhary *et al*., (1997) [14].

Water retaining capacity (%) of soil

The water retaining capacity of soil influenced in various treatment combinations were subjected. The maximum water retaining capacity of soil was recorded at T_9 @100% NPK, @100% S, @100% Zn (59.19) and (62.74) at depth 0-15 cm and 15-30 cm and the minimum water retaining capacity of soil was recorded at T_1 (Control) (49.71) and (53.72) at depth 0-15 cm and 15-30 cm. There is significant difference among the treatments. It was found that water retaining capacity of the soil increases as the depth of the soil increases. This is due to the increasing application of inorganic fertilizer significantly improves the water holding capacity. Similar findings also reported by Singh *et al.*, (2016) [27] and Mann *et al.*, (2006) [21].

Chemical analysis

Soil pH

The pH (1:2.5) of soil influenced in various treatment combinations were subjected. The maximum pH of soil was recorded at T_9 @100% NPK, @100% S, @100% Zn (7.58) and (7.62) at depth 0-15cm and 15-30cm and minimum pH of soil was recorded at T_1 (control) (7.10) and (7.15) at depth 0-15 cm and 15-30 cm. There is significant difference among the treatments. The above findings showed that the optimum dose of inorganic fertilizers increased the soil pH significantly. It was found that application of acidic fertilizers changes the soil pH. Similar findings also reported by Walia (2010) [32], Aphale *et al*., (2005) [4] and Thomson *et al*., (2008)

EC (dS m^{-1}) of soil

The EC of soil influenced in various treatment combinations were subjected. The maximum EC recorded at T_9 @100% NPK, @ 100% S, @ 100% Zn (0.26) and (0.28) at depth 0-15 cm and 15-30 cm respectively and the minimum EC recorded at T_1 (Control) (0.18) and (0.19) at depth 0-15 cm and 15-30 cm. There is significant difference among the treatments. The above findings showed that the optimum dose of inorganic fertilizers increased the EC significantly. 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 Aphale *et al*., (2005) [4] and Prakash *et al*., (2017) [25].

Organic carbon (%) in soil

The organic carbon influenced in various treatment combinations were subjected. The maximum organic carbon was recorded at T_1 (Control) (0.46) and (0.41) at depth 0-15cm and 15-30 cm. The minimum organic carbon recorded at T_9 @100% NPK, @ 100% S, @ 100% Zn (0.18) (0.10) at depth 0-15 cm and 15-30 cm. There is significant difference among the treatments. The above findings showed that the optimum dose of Nitrogen, Phosphorus, Potassium, Sulphur and Zinc decreased the organic carbon significantly. Similar findings also reported by Gangwar *et al*., (2009) [16] and Bhattacharya *et al*., (2017) [6].

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

The available Nitrogen in soil influenced in various treatment combinations were subjected. The maximum available nitrogen in soil was recorded at T_9 @100% NPK, @ 100% S, @ 100% Zn (235.34) at depth 0-15cm and (232.04) at a depth 15-30 cm respectively and the minimum available nitrogen in soil recorded at T_1 (Control) (210.32) and (209.78) at depth 0-15cm and 15-30 cm. There is significant difference among the treatments. The above findings showed that the optimum dose of inorganic fertilizers increased the available nitrogen in soil significantly. 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 Thompson (2008) [30] and Bolding *et al*., (2009) [8].

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

The available Phosphorus in soil influenced in various treatment combinations were subjected. The maximum available Phosphorous in soil was recorded at T_9 @100% NPK, @ 100% S, @ 100% Zn (23.30) and (20.14) at depth 0-15cm and 15-30 cm depth and the minimum available

Phosphorous in soil was recorded at T_1 (control) (11.75) and (11.17) at 0-15 cm and 15-30 cm respectively. There is significant difference among the treatments. The above findings showed that the optimum dose of inorganic fertilizers increased the available phosphorus in soil significantly. The deficiency of Phosphorus causes significant yield reduction in leguminous crops. Moreover, incorporation of legumes in cropping system with better phosphorus management under phosphorus-deficient conditions could be a promising tool for improving legume productivity. The similar findings were reported by of Chavan *et al.,* (2015) [12] and Singh *et al.*, (2016) [27].

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

The available potassium in soil influenced in various treatment combinations were subjected. The maximum available potassium in soil was recorded at T_9 @100% NPK, @ 100% S, @ 100% Zn (249.96) and (236.99) at depth 0-15 cm and 15-30 cm respectively and the minimum available potassium in soil was recorded at T_1 (Control) (213.93) and (196.38) at depth 0-15 cm and 15-30 cm respectively. There is significant difference among the treatments. The above findings showed that the optimum dose of inorganic fertilizers increased the available potassium in soil significantly. 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 Thompson (2008) [30], Singh *et al.*, (2016) [27] and Bolding *et al.*, (2009) [8].

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

The available sulphur in soil influenced in various treatment combinations were subjected. The maximum available sulphur is recorded in T_9 @100% NPK, @ 100% S, @ 100% Zn (19.07) and (15.51) at depth 0-15 cm and 15-30 cm respectively and the minimum available sulphur is recorded in T_1 (Control) (11.67) and (9.95) at depth 0-15 cm and 15-30 cm respectively. There is a significant difference among the treatments. The above findings showed that the optimum dose of inorganic fertilizers increased available sulphur in soil significantly which may be attributed to bringing the inorganic fertilizer, therefore helps in proving the available sulphur in soil. Similar findings were reported by Sunil *et al*. (2018) [26] and Kuniya *et al*., (2019) [18].

Available Zinc (ppm) in soil

The available zinc in soil influenced in various treatment combinations were subjected. The maximum available zinc is recorded at T_9 @100% NPK, @ 100% S, @ 100% Zn (1.62) and (1.03) at depth 0-15 cm and 15-30 cm and the minimum available zinc was recorded at T_1 (Control) (0.75) and (0.54) at depth 0-15 cm and 15-30 cm respectively. There is significant difference among the treatments. The above findings showed that the optimum dose of inorganic fertilizers increased the available Zinc in soil significantly. The basal application of zinc as an inorganic fertilizer helps the soil from being deficit of zinc. Similar findings were reported by Prakash *et al.*, (2017) [25], Mann *et al.*, (2006) [27], Pandey *et al*., (2019) [24].

Table 1: Effect of Nitrogen, Phosphorus, Potassium, Sulphur and Zinc on Physical Analysis of soil.

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	1.12	1.20	2.46	2.47	48.20	44.67	49.71	53.72
T_2	1.14	1.21	2.49	2.50	52.16	48.03	53.02	57.32
T_3	1.19	1.24	2.50	2.52	53.01	49.21	53.99	57.94
T_4	1.22	1.28	2.62	2.64	54.32	50.07	55.96	58.21
T_5	1.24	1.30	2.64	2.66	58.63	54.49	56.93	59.73
T_6	1.25	1.31	2.65	2.66	62.58	57.94	57.89	60.24
T_7	1.27	1.34	2.66	2.67	60.14	55.73	56.09	58.19
T_8	1.28	1.35	2.66	2.68	61.38	56.32	58.46	62.43
T_9	1.29	1.37	2.67	2.70	63.42	58.49	59.19	62.74
F- test	S	S	S	S	S	S	S	S
S. Ed. (±)	0.01	0.01	0.01	0.01	1.26	0.41	0.22	0.40
C. D. (P = 0.05)	0.01	0.02	0.02	0.01	2.68	1.22	2.59	0.85

Table 2: Effect of Nitrogen, Phosphorus, Potassium, Sulphur and Zinc on Chemical Analysis of soil.

Treatments	Soil pH		Electrical Conductivity (dS m^{-1})		Organic Carbon (%)		Available Nitrogen (kg ha^{-1})		Available Phosphorus (kg ha^{-1})		Available Potassium (kg ha^{-1})		Available Sulphur (kg ha^{-1})		Available Zinc (ppm)	
	Depth (cm)		Depth (cm)		Depth (cm)		Depth (cm)		Depth (cm)		Depth (cm)		Depth (cm)		Depth (cm)	
	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
T_1	7.10	7.15	0.18	0.19	0.46	0.41	210.32	209.78	11.75	11.17	213.93	196.38	11.67	9.95	0.75	0.54
T_2	7.26	7.28	0.19	0.20	0.41	0.39	216.15	215.68	13.72	13.05	226.38	207.67	12.71	11.59	0.83	0.69
T_3	7.39	7.42	0.20	0.21	0.39	0.37	217.60	216.09	14.70	13.48	227.38	208.49	13.23	12.51	0.90	0.75
T_4	7.15	7.18	0.20	0.22	0.42	0.40	226.12	216.92	16.01	14.13	238.35	222.31	12.35	11.32	0.78	0.63
T_5	7.47	7.49	0.23	0.25	0.35	0.34	226.98	224.05	16.86	15.98	239.38	227.00	14.78	12.98	1.24	0.84
T_6	7.51	7.56	0.25	0.27	0.32	0.30	228.60	224.96	17.04	16.28	240.91	229.78	17.50	14.22	1.47	0.91
T_7	7.33	7.37	0.24	0.26	0.38	0.35	231.63	226.57	20.29	17.59	244.04	231.41	14.46	12.56	1.13	0.78
T_8	7.48	7.55	0.25	0.27	0.27	0.26	234.94	231.56	21.46	19.07	245.08	234.45	17.24	13.94	1.42	0.93
T_9	7.58	7.62	0.26	0.28	0.18	0.10	235.34	232.04	23.30	20.14	249.96	236.99	19.07	15.51	1.62	1.03
F- test	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
S. Ed. (±)	0.02	0.01	0.01	0.01	0.01	0.01	0.81	0.57	0.28	0.26	1.14	1.15	0.56	0.49	0.03	0.04
C. D. (P = 0.05)	0.05	0.03	0.01	0.02	0.02	0.02	1.71	1.22	0.60	0.55	2.43	2.44	1.19	1.03	0.07	0.08

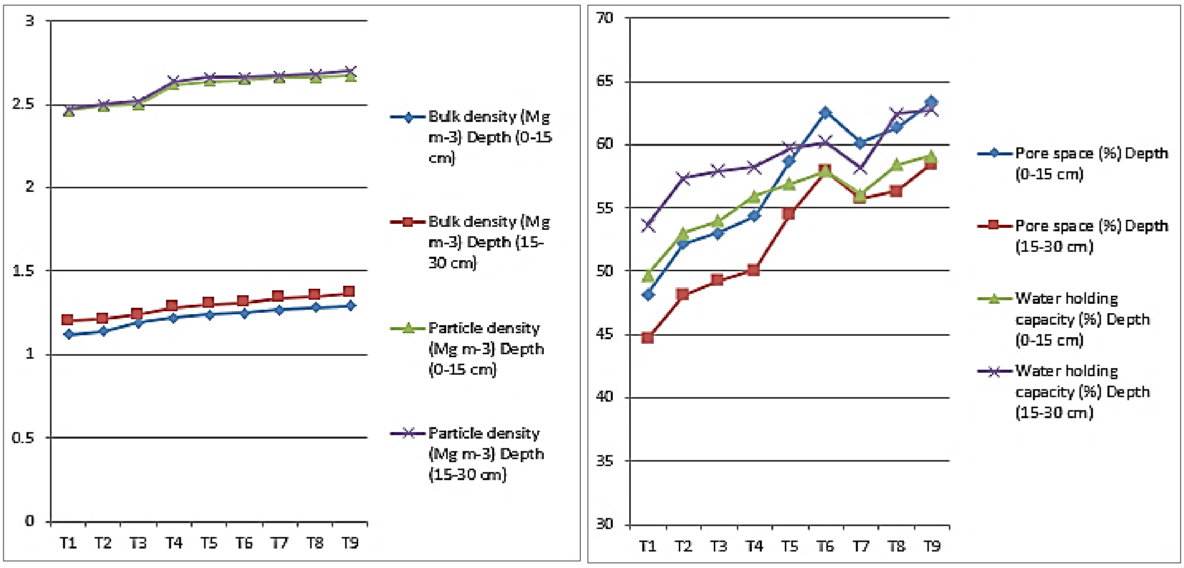

Fig 1 & 2: Effect of Nitrogen, Phosphorus, Potassium, Sulphur and Zinc on Physical Analysis of soil.

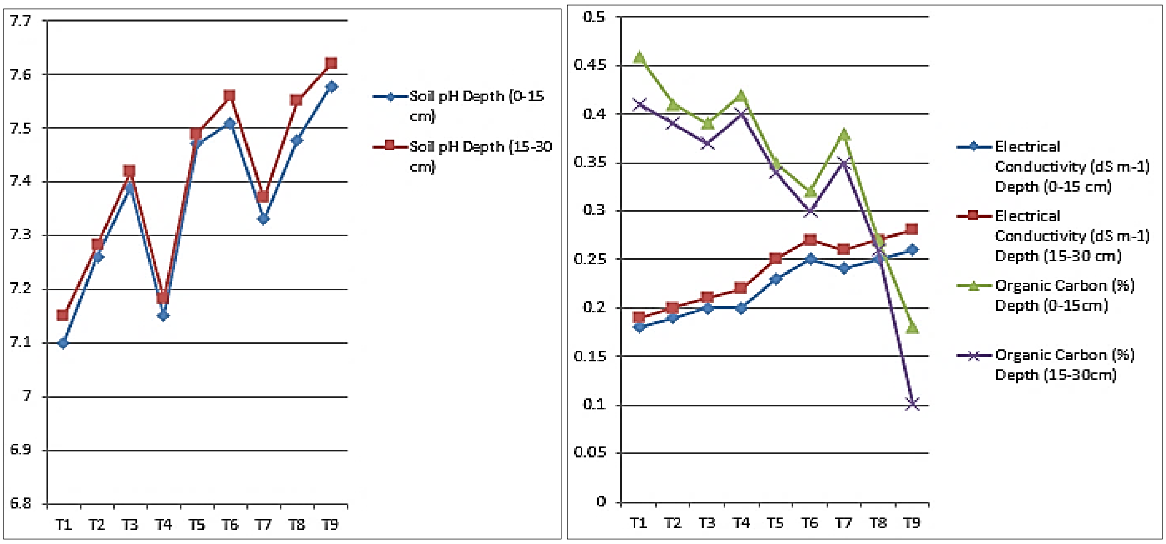

Fig 4 & 5: Effect of Nitrogen, Phosphorus, Potassium, Sulphur and Zinc on Chemical Analysis of soil.

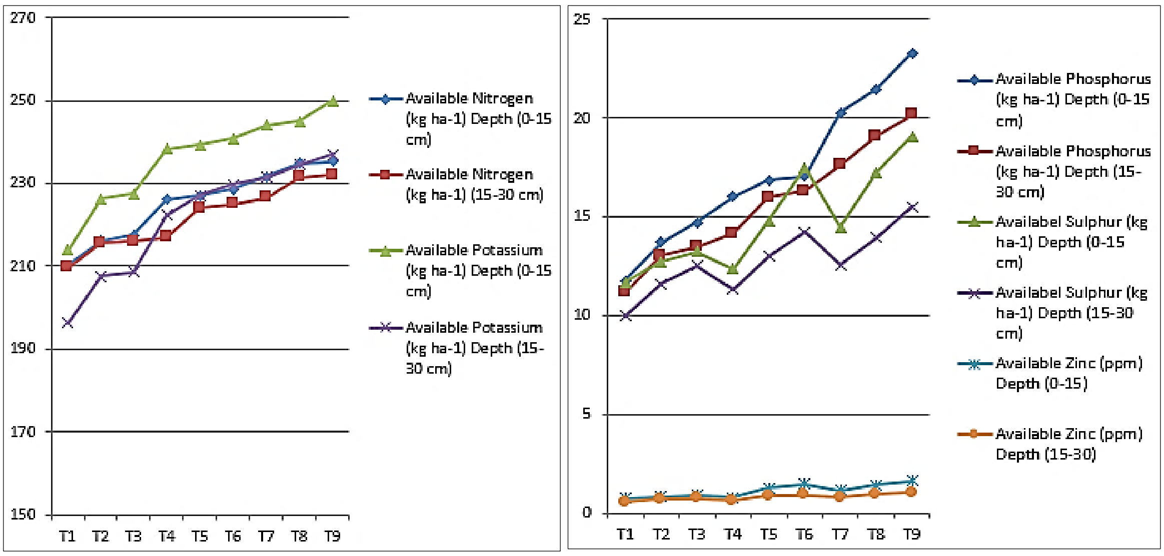

Fig 5 & 6: Effect of Nitrogen, Phosphorus, Potassium, Sulphur and Zinc on Chemical Analysis of soil.

Conclusion

The present investigation concludes that treatment T_9@100% NPK, @100% S, @100% Zn was best with respect to the other treatment combinations. Treatment T_9 @100% NPK, @100% S, @100% Zn exhibited foremost result with respect to plant height(cm), number of branches plant^{-1}, number of leaves plant^{-1}, number of pod plant^{-1}, number of seeds pod^{-1} and gave highest pod yield (q ha^{-1}), bulk density (Mg m^{-3}), Particle density (Mg m^{-3}), pH, Pore space (%), water retaining capacity (%), Electrical Conductivity (dS m^{-1}), available nitrogen (kg ha^{-1}), available phosphorus (kg ha^{-1}), available potassium (kg ha^{-1}), available sulphur (kg ha^{-1}) and available zinc (ppm). Organic Carbon (%) was maximum in T_1 (Control). From the economic point of view the maximum gross return (₹ 1,68,750), maximum net profit (₹ 1,09,845.48) and maximum benefit cost ratio (2.86:1) was found in treatment T_9 @100% NPK, @100% S, @100% Zn.

Based on the above findings, it was concluded that nutrient management with recommended dose of Nitrogen, Phosphorus, Potassium, Sulphur and Zinc improved the Physico-Chemical properties of soil and maximum growth, yield, benefit cost ratio of cluster bean

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Competing interests

Authors have declared that no competing interests exist.

References

1. Ayub M, Nadeem MA, Naeem M, Tahir M, Tariq M, Ahmad W. Effect of different levels of P and K on growth, forage yield and quality of cluster bean (*Cyamopsis tetragonolobus* L.). The Journal of Animal & Plant Sciences 2012;22(2):479-483.
2. Ayub M, Tahir Ather Nadeem M, Arif Zubair M, Tariq M, Ibrahim M. Effect of Nitrogen Applications on Growth, Forage Yield and Quality of Three Cluster Bean Varieties. Pak. J Life Soc. Sci 2010;8(2):111-116.
3. Alloway BJ. Zinc in Soils and Crop Nutrition. International Zinc Association 2008.
4. Aphale SL, Stokes TS, Black CR, Taylor IB, Roberts JA. Role of root to shoot signalling in coordinating responses to soil compaction. Proceedings of the 32nd Annual Meeting of the Plant Growth Regulation Society of America 2005.
5. Aykroyd WR, Gopalan C, Balasubramanian SC. The nutritive value of Indian Foods and the planning of satisfactory diets. (6th revised ed). Indian Council of Medical Research, New Delhi 1963, 42.
6. Bhattacharya R, Kundu VS, Srivastava AK, Gupta HS. Effect of long-term manuring on soil organic carbon, bulk density and water. Int. J Curr. Microbiol. App. Sci 2017;6(10):1374-1378.
7. Bavisker VS, Damame HS, Raj VC, Shete PG. Growth, yield and quality parameters of clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] as influenced by organic fertilizers and different levels of sulphur for vegetable purpose. *Crop Research* 2012;43(1-3):52-54.
8. Bolding MC, Kellogg LD, Davis CT. Soil compaction and visual disturbance following an integrated mechanical forest fuel reduction operation in southwest Oregon. International Journal of Forest Engineering 2009;20(2):47-56.
9. Bhattacharya R, Kundu VS, Srivastava AK, Gupta HS. Effect of long term manuring on soil organic carbon, bulk density and water retention characteristics under soybean-wheat cropping sequence in north-Western Himalaya. Journal of the Indian society of soil science 2004;52:238-242.
10. Bardsley CE, Landcaster JD. Determination of reserve sulfur and soluble sulfates in soils. Soil Science Society of America Journal 1960;24(4):265-268.
11. Bouyoucos GJ. The hydrometer as a new method for the mechanical analysis of soils. Soil Science 1927;23:343-353.
12. Chavan BL, Vedpathak MM, Pirgonde BR. Effects of organic and chemical fertilizers on cluster bean (*Cyamopsis tetragonoloba*). European Journal of Experimental Biology 2015;5(1):34-38.
13. Chauhan TM, Javed Ali, Singh1 SP, Singh SB. Effect of nitrogen and zinc nutrition on yield, quality and uptake of nutrients by wheat. Annals of Plant and Soil Research Agra 2014, 98-101.
14. Chaudhary NR, Vyas AK, Singh AK. Growth and nutrient uptake in wheat as influenced by nitrogen phosphorous and zinc application. Annals of Agriculture Research 1997;18:365-366.
15. Fisher RA, Yates F. Statistical tables for biological agriculture and medical research. In: 5Aufl. Oliver and Boyd. Edinburgh 1960.
16. Gangwar KS, Chaudhary VP, Gangwar B, Pandey DK. Effect of crop establishment and tillage practices in rice (*Oryza sativa*) based cropping systems. Indian Journal of Agricultural Sciences 2009;79(5):334-339.
17. Jackson ML. Soil Chemical analysis Prentice Hall of Indian Ltd. New Delhi 1967, 219-221.
18. Kuniya N, Patel BB, Malav JK, Chaudhary N, Pavaya RP, Patel JK *et al*. Yield and nutrient content and uptake by clusterbean (*Cyamopsis tetragonoloba* L.) as influenced by different levels of sulphur and zinc application under light textured soil. Journal of Pharmacognosy and Phytochemistry 2019;8(3):2160-2163.
19. Kherawat BS, Munna Lal, Agarwal M, Yadav HK, Sushil Kumar. Effect of Applied Potassium and Manganese on Yield and Uptake of Nutrients by Cluster bean (*Cyanosis tetragonoloba*). Journal of Agricultural Physics 2013;13(1):22-26.
20. Lindsay WL, Norvell WA. Development of DTPA soil test for zinc, iron, manganese and copper. Soil Science Society America Journal 1978;42:421-428.
21. Mann KK, Brar BS, Dhillon NS. Influence of long-term use of farmyard manure and inorganic fertilizers on nutrient availability in a Typic Ustochrept. Indian Journal of Agricultural Sciences 2006;76(8):477-480.
22. Muthuvel P, Udayasoorian C, Natesan R, Ramaswamy PP. Introduction to Soil Analysis, Tamil Nadu Agricultural University Coimbatore-641002 1992.
23. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate ($NaHCO_3$). U.S.D.A. Circular 1954;939:1-19.
24. Pandey AK, Singh M, Kumar S, Meena VK, Santosh Onte, Manish Kushwaha. Influence of stage of harvesting and zinc application on yield and zinc uptake in cluster bean [*Cyamopsis tetragonoloba* (L.) TAUB]. Legume research an International Journal 2019, 0250-5371.
25. Prakash Dev Verma, Narendra Swaroop, Yogesh Upadhyay, Akash Swamy, Soman Singh Dhruw. Role of Phosphorus, Zinc and Rhizobium on Physico-Chemical

Properties of Soil in Field Pea (*Pisum sativum* L.) Cv. Rachna. Int. J Curr. Microbiol. App. Sci 2017;6(7):4423-4428.
26. Sunil Dahiya S, Bhattoo MS, Khedwal RS, Kathwal R. Productivity and Quality of Clusterbean (*Cyamopsis tetragonoloba* (L.) Taub.) As Influenced by Zinc and Sulphur. International Journal of Pure Applied Bioscience 2018;6(3):544-549.
27. Singh AP, Lal M, Pal AK, Singh AP. Effect of FYM, potassium and zinc on yield, quality and uptake of nutrients in forage clusterbean in alluvial soil. Annals of Plant and Soil Research 2016;18(3):246-250.
28. Sharma OP, Singh GD. Effect of sulphur and growth substances on yield, quality and nutrient uptake of clusterbean. Journal of Environment and Ecology 2004;22(4):746-748.
29. Subbiah BV, Asiija CL. A Rapid procedure for estimation of available nitrogen in soil. Current Science 1956;25(8):259-260.
30. Thompson CJ, Marschner H, Romheld V. Effect of nitrogen fertilizer form on pH of the bulk soil and rhizosphere, and on the growth, phosphorus, and micronutrient uptake of bean 2008. Published online: Article Views 27.
31. Toth SJ, Prince AI. Estimation of cation exchange capacity and exchangeable Ca, K and Na content of soil by flame photometer technique. Soil Sci 1949;67:439-445.
32. Walia MK, Walia SS, Dhaliwal SS. Long-term effect of integrated nutrient management of properties of typic ustochrept after 23 cycles of an irrigated rice (*Oryza sativa* L.) - wheat (*Triticum aestivum* L.) system. Journal of Sustainable Agriculture 2010;34(7):724-743.
33. Wilcox LV. Electrical conductivity. Am. Water Works Assoc. J 1950;42:775-776.
34. Walkley A, Black IA. An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. Soil Science 1934;37:29-38.