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Effect of nitrogen phosphorus potassium boron and zinc on soil health parameters

Kousar Tasleem Shaik, Narendra Swaroop, Tarence Thomas and Akshita Barthwal

Abstract
A field experiment was conducted during August – November (Late *kharif*) 2020 at the research farm of Department Soil Science and Agricultural Chemistry, NAI, SHUATS, laid out in Randomized Block Design. To achieve higher growth and yield of rainy cowpea variety GOMATI, it was found application of T5 @ 50% NPK+ @ 50% Boron + @ 50% Zinc has shown effective growth under Prayagraj climatic conditions. It was observed that for physical and chemical properties of soil in treatment T5 @50% NPK + @ 50% Boron + @50% Zinc were improved significantly due to application of Nitrogen, Phosphorus, Potassium, Boron and Zinc use of inputs. The results showed that progressive increase of Bulk density (Mg m^{-3}) as the depth increase, pH of the soil is increased as the depth increase as the fertilizer used was Di Ammonium Phosphate and use of MOP does not affected the soil pH, use of Borax and Zinc sulfate increased the soil pH., Pore space (%) of the soil decreased as the depth of the soil increases, Water Holding Capacity (%) of the soil is increased as the depth of the soil increases, Electrical conductivity (dS $m^{-1)}$ of the soil is increased as the depth of the soil is increased, Organic Carbon Content (%) of the soil is decreased as the depth of the soil is increased, available Nitrogen (kg ha^{-1}), available Phosphorous (kg ha^{-1}), available Potassium (kg ha^{-1}), available Boron (kg ha^{-1}), available Zinc (kg ha^{-1}) in soil is decreased as the depth of soil is increased and the plant height, Number of branches, Number of seeds per pod, Number of pods per plant and pod yield has increased with the application of inorganic fertilizers and micronutrients.

Keywords: Physical properties, chemical properties, nitrogen, phosphorus, potassium, boron, zinc and cowpea

Introduction
Cowpeas were domesticated in Africa and are one of the oldest crops to be farmed. A second domestication event probably occurred in Asia, before they spread into Europe and the Americas. The seeds are usually cooked and made into stews and curries, or ground into flour or paste. Cowpea is lucrative summer season vegetable and valued for its proteins, minerals and Energy. Cowpea seed is a nutritious component in the human diet, and cheap livestock feed as well. Both the green and dried seeds are suitable for canning and boiling as well. Cowpeas are regularly intercropped with cereals such as sorghum and maize. Cowpea, whether utilized for green pods (vegetable) or dry seed (pulse)-forms an important component of farming systems from the arid to the humid tropics. Cowpea cultivars grown for the immature green pods that are used as a vegetable are variously known as asparagus bean, snake bean, and yard-long bean; when grown for dry or immature seed, they are known as black-eye pea, kaffir pea, china pea, and southern bean. Cowpea is well adapted to stress and has excellent nutritional qualities. It is a key dietary staple for the poorest sector of many developing countries and greatly improves an otherwise bland and unbalanced diet. It is one of the most ancient human food sources and has probably been used as a crop plant since Neolithic times. Cowpea-the crop of all-round utilization-is grown for dry seed, immature seed, immature green pod, green leaves, and even roots. It is one of the food legumes that is an important source of nutrients and provides high-quality, inexpensive protein to diets based on cereal grains or starchy food. The mature cowpea seed contains 24.8% protein, 63.6% carbohydrate, 1.9% fat, 6.3% fiber, 7.4 ppm thiamine, 4.2 ppm riboflavin and 28.1 ppm niacin. The protein concentration ranges from about 3 to 4% in green leaves, 4 to 5% in immature pod and 25 to 30% in mature seeds. The amino acid profile reveals that lysine, leucine and phenylalanine contents are relatively high in cowpea. Trends in the production of pulse is adversely affected the per capita availability of pulses. (Lonardi *et al.*, 2019).

Nitrogen uptake by legumes during growth and maturity indicate that there is not much uptake of nitrogen after the start of fruit development. In fact, there is a sharp fall in the nitrogen content of leaves, stems and nodules after flowering. Absorption of phosphorus occurs primarily at the end of the growing period and is mainly transported to the seed, whereas potassium is transported mainly to the stem in early growth and later to the seeds. The adverse effects of soil anaerobiosis to plant growth are believed to be mediated through several factors which include the production of toxic (Buhlebelive *et al.*, 2020) [5].

Zinc is an essential micronutrient required in small quantities by all organisms. The average total zinc concentration in cultivated soils is around 65 mg kg^{-1} and is predominantly taken up as a divalent cation (Zn^{+2}) or bound to an organic acid. As for micronutrients, zinc is an element whose deficiency symptoms are frequently observed in crops grown in tropical soils. In plants, zinc is involved in correct membrane function, photosynthesis, gene expression, and protection against drought and pathogens, as well as in the synthesis of hormones that are involved in plant growth and development (Arunachalam *et al.*, 2013) [1].

Boron is a micro nutrient critical to the growth Boron also affects the levels of other nutrients (e. g: potassium, nitrogen, calcium) that are available for plant uptake (Ahmad *et al.*, 2012) [2].

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- 5º C, while in the summer months (May-June) temperature reaches above 45-48º C. 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) [6].

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 (0, 50, 100%) Boron and Zinc respectively, the treatments are replicated into three time dividing the experimental area into twenty seven plots.

Plant analysis

Plant height Number of branches per plant No. of pods per plant Number of seeds per pod were recorded at 30, 60 DAS and Pod yield (q ha^{-1}) from the net plot area was recorded in kg $plot^{-1}$ and value converted into q/ha.

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, Partical density, Porespace 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) [15]. The Phoshorus and Potassium contents were determined by “Olsen colorimetric method” (Olsen *et al.*, 1954) [13] and flame Photometer (Toth and Prince, 1949) [18] respectively. The soil organic matter was estimated by “hydrochloric and oxidation method” as suggested by (Wakley and Black, 1947) [20]. The pH of soil was determined by Digital Electric pH meter and the EC was determined by electrical Conductivity meter (Jackson 1958) [10].

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 Panse and Sukhatme (1967) [14] 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 Nitrogen, Phosphorus, Potassium, Boron and Zinc is given in table 1 and graphically illustrated in fig 1. The data shows significant effect on different levels of NPK, Boron and Zinc on bulk density of soil properties. The maximum bulk density of soil at depth 0-15 and 15-30 was 1.19, 1.23 recorded at T1 Control whereas the minimum bulk density of soil at depth 0-15 and 15-30 1.1, 1.14 was found in T5 @50% NPK + @50% Boron+@50% Zinc. The mean of Bulk density of soil was found significant at the result of the data depicted in table 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 Bhattachrya *et al.*, (2004) Thomson *et al.*, (2008) [17] and Bhattacharya *et al.*, (2017) [7].

Partical density (Mg m-3) of Soil

The mean of Partical density of soil was found significant at Nitrogen, Phosphorus, Potassium, Boron and Zinc. The result of the data depicted in table 1 the maximum Partical density of soil at depth 0-15 and 15-30 cowpea found in T1 (control) which was 2.21, 2.30 the minimum Partical density of soil at depth 0-15 and 15-30 was found in T5 @50% NPK + @50% B + @50% Zn which was 2.10, 2.17. It was found that due to the application of inorganic fertilizers the partical density of the soil is decreased. Similar results have also been recorded by Bhattachrya *et al.* (2004).

Pore space (%) of Soil

The mean of Pore space of soil was found significant at Nitrogen, Phosphorus, Potassium, Boron and Zinc. The result of the data depicted in table 1 the maximum Pore space of soil at depth 0-15 and 15-30 found in T5 @50% NPK + @50% B + @50% Zn which was 52.37, 40.48 the minimum Pore space of soil at depth 0-15 and 15-30 was 41.28, 31.29, 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 Verma *et al.*, (2015) [19].

Water Holding Capacity (%) of Soil

The mean of Water holding capacity of soil was found significant at Nitrogen, Phosphorus, Potassium, Boron and Zinc. The result of the data depicted in table 1 the maximum Water Holding Capacity of soil at depth 0-15 and 15-30 was 59.06, 58.46 found in T5 @50% NPK + @50% B + @50% Zn the minimum Water holding capacity of soil at depth 0-15 and 15- 30 was 50.67 (%), 49.72 (%) found in T1 Control. Water Holding Capacity increases with increase in organic matter. Similar findings also reported by Sharma *et al.*, (2016) [16].

Chemical analysis

Effect of Nitrogen, Phosphorus, Potassium, Boron and Zinc on Soil pH

The mean of Soil pH was found significant at Nitrogen, Phosphorus, Potassium, Boron and Zinc. 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 7.56, 7.68 the minimum pH (7.15) was found in T5 @50% NPK + @50% B + @50% Zn was 7.15, 7.38. It was found from above findings that application acid fertilizers the change in the pH occurred. Similar findings also reported by Aphale *et al.* (2005) [3] and Thomson *et al.* (2008) [17].

Electrical Conductivity of Soil (dS m-1)

The mean of Electrical conductivity of soil was found significant at Nitrogen, Phosphorus, Potassium, Boron and Zinc. 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 T1 (control) which was 0.26, 0.28 the minimum Electrical conductivity of soil at depth 0-15 and 15-30 was found inT5 @50% NPK + @50% B +@50% Zn was 0.15, 0.19. 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) [3] and Prakash *et al.* (2017) [7].

Organic Carbon content (%) in Soil

The mean of Organic Carbon content in soil was found significant with Nitrogen, Phosphorus, Potassium, Boron and Zinc. The result of the data depicted in table 2 the maximum Organic carbon of soil at depth 0-15 and 15-30 was 0.69,0.58 found in T5 @50% (NPK) + @50% B + @50% Zn,the minimum Organic carbon content of soil at depth 0-15 and 15-30 was found in T1 (control) which was 0.45,0.32 The above findings showed that the optimum dose of Nitrogen, Phosphorus, Potassium, Boron and Zinc and their interaction increased percentage organic carbon in significantly which may attribute to bringing the inorganic fertilizer, therefore helps in improving the percentage organic carbon in soil and long-term productivity of the soil, are enhanced by balanced application of nutrients. Similar findings also reported by Gangwar *et al.*, (2009) [9] and Bhattacharya *et al.*, (2017) [7].

Available Nitrogen (kg ha-1) in Soil

The mean of Available Nitrogen in soil was found significant at Nitrogen, Phosphorus, Potassium, Boron and Zinc. The result of the data depicted in table 2 the maximum Available Nitrogen in soil at depth 0-15 and 15-30 found in T5 @50% (N,P,K) + @50% B + @50% Zn which was 292.19, 289.84 the minimum available Nitrogen in soil at depth 0-15 and 15-30 was found in T1 Control was 251.17, 253.25. 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 Thompson (2008) [17] and Bolding *et al.*, (2009) [4].

Available Phosphorus (kg ha-1) in Soil

The mean of available Phosphorus in soil was found significant at Nitrogen, Phosphorus, Potassium, Boron and Zinc. The result of the data depicted in table 2 the maximum available Phosphorus in soil at depth 0-15 and 15-30 found in T5 @50% (NPK) + @50% B + @50% Zn which was 28.53, 26.64 the minimum available Phosphorus in soil at depth 0-15 and 15-30 was found in T1 (control) was 21.29,20.82. From above findings 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. These results are in close conformity with the findings of Desai *et al.*, (2001) [8] and Jat *et al.*, (2012) [11].

Available Potassium (kg ha-1) in Soil

The mean of Available Potassium in soil was found significant at Nitrogen, Phosphorus, Potassium, Boron and Zinc. The result of the data depicted in table 2 the maximum available Potassium in soil at depth 0-15 and 15-30 in T5 @50% (NPK) + @50% B + @50% Zn which was 154.15, 154.36, the minimum available Potassium in soil at depth 0-15 and 15-30 was found in T1 (control) was 122.18, 124.26. 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) [17] and Bolding *et al.*, (2009) [4].

Available Boron (kg ha-1) in Soil

The mean of available Boron in soil was found significant at Nitrogen, Phosphorus, Potassium, Boron and Zinc. The result of the data depicted in table 2 the maximum available Boron in soil at depth 0-15 and 15-30 found in T5 @50% (N,P,K) + @50% B + @50% Zn which was 1.25, 1.08, the minimum available Boron in soil at depth 0-15 and 15-30 was found in T1 (control) was 0.61, 0.58. The above findings showed that the optimum dose of Boron and their interaction increased available Boron in soil significantly which may be attributed to bringing the inorganic fertilizer, therefore helps improving the available Boron in soil. Similar findings were reported in Baboo and Mishra (2001) and Mandal *et al.*, (2009) [12].

Available Zinc (kg ha-1) in Soil

The mean of Available Zinc in soil was found significant at Nitrogen, Phosphorus, Potassium, Boron and Zinc. The result of the data depicted in table 2 the maximum Available Zinc in soil at depth 0-15 and 15-30 found in T5 @50% (N,P,K) + @50% B + @50% Zn which was 1.39, 1.29, the minimum Available Zinc in soil at depth 0-15 and 15-30 (0.71) was found in T1 (control) was 0.71, 0.69. The above findings showed that the optimum dose of Zinc and their interaction increased available Zinc in soil significantly which may be attributed to bringing the inorganic fertilizer, therefore helps in proving the available Zn in soil. Similar findings were reported by Prakash *et al.*, (2017) [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
T1	Control	1.19	2.21	2.21	2.30	41.28	31.29	50.67	49.72
T2	@0%NPK+@50%B+@50%Zn	1.17	2.20	2.20	2.26	44.31	32.31	51.86	50.80
T3	@0%NPK+@100%B+@100%Zn	1.16	2.18	2.18	2.23	46.65	30.08	52.67	51.20
T4	@50%NPK+@0%B+@0%Zn	1.14	2.15	2.15	2.21	47.75	33.48	54.54	52.32
T5	@50%NPK+@50%B+@50%Zn	1.11	2.10	2.10	2.17	52.37	40.48	59.06	58.46
T6	@50%NPK+@100%B+@100%Zn	1.12	2.12	2.12	2.16	49.56	36.59	57.47	57.01
T7	@100%NPK+@0%B+@0%Zn	1.13	2.14	2.14	2.15	50.74	38.86	55.47	54.08
T8	@100%NPK+@50%B+@50%Zn	1.12	2.17	2.17	2.21	48.67	34.59	57.15	56.26
T9	@100%NPK+@100%B+@100%Zn	1.13	2.14	2.14	2.20	50.30	38.49	56.42	55.40
F-Test		S	S	S	S	S	S	S	S
S.Em		0.05	0.018	0.15	0.15	0.05	0.521	1.158	0.861
CD@5%		0.14	0.038	0.44	0.44	0.59	1.520	2.466	1.834

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
T1	Control	7.56	7.68	0.26	0.28	0.45	0.32	251.17	253.25
T2	@0%NPK+@50%B+@50%Zn	7.43	7.36	0.16	0.19	0.47	0.41	251.18	253.80
T3	@0%NPK+@100%B+@100%Zn	7.41	7.62	0.18	0.21	0.50	0.43	252.17	254.30
T4	@50%NPK+@0%B+@0%Zn	7.33	7.50	0.2	0.26	0.54	0.42	253.19	254.80
T5	@50%NPK+@50%B+@50%Zn	7.15	7.38	0.15	0.19	0.69	0.58	292.19	291.66
T6	@50%NPK+@100%B+@100%Zn	7.21	7.40	0.23	0.26	0.65	0.54	282.16	284.64
T7	@100%NPK+@0%B+@0%Zn	7.37	7.62	0.2	0.24	0.57	0.52	288.17	287.50
T8	@100%NPK+@50%B+@50%Zn	7.4	7.50	0.24	0.28	0.61	0.55	289.14	288.36
T9	@100%NPK+@100%B+@100%Zn	7.34	7.48	0.21	0.24	0.59	0.46	290.15	289.84
F-Test		S	S	S	S	S	S	S	S
S.Em		0.05	0.037	0.038	0.018	0.024	0.021	0.015	1.645
CD@5%		0.14	0.079	0.081	0.038	0.052	0.045	0.033	3.502

Symbols	Treatments	Available Phosphorus (kg ha-1)		Available Potassium (kg ha-1)		Available Boron (kg ha-1)		Available Zinc (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
T1	Control	21.29	20.82	122.18	124.26	0.61	0.58	0.71	0.69
T2	@0%NPK+@50%B+@50%Zn	22.15	21.60	123.12	124.80	0.82	0.79	0.79	0.70
T3	@0%NPK+@100%B+@100%Zn	24.12	22.94	128.14	129.32	0.92	0.89	0.86	0.80
T4	@50%NPK+@0%B+@0%Zn	25.36	23.86	130.15	131.60	0.62	0.60	0.74	0.71
T5	@50%NPK+@50%B+@50%Zn	28.53	26.64	154.15	154.36	1.25	1.08	1.39	1.29
T6	@50%NPK+@100%B+@100%Zn	26.12	25.72	133.19	134.44	0.94	0.91	1.37	1.31
T7	@100%NPK+@0%B+@0%Zn	26.26	25.86	142.10	143.76	0.64	0.60	0.84	0.80
T8	@100%NPK+@50%B+@50%Zn	26.38	25.94	141.26	143.10	0.96	0.88	0.85	0.81
T9	@100%NPK+@100%B+@100%Zn	27.19	26.76	147.16	148.26	0.98	0.84	1.29	1.31
F-Test		S	S	S	S	S	S	S	S
S.Em		0.05	2.073	1.822	1.960	1.917	0.034	0.060	0.081
CD@5%		0.14	4.412	3.878	4.173	4.081	0.073	0.129	0.173

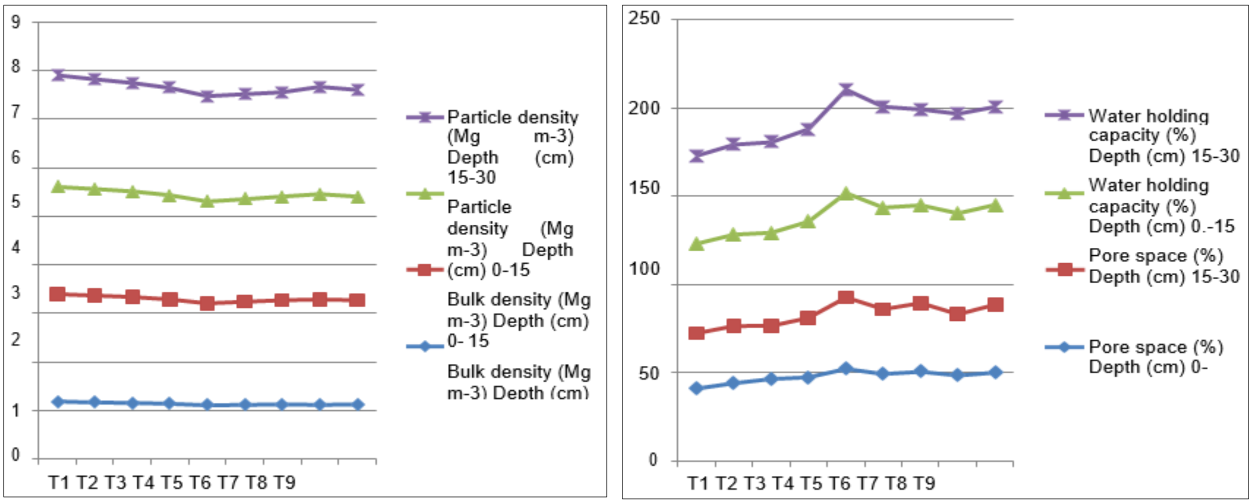

Fig 1: Effect of Nitrogen, Phosphorus, Potassium, Boron and Zinc on Physical Analysis of soil

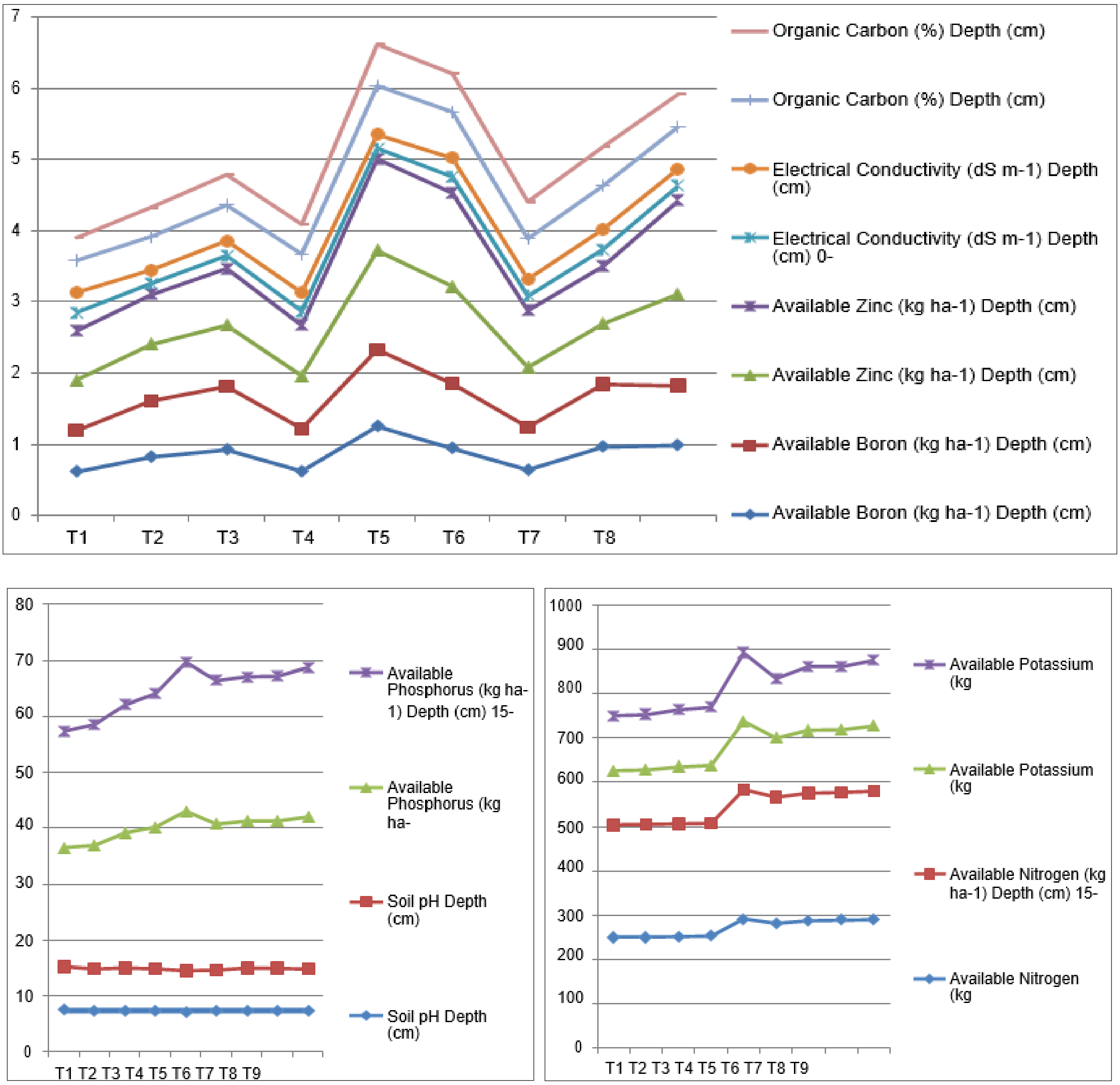

Fig 2: Effect of Nitrogen, Phosphorus, Potassium, Boron and Zinc on Chemical Analysis of soil

Conclusion

It was concluded from the trial that the effect levels in the experiment. The best treatment combination was T5 @50% NPK + @50% B + @50% Zn found to be appropriate for cowpea (*Vigna unguiculata* L.) var. GOMATI in Prayagraj. Based on above findings, it was concluded that nutrient management with recommended dose of Nitrogen, Phosphorus, Potassium and micronutrients i.e., Boron and

Zinc can augment the economic yield of cowpea in green pod. It was also found that Physical and chemical properties of the soil was improved due to the addition of micro-nutrients. Farmers should use micronutrients along with the Nitrogen, Phosphorus, Potassium fertilizers 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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