

Response of Different Levels of NPK and Zinc on Soil Health in Black gram (*Vigna mungo* L.)

ABSTRACT

An experiment was conducted during in *Zaid* season (March 2022-June 2022) to study the “effect of different levels of NPK and Zinc on soil health in black gram (*Vigna mungo* L.)” on central research farm of Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj. A randomized block design was used to set up the experiment, with three levels of NPK (0%, 50%, and 100% NPK) and three levels of zinc (0%, 50%, and 100% zinc). The outcome demonstrates that inorganic fertilizer application had a non-significant effect on soil physical-chemical parameters (BD, PD, pH, EC and OC) and significant increase in pore space, water holding capacity, available nitrogen, phosphorus, potassium and zinc in treatment T₉ [NPK at 100% + zinc at 100%] than other treatments.

Key word: NPK, Physical, Chemical properties, Soil health, Zinc etc.

Introduction

A natural body made up of solids (minerals and organic matter), liquid, and gases, soil is defined as "a natural body that occurs on the land surface, occupies space, and is characterized by one or both of the following: horizons, or layers, that are distinguishable from the initial material as a result of additions, losses, transfers, and transformations of energy and matter, or

the ability to support rooted plants in a natural environment." As per the United States Department of Agriculture (USDA).

Fertilizers containing nitrogen are crucial for raising crop productivity and enhancing soil fertility. The crop's biomass and grain production rise when nitrogen fertilizer is used. It increases the soil's residual N by 18 to 34%. The effects of sole residue integration or combination with N fertilizer on plant development and production as well as the Physico-chemical properties of the soil are favorable. A crucial component that plants need is nitrogen. It enhances the amount of protein in pulses and the growth and development of all biological tissues. The synthesis of amino acids, chlorophyll, and other organic chemicals that serve as the building blocks of proteins as well as promoting plant growth make nitrogen one of the most important nutrients (Sarvsade *et al.*, 2019; Ghosh *et al.*, 2022; Thakur *et al.*, 2023).

One of the three main macronutrients that plants need for the greatest growth and development is phosphorus (P), which is a crucial nutrient element. Photosynthesis, respiration, energy storage, root growth, cell elongation, and crop quality are all impacted by phosphorus. Plants with deficiencies may have erect, thin stems that are wiry, and their leaves may turn a bluish green tint. The growth of root nodules is boosted, and Rhizobium activity is improved. As a result, it aids in the root nodules' ability to fix more nitrogen from the atmosphere.(Ghosh *et al.*, 2022)

It has been said that potassium is a "quality element" and a "master cation" that is essential for the growth and development of the plant. Numerous crucial enzymes, including those involved in protein synthesis, sugar transport, disease resistance, drought tolerance, N and C metabolism, and photosynthesis, are activated by it. Potassium is crucial for improving quality and raising output (Subba Rao and Tilak, 1977; Balasubramanian, 1999; Gangwat *et al.*, 2013; Pathariya *et al.*, 2022).

The most deficient micronutrient in Indian soils is zinc, which is also considered to be the third-most crucial component for crop productivity after nitrogen and phosphorus. Due to zinc's significant effects on yield qualities and its significance in metabolic processes, the rise in yield may be explained by these factors. According to Hafeez Z *et al.* (2013), zinc contributes to the synthesis of auxin, the activation of dehydrogenase enzymes, and the stabilization of ribosomal fractions.

Materials and Methods

A field experiment to study the Effect of Different Levels of NPK and Zinc on Soil Health in Black Gram (*Vigna mungo* L.) was conducted at central research farm department of Soil Science and Agricultural Chemistry, SHUATS, Prayagraj. This area normally falls under the subtropical belt in the southeast of Uttar Pradesh, where the summers are quite hot and the winters are moderately chilly. The location's highest temperature occasionally drops below 4⁰C or 5⁰C and can reach up to 46⁰C to 48⁰C. Between 20 to 94% the relative humidity was present. Around 1100 mm of rain precipitation occurs yearly on average in this region. The experimental site is located 98 meters above sea level at 25⁰ 57'N latitude and 81⁰ 59'E longitude. The soil in the experimental region is classified as Inceptisol, and its texture is sandy loam (sand content: 62.71%; silt content: 23.10%; clay content: 14.1%). The experiment was set up using a randomized block design (RBD), which included nine treatments and three doses of NPK (0, 50, and 100%) and Zn (0, 50, and 100%). Three replicates of the treatment have been made. There were 27 plots in total. Black gram sowing in 2 x 2 m plots during the *Zaid* season, with a spacing of 30 x 10 cm. Soil samples were taken from each plot both before and after the experiment at a depth of 0-15 to 15–30 cm by using a soil auger. The soil samples were air-dried, put through a 2 mm screen, and then had their different soil qualities examined. M.L. Jackson (1958) assessed the soil pH with a pH meter, and Wilcox (1950) measured the electrical conductivity (EC) with a conductivity meter. The available nitrogen (N) was calculated using the Subbiah and Asija method (1956), the phosphorus (P) was calculated using the Olsen et al. method (1954), the potassium (K) was calculated using the Toth and Prince method (1949), and the zinc (Zn) was estimated using the Lindsay and Norvell method (1978). The soil organic carbon (SOC) was estimated using the Walkley and Black method (1947).

RESULTS AND DISCUSSION

Physical properties

Bulk density (Mg m⁻³)

The response on the soil bulk density found to be non-significant. The maximum bulk density of soil was found 1.288 Mg m⁻³ and 1.296 Mg m⁻³ in treatment T₉ (NPK @ 100% + Zn @ 100%) and the minimum was 1.243 Mg m⁻³ and 1.250 Mg m⁻³ found at soil depths of 0-15 and 15-30 cm in treatment T₁ (NPK @ 0 % + Zn @ 0 %) respectively. It was also observed the

bulk density of soil was gradually increased with an increase in dose of different levels of NPK and Zn. Similar result has been recorded by Kumar *et al.*, 2008; Bhattacharya *et al.*, 2004.

Particle density (Mg m^{-3})

The mean value of particle density of soil (Mg m^{-3}) was found non-significant. The maximum particle density was 2.518 Mg m^{-3} and 2.526 Mg m^{-3} found in T_9 (NPK @ 100 % + Zn @ 100 %) and minimum was 2.475 Mg m^{-3} and 2.482 Mg m^{-3} found at soil depths of 0-15 and 15-30 cm in treatment T_1 (NPK @ 0 % + Zn @ 0 %) respectively. It was also observed the particle density of soil was gradually increased with an increase in dose of different levels of NPK and Zn. Similar result has been recorded by Hussain *et al.*, 2022; Dangi *et al.*, 2020.

Pore space (%)

The response pore space of soil was found to be significant in levels of NPK and Zn. The maximum pore space of soil was recorded 46.58 % and 42.27 % found in T_9 (NPK @ 100% + Zn @ 100 %) and minimum pore space of soil was recorded 41.60 % and 37.42 % found at soil depths of 0-15 and 15-30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0 %)] respectively. It was also observed the pore space of soil was gradually increased with an increase in dose of different levels of NPK and Zn. Similar result has been recorded by; Azadi *et al.*, 2013; Amurta *et al.*, 2017.

Water holding capacity (%)

The response water holding capacity of soil was found to be significant in levels of NPK and Zn. The maximum water holding capacity of soil was recorded 40.26 % and 38.71 % found in treatment T_9 (NPK @ 100% + Zn @ 100 %) and minimum water holding capacity of soil was recorded 34.55 % and 32.48 % founds at of depths 0-15 to 15-30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0 %)] respectively. It was also observed the water holding capacity (%) of soil was gradually increased with an increase in dose of different levels of NPK and Zn. Similar result has been recorded by Azadi *et al.*, 2013; Amurta *et al.*, 2017.

Chemical properties

Soil pH (1:2.5)

The response pH of soil was found to be non-significant in levels of NPK and Zn. The maximum pH of soil was recorded 7.06 and 7.14 founds in treatment T_9 (NPK @ 100% + Zn @ 100 %) and minimum pH of soil was recorded 6.50 and 6.56 found at of depths 0-15 to 15-30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0 %)] respectively. It was also observed the pH of

soil was gradually increased with an increase in dose of different levels of NPK and Zn. Similar result has been recorded by Chandrakar, 2018; Jha *et al.*, 2015.

Soil EC (dS m⁻¹)

The response EC of soil was found to be non-significant in levels of NPK and Zn. The maximum EC of soil was recorded 0.474 dS m⁻¹ and 0.480 dS m⁻¹ founds in treatment T₉ (NPK @ 100% + Zn @ 100 %) and minimum EC of soil was recorded 0.442 dSm⁻¹ and 0.446 dS m⁻¹ found at of depths at 0-15 to 15-30 cm in treatment T₁ [control (NPK @ 0% + Zn @ 0 %)] respectively. It was also observed that EC of soil were gradually increased with increasing dose of NPK and Zn. Similar result has been recorded by Meena and Ram, 2016; Habib *et al.*, 2018.

Organic carbon (%)

The maximum organic carbon of soil was found 0.407 and 0.396 in T₉ (NPK @ 100 % + Zn @ 100 %) and minimum was measured 0.375 and 0.368 % at soil depths 0-15 and 15-30 cm in treatment T₁ (NPK @ 0 % + Zn @ 0 %) respectively. It was also observed that organic carbon of soil was gradually increased with increasing dose of NPK and Zn. Similar result has been recorded by Meena and Ram, 2016; Habib *et al.*, 2018.

Available Nitrogen (kg ha⁻¹)

The response Available Nitrogen of soil was found to be significant in levels of NPK and Zn. The maximum Available Nitrogen of soil was recorded 324.78 kg ha⁻¹ and 318.56 kg ha⁻¹ found in treatment T₉ (NPK @ 100% + Zn @ 100 %) and minimum Available Nitrogen of soil was recorded 292.61 kg ha⁻¹ and 288.34 kg ha⁻¹ at soil depths 0-15 to 15-30 cm in treatment T₁ [control (NPK @ 0% + Zn @ 0 %)] respectively. The nitrogen has its major significant role in completion of crop life cycle. Balanced use of nitrogen (N) fertilizers could play a pivotal role in increasing the yields. In addition to supplying a nutrient for plant growth, N application could enhance drought tolerance of plant to increase yield. Similar result has been recorded by Sharma *et al.*, 2009; Javeed *et al.*, 2017.SS

Available Phosphorus (kg ha⁻¹)

The maximum Available Phosphorus of soil was recorded 21.03 kg ha⁻¹ and 20.89 kg ha⁻¹ found in treatment T₉ (NPK @ 100% + Zn @ 100 %) and minimum Available Phosphorus of soil was recorded 18.41 kg ha⁻¹ and 17.45 kg ha⁻¹ at soil depths 0-15 to 15-30 cm in treatment T₃ (NPK @ 0 % + Zn @ 100 %) respectively. The mean value of Available Phosphorus (kg ha⁻¹) of

soil was found significant. Similar result has been recorded by Sharma *et al.*, 2009; Javeed *et al.*, 2017.

Available Potassium (kg ha^{-1})

The maximum Available Potassium of soil was recorded $210.45 \text{ kg ha}^{-1}$ and $206.72 \text{ kg ha}^{-1}$ found in treatment T₉ (NPK @ 100% + Zn @ 100 %) and minimum Available Potassium of soil was recorded $185.24 \text{ kg ha}^{-1}$ and $181.56 \text{ kg ha}^{-1}$ at soil depths 0-15 to 15-30 cm in treatment T₁ [control (NPK @ 0% + Zn @ 0 %)] respectively. The mean value of Available Potassium (kg ha^{-1}) of soil was found significant. Similar result has been recorded by Sharma *et al.*, 2009; Javeed *et al.*, 2017.

Available Zinc (mg kg^{-1})

The mean value of Available Zinc (mg kg^{-1}) of soil was found significant. The maximum Available Zinc of soil was recorded 0.343 mg kg^{-1} and 0.329 mg kg^{-1} found in treatment T₉ (NPK @ 100% + Zn @ 100 %) and minimum Available Zinc of soil was recorded 0.288 mg kg^{-1} and 0.290 mg kg^{-1} at soil depths 0-15 to 15-30 cm in treatment T₁ [control (NPK @ 0% + Zn @ 0 %)] respectively. Similar result has been recorded by Tripathi *et al.*, 2011; Bameri *et al.*, 2012 and Chaudhary *et al.*, 2014.

Conclusion

According to the trial, the fertilizers [Urea (46% N), + SSP (16% P₂O₅), + MOP (60% K₂O), + ZnSO₄ (36.5% Zn)] used at different levels of NPK and Zn from different sources produced the best results in treatment T₉ (NPK @ 100% + Zn @ 100%), which was followed by treatment T₈. In T₉, the soil health parameters retained the appropriate soil properties. Therefore, for increased farm revenue and sustainable agriculture, it might be advised that farmers receive the finest combination treatment (T₉).

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Table 1: Effect of NPK and Zn on soil physical properties

Treatment	BD (Mg m ⁻³)		PD (Mg m ⁻³)		Pore space (%)		Water holding capacity (%)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
NPK @ 0 % + Zn @ 0 %	1.243	1.250	2.475	2.482	41.60	37.42	34.55	32.48
NPK @ 0 % + Zn @ 50 %	1.248	1.255	2.480	2.487	41.86	37.60	35.07	33.60
NPK @ 0 % + Zn @ 100 %	1.254	1.262	2.486	2.492	42.08	38.15	35.76	35.18
NPK @ 50 % + Zn @ 0 %	1.260	1.268	2.490	2.497	42.42	39.08	36.04	35.26
NPK @ 50 % + Zn @ 50 %	1.265	1.274	2.495	2.504	43.88	39.72	36.61	35.92
NPK @ 50 % + Zn @ 100 %	1.272	1.278	2.501	2.509	44.22	40.52	37.30	36.22
NPK @ 100 % + Zn @ 0 %	1.276	1.285	2.507	2.515	44.61	41.18	38.84	36.09
NPK @ 100 % + Zn @ 50 %	1.282	1.290	2.512	2.520	45.60	41.56	39.51	37.85
NPK @ 100 % + Zn @ 100 %	1.288	1.296	2.518	2.526	46.58	42.27	40.26	38.71
F-Test	NS	NS	NS	NS	S	S	S	S
S.Ed. (±)	-	-	-	-	0.62	0.48	0.68	0.55
C.D. at 0.5%	-	-	-	-	1.32	0.99	2.06	1.65

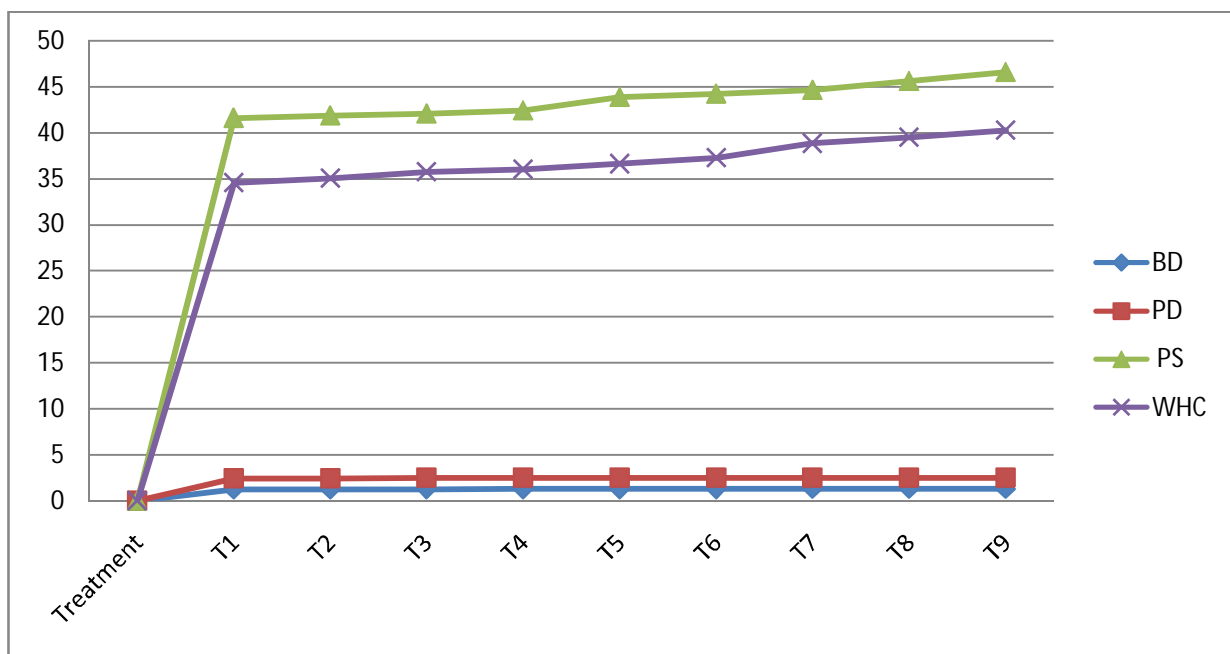


Fig. 1 Effect of different levels of NPK and Zn on BD (Mg m⁻³), PD (Mg m⁻³), PS (%), and WHC (%) of soil depth (0-15 cm)

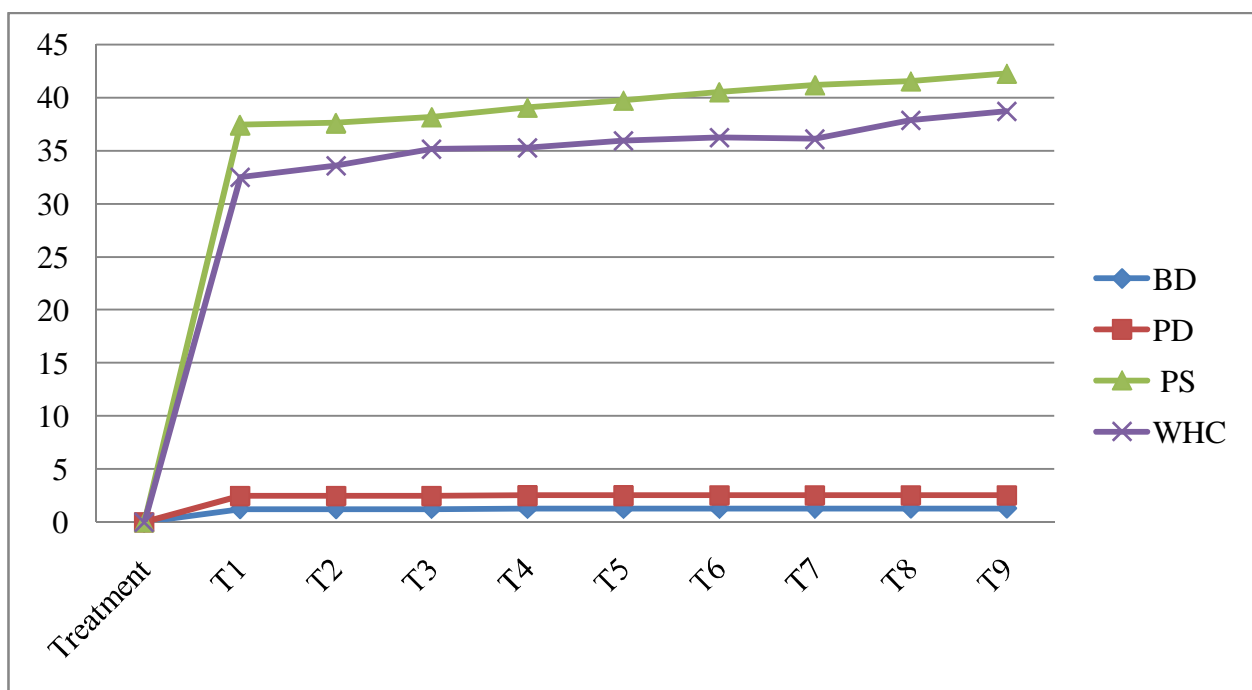


Fig. 2 Effect of different levels of NPK and Zn on BD (Mg m⁻³), PD (Mg m⁻³), PS (%), and WHC (%) of soil depth (15-30 cm)

Table 2: Effect of NPK and Zn on soil chemical properties

Treatment	pH		EC (dSm ⁻¹)		Organic carbon (%)	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
NPK @ 0 % + Zn @ 0 %	6.50	6.56	0.442	0.446	0.375	0.368
NPK @ 0 % + Zn @ 50 %	6.57	6.62	0.447	0.449	0.380	0.372
NPK @ 0 % + Zn @ 100 %	6.64	6.68	0.451	0.453	0.384	0.376
NPK @ 50 % + Zn @ 0 %	6.70	6.75	0.454	0.456	0.389	0.379
NPK @ 50 % + Zn @ 50 %	6.76	6.82	0.458	0.463	0.392	0.381
NPK @ 50 % + Zn @ 100 %	6.81	6.86	0.462	0.467	0.395	0.386
NPK @ 100 % + Zn @ 0 %	6.89	6.91	0.465	0.471	0.398	0.390
NPK @ 100 % + Zn @ 50 %	6.94	6.97	0.470	0.475	0.403	0.393
NPK @ 100 % + Zn @ 100 %	7.06	7.14	0.474	0.480	0.407	0.396
F-Test	NS	NS	NS	NS	NS	NS
S.Ed. (±)	-	-	-	-	-	-
C.D. at 0.5%	-	-	-	-	-	-

Table 3: Effect of NPK and Zn on soil chemical properties

Treatment	Available Nitrogen (kg ha ⁻¹)		Available Phosphorus (kg ha ⁻¹)		Available Potassium (kg ha ⁻¹)		Available Zinc (mg kg ⁻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
NPK @ 0 % + Zn @ 0 %	292.61	288.34	18.41	17.45	185.24	181.56	0.288	0.290
NPK @ 0 % + Zn @ 50 %	293.47	289.06	18.17	17.31	187.42	184.80	0.340	0.352
NPK @ 0 % + Zn @ 100 %	295.38	291.88	17.36	16.85	190.59	187.52	0.354	0.359
NPK @ 50 % + Zn @ 0 %	299.70	293.62	19.23	18.12	192.10	189.77	0.326	0.332
NPK @ 50 % + Zn @ 50 %	302.64	296.29	19.14	17.96	194.54	191.89	0.348	0.337
NPK @ 50 % + Zn @ 100 %	306.82	300.50	18.87	17.08	197.70	194.42	0.336	0.343
NPK @ 100 % + Zn @ 0 %	312.04	306.23	20.61	19.86	202.83	198.61	0.320	0.347
NPK @ 100 % + Zn @ 50 %	319.32	312.35	20.47	19.43	206.97	202.56	0.328	0.324
NPK @ 100 % + Zn @ 100 %	324.78	318.56	21.03	20.89	210.45	206.72	0.343	0.329
F-Test	S	S	S	S	S	S	S	S
S.Ed. (±)	2.18	1.80	1.10	0.68	1.75	1.41	0.12	0.15
C.D. at 0.5%	4.42	3.62	2.23	1.40	3.28	1.85	0.27	0.32

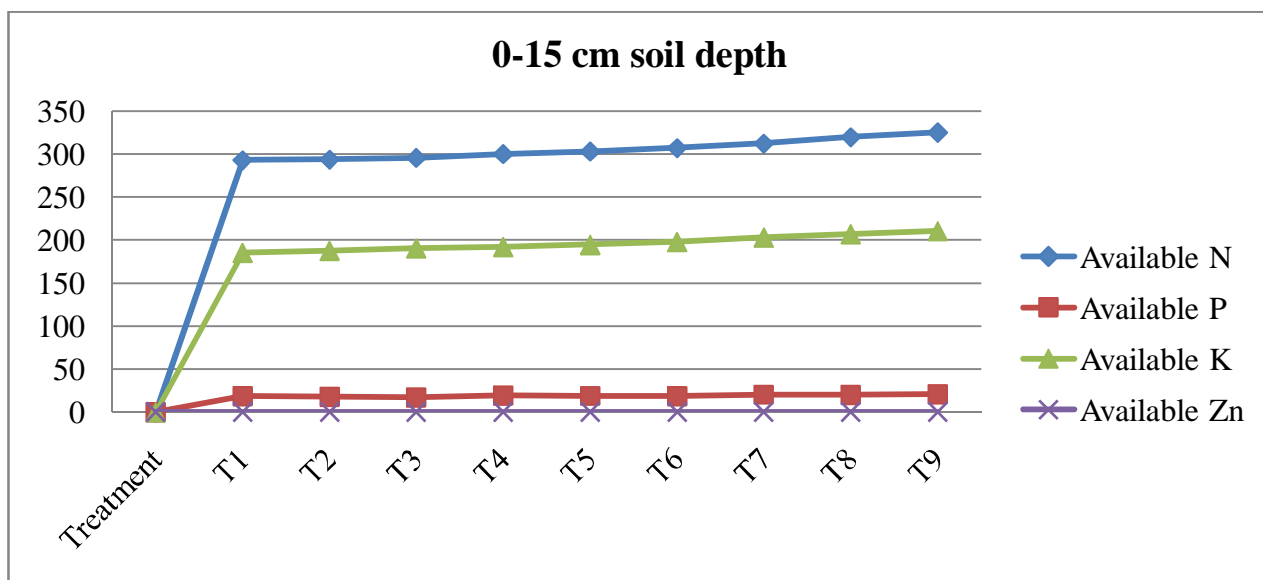


Fig. 3 Effect of different levels of NPK and Zn on Available N (kg h⁻¹), P (kg h⁻¹), K (kg h⁻¹), and Zn (mg kg⁻¹) of soil depth (0-15 cm)

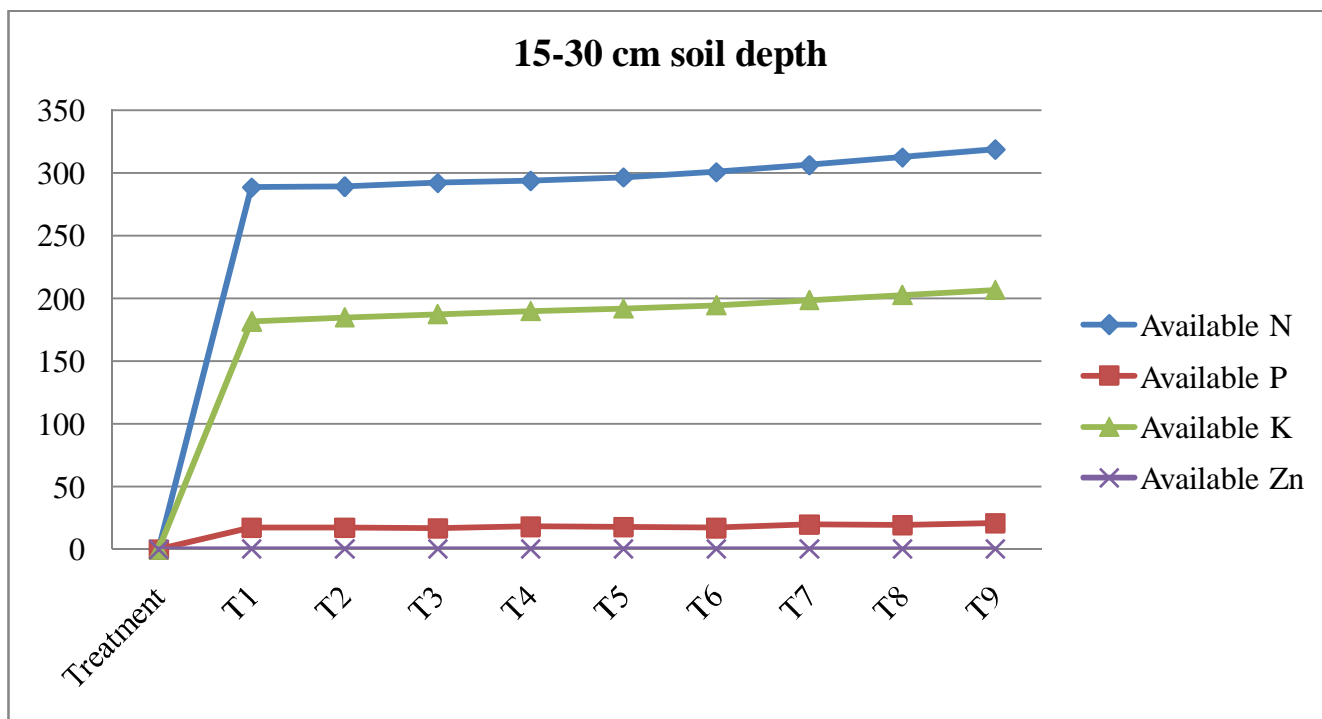


Fig. 4 Effect of different levels of NPK and Zn on Available N (kg h⁻¹), P (kg h⁻¹), K (kg h⁻¹), and Zn (mg kg⁻¹) of soil depth (15-30 cm)