Effect of NPK and Zinc Inorganic fertilizers on Soil Health, Growth and Yield of Chickpea (*Cicer arietinum* L.)

Abstract

An objective of study effect on inorganic sources of NPK and Zn fertilizers on soil health with the experiment was laid out in Randomized Block Design with three levels of NPK (00%, 50% and 100%), and Zinc (00%, 50% and 100%) Recommended Dose of fertilizer applied in all treatments. The result showed that the soil properties, growth and yield of chickpea were significantly affected by application of NPK and Zinc. The highest growth and yield were observed in T_9 (100%NPK +100% Zinc), followed by T_8 (100% NPK and +50%Zinc) ,whereas the lowest growth and yield were observed in T_1 (00% NPK +00% Zinc). The treatment T_9 (NPK @ 100 % +Zn @ 100%) was recorded as best treatment for major soil parameters. The treatment T_9 (NPK @ 100% + Zn @ 100 %) also shows the significantly highest vegetative growth as well as yield attributes and net profit ₹45,186.00 ha^{-1} with cost benefit ratio is 1:2.17.

Key words : Chickpea, NPK, Zinc, Growth and Yield, Physico-chemical Properties of Soil.

Introduction

Soil plays a critical role in chickpea production by providing nutrients, water and physical support for growth. Physico-chemical properties of soil, including texture, pH, organic matter, fertility, moisture, drainage and temperature, play critical role in growth and development of chickpea. Proper management of these properties can lead to a healthy and productive chickpea crop. "Soil is the loose surface material that covers most land. It consists of inorganic particles and organic matter. Soil provides the structural support to plants used in agriculture and is also their source of water and nutrients. Soils vary greatly in their chemical and physical properties. Processes such as leaching, weathering and microbial activity combine to make a whole range of different soil types. Each type has strengths and weaknesses for agricultural production" (Roy *et al*., 2006).

"The three most significant nutrients, without any one of which plants could not endure, are known as the primary macronutrients: Nitrogen (N), Phosphorus (P), and Potassium (K). In particular, nitrogen is crucial to chlorophyll, which allows plants to carry out photosynthesis (the process by which they uptake sunlight to produce sugars from carbon dioxide and water).

Nitrogen is also a major component in amino acids, the base of proteins". (Mishra *et al.*, 2011).

Nitrogen also aids in the compounds that let for storage and use of energy. The plants that are nutritious and healthy while developing have good nitrogen content in them. Phosphorus also encourages the growth of roots, promotes flowering, and is necessary for DNA. Phosphorus fertilizer extract from the phosphate rock (Dixit, G. P., 2016).

Phosphorus is a vital component of ATP, the "energy unit" of plants. "ATP forms during photosynthesis, has phosphorus in its structure, and processes from the beginning of seedling growth through to the formation of grain and maturity. Thus, phosphorus is essential for the general health and vigour of all plants" (Mishra *et al.*, 2011).

Potassium is often referred to as the "value element," because of its contribution to many of the features we connect with quality, such as size, figure, color, and even taste, among others. Potassium provides strength to the plants and can resist diseases (Mishra *et al.*, 2011).

"Zinc is an important component of various enzymes that are responsible for driving many metabolic reactions in all crops. Growth and development would stop if specific enzymes were not present in plant tissue. Carbohydrate, protein, and chlorophyll formation is significantly reduced in zinc-deficient plants" (Singh *et al.*, 2009).

Materials and Methods

A field experiment conducted at the Soil Science Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, during the *Rabi* season 2021-22 growing chickpea *Var.* Sadabahar applied 3 levels of NPK and Zinc respectively 0 %, 50 % and 100 % including RDF for chickpea = 20:40:20 kg ha^{-1} experiment is lead to observe the physical and chemical parameters. In physical parameters like that bulk density, particle density, pore space and water holding capacity through method by 100 ml graduated measuring cylinder and process by Muthuvel *et al.*, 1992. "In chemical parameters through method by- Soil pH – method given by (Jackson, M. L. 1958) through using digital pH meter, Soil EC (dSm^{-1}) - method given by (Wilcox, 1950) through using digital EC meter, Organic Carbon (%) - Wet oxidation method given by (Walkley and Black, 1947), Available Nitrogen (kg ha^{-1}) - Kjeldhal Method (Subbiah and Asija, 1956), Available Phosphorus (kg ha^{-1}) - Colorimetric method by using Jasper single beam U.V. Spectrophotometer at 660 nm wavelength given by (Olsen *et al.*, 1954), Available Potassium (kg ha^{-1}) - Flame photometric method by using Metzer Flame Photometer given by (Toth and Prince, 1949), Available Zinc (mg kg^{-1}) – DTPA extractant method by using AAS given by" (Lindsay and Norvell, 1978)

Result and Discussion

Bulk density (Mg m^{-3})

The data presented in table and fig. 1 shows the effect of NPK and Zinc on bulk density (Mg m^{-3}) of soil after crop harvested. The response of NPK and Zinc on bulk density of soil was found non-significant. The maximum bulk density of soil 1.33 and 1.36 Mg m^{-3} was found at 0-15 and 15-30 cm in treatment T_1 (NPK @ 0 % + Zn @0 %) and minimum bulk density of soil 1.15 and 1.17 Mg m^{-3} was found at 0-15 and 15-30 cm in treatment T_9 (NPK @ 100 % + Zn @ 100 %) respectively. Similar result has been recorded by **Hussain *et al*., (2022); Chintha *et al*., (2021).**

Particle density (Mg m^{-3})

The data presented in table and fig. 1 shows the effect of NPK and Zinc on particle density (Mg m^{-3}) of soil after crop harvested. The response of NPK and Zinc on particle density of soil was found non-significant. The maximum particle density of soil 2.52 and 2.55 Mg m^{-3} was recorded at 0-15 and 15-30 cm in treatment T_1 (NPK @ 0 % + Zn @ 0 %) and minimum particle density of soil 2.38 and 2.45 Mg m^{-3} was recorded at 0-15 and 15-30 cm in treatment T_9 (NPK @ 100 % + Zn @ 100 %) respectively. Similar result has been recorded by **Hussain *et al*., (2022); Chintha *et al*., (2021) and Dangi *et al*., (2020).**

Percent pore space (%)

The data presented in table and fig 1 shows the effect of NPK and Zinc on percent pore space of soil after crop harvested. The response of NPK and Zinc on percent pore space of soil was found significant. The maximum percent pore space of soil 48.7 and 47.60 % was found at 0-15 and 15-30 cm in treatment T_9 (NPK @ 100 % + Zn @ 100 %) and minimum percent pore space of soil 45.11 and 44.77 % was found at 0-15 and 15-30 cm in treatment T_1 (NPK @ 0 % + Zn @ 0 %)] respectively. Similar result has been recorded by **Hussain *et al*., (2022); Chintha *et al*., (2021) and Dangi *et al*., (2020).**

Water holding capacity (%)

The data presented in table and fig. 1 shows the effect of NPK and Zinc on water holding capacity (%) of soil after crop harvested. The response of NPK and Zinc on water holding capacity of soil was found significant. The maximum water holding capacity of soil 44.58 and 42.09 % was found at 0-15 and 15-30 cm in treatment T_9 (NPK @ 100 % + Zn @100 %) and minimum water holding capacity of soil 39.23 and 38.05 % was found at 0-15 and 15-30 cm in treatment T_1 (NPK @ 0 % + Zn @ 0 %) respectively. Similar resulthas been recorded by **Hussain *et al*., (2022); Chintha *et al*., (2021) and Dangi *et al*., (2020).**

Soil pH (1:2.5) w/v

The data presented in table and fig. 2 shows the effect of NPK and Zinc on pH ofsoil after crop harvested. The response NPK and Zinc on pH of soil was found non-significant. The maximum pH of soil 7.36 and 7.41 was found at 0-15 and 15-30 cm in treatment T_1 (NPK @ 0 % + Zn @ 0 %) and minimum pH of soil 7.27 and 7.27 was found at 15-30 cm in treatment T_9 (NPK @ 100 % + Zn @ 100 %) respectively. Similar result has been recorded by **Parmar and Poonia (2020); Sahu *et al*., (2020) and Deshlahare *et al*., (2019).**

Soil EC (dS m^{-1})

The data presented in table and fig. 2 shows the Effect of NPK and Zinc on EC of soil after crop harvested. The response of NPK and Zinc on EC of soil was found non-significant. The maximum EC of soil 0.476 and 0.482 dSm^{-1} was recorded at 0-15 and 15-30 cm in treatment T_9 (NPK @ 100% + Zn @ 100 %) and minimum EC of soil 0.445 and 0.448 dSm^{-1} was recorded at 15-30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0 %)] respectively. Similar result has been recorded by **Parmar and Poonia (2020); Sahu *et al*., (2020) and Deshlahare *et al*., (2019).**

Organic carbon (%)

The data presented in table and fig. 2 shows the effect of NPK and Zinc on organic carbon of soil after crop harvested. The response of NPK and Zinc on organic carbon of soil was found non-significant. The maximum organic carbon of soil 0.43 and 0.38 % was found at 0-15 and 15-30 cm in treatment T_9 (NPK @ 100 % + Zn @ 100 %) and minimum organic carbon of soil 0.36 and 0.32 % was found at 0-15 and 15-30 cm in treatment T_1 (NPK @ 0 % + Zn @ 0 %) respectively. Similar result has been recorded by **Parmar and Poonia (2020); Sahu *et al.*, (2020) and Deshlahare *et al.*, (2019).**

Available nitrogen (kg ha^{-1})

The data presented in table and fig. 2 shows the effect of NPK and Zinc on available nitrogen of soil after crop harvested. The response of NPK and Zinc on available nitrogen of soil was found significant. The maximum available nitrogen of soil 322.75 and 316.59 kg ha^{-1} was recorded at 0-15 and 15-30 cm in treatment T_9 (NPK @ 100% + Zn @ 100 %) and minimum available nitrogen of soil 290.65 and 286.32 kg ha^{-1} was recorded at 0-15 and 15-30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0 %)] respectively. Similar result has been recorded by **Pingoliya *et al.*, (2014); Yadav *et al.*, (2021) and Banjara and Majgahe (2019).**

Available phosphorus (kg ha^{-1})

The data presented in table and fig. 2 shows the effect of NPK and Zinc on available phosphorus of soil after crop harvested. The response of NPK and Zinc on available phosphorus of soil was found significant. The maximum available phosphorus of 35.07 and 33.82 kg ha^{-1} was recorded at 0-15 and 15-30 cm in treatment T_9 (NPK @ 100% + Zn @ 100 %) and minimum available phosphorus of soil 19.40 and 16.43 kg ha^{-1} was recorded at 0-15and 15-30 cm in treatment T_1 (NPK @ 0% + Zn @ 0 %) respectively. Similar result has been recorded by **Pingoliya *et al.*, (2014, Yadav *et al.*, (2021); Banjara and Majgahe (2019)**.

Available potassium (kg ha^{-1})

The data presented in table and fig. 2 shows the effect of NPK and Zinc on available potassium of soil after crop harvested. The response of NPK and Zinc on available potassium of soil was found significant. The maximum available potassium of soil was recorded 208.42 and 204.67 kg ha^{-1} was recorded at 0-15 and 15-30 cm in treatment T_9 (NPK @ 100% + Zn @ 100 %) and minimum available potassium of soil 182.23 kg and 178.55 kg ha^{-1} was recorded at 0-15 and 15- 30 cm in treatment T_1 [control (NPK @ 0% + Zn @ 0 %)] respectively. Similar result has been recorded by **Pingoliya *et al.*, (2014, Yadav *et al.*, (2021); Banjara and Majgahe (2019)**.

Available Zn (mg kg^{-1})

The data presented in table and fig. 2 shows the effect of NPK and Zinc onavailable Zn of soil after crop harvested. The response of NPK and Zinc on available Zn of soil was found significant. The maximum available Zn of soil 0.345 and 0.353 mg kg^{-1} was recorded at 0-15 and 15-30 cm in treatment T_9 (NPK @ 100% + Zn @ 100 %) and minimum available Zn of soil 0.284 and 0.292 mg kg^{-1} was recorded at 0-15 and 15-30 cm in treatment T_1 [control

(NPK @ 0% + Zn @ 0 %)] respectively. Similar result has been recorded by **Pingoliya *et al.*, (2014, Yadav *et al*., (2021); Banjara and Majgahe (2019)**.

Table 1: Effect of NPK and Zn on bulk density (Mg m^{-3}), particle density (Mg m^{-3}), pore space (%) and water holding capacity (%) of soil after crop harvest.

Treatment		Bulk density (Mg m^{-3})		Particle density (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
T_1	NPK @ 0 % + Zn @ 0 %	1.33	1.36	2.52	2.55	45.11	44.77	39.23	38.05
T_2	NPK @ 0 % + Zn @ 50 %	1.30	1.32	2.50	2.53	45.97	45.80	39.03	38.64
T_3	NPK @ 0 % + Zn @ 100 %	1.28	1.31	2.48	2.51	46.24	45.88	41.96	39.26
T_4	NPK @ 50 % + Zn @ 0 %	1.27	1.29	2.51	2.54	45.55	45.11	39.76	38.29
T_5	NPK @ 50 % + Zn @ 50 %	1.24	1.26	2.47	2.52	47.05	46.87	41.51	39.83
T_6	NPK @ 50 % + Zn @ 100 %	1.21	1.25	2.44	2.49	47.38	47.07	42.27	41.87
T_7	NPK @ 100 % + Zn @ 0 %	1.20	1.23	2.46	2.51	46.48	45.52	41.89	40.34
T_8	NPK @ 100 % + Zn @ 50 %	1.18	1.21	2.42	2.48	47.60	47.52	43.05	41.25
T_9	NPK @ 100 % + Zn @ 100 %	1.15	1.17	2.38	2.45	48.71	47.60	44.58	42.09
	F-Test	NS	NS	NS	NS	S	S	S	S
	S.Ed. (±)	-	-	-	-	0.61	0.59	0.68	0.79
	C.D. at 0.5%	-	-	-	-	1.84	1.76	2.06	2.39

Table 2: Effect of NPK and Zn on pH, electrical conductivity (dSm^{-1}), organic carbon (%), available nitrogen (kg ha^{-1}), available phosphorus (kg ha^{-1}), available potassium (kg ha^{-1}) and available zinc (mg kg^{-1}) of soil after crop harvest.

Treatment		Soil pH (1:2.5) w/v		Electrical Conductivity (dSm^{-1})		Organic Carbon (%)		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**	**0 – 15 cm**	**15 – 30 cm**	**0 – 15 cm**	**15 – 30 cm**	**0 – 15 cm**	**15 – 30 cm**
T_1	NPK @ 0 % + Zn @ 0 %	7.36	7.41	0.445	0.448	0.36	0.32	290.65	286.32	19.40	16.43	182.23	178.55	0.284	0.292
T_2	NPK @ 0 % + Zn @ 50 %	7.36	7.40	0.449	0.451	0.36	0.33	291.45	287.05	20.26	17.87	184.41	181.82	0.328	0.334
T_3	NPK @ 0 % + Zn @ 100 %	7.35	7.40	0.453	0.456	0.38	0.34	293.37	289.91	22.87	19.09	187.58	185.56	0.288	0.296
T_4	NPK @ 50 % + Zn @ 0 %	7.32	7.38	0.456	0.459	0.40	0.36	297.72	291.65	23.50	20.60	188.08	186.72	0.321	0.329
T_5	NPK @ 50 % + Zn @ 50 %	7.31	7.38	0.460	0.465	0.41	0.38	300.68	294.27	25.24	22.28	191.56	189.80	0.331	0.338
T_6	NPK @ 50 % + Zn @ 100 %	7.31	7.37	0.464	0.469	0.41	0.39	304.80	298.53	28.16	26.54	194.78	192.45	0.337	0.342
T_7	NPK @ 100 % + Zn @ 0 %	7.28	7.31	0.467	0.473	0.42	0.39	310.06	304.26	30.45	28.27	199.81	195.72	0.340	0.344
T_8	NPK @ 100 % + Zn @ 50 %	7.28	7.30	0.472	0.477	0.42	0.39	317.35	309.38	33.71	31.20	202.95	198.65	0.342	0.348
T_9	NPK @ 100 % + Zn @ 100 %	7.27	7.29	0.476	0.482	0.43	0.38	322.75	316.59	35.07	33.82	208.42	204.67	0.345	0.353
	F-Test	NS	NS	NS	NS	NS	NS	S	S	S	S	S	S	S	S
	S.Ed. (±)	-	-	-	-	-	-	2.27	1.84	1.08	0.78	1.57	1.35	0.07	0.08
	C.D. at 0.5%	-	-	-	-	-	-	4.62	3.71	2.19	1.61	2.25	1.78	0.16	0.19

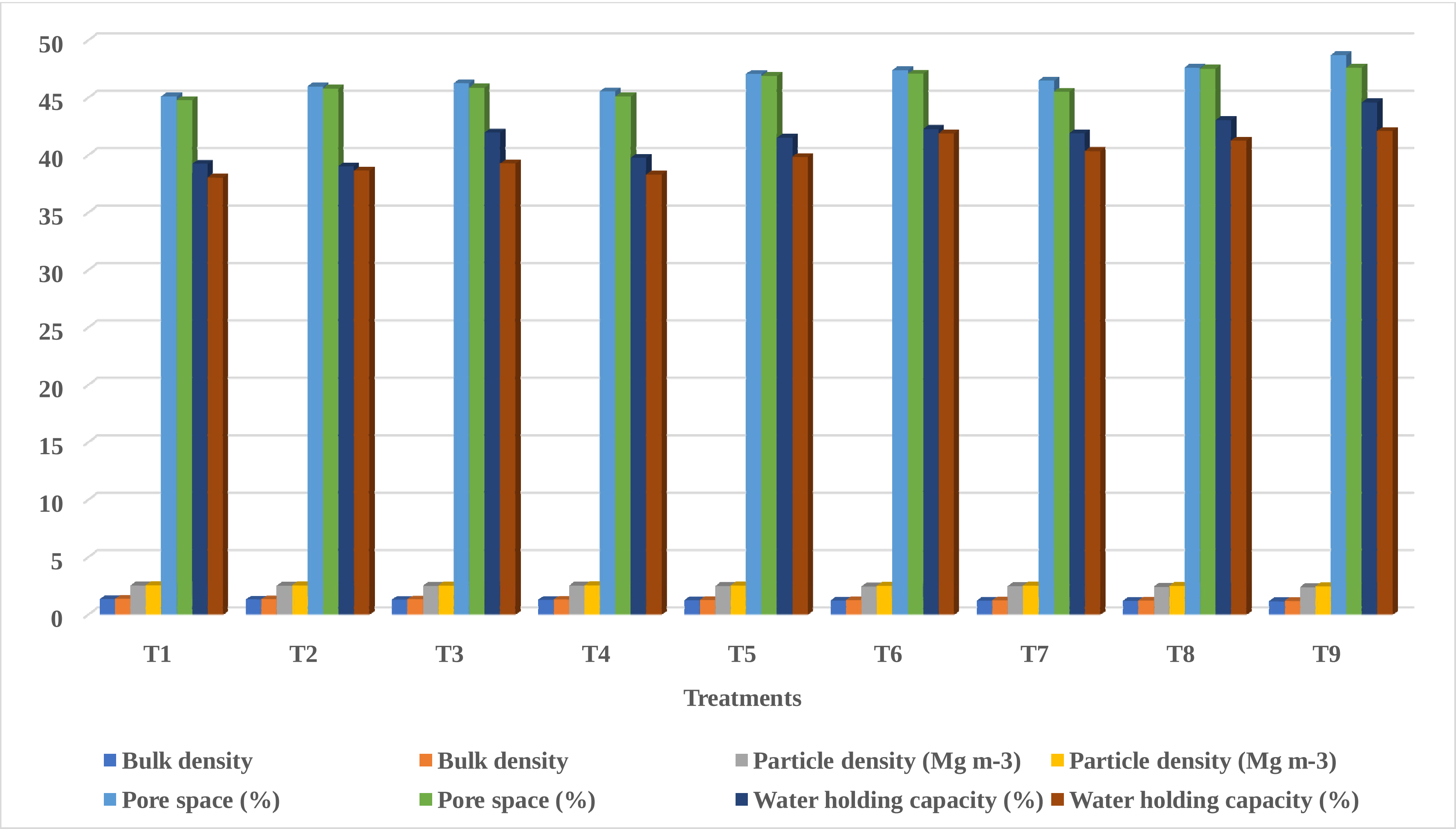

Fig. 1: Effect of NPK and Zn on bulk density (Mg m^{-3}), particle density (Mg m^{-3}), pore space (%) and water holding capacity (%) of soil after crop harvest.

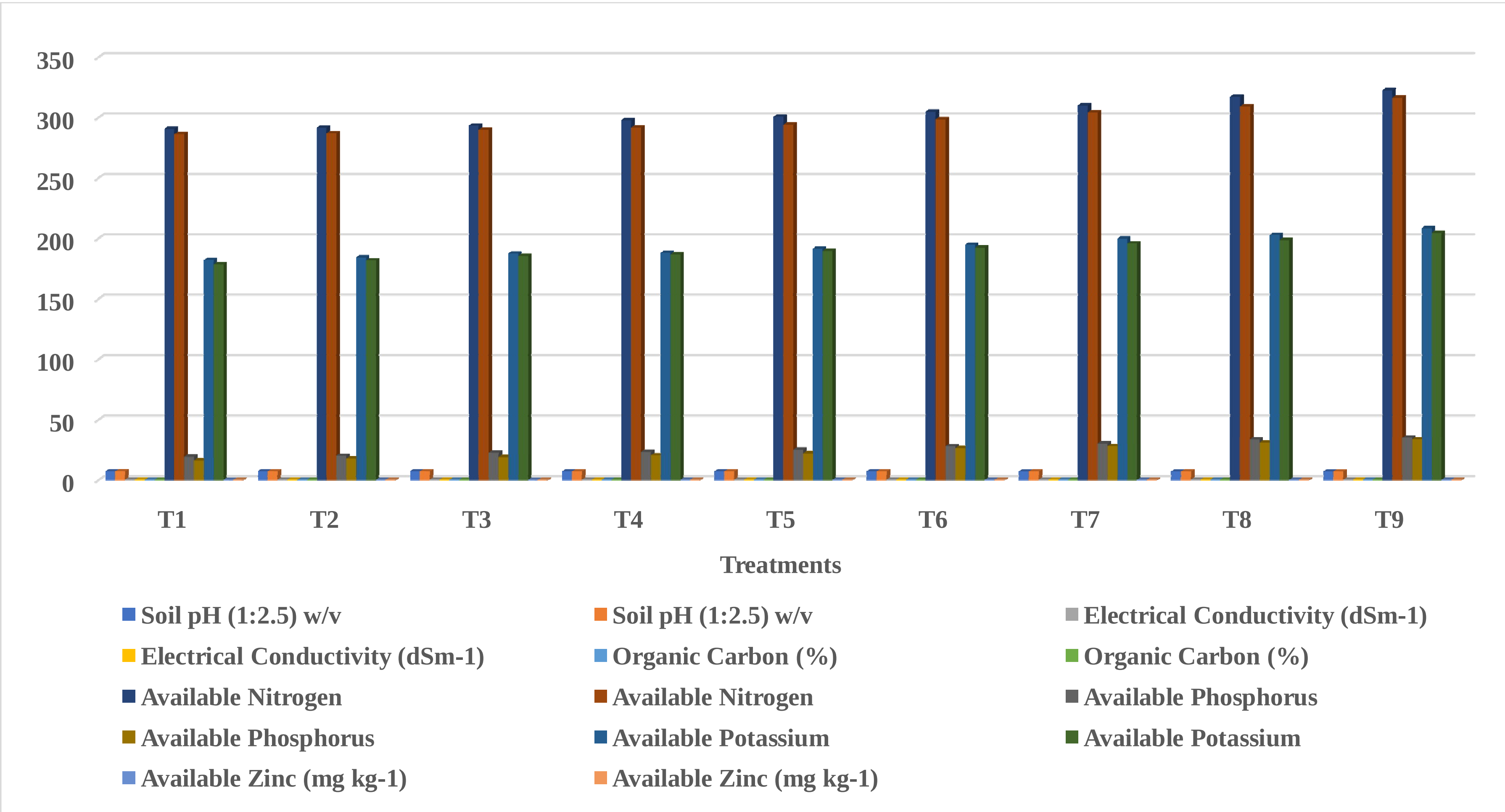

Fig. 2: Effect of NPK and Zn on pH, electrical conductivity (dSm^{-1}), organic carbon (%), available nitrogen ($kg\ ha^{-1}$), available phosphorus ($kg\ ha^{-1}$), available potassium ($kg\ ha^{-1}$) and available zinc ($mg\ kg^{-1}$) of soil after crop harvest.

Conclusion

The results of the experiment are concluded as the effect of NPK and Zinc on nitrogen (kg ha^{-1}), phosphorus (kg ha^{-1}), potassium (kg ha^{-1}), % pore space and water holding capacity (%) of soil after crop harvest was found significant except on bulk density (Mg m^{-3}), particle density (Mg m^{-3}), pH, EC (dsm^{-1}) and organic carbon (%) of soil after harvest. The treatment T_9 (NPK @ 100 % +Zn @ 100%) was recorded as best treatment for major soil parameters. Therefore, it can be recommended for farmers to obtain best combination Treatment (T_9) for higher farm income and sustainable agriculture.

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