Response of different level of nitrogen and foliar application of nano zinc on physico-chemical properties of soil in wheat (*Triticum aestivum*.) Var. PWB-373

ABSTRACT

Afield experiment was conducted during the of 2023-24 at the Research Farm, Department of Soil Science and Agricultural Chemistry, Naini Agriculture Institute, Sam Higginbottom University of Agriculture Technology and Sciences, to investigate the impact of different levels of nitrogen and foliar nano zinc on soil health and yield attributes of wheat (*Triticum aestivum* L.). We designed theexperiment using a Randomized Block Design (RBD) with 10 treatments and threereplications. Results indicated that the application of nano fertilizers significantly ($P<0.05$) influenced various soil physicochemical properties. Bulk density was1.231Mg m^{-3} to 1.264 Mg m^{-3} at 0-15 cm soil depth, and 1.399 to 1.424 Mg m^{-3} at 0-15 and15-30 cmsoil depth. Particle density was 2.234 to 2.249 Mg m^{-3} at 0-15 cm depth, and from 2.276 to 2.299 Mg m^{-3} at15-30 cmdepth. Porosity was 43.80% to 44.86% at 0-15 cm depthanddecreasedto between 38.09% and 38.91% at 0-15 and15-30 cmdepth. Water holding capacity varied between 53.46% and 55.70% at 0-15 cm depth, decreasing to between 47.25% and 50.20% at 15-30 cmdepth. Soil pH was 6.80 to 6.95 at 0-15 cm depth and from7.23 to 7.38 at 15-30 cm depth. Electrical conductivity (EC) was 0.204 dS m^{-1} to 0.223 dS m^{-1} at 0-15 cm depth,and from 0.141:dS m^{-1} to 0.163 dS m^{-1} at 15-30 cmdepth. Organic carbon content was 0.493% at 0-15 cm depth and 0.334% at 15-30 cm depth. The application of nano fertilizers also significantly influenced the growth and yield parameters of wheat, with the maximum plant height recorded at 86.07 cm at 100 DAS, and the highest seed yield at 5180.22 kg ha^{-1}. The treatment involving 100% nitrogen, phosphorus, and potassium fertilizers, along with two sprays of nano nitrogen and nano zinc (4 ml/l) at 25-30 DAS, resulted in the highest gross return (₹ 1,31,711 ha^{-1}), net return (₹ 89,872 ha^{-1}), and BC ratio (2.15). These findings suggest that nano fertilizers can effectively enhance soil health and wheat productivity.

Keywords: -*Field experiment,Foliar application, Nano fertilizers, N P K,Organic Carbon, Wheat.*

INTRODUCTION

"Soils of India are especially deficient in nitrogen and zinc which are compulsory for plant growth. Nitrogen (N) is the most critical element limiting agricultural production at a global scale. Since nitrogen is a component of many proteins, enzymes, and chlorophyll, it is the most significant nutrient essential forplants for growth and metabolic activity. The wellness of plant parts (leaves, roots, trunks,*etc*.) depends on the availability of essential nutrients like nitrogen to enhance the plant's biological processes including growth, absorption, transpiration, and excretion"[20-23]. "Nitrogen is a component of nucleic acid that forms DNA a genetic material significant in the transfer of certain crop traits and characteristics that aid in plant survival. It also helps hold the genetic code in the plant nucleus. N is the nutrient that typically restricts crop production out of all the nutrients essential by plants for crop growth"**(Mosier *et al*. 2001).**

Zinc is the fourth most yield-limiting nutrient in Indian soils and worldwide, after potassium, phosphorus, and nitrogen. According to (**Arvind *et al.* 2019),**"36.5% of Indian soils are estimated to have zinc deficient. It is an important cofactor for about 200 enzymes, the most significant are carbonic anhydrase, alcoholic dehydrogenase, and Zn Cu-super oxide dismutase". "Zinc is one of the essential micronutrients for crop nutrition as it plays an important role in metabolic processes like carbohydrate, nucleic acid, lipid, and protein synthesis as well as their degradation. It has a crucial role in the production of indole acetic acid (IAA), a phytohormone that drastically controls plant growth, chlorophyll synthesis, pollen development, tolerance to environmental stress, water uptake, and transport to plant parts. It is responsible for regulating and maintaining the gene expression responsible for tolerating environmental stresses. Zn influences the translocation and transport of P in plants. Under Zn deficiency, excessive translocation of P occurs resulting in P toxicity.Ensuring "food security for an ever-increasing population and scaling down poverty while sustaining agricultural systems under the present condition of depleting natural resources, calamities of climatic variability, continuous rise of inputs cost, and volatile food prices are the major challenges for most Asian countries"**(Bhan and Behera 2014)".**

"Wheat is one of the most important and widely cultivated staple food crops among the cereals and is contributing about30% to the food basket of the country. It is agronomically and nutritionally the most important cereal essential for food security, poverty alleviation, and improved livelihoods. The world acreage under wheat crop accounts for 223.11 million hectares with a production of 737.83million metric tons with an average productivity of 3.39 tons/ha (USDA report, 2017). After China, India is the leading producer of wheat in the world. In India, wheat comes second in number after rice among cereals and is cultivated in an area of 30 million hectares with the production of 97.44 metric tons recorded in 2016-17"**(Kumar *et al.* 2017)**. "In Uttar Pradesh, wheat is grown on an area of 9.65 million hectares with a production of 26.87 million tons and productivity of 2785 kgha^{-1}"**(Anonymous 2016)**. "Uttar Pradesh ranks first in area (36.6%) and production (39.3 %) of wheat in the country. Out of 100 leading wheat-producing districts (each with more than lactones of production), 43 belong to Uttar Pradesh and of them, 19 to the western part of the state particularly wheat productivity is far lower than in Punjab and Haryana. This is because of late sowing of wheat due to long-duration rice varieties and late harvest of sugarcane, poor seed replacement rate, lack of quality seed at the right time and place, lack of inputs (fertilizers, irrigation water) due to limited resources and small holding size and poor mechanization, *etc*".[24]

"The sustainability and profitability of the wheat crop system in Indian agriculture is the lifeline and future of the Indian economy with more than 60% of people living in rural areas. The challenges are enormous ranging from conservation of natural resources to investment in new technologies. Increasing food production inthe country in the next 20 years due to population growth is a big challenge in India. It is more difficult because land area devoted to agriculture will stagnate or decline and better quality of land and water resources will be divided amongthe other sectors of the national economy. To grow more food from marginal and good-quality lands, the quality of natural resources like seed, water, varieties, and fuel must be improvedand sustained. The main reasons for its low productivity are poor crop establishment, improper scheduling of irrigation, and deficient nutrition. Amongst the other agronomic practices, proper crop establishment methods may considerably increase the production of wheat to some extent. Ideal planting geometry is important for better and more efficient utilization of plant growth resources to get the optimum productivity of wheat". [24] It is also a well-known fact that nutrient management is one of the major factors responsible for achieving better harvests in crop production. Both, crop establishment method and fertilization in wheat, also affect its nutrient-use efficiency and economics.

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 of (Dec 2022- April 2023) growing Wheat var **PWB-373**applied threelevels of Nitrogen and foliar application of nano zinc respectively, Nitrogen and foliar application of nano zinc (0 and100 %) experiment is lead to observe the physicochemical parameters.

Table 1. The treatment combinations of wheat PWB-373

Treatment	Treatment combinations
T_1	Control
T_2	[N @ 0%+ P @100% +K @ 100% + N Zn (2 ml l-1)
T_3	[N @ 0% +P @ 100% +K @ 100% + N Zn (4 ml 1-1)
T_4	[N @ 50% + P @100%+K @ 100% + N Zn (0 ml1 1)
T_5	[N @ 50% + P @ 100% + K @ 100% + N Zn (2ml 1-1)
T_6	[N @ 50% + P @ 100% + K @ 100% + N Zn (4ml l-1)
T_7	[N @ 100%+ P @ 100% + K @100% + N Zn (0ml l-1)
T_8	[N @ 100% + P @ 100% + K @100% + N Zn (2ml 1-1)
T_9	[N @ 100% + P @ 100% + K @ 100% + N Zn (4ml 1-1)

Soil physical parameters

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**.

Soil Chemical parameters

The soil pH methodgiven by **M. L. Jackson, 1958** using a digital pH meter, **Soil EC (dSm^{-1})** method given by **Wilcox, 1950** using a digital EC meter,**Organic Carbon (%)** was measured using the Wet oxidation method given by **Walkley and Black, 1947,Available Nitrogen (kg ha^{-1}) by** Kjeldhal

Method by **Subbiahand Asija, 1956,Available Phosphorus (kg ha^{-1})**withColorimetric method using Jasper single beam, U.V. Spectrophotometer at 66 wavelength given by **Olsen *et al.*, 1954**, and**Available Potassium (kg ha^{-1}-) using** Flame photometric method withMetzer Flame Photometer given by **Totl Prince, 1949.**

RESULTS AND DISCUSSION

As revealed the bulk density of soil was found to be non-significant in levels of organic and inorganic fertilizer. The maximum bulk density of soil 1.31 m^{-3} and 1.32 Mg m^{-3} at 0-15 cm and 15-30 cm was recorded in T_1([Absolute Control) and the minimum 1.27 Mg m^{-3} and 1.29 Mg m^{-3} at 0-15 cm and 15-3(was recorded in T_6(N @50 + P @100 % + K @100 % N Zn (4ml l^{-1})) respectively. A similar result has been recorded by (**Meena *et al.* 2018).** The maxin particle density of soil 2.67 Mg m^{-3} and 2.62 Mg m^{-3} at 0-15 cm and 15-30 cm was recorded in treatment T_4 (N @50 + P @100%+K @100 % N Zn (0 ml and the minimum 2.66 Mg m^{3} and 2.61 Mg m^{-3} at 0-15 cm and 15-30 cm was recorded in treatment T_8(N @100 + P @100% + K @100% N Zn 2ml respectively. Similar resultshavebeen recorded by (**Kumar *et al*. 2019** and **Meena *et al.* 2018).** The response pore space of soil was found to be signifi ($P<0.05$) in levels of Nitrogen and nano Zinc. The maximum pore space of soil 48.99 % and 48.84 % at 0-15 cm and 15-30 cm was recorded in treatment T @50 + P @100%+K @100 % N Zn (0 ml 1 $^{-1}$) and the minimum 47.09 % and 47.05 % at 0-15 cm and 15-30 cm was recorded in treatment T_1 (Absc Control) respectively. Similar resultshavebeen recorded by (**Kumar *et al.* 2019**and **Mishra *et al.* 2019).** The response water holding capacity of soil was fc to be significant ($P<0.05$) in levels of organic and inorganic fertilizers. The maximum water holding capacity of the soil 45.64 % and 46.89 % at 0-15 cm 15-30 cm was recorded in treatment T_2 (N @0 + P @100 +K @100% + N Zn (2 ml l^{-1})

As revealed the pH of soil was found to be non-significant in levels of organic and inorganic fertilizer. The maximum pH of soil 7.04 and 7.05 at 0-15 and 15-30 cm was recorded in treatment T_2(N @0 + P @100 +K @100% + N Zn (2 ml l^{-1}) andthe minimum 6.98 and 7.00 at 0- 15 cm and 15-30 cm recordedin treatment T_5(N @50 + P @100% + K @100% N Zn (2ml 1^{-1}%) respectively. Similar resultshavebeen recorded (**Mishra *et al.* 2019** and **Kuma *al.* 2019).** The response EC of soil was found to be non-significant in levels of organic and inorganic fertilizer. The maximum EC of soil 00.19 dSm^{-1} and 0.(dSm^{-1} at 0-15 cm and 15-30 cm was recorded in treatment T_6(N @50 % + P @100 % + K @100 % N Zn (4ml l^{-1}) and minimum 0.13 dSm^{-1} and 0.12 dSm

0-15 cm and 15-30 cm was recorded in treatment T_3(N @0 +P @100 +K @100 % + N Zn (4 ml 1^{-1}) respectively. Similar resultshavebeen recorded by (**Mishra *et al.* 2019** and **Sahar *et al.* 2020).**

As revealed the organic carbon of soil was found to be non-significant in levels of organic and inorganic fertilizer. The maximum OC of soil 0.493 % and 0.0.334 % at 0-15 cm and 15-30 cmwas recorded in treatment T_9 (N @100 % + P @100% + K @100% N Zn (4ml 1^{-1}) and minimum 0.423 % and0.261 % at 0-15 cm and 15-30 cm was recorded in treatment T_1 (Absolute Control) respectively. Similar revealed has been recorded**(Sahar *et al.* 2020** and **Nibin*et al.* 2019)**. The response available nitrogen of soil was found to be significant ($P<0.05$) in levels of organic and inorganic fertilizer. The maximum available nitrogen 225.13 kg ha^{-1} and 206.19 kg ha^{-1} at 0-15 cm and 15-30 cm was recorded in treatment T_9 (N @100% + P @100% + K @100% N Zn (4ml 1^{-1}) and the minimum 192.94 kg ha^{-1} and 166.38 kg ha^{-1} at 0-15 cm and 15-30 cm was recorded in treatment T_1(Absolute Control) respectively. Similar resultshavebeen recorded by (**Rajonee*et al.* 2016** and **Gupta *et al*. 2018).** The response available phosphorus of soil was found to be significant ($P<0.05$) in levels of organic and inorganic fertilizer. The maximum available phosphorus of soil 20.75 kg ha^{-1} and 18.39 kg ha^{-1} at 0-15 cm and 15-30 cm was recorded in treatment T_9 (N @100 + P @100% + K @100% N Zn (4ml 1^{-1}) and the minimum 17.20 kg ha^{-1} and 16.33 kg ha^{-1} at 0-15 cm and 15-30 cm was recorded in treatment T_1 (Absolute Control %) respectively. Similar resultshavebeen recorded by (**Gupta *et al*. 2018** and **Kumar *et al.* 2019).** The maximum available potassium of soil 187.00 kg ha^{-1} and 184.00 kg ha^{-1}at 0-15 cm and 15-30 cm was recorded in treatment T_9 N @100 % + P @100% + K @100% N Zn (4ml 1^{-1}) and the minimum 162.00 kg ha^{-1} and 155.00 kg ha^{-1} at 0-15 cm and 15-30 cm was recorded in treatment T_1(Absolute Control %) respectively. A similar result has been recorded by (**Kumar *et al*. 2019).**The maximum available Zinc of soil 0.767 kg ha^{-1} and 0.710 kg ha^{-1} at 0-15 cm and 15-30 cm was recorded in treatment T_9 N @100 % + P @100% + K @100% N Zn (4ml 1^{-1}) and the minimum 0.350 kg ha^{-1} and 0.260 kg ha^{-1} at 0-15 cm and 15-30 cm was recorded in treatment T_1 (Absolute Control %) respectively.

Table 2. Response of different levels of NPK and NanoZn application on post-harvest soil

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	15-30cm
T_1 [Absolute Control]	1.31	1.32	2.67	2.62	47.80	47.09	45.46	45.25

T_2 **[N @0% + P @100% +K @100% + N Zn (2 ml l^{-1})]**	1.30	1.30	2.65	2.60	47.09	48.84	46.57	45.87
T_3 **[N @0% +P @100 %+K @100% + N Zn (4 ml 1^{-1})]**	1.29	1.30	2.67	2.62	48.86	48.69	45.64	46.89
T_4 **[N @50% + P @100%+K @100% + N Zn (0 ml 1^{-1})]**	1.29	1.31	2.67	2.62	48.95	48.69	45.22	45.81
T_5 **[N @50% + P @100% + K @100% + N Zn (2 ml 1^{-1})**	1.28	1.29	2.67	2.62	48.99	47.70	45.33	45.80
T_6 **[N @50% + P @100 % + K @100 % + N Zn (4 ml l^{-1})**	1.27	1.29	2.66	2.61	47.28	47.91	46.38	45.14
T_7 **[N @100% + P @100% + K @100 % + N Zn (0 ml l^{-1})**	1.27	1.32	2.67	2.62	47.68	47.54	45.54	46.38
T_8 **[N @100% + P @100% + K @100% + N Zn (2 ml 1^{-1})**	1.28	1.31	2.66	2.61	48.74	48.69	45.97	45.05
T_9 **[N @100% + P @100% + K @100% + N Zn (4 ml 1^{-1})**	1.27	1.32	2.65	2.60	47.86	48.56	45.70	45.20
F-Test	NS	NS	NS	NS	NS	NS	S	S
S.Ed. (±)	-	-	-	-	0.86	0.68	1.00	1.16
C.D. at 0.5%	-	-	-	-			2.99	3.49

Table 3. Response of different levels of NPK and Nano Zn application ofPost-harvest soil

Treatment	**pH**	**EC (dS m^{-1})**	**Organic carbon (%)**

	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T_1 [Absolute Control]	7.04	7.05	0.17	0.16	0.423	0.261
T_2 [N @0% + P @100 % +K @100% + N Zn (2 ml l^{-1})]	7.04	7.05	0.13	0.13	0.435	0.270
T_3 [N @0% +P @100 % +K @100 % + N Zn (4 ml 1^{-1})]	7.04	7.03	0.13	0.13	0.445	0.285
T_4 [N @50% + P @100 %+K @100 % N Zn (0 ml 1^{-1})]	7.02	7.01	0.16	0.15	0.432	0.267
T_5 [N @50% + P @100 % + K @100% N Zn (2 ml 1^{-1})]	6.98	7.02	0.14	0.14	0.434	0.274
T_6 [N @50% + P @100 % + K @100 % N Zn (4 ml l^{-1})]	7.03	7.02	0.19	0.19	0.456	0.294
T_7 [N @100% + P @100 % + K @100 % N Zn (0 ml l$^{-1]}$)	7.01	7.00	0.18	0.18	0.431	0.273
T_8 [N @100 %+ P @100 % + K @100% N Zn (2 ml 1^{-1})]	7.02	7.05	0.18	0.18	0.449	0.289
T_9 [N @100% + P @100 % + K @100% N Zn (4 ml 1^{-1})]	7.01	7.02	0.16	0.17	0.493	0.334
F-Test	NS	NS	NS	NS	S	S
S.Ed. (±)	0.04	0.05	0.005	0.004	0.013	0.013
C.D. at 0.5%	-	-	-	-	0.039	0.038

Table 4. Response of different levels of N P K and Nano Zn application on post-harvest soil

Treatments	N (kg ha^{-1})		P_2O_5 (kg ha^{-1})		K_2O (kg ha^{-1})		Zn (kg ha^{-1})	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30cm
T_1 [Absolute Control]	192.94	166.38	17.20	16.32	162.00	155.00	0.350	0.260
T_2 [N @0% + P @100 % +K @100% + N Zn (2 ml l^{-1})]	198.73	170.63	17.27	16.40	163.00	159.00	0.430	0.387
T_3[N @50% + P @100 %+K @100 % N Zn (0 ml 1^{-1})]	203.28	176.50	17.50	16.56	165.00	161.00	0.561	0.469
T_4[N @50%+ P @100 %+K @100 % N Zn (0 ml 1^{-1})]	197.01	168.92	17.74	16.87	172.00	164.00	0.429	0.322
T_5[N @50% + P @100 % + K @100% N Zn (2 ml 1^{-1})]	197.98	173.39	18.72	17.463	174.00	166.00	0.519	0.401
T_6 [N @50% + P @100 % + K @100 % N Zn (4 ml l^{-1})]	208.04	184.48	18.94	16.92	175.00	168.00	0.683	0.610

T_7 [N @100% + P @100 % + K @100 % N Zn (0 ml l$^{-1]}$)	196.72	171.65	19.59	17.42	181.00	176.00	0.485	0.362
T_8[N @100 %+ P @100 % + K @100% N Zn (2 ml 1^{-1})]	205.15	179.72	20.75	18.12	184.00	179.00	0.599	0.522
T_9[N @100% + P @100 % + K @100% N Zn (4 ml 1^{-1})]	225.13	206.19	20.37	18.39	187.00	184.00	0.767	0.710
F-Test	S	S	S	S	S	S	S	S
S.Ed. (±)	1.98	3.42	0.45	0.56	1.29	0.74	0.012	0.018
C.D. at 0.5%	5.92	10.24	1.35	1.69	3.86	2.21	0.037	0.054

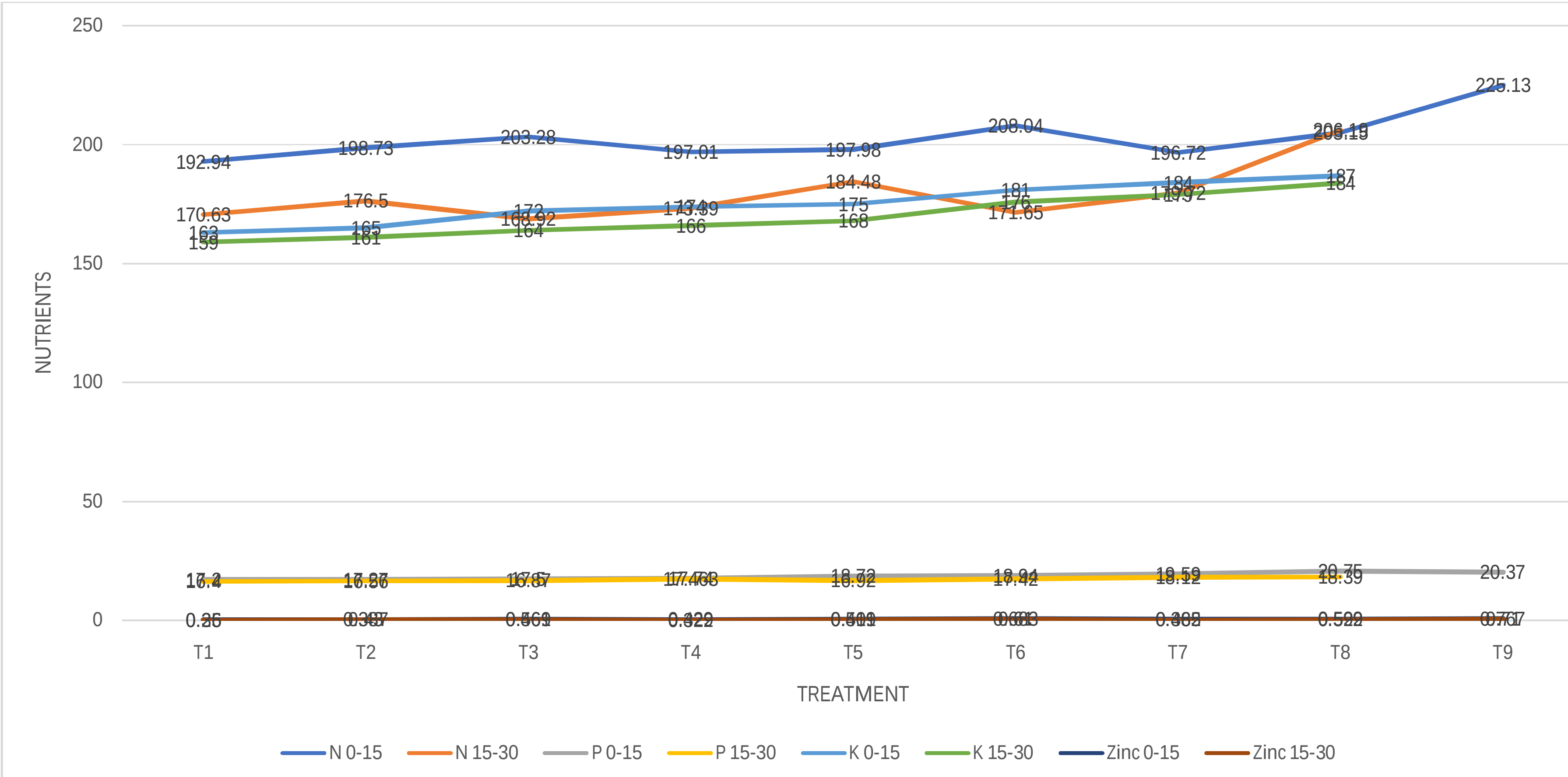

Fig. 1. Effect of different levels of Nitrogen and nano Zinc on Available N (kg h^{-1}), P (kg h^{-1}), and K (kg h^{-1}) of soil depth (0-15 cm) and (15-30

CONCLUSION

The level of NPK and Nano Zinc used in the treatment combination T_9-N @100 + P @100% + K @100% N Zn (4ml 1^{-1})wasfound to be the best treatment that gave better production of Wheat (*Triticum aestivum* L.) var. PBW-373. Treatments with Nano Zinc arebetter for soil health and Wheat production the important physicochemical properties of soil arealso improved significantly under this treatment. T_8-N @100 + P @100% + K @100% N Zn (2ml 1^{-1}) which is almost the second-best treatment combination in all aspects proven to be economically optimal, is the recommendation based on the current study work. So, Wheat should be applied with Nano Zinc with 4ml 1^{-1} to achieve high productivity in Prayagraj.

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