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Response of Different Level of Nitrogen and Foliar Application of Nano Zinc on Physico-chemical Properties of Soil in Wheat (*Triticum aestivum*. L) Var. PWB-373

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field 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 Response of different levels of Nitrogen and Foliar application of nano zinc on Soil Health and Yield of Wheat (*Triticum aestivum* L.). We designed the experiment using a Randomized Block Design (RBD) with 10 treatments and three replications. Results indicated that the application of nano fertilizers significantly influenced various soil physico chemical properties. Bulk density was 1.27Mg m^{-3} to 1.31 Mg m^{-3} at 0-15 cm soil depth, and 1.29 to 1.32 Mg m^{-3} at 0-15 and 15-30 cm soil depth. Particle density was 2.65 to 2.67 Mg m^{-3} at 0-15 cm depth, and from 2.60 to 2.62 Mg m^{-3} at 15-30 cm depth. Pore space was 47.09% to 48.99% at 0-15 cm depth and 47.09% and 48.84% at 0-15 and 15-30 cm depth. Water holding capacity varied between 45.22% and 46.64% at 0-15 cm depth, and 45.14% and 46.89% at 15-30 cm depth. Soil pH was 6.98 to 7.04 at 0-15 cm depth and from 7.00 to 7.05 at 15-30 cm depth. Electrical conductivity (EC) was 0.13 dS m^{-1} to 0.19 dS m^{-1} at 0-15 cm depth, and from 0.13 dS m^{-1} to 0.19 dS m^{-1} at 15-30 cm depth. Organic carbon content was 0.423%-0.493% at 0-15 cm depth and 0.261% to 0.334% at 15-30 cm depth. The use of NPK and nano zinc also significantly influenced the availability of available nitrogen, phosphorus, potassium, and zinc. 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.

1. 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 for plants 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" [1-4]. "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" [5].

Zinc is the fourth most yield-limiting nutrient in Indian soils and worldwide, after potassium, phosphorus, and nitrogen. According to Arvind et al. [6], "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" [7]".

"Wheat is one of the most important and widely cultivated staple food crops among the cereals and is contributing about 30% 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 737.83 million 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" [8]. "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 kg ha^{-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"* [9].

"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 in the 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 among the 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 improved and 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" [9]. 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.

2. 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 three levels of Nitrogen and foliar application of nano zinc respectively, Nitrogen and foliar application of nano zinc (0 and 100 %) experiment is lead to observe the physicochemical parameters.

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 method given by M. L. Jackson, [10] using a digital pH meter, Soil EC (dSm^{-1}) method given by Wilcox, [11] using a digital EC meter, Organic Carbon (%) was measured using the Wet oxidation method given by Walkley and Black, [12], Available Nitrogen (kg ha^{-1}) by Kjeld Hal Method by Subbiah and Asija, [13], Available Phosphorus (kg ha^{-1}) with Colorimetric method using Jasper single beam, U.V. Spectrophotometer at 660 nm wavelength given by Olsen et al*.*, [14], and Available Potassium (kg ha^{-1}-) using Flame photometric method with Metzer Flame Photometer given by Toth and Prince, [15].

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)

3. 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 Mg 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 15-30 cm 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. [16]. The maximum 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 1 $^{-1}$) 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 1^{-1}) respectively. Similar results have been recorded by Kumar et al. [17] and Meena et al. [16]. The response pore space of soil was found to be significant 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_4(N @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 (Absolute Control) respectively. Similar results have been recorded by Kumar et al. [17] and Mishra et al. [18]. The response water holding capacity of soil was found to be significant in levels of organic and inorganic fertilizers. The maximum water holding capacity of the soil 45.64 % and 46.89 % at 0-15 cm and 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 cm and 15-30 cm was recorded in treatment T_2 (N @ 0 + P @100 + K @100 % + N Zn (2 ml l^{-1}) and the minimum 6.98 and 7.00 at 0- 15 cm and 15-30 cm was recorded in treatment T_5(N @50 + P @100% + K @100% N Zn (2ml 1^{-1}%) respectively. Similar results have been recorded [18,17]. 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 0.0.19 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^{-1} at 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 results have been recorded by Mishra et al. [18] and Sahar et al. [19].

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 cm was recorded in treatment T_9 (N @100 % + P @100% + K @100% N Zn (4ml 1^{-1}) and minimum 0.423 % and 0.261 % at 0-15 cm and 15-30 cm was recorded in treatment T_1 (Absolute Control) respectively. Similar revealed has been recorded [19,20]. The response available nitrogen of soil was found to be significant 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 results have been recorded by Rajonee et al. [21] and Gupta et al. [22]. The response available phosphorus of soil was found to be significant 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 results have been recorded by Gupta et al. [22] and Kumar et al. [17]. 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. [17]. 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 [23,24].

Table 2. Response of different levels of N P K and Nano Zn application on post-harvest soil

Treatment capacity (%)		Bd (Mg m^{-3}		Pd (Mg m^{-3})		Pore space (%)		Water holding	
		0-15 cm	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30 cm**	**0-15 cm**	**15-30cm**
T1	[Absolute Control]	1.31	1.32	2.67	2.62	47.80	47.09	45.46	45.25
T2	[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
T3	[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
T4	[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
T5	[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
T6	[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
T7	[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
T8	[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
T9	[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 N P K and Nano Zn application of Post-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**
T1	[Absolute Control]	7.04	7.05	0.17	0.16	0.423	0.261
T2	[N @0% + P @100 % +K @100% + N Zn (2 ml l^{-1})]	7.04	7.05	0.13	0.13	0.435	0.270
T3	[N @0% +P @100 % +K @100 % + N Zn (4 ml 1^{-1})]	7.04	7.03	0.13	0.13	0.445	0.285
T4	[N @50% + P @100 %+K @100 % N Zn (0 ml 1^{-1})]	7.02	7.01	0.16	0.15	0.432	0.267
T5	[N @50% + P @100 % + K @100% N Zn (2 ml 1^{-1})]	6.98	7.02	0.14	0.14	0.434	0.274
T6	[N @50% + P @100 % + K @100 % N Zn (4 ml l^{-1})]	7.03	7.02	0.19	0.19	0.456	0.294
T7	[N @100% + P @100 % + K @100 % N Zn (0 ml $l^{-1]}$)	7.01	7.00	0.18	0.18	0.431	0.273
T8	[N @100 %+ P @100 % + K @100% N Zn (2 ml 1^{-1})]	7.02	7.05	0.18	0.18	0.449	0.289
T9	[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**
T1	[Absolute Control]	192.94	166.38	17.20	16.32	162.00	155.00	0.350	0.260
T2	[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
T3	[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
T4	[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
T5	[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
T6	[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
T7	[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
T8	[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
T9	[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

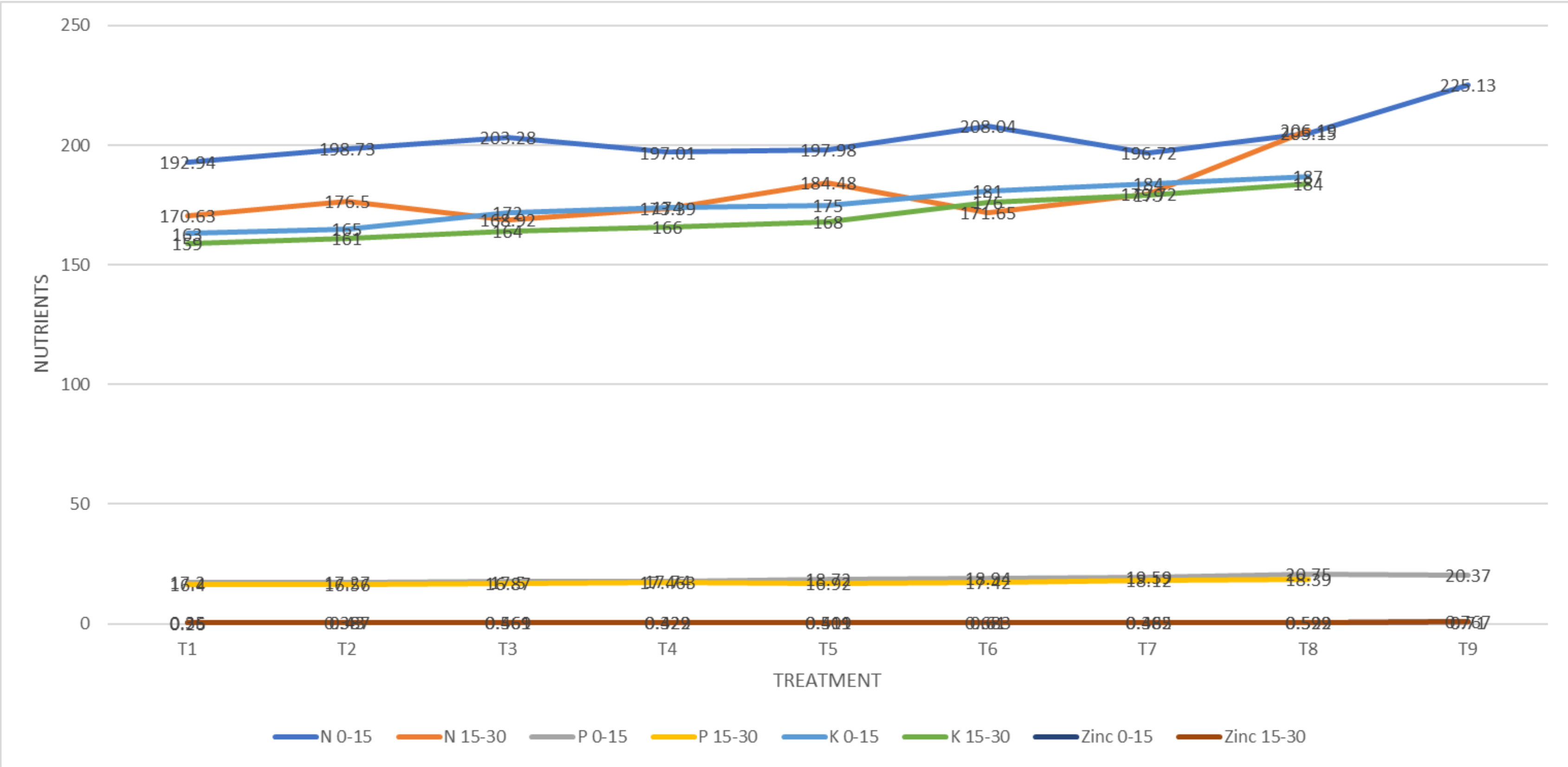

Fig. 1. Effect of different levels of Nitrogen and nano Zinc on Available N (kg h^{-1}), P (kg h^{-1}), and K (kg h^{-1}) of soil depth (0-15 cm) and (15-30 cm)

4. 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}) was found to be the best treatment that gave better production of Wheat (*Triticum aestivum* L.) var. PBW-373. Treatments with Nano Zinc are better for soil health and Wheat production the important physicochemical properties of soil are also 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.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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