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Response of macro nutrient and nano zinc on soil health parameters yield attributes of maize (*Zea mays* L). var white pearly

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Abstract
An experiment was carried out at research farm of soil science and agricultural chemistry, shuats prayagraj during the summer seasons of 20223-24. Effect of different level of N:P: K (19:19:19) and nano zinc on the physicochemical properties of soil, growth, and yield of maize. The design applied in RBD with three level of RDF applied of N, P, K @ 0%, 50% and 100% respectively and three levels of Nano Zn @ 0%, @ 50% and @ 100% respectively, results showed that T_9 was at par than any other treatment in particle density, pore space, water holding capacity, organic carbon, available nitrogen, phosphorus and potassium respectively were found to be significant and followed by T_8 The investigation of NPK (19:19:19), nano zinc (Iffco), and spraying maize crops, different combinations with suggested fertilizer dosages. The treatment T_9 - [NPK @ 100% + Nano Zinc @ 100%] had a significant effect on growth and yield parameters, resulting in a maximum yield of 46.96 q h^{-1}a and B:C of 2:1. The macro, micro-nutrients, organic manures, biofertilizers and crop residues can sustain the fertility of and productivity of soil for long period of time and can provide higher yield maize and economic of the farmers.

Keywords: Soil physical properties and soil chemical properties, etc.

Introduction
Soil is the non-renewable dynamic resource, comprising of unconsolidated minerals and organic matter including water and air within the uppermost layers of the earth's surface and plays a crucial role in maintaining the terrestrial ecosystem on which all life depends. As compared to previous year an increase of 11 Lakh Metric tonnes increases. According to the reports of Krishi Vigyan Kendra of (Allahabad) Prayagraj, in kharif 2023, maize was cultivated under 116 ha^{-1} area in district and having production of 1720 metric tonnes and productivity of 14.45 (q ha^{-1}) reported. According to the Ministry of Agriculture and Welfare (2023), kharif maize production is estimated at 224.82 lakh metric tonnes in 2023. The chemical and physical properties of soil have a big role in a plant's ability to extract water and nutrients. Soil is that the product of biochemical weathering of the parent material and its formation is influenced by the soil formation factors like climate, organism, parent material, relief, and time (Kherawat *et al.*, 2013) [16]. Soil is a mixture of organic matter, minerals, gases, water and living organisms that together support life (Brady and Weil, 2016) [6]. Soil plays a critical role in maize production by providing nutrients, water and physical support for growth (Pathak *et al.*, 2013) [40]. Monitoring soil moisture levels is essential, with optimal levels between 50% and 75% of field capacity, managed through irrigation and water conservation (Kumar *et al.*, 2018) [15]. Maize requires well-drained, fertile soil with good water-holding capacity and aeration. Soil fertility management via organic and inorganic fertilizers can improve fertility and increase maize yield (Gebrehiwot *et al.*, 2016) [12]. Micronutrient deficiency is a significant concern in underdeveloped countries. Zinc insufficiency is a significant risk factor for human health and mortality worldwide (Cakmak *et al.*, 1998; Salunke *et al.*, 2012) [8, 33]. Micronutrient deficiencies have a significant impact on plant growth, metabolism, and reproduction in animals and humans (Rattan *et al.*, 2009) [29].

Approximately 230 million people in India are undernourished, making up more than 27% of the population. Chakraborti *et al.* (2011) [41] report on the world's undernourished population. (Waters and Sankaran 2011) [39] and White and Broadley 2005) [38] propose biofortification as a method for enhancing bio-available nutrients like Fe and Zn in staple crops, rather than using fortifications or supplements. The major goal of foliar sprays is to allow fertilizer-enhanced nutrient uptake by the plant, maximizing their usage. STCR-NPK fertilizers with NPK (19:19:19), Pink-Pigmented Facultative Methylotrophs (PPFM), and Micronutrient mixtures are most suited for this purpose. Applying a balanced fertilizer throughout important periods of growth will increase the benefits and quality of agricultural products. Soil grade and drip irrigation. (NPK 19:19:19).

Foliar Spray - 1.0 to 1.5% solution (10 to 15 gm per liter of water) 2–3 sprays from 40-50 to 60–70 days after sowing at 10-15 days interval. NPK (19:19:19) contain nutritional value Nitrogen - 19% Phosphorus - 19% Potassium - 19% (IFFCO 2020). Foliar application is usually preferred because very small amounts of fertilizers are applied per unit area and decrease groundwater pollution. Application of NPK (19:19:19) at 2% concentration twice at 30 and 60 days after sowing (DAS) produced the highest single leaf area (415.0 cm 2) when compared with other application timings (Amanullah *et al.*, 2013) [3]. Zinc (Zn) is a micronutrient that improves photosynthesis (Cabot *et al.*, 2019) [7], chlorophyll content (Sakya *et al.*, 2018) [31], grain yield (Mahmood *et al.*, 2019) [22], relative water content (Pavia *et al.*, 2019) [27], antioxidant defense system (Olechnowicz *et al.*, 2018) [26].

Nano zinc is applied @ 2 mL L-1 of water. Nano zinc contains 1% zinc in nano form. These are applied at critical crop growth stages when the zinc requirement is more or at a time when the crop may be experiencing its stress. One spray of nano zinc should be done 30-35 days after germination or 20-25 days after transplanting. Nano Zinc were undertaken as per "Guidelines for Evaluation of (Nano-Based-Agri-Input and Food Products in India 2020"), released by Department of Biotechnology, Government of India. These have been evaluated by NABL-accredited and GLP-certified laboratories and are reported to be safe for the user and for the environment. For the initial vegetative growth period, bud bursting, rejuvenation of vegetative growth.

Maize is one of the world's most important cereals, alongside wheat and rice, particularly in India. It is one of the most versatile crops. Maize is known as the "Queen of Cereals" for its great productivity, ease of processing, and lower cost compared to other cereals (Jaliya *et al.*, 2008) [14]. Maize grain has a high nutritional value, with 72% starch, 10% protein, 4.8% oil, 5.8% fiber, and 3.0% sugar (Rafiq *et al.*, 2010) [28]. Southern Rajasthan's provincial populations rely heavily on it for their daily calorie and mineral requirements. But unfortunately, maize has low protein and mineral content, particularly zinc and iron. This crop is prone to micronutrient deficiencies, particularly zinc and iron, because to its high demand for nutrients. In India, maize is used for human food (23%), poultry feed (49%), animal feed (12%), industrial starch products (15%), drinks, and seed (1% each) (Malhotra 2017) [18]. Furthermore, the introduction of high-yielding agricultural cultivars during the green revolution has exacerbated the issue. Maize is known as a marker plant for testing zinc, shortage of dirt. Foliar feeding is an excellent approach for repairing nutrient shortages and overcoming the soil's inability to transport nutrients to the maize plant during low moisture circumstances.

Materials and Methods

The experiment trial was conducted during kharif season 2023-24 on crop research farm of the department of soil science and agricultural chemistry. Which is located at 25024'30" N latitude, 810 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 (0-10% slope)] and agro-climatic zone (Upper Gangetic Plain Region). The trial was conducted in a randomized block design (RBD) with three levels of inorganic fertilizers N: P: K (19:19:19) (@ 0.0% + @ 50.0%, @ 100.0% dosage), Nano Zinc respectively, the treatments are replicated into three times dividing the experimental area into twenty-seven plots.

Soil physical parameters are bulk density (Mg m-3), particle density (Mg m-3), pore space (%) and water retaining capacity (%), Muthuval *et al.* (1992) [23] and chemical properties of soil pH W/V (1:2.5) Jackon (1958) [13], EC (dS m-1) (1:2.5) Wilcox (1950), organic Carbon (%) Walkley and Black (1947) [37], nitrogen (kg ha^{-1}) Subbiah and Asija (1956) [35], phosphorus (kg ha^{-1}) Olsen *et al.* (1954), potassium (kg ha^{-1}) Toth and Prince, (1949). Permissible limit NPK and nano zinc for soil nitrogen kg ha^{-1} low (<280), medium (280-560), high (>560) and phosphorus kg ha^{-1} (<12.25), medium (12.25), high (>25), potassium low (<135), medium (135-335), high (>335). (Awanish *et al.*, 2014) [42] and nano zinc (1- 5 ppm) Alloway, *et al.*, (2008) [2]. Soil texture of the soil sample was taken on depth of 0-15cm. Sand 66.64 (%), Silt 24.09 (%) and Clay 16.27 (%) was observed which indicates soil texture sandy loam. Soil color was observed at different depths, with a light yellowish-brown color in dry conditions and an olive brown color in wet conditions. Crop calendar provides a general framework for pre-sowing field operations for maize. Adjustments might be necessary based on your specific climate, soil conditions, and other factors. Tillage operation (Open ploughing by mould board plough followed by harrowing and ploughing), Layout and demarcation of plot (Manually), Collection of soil sample for analysis (Randomly from a depth of 0-15 cm), fertilizer application (N: P: K: 19:19:19] and Nano Zinc), Seed sowing (Manually) Plant observation is included hight (cm) number of cobs, yield (q ha^{-1}).

Results and Discussion

Table 1: Effect of different levels of NPK and Nano Zinc on pore space and water holding capacity of soil at different depths

Treatments	Pore space (%)	WHC (%)
	0-15 cm	0-15 cm
T_1	51.89	45.56
T_2	53.87	46.24
T_3	53.33	52.03
T_4	54.42	53.71
T_5	52.59	55.77
T_6	56.47	58.74
T_7	59.48	60.33
T_8	62.05	62.45
T_9	63.89	62.94
F- test	S	S
S. Em. (±)	0.42	0.41
C.D.	0.89	0.86

As reported in table 1 the maximum pore space of soil at depth 0-15 cm maximum was 63.89 in treatment T_9 [N:P: K @ 100% + Nano Zinc @ 100%] followed by T_8 62.05 [N:P: K @ 0% +

Nano Zinc @ 50%] and minimum 51.89 was in treatment T_1 [N:P: K @ 0% + Nano Zinc @ 0%] were significant respectively. These results were in close conformity with the findings of Dekhane *et al.* (2011) [9], Das *et al.* (2013) [10], Singh *et al.* (2013) [32] and Nadeem *et al.* (2017) [24], and the maximum water holding capacity (%) of soil at depth 0-15 cm maximum was 63.94 in treatment T_9 [N:P: K @ 100% + Nano Zinc @ 100%] followed by T_8 62.45 [N:P: K @ 0% + Nano Zinc @ 50%] and minimum 45.56 was in treatment T_1 [N:P: K @ 0% + Nano Zinc @ 0%] were significant respectively. These results were in close conformity with the findings of Dekhane *et al.* (2011) [9], Das *et al.* (2013) [10], Singh *et al.* (2013) [32] and Nadeem *et al.* (2017) [24].

Table 2: Effect of different levels of NPK and Nano Zinc on organic carbon and organic matter of soil at different depths

Treatment	Organic carbon (%)	Organic matter (%)
	0-15cm	0-15 cm
T_1	0.312	0.536
T_2	0.318	0.546
T_3	0.321	0.552
T_4	0.325	0.559
T_5	0.328	0.564
T_6	0.331	0.569
T_7	0.336	0.577
T_8	0.341	0.586
T_9	0.346	0.588
F- test	S	S
S. Em. (±)	0.01	0.01
C.D.	0.01	0.02

As revealed in table 2 that the maximum organic carbon of soil at depth 0-15 cm maximum was 0.346 in treatment T_9 [N:P: K @ 100% + Nano Zinc @ 100%] followed by T_8 0.341 [N:P: K @ 100% + Nano Zinc @ 50%] and minimum 0.312 was in treatment T_1 [N:P: K @ 0% + Nano Zinc @ 0%] respectively. These results were in *close* conformity with the findings of Dekhane *et al.* (2011) [9], Das *et al.* (2013) [10], Singh *et al.* (2013) [32] and Nadeem *et al.* (2017) [24] and the maximum organic matter (%) of soil at depth 0-15 cm maximum was 0.588 in treatment T_9 [N:P: K @ 100% + Nano Zinc @ 100%] followed by T_8 0.86 [N:P: K @0% + Nano Zinc @ 50%] and minimum 0.536 was in treatment T_1 [N:P: K @ 0% + Nano Zinc @ 0%] were significant respectively. These results were in close conformity with the findings of Dekhane *et al.* (2011) [9], Das *et al.* (2013) [10], Singh *et al.* (2013) [32] and Nadeem *et al.* (2017) [24].

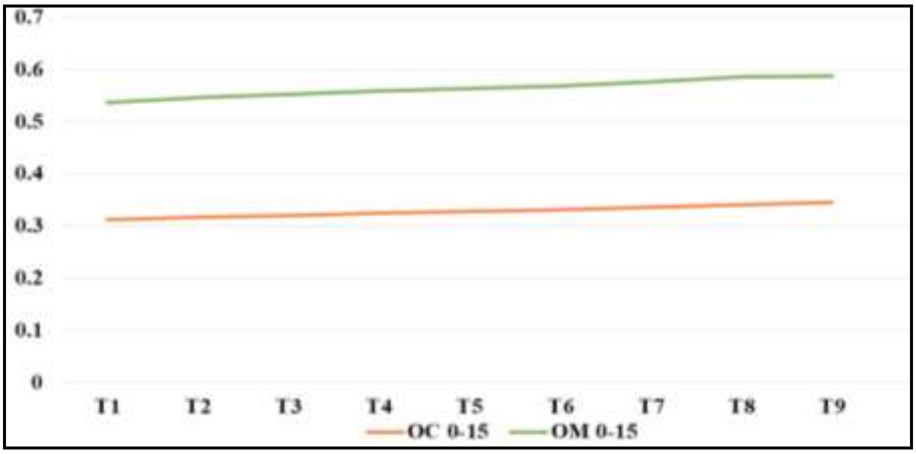

Fig 1: Effect of various NPK and Nano zinc on organic carbon (%) and organic matter (%).

Table 3: Effect of different levels of NPK and nano zinc on nitrogen phosphorous and potassium (Kg ha^{-1}) at different depth

Treatment	Nitrogen (Kg ha^{-1})	Phosphorus (Kg ha^{-1})	Potassium (Kg ha^{-1})
	0-15 cm	0-15 cm	0-15cm
T_1	244.25	18.22	116.6
T_2	242.56	18.24	26.2
T_3	253.45	19.46	131.1
T_4	242.58	19.69	128.5
T_5	254.59	21.28	142.0
T_6	256.56	20.22	137.0
T_7	257.25	19.09	142.9
T_8	258.65	19.97	148.4
T_9	257.65	21.92	151.1
F- test	S	S	S
S. Em. (±)	0.48	0.29	0.66
C.D.	1.01	0.62	1.41

As depicted table 3 the maximum nitrogen (Kg ha^{-1}) of soil at depth 0-15 cm maximum was 258.65 in treatment T_9 [N:P: K @ 100% + Nano Zinc @ 100%] followed by T_8 257.65 [N:P: K @ 100% + Nano Zinc @ 50%] and minimum 242.56 was in treatment T_1 [N:P: K @ 0% + Nano Zinc @ 0%] respectively. These results were in close conformity with the findings of Dekhane *et al.* (2011) [9], and the maximum phosphorus (Kg ha^{-1}) of soil at depth 0-15 cm maximum was 21.92 in treatment T_9 [N:P: K @ 100% + Nano Zinc @ 100%] followed by T_8 21.28 [N:P: K @ 100% + Nano Zinc @ 50%] and minimum 18.22 was in treatment T_1 [N:P: K @ 0% + Nano Zinc @ 0%] were significant respectively. These results were in close conformity with the findings of Dekhane *et al.* (2011) [9]. As reported in table 3 the maximum potassium (Kg ha^{-1}) of soil at depth 0-15 cm maximum was 151.12 in treatment T_9 [N:P: K @ 100% + Nano Zinc @ 100%] followed by T_8 148.48 [N:P: K @ 100% + Nano Zinc @ 50%] and minimum 116.44 was in treatment T_1 [N:P: K @ 0% + Nano Zinc @ 0%] were significant respectively. These results were in close conformity with the findings of Dekhane *et al.* (2011) [9].

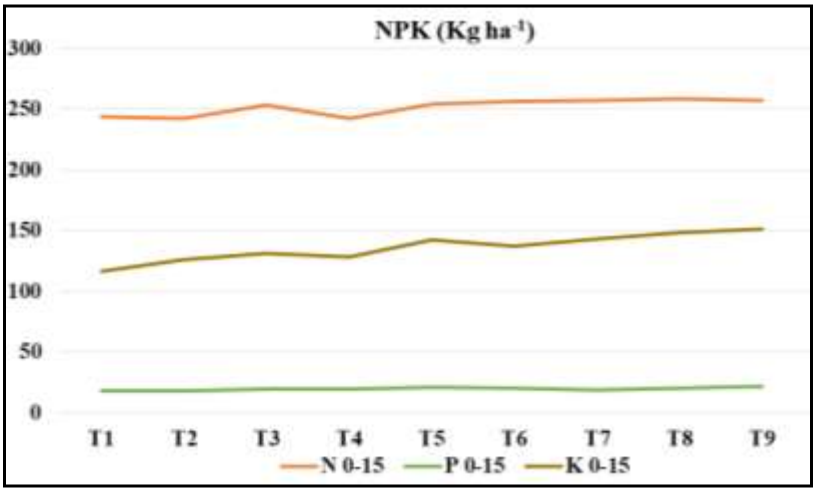

Fig 2: Effect of various NPK and Nano zinc on nitrogen phosphors and potassium.

Table 2: Effect of different levels of NPK (19:19:19) and nano zinc on zinc (Mg kg-1) at different depth

Treatment	Available Zinc (mg kg^{-1}) 0-15 cm
T_1	0.49
T_2	0.78
T_3	0.95
T_4	1.01
T_5	1.17
T_6	1.22
T_7	1.35
T_8	1.45
T_9	1.58
F- test	S
S. Em. (±)	0.02
C.D.	0.04

As descripted in table 4 the maximum zinc of soil at depth 0-15 cm maximum was 1.58 in treatment T_9 [N:P: K @ 100% + Nano Zinc @ 100%] followed by T_8 1.45 [N:P: K @ 100% + Nano Zinc @ 50%] and minimum 0.49 was in treatment T_1 [N:P: K @ 0% + Nano Zinc @ 0%] were significant respectively. These results were in close conformity with the findings of Dekhane *et al.* (2011) [9].

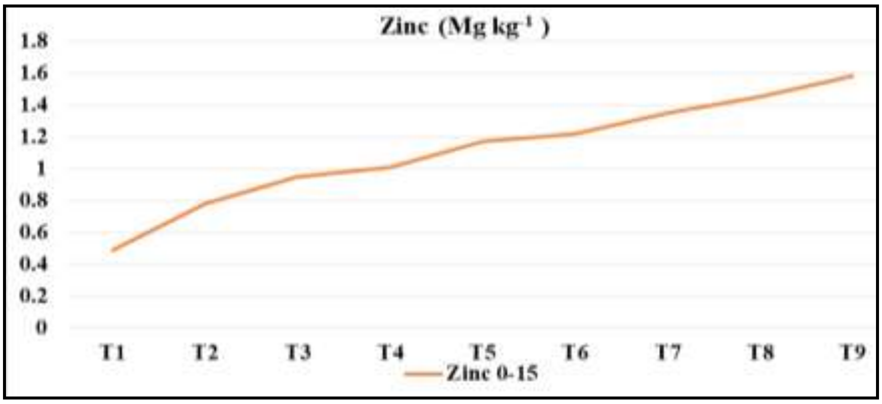

Fig 3: Effect of various NPK and Nano zinc on zinc (Kg m-1).

Table 5: Effect of different levels of NPK (19:19:19) and nano zinc on soil pH (w/v) and EC (dS m-1) at different depth

Treatment	pH (w/v)	EC (dS m -1)
	0-15cm	0-15cm
T_1	7.42	0.31
T_2	7.41	0.32
T_3	7.43	0.34
T_4	7.48	0.35
T_5	7.56	0.37
T_6	7.61	0.38
T_7	7.44	0.41
T_8	7.42	0.43
T_9	7.53	0.44
F- test	NS	NS
S. Em. (±)	-	-
C.D.	-	-

As descripted in table 5 the maximum pH of soil at depth 0-15 cm maximum was 7.61 in treatment T_9 [N:P: K @ 100% + Nano Zinc @ 100%] followed by T_6 7.53 [N:P: K @ 50% + Nano Zinc @ 100%] and minimum 7.41 was in treatment T_2 [N:P: K @ 0% + Nano Zinc @ 50%] respectively. These results were in close conformity with the findings of Dekhane *et al.* (2011) [9].
As reported in table 4 the maximum EC (dS m-1) of soil at depth 0-15 cm maximum was 0.44 in treatment T_9 [N:P: K @ 100% + Nano Zinc @ 100%] followed by T_8 0.43 [N:P: K @ 100% + Nano Zinc @ 50%] and minimum 0.31 was in treatment T_1 [N:P: K @ 0% + Nano Zinc @ 0%] respectively. These results were in close conformity with the findings of Dekhane *et al.* (2011) [9].

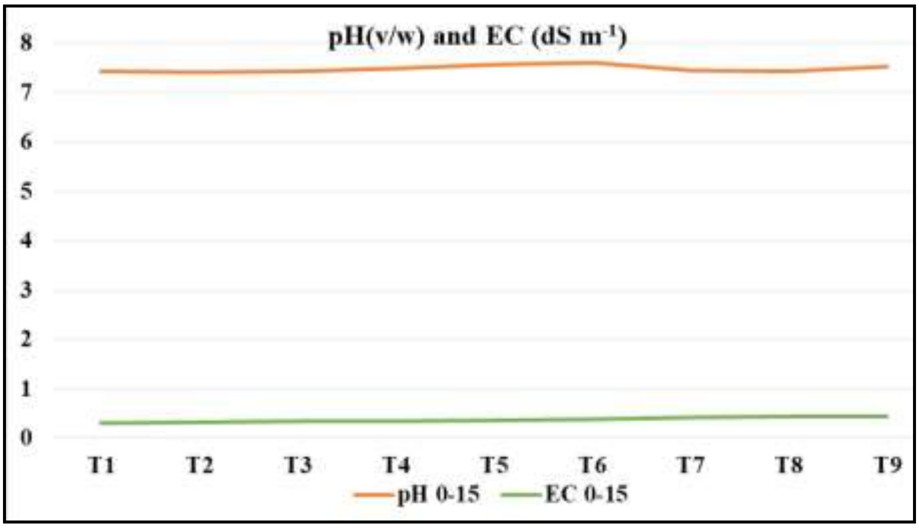

Fig 4: Effect of various NPK and Nano zinc on pH (v/w) and EC (dSm-1).

The study analyzed the financial aspects of various therapies by calculating the cost of cultivation for each treatment, calculating gross returns and net returns and dividing the net return by the cost of cultivating each unique treatment combination to determine the benefit-cost ratio. The highest benefit cast ratio is T_9 (₹ 2:1), followed by T_6 (₹ 2:0) minimum was T_1 (₹ 1.4:0)

Summary and Conclusion

The trial was conducted in research farm of SSAC, [NAI], SHUATS, Prayagraj (Allahabad), U.P., India topic taken for the study the topic “Response of Macro nutrient and Nano Zinc on Soil health Parameters Yield attributes of Maize (*Zea mays* L). var White Pearly” objectives were on soil health parameters chemical parameters *i.e.* nitrogen, phosphorus, potassium and, zinc, organic carbon and organic matter, physical parameters particle density, pores space and water holding capacity were found to be significant.
Maize plant height, number of cobs, yield and economics of the treatments, were found to be significant.
Macronutrients and nano zinc positively impact soil health and yield in white pearly maize cultivation, enhancing soil fertility, supporting healthy plant growth, and boosting yield attributes. However, optimal results depend on balanced application and management practices. The highest yield production was observed in the combination of N: P: K and nano zinc.
In’s revealed form the trail that T_9- [NPK @ 100 + nano zinc @ 100%] followed by T_6 – [NPK @ 50 + nano zinc @ 100%], the best economics was reported in T_9 and found to at par than any other treatments of maize var. white pearly. Foliar applications of N:P:K (19:19:19) and nano zinc can efficiently address nutrient needs, reduce environmental impact, and enhance maize growth and yield, especially in alkaline or compacted soils, provided proper management and sustainable for sustainable agriculture.

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