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Assessment of different level of macro-micro nutrients and rhizobium on soil health parameters and yield of blackgram (*Vigna mungo* L.) var. Shekhar-2

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Abstract
An experiment was conducted during in Kharif season (July 2023 - August 2023) to study the "Assessment of different level of Macro-micro Nutrients and Rhizobium on Soil health Parameters and Yield of Blackgram (*Vigna mungo* L.) var. Shekhar-2" 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 results shows 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 T_9 - [NPK @ 100% + Zinc @ at 100%] that found to be at par than any other treatments than other treatments.

Keywords: 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 favourable. 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.

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 [1]. 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 [3-6]. 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 *et al.*, [7], zinc contributes to the synthesis of auxin, the activation of dehydrogenase enzymes, and the stabilization of ribosomal fractions.

Materials and Methods

The location's highest temperature occasionally drops below 40 °C or 50 °C and can reach up to 46 °C to 48 °C. Between 20 to 94% the relative humidity was present. Around 1100.00 mm of rain precipitation occurs yearly on average in this region. The experimental site is located 98 meters above sea level at 25^0 57'N latitude and 81^0 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. Blackgram sowing in 2 x 2 m plots during the Kharif 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 [8] assessed the soil pH with a pH meter, and Wilcox [9] 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) [10]. The soil organic carbon (SOC) was estimated using the Walkley and Black method (1947) [11].

Result and Discussion

Physical Properties of Soil

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 1.285 Mg m^{-3} and 1.295 Mg m^{-3} in treatment T_9 (NPK @ 100% + Zn @ 100%) and the minimum was 1.244 Mg m^{-3} and 1.251 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 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.,* [12]; Bhattacharya *et al.,* [13].

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 2.525 Mg m^{-3} found in T_9 (NPK @ 100% + Zn @ 100%) and minimum was 2.476 Mg m^{-3} and 2.483 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*., [14]; Dangi *et al.,* [15].

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 46.63% and 41.98% found in T_9(NPK @ 100% + Zn @ 100%) and minimum pore space of soil was recorded 41.10% and 36.80% 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 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*., [16]: Amurta *et al.,* [17].

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 48.26% and 45.71% found in treatment T_9 (NPK @ 100% + Zn @ 100%) and minimum water holding capacity of soil was recorded 36.55% 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*., [16]: Amurta *et al.,* [17].

Chemical Properties of Soil

Soil pH (1:2.5) w/v

The response pH of soil was found to be non-significant in levels of NPK and Zn. The maximum pH of soil was recorded 7.07 and 7.16 found in treatment T_9 (NPK @ 100% + Zn @ 100%) and minimum pH of soil was recorded 6.51 and 6.55 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, [18]: Jha *et al.,* [19].

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 0.475 dS m^{-1} and 0.479 dS m^{-1} founds in treatment T_9 (NPK @ 100% + Zn @ 100%) and minimum EC of soil was recorded 0.441 dSm^{-1} and 0.445 dS m^{-1} found at of depths at 0-15 to 15-30 cm in treatment T_1 [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, [20]; Habib *et al.,* [21].

Organic Carbon (%)

The maximum organic carbon of soil was found 0.405 and 0.397 in T_9 (NPK @ 100% + Zn @ 100%) and minimum was measured 0.375 and 0.368%at soil depths 0-15 and 15-30 cm in treatment T_1 (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, [20]; Habib *et al.,* [21].

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 322.78 kg ha^{-1} and 317.56 kg ha^{-1} found in treatment T_9 (NPK @ 100% + Zn @ 100%) and minimum Available Nitrogen of soil was recorded 291.61 kg ha^{-1} and 287.34 kg ha^{-1} at soil depths 0-15 to 15-30 cm in treatment T_1 [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*., [22]; Javeed *et al*., [23].

Available phosphorus (kg h(a^{-1})

The maximum Available Phosphorus of soil was recorded 23.55 kg ha^{-1} and 20.82 kg ha^{-1} found in treatment T_9 (NPK @ 100% + Zn @ 100%) and minimum Available Phosphorus of soil was recorded 16.20 kg ha^{-1} and 14.38 kg ha-1 at soil depths 0-15 to 15-30 cm in treatment T_1 (NPK @ 0% + Zn @ 0%) respectively. The mean value of Available Phosphorus (kg ha^{-1}) of soil was found significant. Similar result has been recorded by Sharma *et al.*, [22]; Javeed *et al*., [23].

Available potassium (kg ha^{-1})

The maximum Available Potassium of soil was recorded 209.89 kg ha^{-1} and 205.03 kg ha^{-1} found in treatment T_9 (NPK @ 100% + Zn @ 100%) and minimum Available Potassium of soil was recorded 184.43 kg ha^{-1} and 182.05 kg ha-1 at soil depths 0-15 to 15-30 cm in treatment T_1 [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*., [22]; Javeed *et al*., [23].

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 0.362 mg kg^{-1} and 0.353 mg kg^{-1} found in treatment T_9 (NPK @ 100% + Zn @ 100%) and minimum Available Zinc of soil was recorded 0.287 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 [24-29]. Similar result has been recorded by Tripathi *et al.*, [30]; Bameri *et al*., [31] and Chaudhary *et al*., [32].

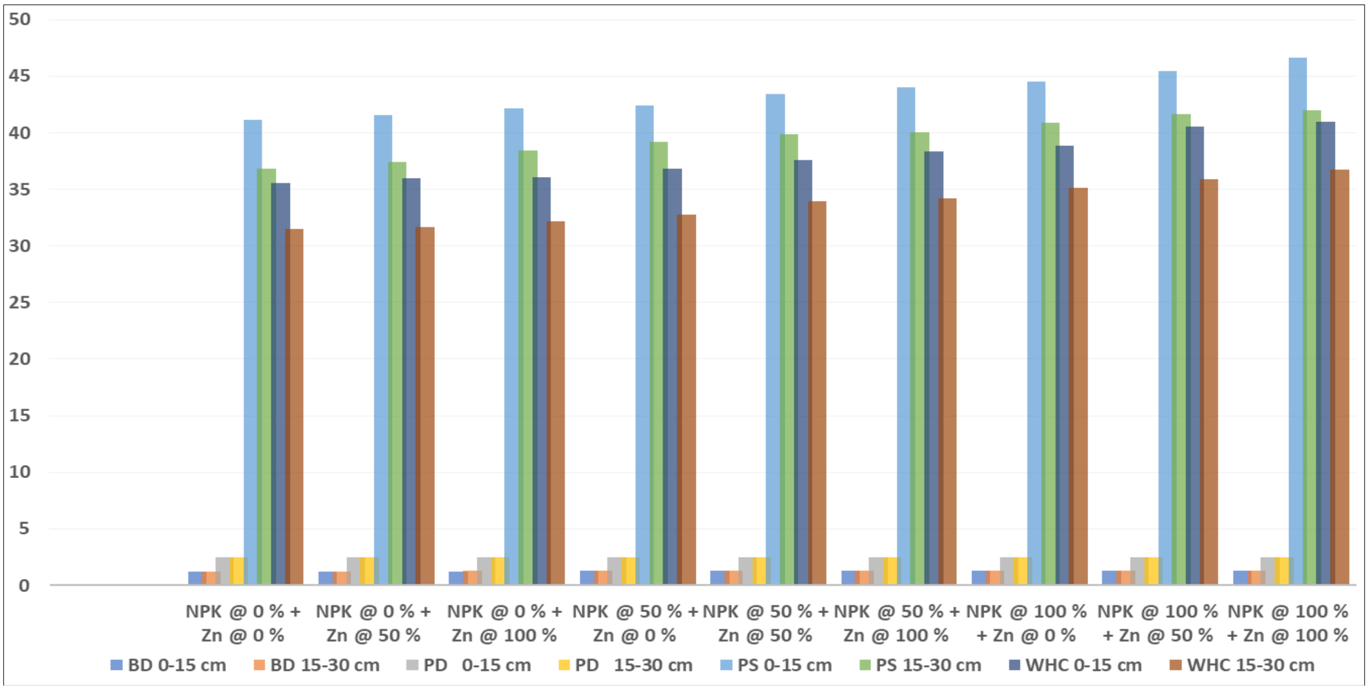

Fig 1: Effect of different levels of NPK and Zn on BD (Mg m^{-3}), PD (Mg m^{-3}), PS (%), and WHC (%) of soil depth (0-15 cm) & (15-30 cm)

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%	1.244	1.251	2.476	2.483	41.10	36.80	35.55	31.48
NPK @ 0% + Zn @ 50%	1.247	1.256	2.481	2.488	41.56	37.43	35.97	31.70
NPK @ 0% + Zn @ 100%	1.250	1.263	2.487	2.493	42.18	38.46	36.07	32.18
NPK @ 50% + Zn @ 0%	1.261	1.269	2.489	2.495	42.43	39.21	36.84	32.72
NPK @ 50% + Zn @ 50%	1.263	1.275	2.494	2.501	43.38	39.87	37.61	33.92
NPK @ 50% + Zn @ 100%	1.270	1.279	2.499	2.510	43.98	40.06	38.30	34.22
NPK @ 100% + Zn @ 0%	1.274	1.284	2.505	2.516	44.50	40.86	38.84	35.09
NPK @ 100% + Zn @ 50%	1.280	1.289	2.510	2.522	45.48	41.67	40.51	35.85
NPK @ 100% + Zn @ 100%	1.285	1.295	2.518	2.525	46.63	41.98	40.96	36.71
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

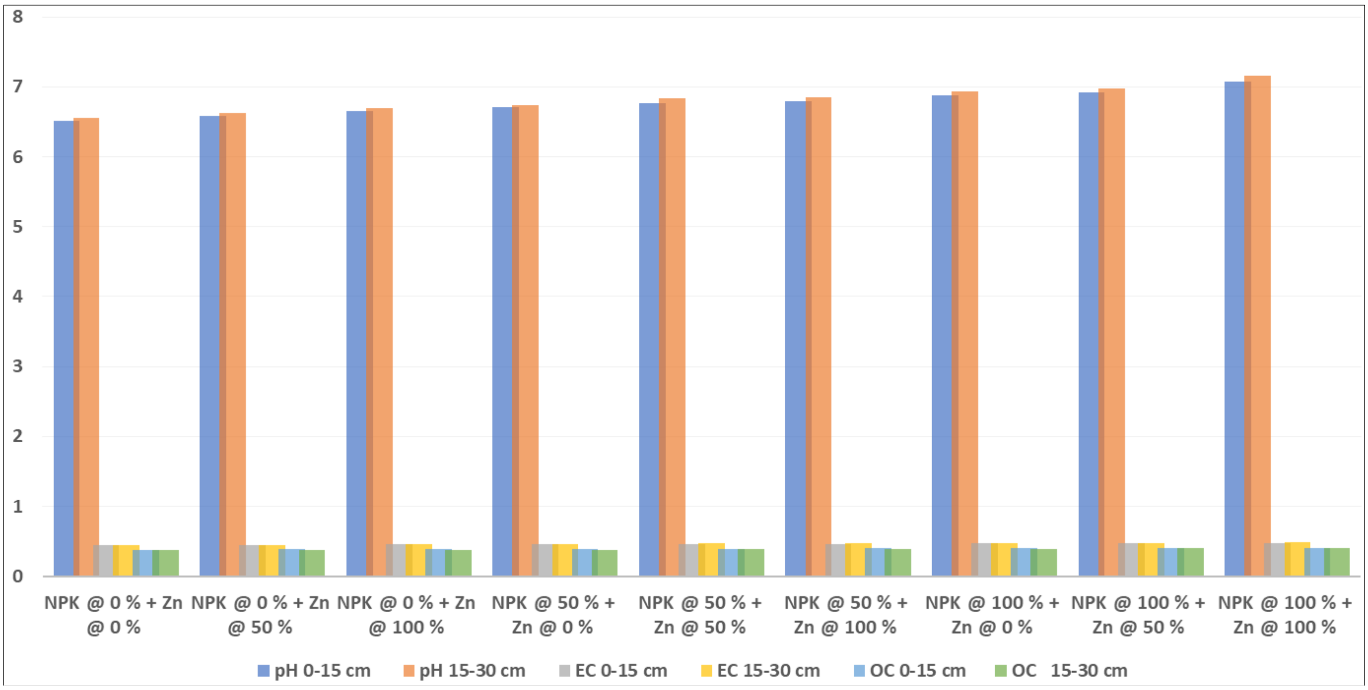

Fig 2: Effect of different levels of NPK and Zn on pH, EC (dS m^{-1}), OC (%), of soil depth (0-15 cm) and (15-30 cm)

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

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
NPK @ 0% + Zn @ 0%	6.51	6.55	0.441	0.445	0.376	0.367
NPK @ 0% + Zn @ 50%	6.58	6.63	0.446	0.448	0.381	0.373
NPK @ 0% + Zn @ 100%	6.65	6.70	0.450	0.454	0.383	0.375
NPK @ 50% + Zn @ 0%	6.71	6.74	0.453	0.457	0.388	0.378
NPK @ 50% + Zn @ 50%	6.77	6.83	0.457	0.464	0.393	0.382
NPK @ 50% + Zn @ 100%	6.80	6.85	0.463	0.468	0.394	0.384
NPK @ 100% + Zn @ 0%	6.88	6.93	0.464	0.472	0.399	0.391
NPK @ 100% + Zn @ 50%	6.92	6.98	0.471	0.476	0.402	0.394
NPK @ 100% + Zn @ 100%	7.07	7.16	0.475	0.479	0.405	0.397
F-Test	NS	NS	NS	NS	NS	NS
S.Ed. (±)	-	-	-	-	-	-
C.D. at 0.5%	-	-	-	-	-	-

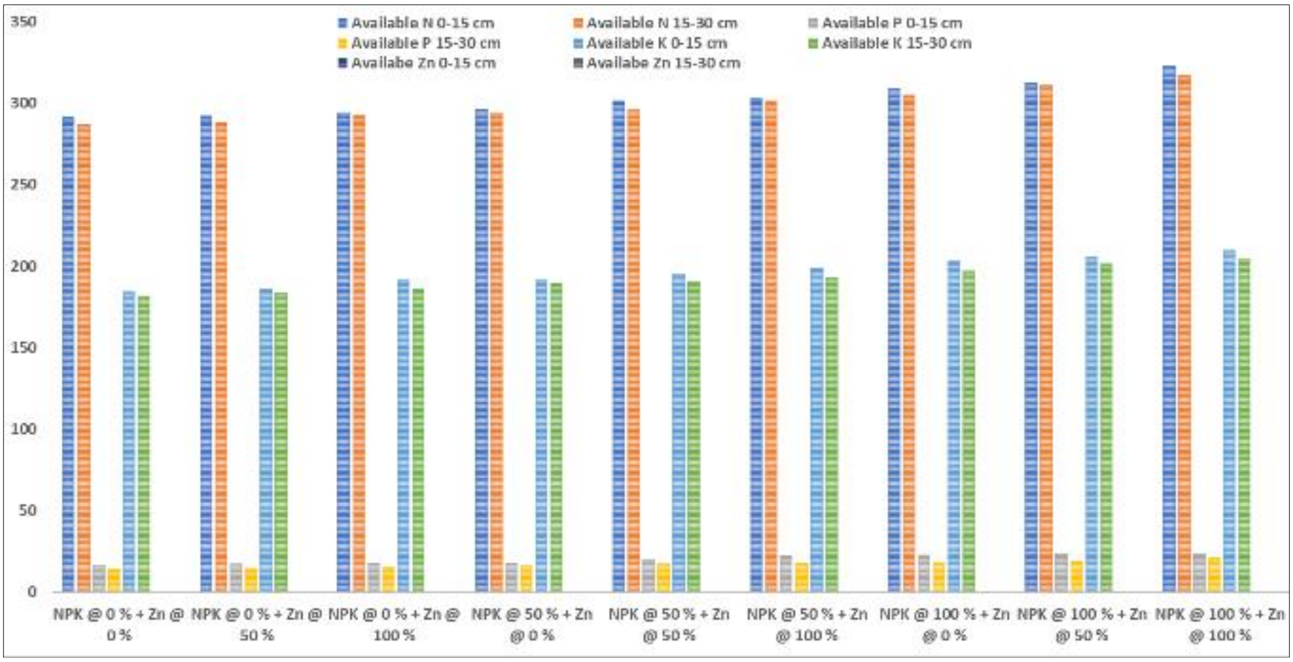

Fig 2: Effect of different levels of NPK and Zn on Available N (kg ha^{-1}), P (kg h^{-1}), K(kg ha^{-1}) and Zn (mg kg^{-1}) of soil depth (0-15 cm) and (15-30 cm)

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%	291.61	287.34	16.20	14.38	184.43	182.05	0.287	0.290
NPK @ 0% + Zn @ 50%	292.47	288.06	17.52	14.87	186.38	183.80	0.321	0.325
NPK @ 0% + Zn @ 100%	294.38	292.88	17.90	15.09	191.59	186.52	0.329	0.345
NPK @ 50% + Zn @ 0%	296.70	294.62	18.02	16.65	192.10	189.65	0.298	0.297
NPK @ 50% + Zn @ 50%	301.64	296.01	20.50	17.32	195.54	190.89	0.334	0.332
NPK @ 50% + Zn @ 100%	303.82	301.50	22.43	17.83	198.70	193.24	0.340	0.347
NPK @ 100% + Zn @ 0%	309.04	305.23	22.96	18.19	203.05	197.16	0.303	0.302
NPK @ 100% + Zn @ 50%	312.32	311.35	23.38	19.39	205.97	201.65	0.347	0.348
NPK @ 100% + Zn @ 100%	322.78	317.56	23.55	20.82	209.89	205.03	0.362	0.353
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

Conclusion

According to the trial, the fertilizers [Urea (46% N), + SSP (16% P_2O_5), + MOP (60% K_2O), + $ZnSo_4$ (36.5% Zn)] used at different levels of NPK and Zn from different sources produced the best results in treatment T_9 (NPK @ 100% + Zn @ 100%), which was followed by treatment T_8. In T_9, 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 (T_9).

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