Original Research Article

Influence of Zinc and Boron on physico-chemical properties of soil under Maize crop in an Inceptisol of Prayagraj, (Uttar Pradesh)

Abstract

The research entitled "Influence of Zinc and Boron on Soil Health Parameters and Yield Attributes of Maize in an inceptisol of Prayagraj U.P." conducted at the department of Soil Science and Agricultural Chemistry Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P during the *Rabi-Jayad* 2020-2021 and 2021-2022. The experiment was laid out in Randomized Block Design with sixteen treatments and three replications with four levels of Zinc and Boron along with NPK as RDF. The non-significant findings that is B.D, P.D, % pore space, water holding capacity, and pH were as, macro- micro nutrients, in soil also the morphological parameters have significant findings which comprises yellowish brown sandy loam textured neutral to alkaline soil that is non- saline in nature among all the treatment combination applied the OC, N,P,K were founded significantly medium to high in treatment T_{16} RDF (120:60:40 NPK kg ha^{-1}) + Zinc@20 kg ha^{-1}+ Boron @5 kg ha^{-1}), micro-nutrients such as Zinc, Boron were significantly medium to high in treatment. the increasing mean value for bulk density (1.33 Mg m^{-3}), particle density (2.589 Mg m^{-3}) percent pore space (47.98%), and percent maximum water holding capacity (45.87%) were increased and chemical soil parameters with a cumulative mean of slightly saline soil pH (7.93), average electrical conductivity (0.41 dS m^{-1}), maximum percent O.C. (0.42), high Available N (288.52 kg ha^{-1}), high Available P in T_2 (16.85 kg ha^{-1}) due to the antagonistic effect of zinc on Phosphorous, high Available K (207.98 kg ha^{-1}), high Available Zn (1.144 mg kg^{-1}), and high Available B (1.243 mg kg^{-1}) were categorized in evaluation to other NPK and micronutrients levels treatments.

Key words: Soil health, Maize, Zinc, Boron and soil properties

Introduction

Maize (*Zea mays* L.) is a member of family Gramineae and it is one of the most important cereal crops. It is also important about its nutritional value for humans, poultry and livestock. Throughout the world, Maize is one of the prominent cereal crop and total yield of Maize is more as compared to other cereal crops **(FAO, 2011).**

Origin of Maize is Latin America. It is extremely cultivated in USA, Rumania, Argentina, Brazil, Russia, Mexico, South Africa and Italy (Anonymous 2016). Total production of Maize is 38.105 million tones and some major growing countries are USA (13601mt), China (8841mt), Brazil (3208mt), Mexico (925mt) and India (827mt) etc. In India, Maize ranks 5_{th} in total area and 6_{th} in production and productivity **(Anonymous 2016).**

In India, Andhra Pradesh was reported to be the largest producer of Maize among the producing state contributing 21 per cent (%) of total production, followed by Karnataka 16%, Rajasthan 10%, Bihar and Maharashtra 9% each as well as Uttar Pradesh and Madhya Pradesh each contribute 6% (**Chennankrishnan, and Raja, 2012**). Majorly poor management of fertilizer has key role to play in obtaining low yield productivity, so in order to achieve optimum crop productivity management of nutrients through judicious application of organic sources, bio-fertilizers and micro-nutrients are required. Furthermore, the fertilizer management is one of the most important factors that influence the growth and yield of Maize crop. **(Ghaffari *et al.*, 2011).**

It is the third most important staple food crop both in terms of area and production after wheat and rice in Egypt. Total area under cultivation of Maize in Egypt is 888329 hectare which is about 25.17 % of the total cultivated agricultural land while average yield is 7.80-ton ha^{-1}. It is about 21.90 % of the total cereals production **(FAO, 2011).** The rapidly increasing demand of Maize is driven by the increased demand for direct human consumption in the hills as a staple food crop **(Ghimire *et al.*, 2007).** As food, it can be consumed directly as green cob, roasted cob or popped grain. Its grain can be used for human consumption in various ways such as corn meal, fried grain and flour. Its grain has high nutritive value containing 66.2% starch, 11.1% protein, 7.12% oil and 1.5% minerals. Moreover, it contains 90 mg carotene, 1.8 mg niacin, 0.8 mg thiamin and 0.1 mg riboflavin per 100 g grains. **(Khan *et al.*, (2012)**

Zinc is an important part of the package or suggested practices for reclaiming sodic soils. Zn shortage is a critical nutritional limitation for good crop development, regardless of the fact that crops have shown a strong response to Zn application. The Available Zn content in Indian soils ranged from traces to 22 mg kg^{-1}, with 47 percent of Indian soils being Zn deficient (**Mishra *et al.*, 2011**).

Boron is unique, not only in its chemical properties, but also in its roles in biology. Since Boron discovery as essential plant nutrient, the importance of B element as an agricultural chemical has grown very rapidly and its availability in soil and irrigation water is an important determinant of agricultural production. Boron deficiency is the most common and widespread micronutrient deficiency problem, which impairs plant growth and reduces yield. Normal healthy plant growth requires a continuous supply of B, once it is taken up and used in the plant; it is not translocated from old to new tissue. That is why, deficiency symptoms start with the youngest growing tissues. Therefore, adequate B supply is necessary for obtaining high yields and good quality y of agriculture crops**. (Saleem *et al.*, 2011)**
Hence, objectives of the study are simply justified. Keeping these considerations in view, an investigation was carried out during *rabi* season of 2020-21 and 2021-22.

Material and Methods

3.1 Experimental site and location

The investigational site of the research farm which falls under Geographical Co-ordinates of Prayagraj District which is located at 25^0 58' N latitude and 81^0 52' E longitude with an altitude of 98 meter above mean sea level and is situated 5 km away on the right bank of Yamuna-river. Representative the Agro-Ecological Sub Region [North Alluvial plain zone **(**0-1 % slope**)**] and Agro-Climatic Zone (Upper Gangetic Plain Region).

3.2 Climate condition

The area of the region which is characterized by sub-tropical and has a semi-arid type of climate, which experience extremely hot and dry summer spells from April to June where temperature reaches maximum up to 46^0C and touches 48^0C followed by relative humidity during July to September ranged from 20 - 90 percent, fairly seldom falls of cold with frosty spells as low as 4^0C and dips up to 2^0C is noticed. Here a few showers of cyclonic rains are received are called as winter monsoon (North-East monsoon), which is seen during November to January and mild climate from February to March. The rainfall in this particular region starts from middle of July to end of September and commonly known as summer monsoon (South-West monsoon). This South-West monsoon brings major portion of the rainfall (75 percent) with mean annually around 900 to 1100 mm.

3.6 Experimental details

The present research investigation was setup in a randomized block design (RBD) having sixteen treatment combinations which is replicated thrice, randomly allocated in each replication, dividing the research site into forty-eight plots. The Maize variety P3396 was grown during the two experimental years 2020-21 and 2021-22. In this study, inorganic fertilizers like Nitrogen, Phosphorous, Potassium, were applied as RDF and Zinc and Boron were applied in four different doses.

Table 1: Randomized Block Design (RBD) having sixteen treatment combinations

Treatment	**Treatment Combination**	**Symbols**
T_1	(Control)	$Z_0 B_0$
T_2	RDF + Zn @ 0 kg ha^{-1}+ B@ 2 kg ha^{-1}	$Z_0 B_1$
T_3	RDF + Zn @ 0 kg ha^{-1}+ B@ 4 kg ha^{-1}	$Z_0 B_2$
T_4	RDF + Zn @ 0 kg ha^{-1}+ B@ 6 kg ha^{-1}	$Z_0 B_3$
T_5	RDF + Zn @ 10 kg ha^{-1}+ B@ 0 kg ha^{-1}	$Z_1 B_0$
T_6	RDF + Zn @ 10 kg ha^{-1}+ B@ 2 kg ha^{-1}	$Z_1 B_1$
T_7	RDF+ Zn @ 10 kg ha^{-1}+ B@ 4 kg ha^{-1}	$Z_1 B_2$
T_8	RDF+ Zn @ 10 kg ha^{-1}+ B@ 6 kg ha^{-1}	$Z_1 B_3$
T_9	RDF+ Zn @ 15 kg ha^{-1}+ B@ 0 kg ha^{-1}	Z_2B_0
T_{10}	RDF+ Zn @ 15 kg ha^{-1}+ B@ 2 kg ha^{-1}	Z_2B_1
T_{11}	RDF+ Zn @ 15 kg ha^{-1}+ B@ 4 kg ha^{-1}	Z_2B_2
T_{12}	RDF+ Zn@ 15 kg ha^{-1}+ B@ 6 kg ha^{-1}	Z_2B_3
T_{13}	RDF+ Zn @ 20 kg ha^{-1}+ B@ 0 kg ha^{-1}	Z_3B_0
T_{14}	RDF+ Zn @ 20 kg ha^{-1}+ B@ 2 kg ha^{-1}	Z_3B_1
T_{15}	RDF+ Zn@ 20 kg ha^{-1}+ B@ 4 kg ha^{-1}	Z_3B_2
T_{16}	RDF+ Zn @ 20 kg ha^{-1}+ B@ 6 kg ha^{-1}	Z_3B_3

Fertilizer application

Recommended dose of NPK (100%) was applied to the maize were N (120 kg ha^{-1}), P_2O_5 (60 kg ha^{-1}) and K_2O (60 kg ha^{-1}). The 100 percent application of N, P and K was applied as basal dose at the time of sowing. In addition to these applications, Zinc was applied as basal @ 0,10,15 and 20 kg ha^{-1} with Boron 0, 2, 4, and 6 kg ha^{-1} only to the treatment with Zn and B. The sources of NPK fertilizers were Phosphorus through single superphosphate (16% P_2O_5), Potash through Muriate of Potash (60% K_2O) and Zinc through Zinc sulphate (21% Zn) and Boron through borax (11.3% B) was applied previous to sowing in concerning treatments just before the seed sowing. Nitrogen through urea (46% N), were applied in 3 different doses

Sowing of Maize crop was carried out on 15th and 18th of October month during 2020 and 2021, respectively by manually. Seed variety P3396 was sown at the rate of 18-20 kg ha^{-1} and at a row to row spacing of 60 cm and plant to pant spacing 20 cm.

Soils analysis

The soils from each plot were separately collected, air-dried, ground and passed through 2-mm size sieve for laboratory analysis. Soil samples were analyzed for OC by Walkley and Black method (Walkley and Black 1934), water holding capacity (WHC) using 100 ml measuring cylinder (Muthuval, (1992), pH, available K (Jackon 1973) and available P (Olsen *et al.* 1954.) before sowing the experimental crop and after the harvest of crop. The soil samples were extracted for available B, the extract was treated with activated charcoal and estimated calorimetrically using azomethine-H method (Lindsay and Norvell, 1978). Available Zn was extracted with DTPA-TEA (pH 7.3) (Lindsay and Norvell, 1978) and estimated with the help of atomic absorption spectrophotometer (AAS, Model: ELCO-SL194)

Statistical analysis

The statistical analysis of the data was carried out using STATISTICA (7.0) software.

Results and Discussion

Effect of nutrient management in physical properties of soil after harvest of Maize

The data found that, bulk density of soil were found 1.29 and 1.33 Mg m^{-3} and 1.30 and 1.31 Mg m^{-3}, particle density 2.581 and 2.58 Mg m^{-3} and 2.579 and 2.589 Mg m^{-3}, pore space 47.97 and 47.67 % and 47,98 and 47.32 %, water retention capacity 46.19 % and 46.82 % and 46.27 % and 46.87 % of soil were got highest in treatment T_{16} RDF(120:60:40 NPK kg ha^{-1}) + Zinc@20 kg ha^{-1}+ Boron @5 kg ha^{-1}) over absolute control treatment at 0-15 cm depth and at 15-30 cm depth during the years 2021 and 2022 (Table 2). This corroborates with the findings of Panwar, *et al.*, 2011, and Yadav *et al*., 2020.

Effect of nutrient management in chemical properties of soil after harvest of maize

The data showed that the treatment T_{16} with RDF (120:60:40 NPK kg ha^{-1}) + Zinc@20 kg ha^{-1}+ Boron @5 kg ha^{-1}) significantly influenced the soil pH 8.24 and 8.34 in the year 2020-21 and 8.22 and 8.34, in the year 2021-22 electrical conductivity 0.414 and 0.416 and 0.413 and 0.415, organic carbon 0.421 and 0.425 % and 0.422 and 0.426 % content in soil, however lowest values were observed in the treatments T_1 (absolute control) at 0-15 cm depth and at 15-30 cm depth during the years 2020-21 and 2021-22, accordingly (Table 3).

There was significant build-up of available N, available K, available Zn and available B with the applied treatments (Table 4). Maximum build-up of available N (283.27, 287.12 kg ha^{-1} and 284.59, 288.52 kg ha^{-1}), available K (206.75, 206.31 kg ha^{-1} and 207.68, 205.67 kg ha^{-1}), available Zn (1.144, 1.108 mg kg^{-1} and 1.134, 1.112 and mg kg^{-1}) and available B (1.243, 1.221 mg kg^{-1} and 1.235, 1.224 mg kg^{-1}) was recorded under the treatment T_{16} RDF (120:60:40 NPK kg ha^{-1}) + Zinc@20 kg ha^{-1}+ Boron @5 kg ha^{-1}) which was at par with the treatments T_9 with (RDF 20:40:20 NPK kg ha^{-1} + Zinc@6 kg ha^{-1} and Boron @1 kg ha^{-1}) and T_{10} with (RDF 20:40:20 NPK kg ha^{-1} + Zinc@6 kg ha^{-1} and Boron @2 kg ha^{-1}). Thus, the results indicate that both B and Zn significantly affected N, K, Zn and B availability in the soil. However, build-up of available P was drastically reduced with the application of Zn and B. optimum results were found in treatment T_2 with RDF *i.e.* NP and K only (16.75, 16.31 kg ha^{-1} and 16.85, 16.32 kg ha^{-1}) over all other remaining treatment combinations at 0-15 cm and at 15-30 cm soil depth during the years 2020-21 and 2021-22, accordingly. This may be due to negative interaction of Zn and B on availability of soil. Kumari *et al.*, 2017, Kudi *et al*., 2018 and Karthik *et al*., 2021 also reported similar trends of results with Maize.

Conclusion

Based on the results, it is concluded that the application of NPK with micronutrient levels (Zinc and Boron) in treatment (T_{16}) T_{16} with RDF (120:60:40 NPK kg ha^{-1}) + Zinc@20 kg ha^{-1}+ Boron @5 kg ha^{-1}), was found primary in improving physical and chemical properties of soil, namely bulk density, particle density, % pore space, water holding capacity, EC, pH, organic carbon, available NPK and micronutrients *(*Zinc and Boron) than other treatment, combined with NPK and different doses of Zinc and Boron. Thus, it can be concluded that NPK and different levels of micronutrients (Zinc and Boron) enhanced soil available nutrients *i.e.* soil available Nitrogen, Phosphorus, Potassium, Zinc, Boron and electrical conductivity. However, pH of soil increased and also the treatments T_{16} recorded the premium treatment which increased the availability of nutrients and changed physico-chemical properties of soil.

Zinc and Boron nutrition with NPK knowingly recovers the soil health in Maize crop. The soil method of application of Zinc and Boron with NPK show advantageous results. It is better nutrient (NPK with micronutrient) organization option for enhancing the fertility of the soil. Hence, it can be suggested that to upgrade sustainability of soil fertility in the inceptisol, the combined application of NPK, Zinc and Boron is the finest option.

Reference

Anonymous, (2016). FAOSTAT, Production. Cited February 12, 2015, 33: S141–S145

Chennankrishnan, P, Raja K. Maize Production in India: Fighting Hunger and Malnutrition. Facts for You, 2012.

FAO, 2011.Agricultural production statistics, 2011.

Ghaffari, A., Ali, A., Tahir, M., Waseem M., Ayub, M. (2011) Influence of Integrated Nutrients on Growth, Yield and Quality of Maize. *American Journal of Plant Science.*, 63-69

Karthik, B., Umesha, C., Meshram, M. R., Mahesh, K., and Priyadharshini, A. S. (2021). Effect of nitrogen levels and boron on growth and economics of green-gram (Vigna radiata L.).

Kudi, S., Swaroop, N., David, A. A., Thomas, T., Hasan, A., and Rao, S. (2018). Effect of different levels of Sulphur and zinc on soil health and yield of Green-gram (Vigna radiata L.) Var. Patidar-111. Journal of Pharmacognosy and Phytochemistry, 7 (3), 2271-2274.

Olsen, S. R., Cole, C. V., Watanabe, F. S. and Dean, L. A. 1954. Estimation of Available Phosphorus in soils by extraction with sodium bicarbonate (NaHCO3), *U.S.D.A. Circular*. **939**: 1-19

Panwar, Q. A., Radziah, D., Hhanif, Y. N. and Nahar,V.A. (2011). Application of Boron and Zinc in tropical soils and effect on Maize (Zea mays L.) growth and soil microbial environment. *Australian J. of Crop Science,***5 (12)**: 1649-1654.

Saleem, A.M, Sardar, M.S.A., Ullah, M.J, Kawochar, M.A, and Islam, M.k. (2011) effect of different spacing and levels of Nitrogen fertilizer on the yield attributes and yield of Hybrid Maize, *J. expt. Biosci*. **1 (2)**, 57-61

Subbiah, B. V. and Asiija, E. C. 1956.A rapid procedure for estimation of Available Nitrogen in soil. Current Science **25(8)**: 259-260

Walkley, A. and Black, I. A. 1934. Estimation of soil organic carbon by the chromic acid titration method. Soil Science. 47: 29-38.

Lindsay, W. L. and Norvell, W. A., 1978, Development of DTPA-soil test for Zn, Fe, Mn and Cu. Soil Sci. *Soc. America J.*, 42: 421-428.

Jackson, M. L. 1973. Soil chemical analysis Prentice Hall of India Ltd. New Delhi. 219- 221.

Black, C. A., 1965, Methods of Soil Analysis Part – II. Chemical and microbiological properties. Agronomy Monograph No. 9. *American Society of Agronomy, Inc. Madison, Wisconsin, USA,* 18-25.

Table 2. Soil physical properties after harvest of Maize as influence by different treatment combinations.

Treatments		Bulk density (Mg m^{-3})				Particle density (Mg m^{-3})				Pore space (%)				Water retention capacity (%)			
		2021		2022		2021		2022		2021		2022		2021		2022	
		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	0-15 cm	15-30 cm
T_1	(Control)	1.19	1.21	1.20	1.22	2.403	2.408	2.401	2.403	44.52	43.42	44.34	43.54	43.21	43.87	41.32	41.87
T_2	RDF + Zn @ 0 kg ha-1+ B@ 2 kg ha-1	1.20	1.23	1.21	1.24	2.433	2.438	2.432	2.433	45.14	44.34	45.66	44.22	44.14	44.76	43.24	43.66
T_3	RDF + Zn @ 0 kg ha-1+ B@ 4 kg ha-1	1.25	1.26	1.25	1.26	2.457	2.462	2.454	2.457	45.20	44.26	45.32	45.78	44.25	44.49	42.41	42.69
T_4	RDF + Zn @ 0 kg ha-1+ B@ 6 kg ha-1	1.23	1.25	1.23	1.24	2.417	2.422	2.411	2.417	47.14	46.11	47.67	46.87	44.60	44.95	43.33	43.70
T_5	RDF + Zn @ 10 kg ha-1+ B@ 0 kg ha-1	1.22	1.25	1.24	1.26	2.428	2.433	2.424	2.428	47.31	46.24	47.21	46.28	45.31	45.90	45.12	45.70
T_6	RDF + Zn @ 10 kg ha-1+ B@ 2 kg ha-1	1.26	1.27	1.26	1.27	2.465	2.47	2.461	2.465	46.42	45.23	46.12	45.29	44.62	44.86	44.63	44.86
T_7	RDF+ Zn @ 10 kg ha-1+ B@ 4 kg ha-1	1.25	1.26	1.27	1.28	2.505	2.51	2.507	2.505	46.78	45.89	46.32	46.83	45.14	45.59	45.18	45.84
T_8	RDF+ Zn @ 10 kg ha-1+ B@ 6 kg ha-1	1.26	1.28	1.25	1.26	2.484	2.489	2.482	2.484	46.81	46.42	46.65	45.25	45.32	44.65	44.77	44.93
T_9	RDF+ Zn @ 15 kg ha-1+ B@ 0 kg ha-1	1.24	1.26	1.24	1.27	2.511	2.516	2.517	2.511	47.21	46.65	47.34	46.69	45.50	45.88	44.33	44.80
T_{10}	RDF+ Zn @ 15 kg ha-1+ B@ 2 kg ha-1	1.27	1.28	1.26	1.29	2.521	2.526	2.521	2.521	47.14	46.78	47.54	45.75	44.10	44.60	43.10	43.84
T_{11}	RDF+ Zn @ 15 kg ha-1+ B@ 4 kg ha-1	1.25	1.27	1.25	1.28	2.528	2.533	2.526	2.528	46.52	45.98	46.11	45.98	44.47	44.74	44.21	44.72
T_{12}	RDF+ Zn@ 15 kg ha-1+ B@ 6 kg ha-1	1.27	1.28	1.27	1.29	2.554	2.559	2.551	2.554	46.77	45.87	46.44	46.84	44.33	45.91	45.32	45.77
T_{13}	RDF+ Zn @ 20 kg ha-1+ B@ 0 kg ha-1	1.28	1.29	1.27	1.30	2.565	2.57	2.563	2.565	47.34	47.22	47.53	47.23	44.58	45.94	44.64	44.85
T_{14}	RDF+ Zn @ 20 kg ha-1+ B@ 2 kg ha-1	1.27	1.30	1.28	1.29	2.543	2.548	2.541	2.543	47.72	47.64	47.78	46.68	46.18	46.60	45.19	46.13
T_{15}	RDF+ Zn@ 20 kg ha-1+ B@ 4 kg ha-1	1.28	1.32	1.30	1.31	2.575	2.58	2.573	2.575	46.92	46.78	46.65	46.79	45.04	45.75	46.29	45.81
T_{16}	RDF+ Zn @ 20 kg ha-1+ B@ 6 kg ha-1	1.29	1.33	1.30	1.31	2.581	2.589	2.579	2.581	47.97	47.67	47.98	47.32	46.19	46.80	46.27	46.87
SE m (±)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CD (P=0.05)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3. Soil chemical properties after harvest of Maize as influence by different treatment combinations.

Treatments		**pH**				**EC**				**OC (%)**				**Available Nitrogen (kg ha^{-1})**			
		2021		**2022**		**2021**		**2022**		**2021**		**2021**		**2022**		**2021**	
		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**	**0-15 cm**	**15-30 cm**
T_1	(Control)	7.42	7.53	7.43	7.48	0.343	0.345	0.342	0.343	0.368	0.370	0.367	0.368	259.21	261.32	258.94	260.70
T_2	RDF + Zn @ 0 kg ha-1+ B@ 2 kg ha-1	7.65	7.74	7.62	7.67	0.350	0.353	0.356	0.354	0.389	0.392	0.389	0.392	264.24	266.52	265.58	268.54
T_3	RDF + Zn @ 0 kg ha-1+ B@ 4 kg ha-1	7.66	7.76	7.63	7.72	0.362	0.364	0.365	0.366	0.392	0.395	0.393	0.396	262.53	265.59	263.74	265.39
T_4	RDF + Zn @ 0 kg ha-1+ B@ 6 kg ha-1	7.52	7.67	7.53	7.58	0.348	0.350	0.347	0.352	0.395	0.397	0.396	0.396	265.64	267.79	264.38	267.59
T_5	RDF + Zn @ 10 kg ha-1+ B@ 0 kg ha-1	7.47	7.62	7.44	7.53	0.349	0.351	0.344	0.349	0.387	0.390	0.385	0.392	268.76	272.04	268.52	273.53
T_6	RDF + Zn @ 10 kg ha-1+ B@ 2 kg ha-1	7.76	7.81	7.73	7.79	0.368	0.372	0.368	0.373	0.388	0.389	0.386	0.388	266.58	270.79	267.48	272.90
T_7	RDF+ Zn @ 10 kg ha-1+ B@ 4 kg ha-1	7.85	7.93	7.84	7.91	0.375	0.377	0.375	0.376	0.395	0.398	0.395	0.398	267.46	272.40	266.53	270.32
T_8	RDF+ Zn @ 10 kg ha-1+ B@ 6 kg ha-1	7.74	7.85	7.76	7.84	0.371	0.374	0.376	0.378	0.398	0.403	0.396	0.402	268.43	271.53	265.48	271.26
T_9	RDF+ Zn @ 15 kg ha-1+ B@ 0 kg ha-1	7.53	7.78	7.53	7.68	0.377	0.379	0.375	0.376	0.399	0.405	0.394	0.405	270.46	273.59	272.64	274.47
T_{10}	RDF+ Zn @ 15 kg ha-1+ B@ 2 kg ha-1	7.48	7.67	7.45	7.56	0.383	0.385	0.386	0.388	0.404	0.408	.0.405	0.407	267.83	271.52	268.80	271.49
T_{11}	RDF+ Zn @ 15 kg ha-1+ B@ 4 kg ha-1	8.21	8.23	8.21	8.29	0.385	0.388	0.385	0.387	0.399	0.406	0.397	0.406	271.72	274.18	272.69	275.33
T_{12}	RDF+ Zn@ 15 kg ha-1+ B@ 6 kg ha-1	7.23	7.44	7.25	7.31	0.392	0.395	0.394	0.398	0.406	0.409	0.405	0.407	273.82	275.32	272.59	276.56
T_{13}	RDF+ Zn @ 20 kg ha-1+ B@ 0 kg ha-1	8.13	8.32	8.16	8.32	0.396	0.399	0.395	0.397	0.410	0.413	0.411	0.415	277.45	279.61	275.63	280.27
T_{14}	RDF+ Zn @ 20 kg ha-1+ B@ 2 kg ha-1	7.64	7.87	7.63	7.82	0.388	0.392	0.387	0.391	0.415	0.416	0.414	0.417	276.63	280 .02	277.40	281 .42
T_{15}	RDF+ Zn@ 20 kg ha-1+ B@ 4 kg ha-1	7.89	8.04	7.85	8.07	0.410	0.413	0.411	0.414	0.417	0.418	0.416	0.419	281.43	283.24	282.75	284.49
T_{16}	RDF+ Zn @ 20 kg ha-1+ B@ 6 kg ha-1	8.24	8.34	8.22	8.34	0.414	0.416	0.413	0.415	0.421	0.425	0.422	0.426	283.27	287.12	284.59	288.52
SE m (±)		-	-	-	-	0.02	0.04	0.02	0.03	0.02	0.08	0.06	0.04	13.48	11.46	8.13	10.29
CD (P=0.05)		-	-	-	-	0.01	0.03	0.01	0.02	0.01	0.04	0.03	0.02	1.60	5.61	3.98	5.04

Table 4. Soil chemical properties after harvest of Maize as influence by different treatment combinations.

Treatments		Available Phosphorus (kg ha^{-1})				Available Potassium (kg ha^{-1})				Available Zinc (mg kg^{-1})				Available Boron (mg kg^{-1})			
		2021		2022		2021		2022		2021		2021		2022		2021	
		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	0-15 cm	15-30 cm
T_1	(Control)	13.64	13.23	12.87	12.41	196.64	196.23	195.64	196.44	0.453	0.445	0.465	0.433	0-15	15-30	0-15	15-30
T_2	RDF + Zn @ 0 kg ha-1+ B@ 2 kg ha-1	16.75	16.31	16.85	16.32	197.86	197.12	196.86	195.75	0.625	0.416	0.634	0.421	0.556	0.544	0.565	0.532
T_3	RDF + Zn @ 0 kg ha-1+ B@ 4 kg ha-1	15.89	15.11	15.96	15.10	197.68	198.21	197.18	196..37	0.586	0.524	0.566	0.541	0.723	0.511	0.734	0.523
T_4	RDF + Zn @ 0 kg ha-1+ B@ 6 kg ha-1	13.75	13.23	13.96	14.31	199.75	199.24	198.15	198.86	0.667	0.637	0.657	0.642	0.687	0.623	0.666	0.642
T_5	RDF + Zn @ 10 kg ha-1+ B@ 0 kg ha-1	14.74	14.12	14.80	13.13	201.74	201.12	202.24	201.15	0.656	0.634	0.665	0.651	0.767	0.734	0.757	0.743
T_6	RDF + Zn @ 10 kg ha-1+ B@ 2 kg ha-1	13.63	13.21	14.87	13.12	203.63	201.21	202.23	201.31	0.655	0.635	0.666	0.641	0.754	0.731	0.765	0.752
T_7	RDF+ Zn @ 10 kg ha-1+ B@ 4 kg ha-1	14.84	13.11	13.82	14.33	203.84	202.11	203.22	202.13	0.757	0.716	0.745	0.724	0.757	0.732	0.766	0.742
T_8	RDF+ Zn @ 10 kg ha-1+ B@ 6 kg ha-1	14.80	14.35	13.52	14.24	204.80	204.35	204.65	204.41	0.735	0.734	0.743	0.714	0.854	0.812	0.845	0.823
T_9	RDF+ Zn @ 15 kg ha-1+ B@ 0 kg ha-1	15.64	14.27	14.59	15.27	205.64	203.27	205.68	203.21	0.857	0.726	0.766	0.732	0.933	0.932	0.924	0.913
T_{10}	RDF+ Zn @ 15 kg ha-1+ B@ 2 kg ha-1	13.86	13.31	13.70	14.41	203.86	202.31	203.57	202.41	0.754	0.734	0.764	0.711	0.857	0.823	0.862	0.832
T_{11}	RDF+ Zn @ 15 kg ha-1+ B@ 4 kg ha-1	14.79	14.29	14.79	13.27	204.79	203.29	204.86	203.21	0.827	0.807	0.815	0.801	0.854	0.832	0.863	0.843
T_{12}	RDF+ Zn@ 15 kg ha-1+ B@ 6 kg ha-1	15.86	15.10	14.86	15.31	205.86	202.10	205.79	202.19	0.834	0.714	0.823	0.702	0.921	0.904	0.914	0.909
T_{13}	RDF+ Zn @ 20 kg ha-1+ B@ 0 kg ha-1	14.89	15.16	15.76	14.22	204.89	203.16	204.78	203.20	0.837	0.804	0.843	0.821	0.837	0.811	0.822	0.808
T_{14}	RDF+ Zn @ 20 kg ha-1+ B@ 2 kg ha-1	14.95	14.13	14.70	14.31	204.95	204.13	204.55	204.31	0.834	0.812	0.845	0.815	0.932	0.909	0.943	0.903
T_{15}	RDF+ Zn@ 20 kg ha-1+ B@ 4 kg ha-1	13.68	12.21	12.68	13.21	205.89	205.11	205.65	205.42	1.127	1.117	1.115	1.109	0.934	0.916	0.942	0.912
T_{16}	RDF+ Zn @ 20 kg ha-1+ B@ 6 kg ha-1	14.86	14.52	14.68	13.21	206.75	206.31	20768	207.98	1.144	1.108	1.134	1.112	1.224	1.219	1.213	1.212
SE m (±)		0.62	0.55	0.57	0.62	10.45	8.92	9.76	7.83	0.04	0.03	0.03	0.4	0.04	0.04	0.05	0.04
CD (P=0.05)		0.30	0.27	0.38	0.32	5.11	4.37	4.78	3.83	0.02	0.01	0.02	0.02	0.02	0.02	0.03	0.02