

## 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<sub>16</sub> RDF(120:60:40NPKkg<sup>-1</sup>+Zinc@20kg<sup>-1</sup>+Boron@5kg<sup>-1</sup>), micro-nutrients such as Zinc, Boron were significantly medium to high in treatment. the increasing mean value for bulk density (1.33 Mg m<sup>-3</sup>), particle density (2.589 Mg m<sup>-3</sup>) 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<sup>-1</sup>), maximum percent O.C. (0.42), high Available N (288.52 kg ha<sup>-1</sup>), high Available P in T<sub>2</sub> (16.85 kg ha<sup>-1</sup>) due to the antagonistic effect of zinc on Phosphorous, high Available K (207.98 kg ha<sup>-1</sup>), high Available Zn (1.144 mg kg<sup>-1</sup>), and high Available B (1.243 mg kg<sup>-1</sup>) were categorized in evaluation to other NPK and micronutrients levels treatments.

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

**Comment [L1]:** Restrict Abstract to 300 words and correct format as per journal norms

**Comment [L2]:** It seems that you are missing a verb. Consider adding it. was

**Comment [L3]:** The singular verb **is** does not appear to agree with the plural subject **The non-significant findings**. Consider changing the verb form for subject-verb agreement.

**Comment [L4]:** The singular verb **comprises** does not appear to agree with the plural subject **significant findings**. Consider changing the verb form for subject-verb agreement.

**Comment [L5]:** It appears that you have improperly spaced some punctuation. Consider adding a space

**Comment [L6]:** The plural verb **were** does not appear to agree with the singular subject **K**. Consider changing the verb form for subject-verb agreement.

**Comment [L7]:** The word **Key words** seems to be miswritten. Consider replacing it.

## 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<sup>th</sup> in total area and 6<sup>th</sup> 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. (Ghaffariet 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<sup>-1</sup>. 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 (Ghimireet 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

**Comment [L8]:** Propre guides to Journal normes

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**Comment [L10]:** The singular countable noun **crop** follows the quantifier **one of**, which requires a plural noun. Consider using a plural noun or a different quantifier.

**Comment [L11]:** Your sentence contains a series of three or more words, phrases, or clauses. Consider inserting a comma to separate the elements.

**Comment [L12]:** The noun phrase **key role** seems to be missing a determiner before it. Consider adding an article

**Comment [L13]:** The word **productivity** doesn't seem to fit this context. Consider replacing it with a different one.

**Comment [L14]:** It seems that the verb **are** does not agree with the subject. Consider changing the verb form

**Comment [L15]:** If you don't want **7.80-ton** to be marked as misspelled in the future, you can add it to your personal dictionary

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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<sup>-1</sup>, 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 Coordinates of Prayagraj District which is located at 25<sup>o</sup>58' N latitude and 81<sup>o</sup> 52' E longitude with an altitude of 98 meter above mean sea level and is situated 5km 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<sup>o</sup>C and touches 48<sup>o</sup>C 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<sup>o</sup>C and dips up to 2<sup>o</sup>C 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

**Comment [L17]:** The comma before the conjunction **but also** appears to be unnecessary. Consider removing it

**Comment [L18]:** It seems that you are missing a verb. Consider adding it.

**Comment [L19]:** It appears that you have an unnecessary comma after the subordinating conjunction **why**. Consider removing the comma

**Comment [L20]:** The word **agriculture** doesn't seem to fit this context. Consider replacing it with a different one.

**Comment [L21]:** It seems that this sentence contains a series of three or more words, phrases, or clauses. Consider inserting a comma to separate the elements.

**Comment [L22]:** It seems that preposition use may be incorrect here.

**Comment [L23]:** The noun phrase **middle** seems to be missing a determiner before it. Consider adding an article

monsoon (South-West monsoon). This South-West monsoon brings major portion of the rainfall (75 percent) with mean annually around 900 to 1100mm.

**Comment [L24]:** The noun phrase **major portion** seems to be missing a determiner before it. Consider adding an article

### 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.

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**Comment [L26]:** The word **setup** doesn't seem to fit this context. Consider replacing it with a different one.

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

Treatment	Treatment Combination	Symbols
T <sub>1</sub>	(Control)	Z <sub>0</sub> B <sub>0</sub>
T <sub>2</sub>	RDF + Zn @ 0 kg ha <sup>-1</sup> + B @ 2 kg ha <sup>-1</sup>	Z <sub>0</sub> B <sub>1</sub>
T <sub>3</sub>	RDF + Zn @ 0 kg ha <sup>-1</sup> + B @ 4 kg ha <sup>-1</sup>	Z <sub>0</sub> B <sub>2</sub>
T <sub>4</sub>	RDF + Zn @ 0 kg ha <sup>-1</sup> + B @ 6 kg ha <sup>-1</sup>	Z <sub>0</sub> B <sub>3</sub>
T <sub>5</sub>	RDF + Zn @ 10 kg ha <sup>-1</sup> + B @ 0 kg ha <sup>-1</sup>	Z <sub>1</sub> B <sub>0</sub>
T <sub>6</sub>	RDF + Zn @ 10 kg ha <sup>-1</sup> + B @ 2 kg ha <sup>-1</sup>	Z <sub>1</sub> B <sub>1</sub>
T <sub>7</sub>	RDF + Zn @ 10 kg ha <sup>-1</sup> + B @ 4 kg ha <sup>-1</sup>	Z <sub>1</sub> B <sub>2</sub>
T <sub>8</sub>	RDF + Zn @ 10 kg ha <sup>-1</sup> + B @ 6 kg ha <sup>-1</sup>	Z <sub>1</sub> B <sub>3</sub>
T <sub>9</sub>	RDF + Zn @ 15 kg ha <sup>-1</sup> + B @ 0 kg ha <sup>-1</sup>	Z <sub>2</sub> B <sub>0</sub>
T <sub>10</sub>	RDF + Zn @ 15 kg ha <sup>-1</sup> + B @ 2 kg ha <sup>-1</sup>	Z <sub>2</sub> B <sub>1</sub>
T <sub>11</sub>	RDF + Zn @ 15 kg ha <sup>-1</sup> + B @ 4 kg ha <sup>-1</sup>	Z <sub>2</sub> B <sub>2</sub>
T <sub>12</sub>	RDF + Zn @ 15 kg ha <sup>-1</sup> + B @ 6 kg ha <sup>-1</sup>	Z <sub>2</sub> B <sub>3</sub>
T <sub>13</sub>	RDF + Zn @ 20 kg ha <sup>-1</sup> + B @ 0 kg ha <sup>-1</sup>	Z <sub>3</sub> B <sub>0</sub>
T <sub>14</sub>	RDF + Zn @ 20 kg ha <sup>-1</sup> + B @ 2 kg ha <sup>-1</sup>	Z <sub>3</sub> B <sub>1</sub>
T <sub>15</sub>	RDF + Zn @ 20 kg ha <sup>-1</sup> + B @ 4 kg ha <sup>-1</sup>	Z <sub>3</sub> B <sub>2</sub>
T <sub>16</sub>	RDF + Zn @ 20 kg ha <sup>-1</sup> + B @ 6 kg ha <sup>-1</sup>	Z <sub>3</sub> B <sub>3</sub>

## Fertilizer application

Recommended dose of NPK (100%) was applied to the maize were N (120 kg ha<sup>-1</sup>), P<sub>2</sub>O<sub>5</sub> (60 kg ha<sup>-1</sup>) and K<sub>2</sub>O (60 kg ha<sup>-1</sup>). 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<sup>-1</sup> with Boron 0, 2, 4, and 6 kg ha<sup>-1</sup> only to the treatment with Zn and B. The sources of NPK fertilizers were Phosphorus through single superphosphate (16% P<sub>2</sub>O<sub>5</sub>), Potash through Muriate of Potash (60% K<sub>2</sub>O) 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 15<sup>th</sup> and 18<sup>th</sup> of October month during 2020 and 2021, respectively by manually. Seed variety P3396 was sown at the rate of 18-20 kg ha<sup>-1</sup> 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 (Jackson 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*

**Comment [L27]:** The adjective **previous** is modifying **applied** instead of a noun or pronoun. Use an adverb to modify a verb, adjective, or other adverb.

**Comment [L28]:** The word **pant** doesn't seem to fit this context. Consider replacing it with a different one

The data found that bulk density of soil were found 1.29 and 1.33  $\text{Mg m}^{-3}$  and 1.30 and 1.31  $\text{Mg m}^{-3}$ , particle density 2.581 and 2.58  $\text{Mg m}^{-3}$  and 2.579 and 2.589  $\text{Mg m}^{-3}$ , 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 gothighest in treatment  $T_{16}$  (RDF(120:60:40NPK  $\text{kg ha}^{-1}$ ) + Zinc @ 20  $\text{kg ha}^{-1}$  + Boron @ 5  $\text{kg ha}^{-1}$ ) 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.

**Comment [L29]:** It appears that you have an unnecessary comma after the subordinating conjunction **that**. Consider removing the comma.

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

The data showed that the treatment  $T_{16}$  with RDF(120:60:40NPK  $\text{kg ha}^{-1}$ ) + Zinc @ 20  $\text{kg ha}^{-1}$  + Boron @ 5  $\text{kg ha}^{-1}$ ) 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  $\text{kg ha}^{-1}$  and 284.59, 288.52  $\text{kg ha}^{-1}$ ), available K (206.75, 206.31  $\text{kg ha}^{-1}$  and 207.68, 205.67  $\text{kg ha}^{-1}$ ), available Zn (1.144, 1.108  $\text{mg kg}^{-1}$  and 1.134, 1.112  $\text{mg kg}^{-1}$ ) and available B (1.243, 1.221  $\text{mg kg}^{-1}$  and 1.235, 1.224  $\text{mg kg}^{-1}$ ) was recorded under the treatment  $T_{16}$  (RDF(120:60:40NPK  $\text{kg ha}^{-1}$ ) + Zinc @ 20  $\text{kg ha}^{-1}$  + Boron @ 5  $\text{kg ha}^{-1}$ ) which was at par with the treatments  $T_9$  with (RDF 20:40:20 NPK  $\text{kg ha}^{-1}$  + Zinc @ 6  $\text{kg ha}^{-1}$  and Boron @ 1  $\text{kg ha}^{-1}$ ) and  $T_{10}$  with (RDF 20:40:20 NPK  $\text{kg ha}^{-1}$  + Zinc @ 6  $\text{kg ha}^{-1}$  and Boron @ 2  $\text{kg ha}^{-1}$ ). 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  $\text{kg ha}^{-1}$  and 16.85, 16.32  $\text{kg ha}^{-1}$ ) 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<sub>16</sub>) T<sub>16</sub> with RDF(120:60:40NPKkg<sup>-1</sup>+Zinc@20kg<sup>-1</sup>+Boron@5kg<sup>-1</sup>), 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<sub>16</sub> 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.

**Comment [L30]:** It seems that **treatments** may not agree in number with other words in this phrase.

## 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 ( $\text{NaHCO}_3$ ), *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 Asija, 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.

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2. References are not written as per journal guidelines. **This is mandatory to write all the references strictly as per format** of the journal guidelines. For this please sample paper on the website

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.

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

Treatments		pH				EC				OC (%)				Available Nitrogen (kg ha <sup>-1</sup> )			
		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 <sub>1</sub>	(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 <sub>2</sub>	RDF + Zn @ 0 kg ha <sup>-1</sup> + B@ 2 kg ha <sup>-1</sup>	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 <sub>3</sub>	RDF + Zn @ 0 kg ha <sup>-1</sup> + B@ 4 kg ha <sup>-1</sup>	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 <sub>4</sub>	RDF + Zn @ 0 kg ha <sup>-1</sup> + B@ 6 kg ha <sup>-1</sup>	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 <sub>5</sub>	RDF + Zn @ 10 kg ha <sup>-1</sup> + B@ 0 kg ha <sup>-1</sup>	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 <sub>6</sub>	RDF + Zn @ 10 kg ha <sup>-1</sup> + B@ 2 kg ha <sup>-1</sup>	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 <sub>7</sub>	RDF+ Zn @ 10 kg ha <sup>-1</sup> + B@ 4 kg ha <sup>-1</sup>	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 <sub>8</sub>	RDF+ Zn @ 10 kg ha <sup>-1</sup> + B@ 6 kg ha <sup>-1</sup>	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 <sub>9</sub>	RDF+ Zn @ 15 kg ha <sup>-1</sup> + B@ 0 kg ha <sup>-1</sup>	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 <sub>10</sub>	RDF+ Zn @ 15 kg ha <sup>-1</sup> + B@ 2 kg ha <sup>-1</sup>	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 <sub>11</sub>	RDF+ Zn @ 15 kg ha <sup>-1</sup> + B@ 4 kg ha <sup>-1</sup>	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 <sub>12</sub>	RDF+ Zn@ 15 kg ha <sup>-1</sup> + B@ 6 kg ha <sup>-1</sup>	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 <sub>13</sub>	RDF+ Zn @ 20 kg ha <sup>-1</sup> + B@ 0 kg ha <sup>-1</sup>	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 <sub>14</sub>	RDF+ Zn @ 20 kg ha <sup>-1</sup> + B@ 2 kg ha <sup>-1</sup>	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 <sub>15</sub>	RDF+ Zn@ 20 kg ha <sup>-1</sup> + B@ 4 kg ha <sup>-1</sup>	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 <sub>16</sub>	RDF+ Zn @ 20 kg ha <sup>-1</sup> + B@ 6 kg ha <sup>-1</sup>	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 <sup>-1</sup> )				Available Potassium (kg ha <sup>-1</sup> )				Available Zinc (mg kg <sup>-1</sup> )				Available Boron (mg kg <sup>-1</sup> )			
		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 <sub>1</sub>	(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 <sub>2</sub>	RDF + Zn @ 0 kg ha <sup>-1</sup> + B@ 2 kg ha <sup>-1</sup>	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 <sub>3</sub>	RDF + Zn @ 0 kg ha <sup>-1</sup> + B@ 4 kg ha <sup>-1</sup>	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 <sub>4</sub>	RDF + Zn @ 0 kg ha <sup>-1</sup> + B@ 6 kg ha <sup>-1</sup>	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 <sub>5</sub>	RDF + Zn @ 10 kg ha <sup>-1</sup> + B@ 0 kg ha <sup>-1</sup>	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 <sub>6</sub>	RDF + Zn @ 10 kg ha <sup>-1</sup> + B@ 2 kg ha <sup>-1</sup>	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 <sub>7</sub>	RDF+ Zn @ 10 kg ha <sup>-1</sup> + B@ 4 kg ha <sup>-1</sup>	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 <sub>8</sub>	RDF+ Zn @ 10 kg ha <sup>-1</sup> + B@ 6 kg ha <sup>-1</sup>	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 <sub>9</sub>	RDF+ Zn @ 15 kg ha <sup>-1</sup> + B@ 0 kg ha <sup>-1</sup>	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 <sub>10</sub>	RDF+ Zn @ 15 kg ha <sup>-1</sup> + B@ 2 kg ha <sup>-1</sup>	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 <sub>11</sub>	RDF+ Zn @ 15 kg ha <sup>-1</sup> + B@ 4 kg ha <sup>-1</sup>	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 <sub>12</sub>	RDF+ Zn@ 15 kg ha <sup>-1</sup> + B@ 6 kg ha <sup>-1</sup>	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 <sub>13</sub>	RDF+ Zn @ 20 kg ha <sup>-1</sup> + B@ 0 kg ha <sup>-1</sup>	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 <sub>14</sub>	RDF+ Zn @ 20 kg ha <sup>-1</sup> + B@ 2 kg ha <sup>-1</sup>	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 <sub>15</sub>	RDF+ Zn@ 20 kg ha <sup>-1</sup> + B@ 4 kg ha <sup>-1</sup>	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 <sub>16</sub>	RDF+ Zn @ 20 kg ha <sup>-1</sup> + B@ 6 kg ha <sup>-1</sup>	14.86	14.52	14.68	13.21	206.75	206.31	207.68	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

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