Impact of Zinc and Boron on physico-chemical properties of soil under Green gram crop in an Inceptisol of Prayagraj, Uttar Pradesh, India

Abstract

The research entitled "Impact of Zinc and Boron on Soil Health Parameters and Yield Attributes of Green gram in an inceptisol of Prayagraj U.P., India" 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*Jayad* 2020-2021-2022. 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 and also the morphological parameters have significant findings which comprises yellowish brown sandy-loam textured neutral to alkaline soil that is non- saline in nature between all the treatment combination applied the OC, N,P,K were founded significantly medium to high in treatment T_{16}RDF (20:40:20 NPK kg ha^{-1})+ Zinc@6 kg ha^{-1}+ Boron @3 kg ha^{-1}, micro-nutrients such as Zinc, Boron were knowingly medium to high in treatment. the increasing mean value for bulk density (1.34 Mg m^{-3}), particle density (2.588 Mg m^{-3}) percent pore space (47.63%), and percent supreme water holding capacity (46.25%) were increased and chemical soil parameters with a cumulative mean of slightly saline soil pH (8.35), average electrical conductivity (0.419 dSm^{-1}), maximum percent O.C. (0.427), high Available N (284.62 kg ha^{-1}), high Available P in T_2 (16.60 kg ha^{-1}) due to the antagonistic effect of zinc on Phosphorous, high Available K (206.93 kg ha^{-1}), high Available Zn (1.132 mg kg^{-1}), and high Available B (1.233 mg kg^{-1}) were considered in evaluation to other NPK and micronutrients levels treatments.

Key words: Soil health, Green gram, Zinc, Boron and soil health.

Introduction

Mung bean or green gram,*Vignaradiata* L. is the third most important pulse crop of the covering of an area 31.15 lakh ha during 2019-2020 whereas consumption increased from 23.50 to 23.75 lakh tones. Carry out stock has increased from 9.86 to 11.01 lakh tones for the year 2020-2021. The word "pulse" is derived from Latin word "puls" means pottage, i.e., seed boiled to make porridge or thick soup. Pulses are important source of protein, vitamin and minerals. Pulses play a pivotal role in nutritional security. Considering this Food and Agriculture Organization has marked year 2016 as international year of pulses to show-cause the importance of pulses in human and animal nutrition. Green gram contains about 24% of protein and a good source of riboflavin and thiamine, lysine 0.43%. "The lysine rich protein of pulses is considered as the supplementary for deficiency of amino acid in certain cereals and brings at par with milk's protein in biological efficiency. Being rich in quality protein, minerals and vitamins, they are in separable ingredients in the diets of a vast majority of people. Green gram dal is a healthy, low fat, high fiber source of protein".**(Nemati and Sharifi, 2012).**

quality protein, minerals, and vitamins. Green gram dal is a protein source that is low in fat and high in fibre. The majority of the fat that green gram removes is unsaturated fat. Legumes are extremely important for food and feed all over the world. In comparison to cereals, which have a high carbohydrate content, legumes have a low- fat content, are cholesterol-free, and are high in folate, potassium, iron, and manganese. Legumes are a rich source of protein and can be a healthy alternative to meat, which is higher in fat and cholesterol. Green gramme consumption on a daily basis has been shown to help people lose weight and battle obesity **(Nair, 2019).**

"The calorific value of green gram is 334 cal/100g and chemically it contains crude protein 25%, fat 1.3%, carbohydrates 56.6%, minerals 3.5%, lysine 0.43%, methionine 0.10%, calcium 124 mg, Phosphorus 3.26 mg and iron 7.3mg. Green gram is short duration crop which contains 25% protein of high digestibility and has appreciable amount of riboflavin and thiamine. Dehulled pulses, also known as dals, are famous for their high-quality protein content and are considered as meat substitutes for people in less developed countries" **(Patil and Kasturiba, 2018).**

"Green gram also has potential as detoxification agent, recuperation of mentality, ability to alleviate heat stroke and guideline of gastrointestinal upset. It also provides potential health benefits such as hypoglycemic, hypolipidemic effects, anti-cancer, and immune modulatory properties beyond meeting basic necessities. Furthermore, the polyphenols, polysaccharides, and polypeptides contained in mung bean all exert antioxidant activity, which can contribute to disease prevention" **(Chena., 2017)**.

Pulses are the second most important crop group, with numerous advantages such as biological nitrogen fixation, a deep root system, the ability to shed leaves, and the release of organic acids that allow Phosphorus solubilization, making pulse crops the most effective nutrient recycling agents in nature. Although abiotic pressures, rapid climate change, and novel insect pests all provide challenges to pulse production, another issue, secondary and micronutrient deficiencies, is to blame for reduced crop productivity. In developing countries legumes are considered as one of the world's most important source of food supplies **(Niharika and Preeti Verma, 2016).**

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 **(Jadhav*et al.*, 2022).**

"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 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^{0}C and touches 48^{0}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^{0}C and dips up to 2^{0}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 monsoon (South-West monsoon). This South-West monsoon brings major portion of the rainfall (75 percent) with mean annually around 900 to 1100mm.

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 Green gram variety PDM-139 was grown during the two experimental years 2020-21 and 2021-22. In this study, inorganic fertilizers like Nitrogen, Phosphorous, Potassium, were used as RDF and Zinc and Boron were applied in four different doses.

Table 1: Symbolic presentation of treatment combination

Treatment	Treatment Combination	Symbols
T_1	(Control)	$Z_0 B_0$
T_2	RDF + Zn @ 0 kg ha^{-1}+ B@ 1 kg ha^{-1}	$Z_0 B_1$
T_3	RDF + Zn @ 0 kg ha^{-1}+ B@ 2 kg ha^{-1}	$Z_0 B_2$
T_4	RDF + Zn @ 0 kg ha^{-1}+ B@ 3 kg ha^{-1}	$Z_0 B_3$
T_5	RDF + Zn @ 2 kg ha^{-1}+ B@ 0 kg ha^{-1}	$Z_1 B_0$
T_6	RDF + Zn @ 2 kg ha^{-1}+ B@ 1 kg ha^{-1}	$Z_1 B_1$
T_7	RDF+ Zn @ 2 kg ha^{-1}+ B@ 2 kg ha^{-1}	$Z_1 B_2$
T_8	RDF+ Zn @ 2 kg ha^{-1}+ B@ 3 kg ha^{-1}	$Z_1 B_3$
T_9	RDF+ Zn @ 4 kg ha^{-1}+ B@ 0 kg ha^{-1}	Z_2B_0

T_{10}	RDF+ Zn @ 4 kg ha^{-1}+ B@ 1 kg ha^{-1}	Z_2B_1
T_{11}	RDF+ Zn @ 4 kg ha^{-1}+ B@ 2 kg ha^{-1}	Z_2B_2
T_{12}	RDF+ Zn@ 4 kg ha^{-1}+ B@ 3 kg ha^{-1}	Z_2B_3
T_{13}	RDF+ Zn @ 6 kg ha^{-1}+ B@ 0 kg ha^{-1}	Z_3B_0
T_{14}	RDF+ Zn @ 6 kg ha^{-1}+ B@ 1 kg ha^{-1}	Z_3B_1
T_{15}	RDF+ Zn@ 6 kg ha^{-1}+ B@ 2 kg ha^{-1}	Z_3B_2
T_{16}	RDF+ Zn @ 6 kg ha^{-1}+ B@ 3 kg ha^{-1}	Z_3B_3

Fertilizer application

Recommended dose of NPK20:40:20(100%) was applied to the green gram were N (20 kg ha^{-1}), P_2O_5 (40 kg ha^{-1}) and K_2O (20 kg ha^{-1}). The 100 percent application of N, P, K was used as basal dose at the time of sowing. In adding to these applications, Zinc was used as basal @ 0,2,4and 6 kg ha^{-1} with Boron 0, 1, 2, and 3 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 earlier to sowing in regarding treatments just before the seed sowing. Nitrogen through urea (46% N), were applied in 2 different doses

Sowing of Maize crop was carried out on 15th and 20th of March month during 2021 and 2022, respectively by manually. Seed variety PDM-139 (Samrat) was sown at the rate of 25 kg ha^{-1} and at a row to row spacing of 30 cm and plant to pant spacing 10 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 Bulk density, particle density, pore space, water holding capacity (WHC) using 100 ml measuring cylinder(**Muthuval, 1992**), pH, **(Jackon, 1973)**EC, (**wilcox 1950**) OC by (**Walkley and Black 1934),**andAvailable Nitrogen (**Subbiah and Asija, 1956)**Available P **(Olsen *et al.***

1954) Available Potassium (**Toth and prince, 1949)**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 showed that the bulk density of soil were 1.32 and 1.34 Mg m^{-3} and 1.29 and 1.31 Mg m^{-3}, particle density 2.577 and 2.583Mg $m^{-3}$and 2.582 and 2.588Mg m^{-3}, pore space 47.27 and 47.63 % and 47.23 and 47.42 %, water retention capacity 46.25 % and 45.60 %and 45.46 % and 45.77 % of soilwere found optimum in treatment T_{16}RDF (20:40:20 NPK kg ha^{-1}) + Zinc@6 kg ha^{-1}+ Boron @3 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 Kumari *et al.,* 2017, Kudi *et al.*, 2018 and Karthik *et al*., 2021.

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

The data showed that the treatment T_{16} with RDF (20:40:20 NPK kg ha^{-1}) + Zinc@6 kg ha^{-1}+ Boron @3 kg ha^{-1})significantly influenced the soil pH 8.22 and 8.33and 8.21 and 8.35, electrical conductivity 0.416 and 0.418and 0.417 and 0.419, organic carbon 0.422 and 0.424 % and 0.423 and 0.427 % content in soil, however minimum values were detected in the treatments T_1 (absolute control) at 0-15 cm depth and at 15-30 cm depth during the years 2021 and 2022, 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 (281.03, 283.63 kg $ha^{-1}$and 282.52, 284.62 kg ha^{-1}),available K (205.67, 205.22 kg $ha^{-1}$and 206.61, 206.93 kg ha^{-1}), available Zn (1.110,1.109 mg kg^{-1} and 1.132 and 1.122 mg kg^{-1}) and available B (1.211,1.221 mg kg^{-1} and 1.233,1.221 mg kg^{-1}) was observed under the treatment T_{16}RDF (20:40:20 NPK kg ha^{-1}) + Zinc@6 kg ha^{-1}+ Boron @3 kg ha^{-1}) which was at par with the treatments T_{12} and

T_{10} .Thus, the results indicate that both B and Zn knowingly affected N, K, Zn and B availability in the soil. However, build-up of available P was drastically reduced with the implement of Zn and B.finest results were found in treatment T_2 with RDF *i.e.* NP and K only (16.60,16.17 kg ha^{-1} and 16.30,16.11 kg ha^{-1}) over all other remaining treatment combinations at 0-15 cm and at 15-30 cm soil depth during the years 2021 and 2022, therefore. 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 green gram.

Conclusion

Based on the results, it is concluded that the implement of NPK with micronutrient levels (Zinc and Boron) in treatment (T_{16}) RDF (20:40:20 NPK kg ha^{-1})+ Zinc@6 kg ha^{-1}+ Boron @3 kg ha^{-1}, was found best 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 levels of Zinc and Boron.Thus, it can be concluded that NPK and different levels of micronutrients (Zinc and Boron) improved 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_{11} recorded the finest treatment which increased the accessibility of nutrients and altered physico-chemical properties of soil.

Zinc and Boron nutrition with NPK knowingly improves the soil health in green gram crop. The soil method of application of Zinc and Boron with NPK show favorable results. It is preferable nutrient (NPK with micronutrient) management option for improving the fertility of the soil.Hence, it can be recommended that tobetter 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

Chena, R., Devendra, S., and Jat, B. L. (2017). Effects of different phosphorus levelsandfrequencyofboronlevels on growth and yield of greengram. *AdvanceResearchJournalof CropImprovement*, 8(1), 49-61.

Karthik, B., Umesha, C., Meshram, M. R., Mahesh, K., andPriyadharshini, 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.

Kumari (2017). Effect of Foliar Nutrition on Productivity of Green gram (Vigna radiata L.) (Masters dissertation, Department of Agronomy, BAU, Jharkhand).

Jackson, M. L. (1973). *Soil chemical analysis-advanced course: A manual of methodsuseful for instruction and research in soil chemistry, physical chemistry ofsoils,soil fertility, and soil genesis*.

Jadhav Ravindra, Narendra Swaroop and Tarence Thomas (2022). Response of NPK, Zinc and Boron Fertilization on Physico-chemical Properties of Soil under summer Green Gram (Vigna radiate L.) Cultivation in an Inceptisol of Prayagraj, (Uttar Pradesh). *International Journal of Plant & Soil Science* 34(20): 1-8.

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.

Movalia Janaki *et al.* Effect of Boron and Molybdenumon yield and yield attributes of summer greengram (Vigna radiate L) under medium black calcareous soils. *International Journal of Chemical studies* 2018;6(1):321-322.

Muthuaval, P. C., Udaysooriyan, R., &Natesa,P. P. (1992).Ramaswami. *IntroductiontoSoilAnalysis,TamilNaduAgricultureUniversity,Coimbatore-641002.Muche,M.,Kokeb,A.andMolla,E.AssessingthePhysiochemicalProperties ofSoilUnderDifferentLandUseType*.

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

Rajana Praveena, Gautam Ghosh, Vikram Singh. Effectof foliar spray of boron and different zinc levels ongrowth and yield of kharif greengram (*Vigna radiata* L.) *International Journal of Current Microbiology andApplied Sciences* 2018;7(8):1422-1428

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.

Table 2. Soil physical properties after harvest of green gram 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)	1.18	1.20	1.18	1.21	2.399	2.405	2.404	2.41	44.58	43.41	44.67	43.62	43.32	43.76	41.42	42.77
T_2	RDF + Zn @ 0 kg ha^{-1}+ B@ 1 kg ha^{-1}	1.23	1.26	1.22	1.23	2.429	2.435	2.434	2.44	45.33	44.32	45.32	44.54	44.31	43.67	43.13	43.86
T_3	RDF + Zn @ 0 kg ha^{-1}+ B@ 2 kg ha^{-1}	1.24	1.25	1.24	1.26	2.453	2.459	2.458	2.464	44.64	44.24	45.44	45.62	44.24	43.58	42.33	42.89
T_4	RDF + Zn @ 0 kg ha^{-1}+ B@ 3 kg ha^{-1}	1.26	1.28	1.24	1.25	2.413	2.419	2.418	2.424	47.23	46.10	47.74	46.93	45.52	44.86	43.23	44.90
T_5	RDF + Zn @ 2 kg ha^{-1}+ B@ 0 kg ha^{-1}	1.25	1.27	1.22	1.26	2.424	2.43	2.429	2.435	46.55	46.23	47.86	46.56	45.44	44.80	45.15	43.80
T_6	RDF + Zn @ 2 kg ha^{-1}+ B@ 1 kg ha^{-1}	1.23	1.26	1.25	1.26	2.461	2.467	2.466	2.472	46.22	45.21	46.23	45.24	44.53	44.76	44.36	44.96
T_7	RDF+ Zn @ 2 kg ha^{-1}+ B@ 2 kg ha^{-1}	1.22	1.24	1.26	1.28	2.501	2.507	2.506	2.512	46.46	45.85	46.43	46.56	45.25	43.49	45.15	44.84
T_8	RDF+ Zn @ 2 kg ha^{-1}+ B@ 3 kg ha^{-1}	1.22	1.24	1.25	1.27	2.48	2.486	2.485	2.491	47.84	46.44	46.54	45.45	44.43	45.55	44.46	44.83
T_9	RDF+ Zn @ 4 kg ha^{-1}+ B@ 0 kg ha^{-1}	1.24	1.25	1.23	1.26	2.507	2.513	2.512	2.518	47.63	46.65	47.52	46.54	45.46	45.58	44.45	45.70
T_{10}	RDF+ Zn @ 4 kg ha^{-1}+ B@ 1 kg ha^{-1}	1.25	1.28	1.27	1.28	2.517	2.523	2.522	2.528	47.26	46.74	47.62	45.46	44.23	43.40	43.26	44.74
T_{11}	RDF+ Zn @ 4 kg ha^{-1}+ B@ 2 kg ha^{-1}	1.26	1.29	1.26	1.27	2.524	2.53	2.529	2.535	46.84	45.94	46.46	45.74	45.35	44.54	44.16	45.42
T_{12}	RDF+ Zn@ 4 kg ha^{-1}+ B@ 3 kg ha^{-1}	1.24	1.28	1.27	1.28	2.55	2.556	2.555	2.561	46.35	45.85	46.74	46.47	46.24	45.61	45.25	45.67
T_{13}	RDF+ Zn @ 6 kg ha^{-1}+ B@ 0 kg ha^{-1}	1.27	1.27	1.26	1.29	2.561	2.567	2.566	2.572	47.84	47.24	47.78	47.65	45.46	44.54	44.56	44.65
T_{14}	RDF+ Zn @ 6 kg ha^{-1}+ B@ 1 kg ha^{-1}	1.29	1.31	1.27	1.29	2.539	2.545	2.544	2.55	48.25	47.65	47.24	46.57	45.27	45.70	45.24	45.53
T_{15}	RDF+ Zn@ 6 kg ha^{-1}+ B@ 2 kg ha^{-1}	1.26	1.27	1.28	1.30	2.571	2.577	2.576	2.582	46.65	46.74	46.36	46.81	45.18	45.55	45.33	45.61
T_{16}	RDF+ Zn @ 6 kg ha^{-1}+ B@ 3 kg ha^{-1}	1.32	1.34	1.29	1.31	2.577	2.583	2.582	2.588	47.24	47.63	47.23	47.42	46.25	45.60	45.46	45.77
SE m (±)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CD (P=0.05)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table 3. Soil chemical properties after harvest of green gram 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)	7.41	7.54	7.42	7.46	0.344	0.346	0.343	0.345	0.366	0.371	0.365	0.369	258.92	260.85	257.22	259.54
T_2	RDF + Zn @ 0 kg ha^{-1}+ B@ 1 kg ha^{-1}	7.67	7.76	7.61	7.65	0.352	0.355	0.353	0.355	0.388	0.392	0.388	0.391	263.38	265.85	264.53	267.83
T_3	RDF + Zn @ 0 kg ha^{-1}+ B@ 2 kg ha^{-1}	7.66	7.73	7.64	7.77	0.363	0.364	0.365	0.366	0.392	0.396	0.392	0.395	262.59	264.75	263.83	265.11
T_4	RDF + Zn @ 0 kg ha^{-1}+ B@ 3 kg ha^{-1}	7.53	7.66	7.55	7.55	0.346	0.353	0.347	0.353	0.395	0.397	0.396	0.397	265.95	265.03	265.74	266.38
T_5	RDF + Zn @ 2 kg ha^{-1}+ B@ 0 kg ha^{-1}	7.48	7.63	7.47	7.57	0.348	0.352	0.348	0.350	0.388	0.391	0.384	0.391	267.94	271.79	268.05	272.93
T_6	RDF + Zn @ 2 kg ha^{-1}+ B@ 1 kg ha^{-1}	7.75	7.85	7.73	7.74	0.365	0.373	0.368	0.374	0.389	0.389	0.386	0.388	266.74	269.75	266.60	271.60
T_7	RDF+ Zn @ 2 kg ha^{-1}+ B@ 2 kg ha^{-1}	7.84	7.93	7.86	7.97	0.374	0.375	0.375	0.376	0.396	0.397	0.396	0.398	268.49	271.68	265.74	270.44
T_8	RDF+ Zn @ 2 kg ha^{-1}+ B@ 3 kg ha^{-1}	7.77	7.84	7.73	7.84	0.373	0.374	0.373	0.379	0.398	0.403	0.396	0.401	267.59	272.04	265.64	272.73
T_9	RDF+ Zn @ 4 kg ha^{-1}+ B@ 0 kg ha^{-1}	7.54	7.76	7.56	7.67	0.375	0.378	0.375	0.376	0.398	0.404	0.396	0.403	271.63	273.75	271.64	273.82
T_{10}	RDF+ Zn @ 4 kg ha^{-1}+ B@ 1 kg ha^{-1}	7.45	7.63	7.43	7.55	0.384	0.387	0.385	0.389	0.404	0.408	0.405	0.407	267.50	272.74	268.53	271.47
T_{11}	RDF+ Zn @ 4 kg ha^{-1}+ B@ 2 kg ha^{-1}	8.24	8.25	8.22	8.26	0.386	0.386	0.386	0.387	0.398	0.407	0.396	0.402	272.73	274.64	271.92	274.02
T_{12}	RDF+ Zn@ 4 kg ha^{-1}+ B@ 3 kg ha^{-1}	7.25	7.42	7.26	7.35	0.394	0.397	0.395	0.399	0.406	0.409	0.405	0.407	273.55	274.73	270.89	275.63
T_{13}	RDF+ Zn @ 6 kg ha^{-1}+ B@ 0 kg ha^{-1}	8.14	8.17	8.15	8.37	0.398	0.396	0.396	0.398	0.411	0.413	0.412	0.415	276.74	277.92	275.62	281.82
T_{14}	RDF+ Zn @ 6 kg ha^{-1}+ B@ 1 kg ha^{-1}	7.66	7.78	7.67	7.85	0.386	0.397	0.387	0.391	0.414	0.416	0.414	0.416	277.76	279 .53	275.52	282 .81
T_{15}	RDF+ Zn@ 6 kg ha^{-1}+ B@ 2 kg ha^{-1}	7.83	8.02	7.84	8.05	0.412	0.413	0.416	0.417	0.417	0.417	0.417	0.419	280.74	281.49	281.72	282.30
T_{16}	RDF+ Zn @ 6 kg ha^{-1}+ B@ 3 kg ha^{-1}	8.22	8.33	8.21	8.35	0.416	0.418	0.417	0.419	0.422	0.424	0.423	0.427	281.03	283.63	282.52	284.62
SE m (±)		-	-	-	-	0.04	0.02	0.03	0.02	0.05	0.02	0.03	0.02	11.01	12.83	12.67	11.98
CD (P=0.05)		-	-	-	-	0.03	0.01	0.02	0.01	0.04	0.01	0.02	0.01	5.39	6.28	6.21	5.67

Table 4. Soil chemical properties after harvest of green gram 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)	12.98	12.12	11.82	11.19	195.82	195.15	194.72	195.42	0.467	0.446	0.465	0.434	0-15	15-30	0-15	15-30
T_2 RDF + Zn @ 0 kg ha^{-1}+ B@ 1 kg ha^{-1}	14.79	14.21	14.70	13.26	196.73	196.31	195.63	194.12	0.521	0.454	0.533	0.415	0.568	0.542	0.563	0.522
T_3 RDF + Zn @ 0 kg ha^{-1}+ B@ 2 kg ha^{-1}	13.86	12.32	12.89	13.10	196.75	197.45	196.78	195.15	0.575	0.553	0.665	0.527	0.623	0.554	0.634	0.513
T_4 RDF + Zn @ 0 kg ha^{-1}+ B@ 3 kg ha^{-1}	14.91	13.34	13.69	14.26	198.66	198.16	197.61	197.31	0.586	0.664	0.654	0.625	0.676	0.653	0.762	0.621
T_5 RDF + Zn @ 2 kg ha^{-1}+ B@ 0 kg ha^{-1}	14.81	14.23	14.75	13.20	200.59	200.27	201.72	200.13	0.665	0.621	0.566	0.547	0.687	0.764	0.754	0.721
T_6 RDF + Zn @ 2 kg ha^{-1}+ B@ 1 kg ha^{-1}	13.82	13.32	14.92	13.28	202.85	200.48	200.72	200.42	0.633	0.625	0.564	0.616	0.765	0.751	0.663	0.647
T_7 RDF+ Zn @ 2 kg ha^{-1}+ B@ 2 kg ha^{-1}	14.74	13.12	13.81	14.10	202.67	201.36	202.63	200.11	0.626	0.615	0.746	0.728	0.737	0.729	0.764	0.719
T_8 RDF+ Zn @ 2 kg ha^{-1}+ B@ 3 kg ha^{-1}	15.70	14.21	13.83	14.21	203.83	203.54	203.85	202.44	0.7.55	0.723	0.725	0.716	0.724	0.712	0.843	0.822
T_9 RDF+ Zn @ 4 kg ha^{-1}+ B@ 0 kg ha^{-1}	14.69	14.23	14.73	15.24	204.66	202.25	204.63	202.21	0.776	0.742	0.696	0.639	0.8.56	0.822	0.823	0.816
T_{10} RDF+ Zn @ 4 kg ha^{-1}+ B@ 1 kg ha^{-1}	13.87	13.34	13.92	14.18	202.83	201.33	204.84	201.41	0.763	0.732	0.765	0.749	0.877	0.843	0.793	0.734
T_{11} RDF+ Zn @ 4 kg ha^{-1}+ B@ 2 kg ha^{-1}	14.80	14.29	14.90	13.32	203.85	202.24	203.76	202.23	0.853	0.810	0.714	0.708	0.864	0.831	0.866	0.842
T_{12} RDF+ Zn@ 4 kg ha^{-1}+ B@ 3 kg ha^{-1}	14.87	15.20	14.81	15.19	204.74	201.23	204.82	201.14	0.712	0.703	0.723	0.702	0.954	0.911	0.815	0.809
T_{13} RDF+ Zn @ 6 kg ha^{-1}+ B@ 0 kg ha^{-1}	15.70	15.28	15.70	14.10	203.63	202.53	203.83	201.20	0.773	0.742	0.772	0.703	0.814	0.801	0.822	0.808
T_{14} RDF+ Zn @ 6 kg ha^{-1}+ B@ 1 kg ha^{-1}	14.86	14.19	14.40	14.17	204.76	203.52	203.75	203.32	0.804	0.792	0.762	0.731	0.874	0.843	0.872	0.803
T_{15} RDF+ Zn@ 6 kg ha^{-1}+ B@ 2 kg ha^{-1}	15.95	15.16	15.70	15.21	204.64	204.33	204.82	204.41	1.107	1.108	1.103	1.101	0.905	0.893	0.913	0.901
T_{16} RDF+ Zn @ 6 kg ha^{-1}+ B@ 3 kg ha^{-1}	16.60	16.17	16.30	16.11	205.67	205.22	206.61	206.93	1.110	1.109	1.132	1.122	1.208	1.201	1.212	1.205
SE m (±)	0.70	0.55	0.56	0.56	7.90	8.67	9.26	8.34	0.02	0.03	0.03	0.03	0.05	0.06	0.03	0.03
CD (P=0.05)	0.34	0.27	0.27	0.27	3.87	4.24	4.55	4.08	0.01	0.02	0.02	0.02	0.02	0.03	0.01	0.02