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Influence of zinc and iron on Physico-chemical properties of soil in cluster bean

Tarun Kumar, Tarence Thomas, Narendra Swaroop and Vishal Manohar Dalavi

Abstract
The research was lead at the Soil Science Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, U.P. during the *Kharif* season in 2020-2021. The experiment was laid out in Randomized Block Design with sixteen treatments and three replications with four levels of zinc and iron respectively with NPK as an RDF that leads to the non-significant findings *i.e.* B.D. and P.D. and remaining macro- micro nutrients in soil have significant findings which comprises yellowish brown and sandy loam textured neutral to alkaline soil that is non- saline in nature. Physico-chemical properties of soil was found best in treatment T_{16} (RDF @ 100% + Zinc @ 20 kg ha^{-1} + Iron @ 7.5 kg ha^{-1}) as compare with in treatment T_1 [Absolute control (RDF @ 0% + Zinc @ 0 kg ha^{-1} + Iron @ 0 kg ha^{-1})].

Keywords: Zinc, iron, cluster bean, Physico-chemical properties of soil

Introduction
India is the largest producer, consumer and importer of pulses in the world. It consumes an estimated 26 MT of pulses annually. In 2016-17, the production of pulses was 23.13 MT, in 2017-18, it was 25.42 MT and in 2018-19 is around 23.33 MT. India's pulses production is driven by chickpea and pigeon pea. The contributes of chickpea in total production is around 48% followed by pigeon pea at 17% (IPGA, 2019) [9].

Guar or cluster bean [*Cyamopsis tetragonoloba* (L.) Taub] is native to India and has been cultivated in the country for ages. Guar plant produces a cluster of flowers and pods; therefore, it is also known as cluster bean. It belongs to the family Leguminaceae and subfamily Papillionaceae and is known to improve soil fertility. Being a legume crop, it has the capacity to fix atmospheric nitrogen by its effective root nodules (Kumar *et al.*, 2012) [12]. It is generally 50-100 cm tall and bears 4 to 10 branches (branch type). However, non-branch type varieties have main stem only, which is heavily clustered with pods. The composition of cluster bean is 81.0g moisture, 10.8g carbohydrate, 3.2g protein, 1.4g of fat, 1.4g of minerals, 0.09mg thiamine, 0.03mg riboflavin, 47 I.U. vitamin-C, 316 I.U, vitamin A (per 100 g of edible portion). It provides nutritional concentrate and fodder for cattle and adds to the fertility of soil by fixing considerable amount of atmospheric nitrogen (Singh and Usha, 2003) [20]. In the recent years, this crop has assumed great significance in industrial sector due to the presence of good quality of gum in the endosperm of its seed and also having 28 to 33 per cent gum endosperm (Reddy *et al.*, 2011) [18].

Micronutrient deficiency Zn and Fe is major problem of now days because of use of high yielding varieties, intensive cropping system, inadequate supply of micronutrient and loss of organic matter content by erosion and pollution. Iron involved in chlorophyll and thylakoid synthesis and development of chloroplast and important element for plant growth and development. Zn application influence on synthesis of auxin, nodulation and nitrogen fixation which enhance the plant growth and development of crop and ultimately influence the seed yield (Kasthurikrishna and Ahlawat, 2000) [11].

Zinc deficiency leads to reduction of stem elongation, auxin activities, protein synthesis, flowering and fruit development and also growth period is prolonged resulting in delayed maturity (Tandon, 2009) [24]. Iron (Fe) deficiency is often seen in high pH and calcareous soils in arid regions (Havlin *et al*., 2010) [8]. Fe deficiency is a major constraint for many crops production when grown in semiarid areas and yield losses some pulse crops would likely occur due to Fe deficiency (Zaiter *et al*., 1992) [29].

Materials and Methods

A field experiment conducted at the Soil Science Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, during the *Kharif* season of two years (2020-2021) growing cluster bean *Var*. Gawar Spl. applied 4 levels of zinc and iron respectively Zinc = 0 kg ha^{-1}, 6.67 kg ha^{-1}, 13.34 kg ha^{-1}, 20 kg ha^{-1} and Iron = 0 kg ha^{-1}, 2.5 kg ha^{-1}, 5 kg ha^{-1}, 7.5 kg ha^{-1} including RDF for cluster bean = 25:50:25 kg ha^{-1} experiment is lead to observe the physical and chemical parameters. In physical parameters like that bulk density, particle density, pore space and water holding capacity through method by 100 ml graduated measuring cylinder and process by Muthuvel *et al*., 1992 [16].

In chemical parameters through method by-

a. Soil pH - Method given by (Jackson, M. L. 1958) [10] through using digital pH meter.
b. Soil EC (dSm^{-1}) - Method given by (Wilcox, 1950) [27] through using digital EC meter.
c. Organic Carbon (%) - Wet oxidation method given by (Walkley and Black, 1947) [26].
d. Available Nitrogen (kg ha^{-1}) - Kjeldhal Method (Subbiah and Asija, 1956) [22].
e. Available Phosphorus (kg ha^{-1}) - Colorimetric method by using Jasper single beam U.V. Spectrophotometer at 660 nm wavelength given by (Olsen *et al*., 1954) [17].
f. Available Potassium (kg ha^{-1}) - Flame photometric method by using Metzer Flame Photometer given by (Toth and Prince, 1949) [25].
g. Available Zinc and Iron (mg kg^{-1}) - DTPA Extractant method by using AAS given by (Lindsay and Norvell, 1978) [13].

Result and Discussion

Physical Properties of Soil

A critical perusal of data pertaining in the table 1 and fig.1 the effect of different levels of Zn and Fe on the soil in both the years 2020 and 2021 was found to be non- significant at C.D @ 5%. The soil bulk density was increases according to depth which was found to be maximum 1.302 Mg m^{-3} at 0-15 cm and 1.306 Mg m^{-3} at 15- 30 cm in 2020 and 1.299 Mg m^{-3} at 0-15 cm and 1.312 Mg m^{-3} at 15- 30 cm in 2021 in treatment T_{16} (RDF @ 100% + Zinc @ 20 kg ha^{-1} + Iron @ 7.5 kg ha^{-1}) and minimum 1.276 Mg m^{-3} at 0-15 cm and 1.282 Mg m^{-3} at 15-30 cm in 2020 and 1.278 Mg m^{-3} at 0-15 cm and 1.286 Mg m^{-3} at 15- 30 cm in 2021 in treatment T_1 [Absolute control (RDF @ 0% + Zinc @ 0 kg ha^{-1} + Iron @ 0 kg ha^{-1})]. The soil particle density was increases according to depth which was found to be maximum 2.582 Mg m^{-3} at 0-15 cm and 2.588 Mg m^{-3} at 15- 30 cm in 2020 and 2.603 Mg m^{-3} at 0-15 cm and 2.609 Mg m^{-3} at 15- 30 cm in 2021 in treatment T_{16} (RDF @ 100% + Zinc @ 20 kg ha^{-1} + Iron @ 7.5 kg ha^{-1}) and minimum 2.438 Mg m^{-3} at 0-15 cm and 2.442 Mg m^{-3} at 15-30 cm in 2020 and 2.458 Mg m^{-3} at 0-15 cm and 2.462 Mg m^{-3} at 15- 30 cm in 2021 in treatment T_1 [Absolute control (RDF @ 0% + Zinc @ 0 kg ha^{-1} + Iron @ 0 kg ha^{-1})]. Anuradha *et al*., (2017) [1]; Yadav *et al*., (2021) [28].

The soil pore space was decreases according to depth which was found to be maximum 50.02% at 0-15 cm and 49.98% at 15-30 cm in 2020 and 50.30% at 0-15 cm and 50.10% at 15-30 cm in 2021 in treatment T_{10} (RDF @ 100% + Zinc @ 13.34 kg ha^{-1} + Iron @ 2.5 kg ha^{-1}) and minimum 47.66% at 0-15 cm and 47.50% at 15- 30 cm in 2020 and 47.83% at 0-15 cm and 47.75% at 15- 30 cm in 2021 in treatment T_1 [Absolute control (RDF @ 0% + Zinc @ 0 kg ha^{-1} + Iron @ 0 kg ha^{-1})]. The soil water holding capacity was decreases according to depth which was found to be maximum 51.82% at 0-15 cm and 50.60% at 15- 30 cm in 2020 and 52.23% at 0-15 cm and 51.00% at 15- 30 cm in 2021 in treatment T_{16} (RDF @ 100% + Zinc @ 20 kg ha^{-1} + Iron @ 7.5 kg ha^{-1}) and minimum 48.65% at 0-15 cm and 47.12% at 15-30 cm in 2020 and 49.04% at 0-15 cm and 47.50% at 15-30 cm in 2021 in treatment T_1 [Absolute control (RDF @ 0% + Zinc @ 0 kg ha^{-1} + Iron @ 0 kg ha^{-1})]. Banjara, G. P. and Majgahe, S. K. (2019) [2]; Chintha *et al*., (2021) [4].

Chemical Properties of Soil

A critical perusal of data pertaining in the table 2 and fig. 2 the effect of different levels of Zn and Fe on the soil in both the years 2020 and 2021 was found to be significant at C.D @ 5%. The soil pH was increases according to depth which was found to be maximum 8.18 at 0-15 cm and 8.21 at 15- 30 cm in 2020 and 8.25 at 0-15 cm and 8.28 at 15- 30 cm in 2021 in treatment T_{16} (RDF @ 100% + Zinc @ 20 kg ha^{-1} + Iron @ 7.5 kg ha^{-1}) and minimum 7.50 at 0-15 cm and 7.52 at 15- 30 cm in 2020 and 7.56 at 0-15 cm and 7.58 at 15- 30 cm in 2021 in treatment T_1 [Absolute control (RDF @ 0% + Zinc @ 0 kg ha^{-1} + Iron @ 0 kg ha^{-1})]. The soil EC was increases according to depth which was found to be maximum 0.416 dSm^{-1} at 0-15 cm and 0.420 dSm^{-1} at 15- 30 cm in 2020 and 0.423 dSm^{-1} at 0-15 cm and 0.426 dSm^{-1} at 15- 30 cm in 2021 in treatment T_{16} (RDF @ 100% + Zinc @ 20 kg ha^{-1} + Iron @ 7.5 kg ha^{-1}) and minimum 0.342 dSm^{-1} at 0-15 cm and 0.345 dSm^{-1} at 15-30 cm in 2020 and 0.348 dSm^{-1} at 0-15 cm and 0.352 dSm^{-1} at 15- 30 cm in 2021 in treatment T_1 [Absolute control (RDF @ 0% + Zinc @ 0 kg ha^{-1} + Iron @ 0 kg ha^{-1})]. The soil organic carbon was decreases according to depth which was found to be maximum 0.538% at 0-15 cm and 0.531% at 15- 30 cm in 2020 and 0.542% at 0-15 cm and 0.535% at 15- 30 cm in 2021 in treatment T_{16} (RDF @ 100% + Zinc @ 20 kg ha^{-1} + Iron @ 7.5 kg ha^{-1}) and minimum 0.465% at 0-15 cm and 0.459% at 15- 30 cm in 2020 and 0.469% at 0-15 cm and 0.463% at 15- 30 cm in 2021 in treatment T_1 [Absolute control (RDF @ 0% + Zinc @ 0 kg ha^{-1} + Iron @ 0 kg ha^{-1})]. Deshlahare *et al*., (2019) [6]; Meena *et al*., (2006) [14].

A critical perusal of data pertaining in the table 3 and fig. 3 the effect of different levels of Zn and Fe on the soil in both the years 2020 and 2021 was found to be significant at C.D @ 5%. The soil available nitrogen was decreases according to depth which was found to be maximum 230.52 kg ha^{-1} at 0-15 cm and 212.30 kg ha^{-1} at 15- 30 cm in 2020 and 233.75 kg ha^{-1} at 0-15 cm and 216.28 kg ha^{-1} at 15- 30 cm in 2021 in treatment T_{16} (RDF @ 100% + Zinc @ 20 kg ha^{-1} + Iron @ 7.5 kg ha^{-1}) and minimum 218.06 kg ha^{-1} at 0-15 cm and 196.50 kg ha^{-1} at 15- 30 cm in 2020 and 221.11 kg ha^{-1} at 0-15 cm and 203.58 kg ha^{-1} at 15- 30 cm in 2021 in treatment T_1 [Absolute control (RDF @ 0% + Zinc @ 0 kg ha^{-1} + Iron @ 0 kg ha^{-1})]. The soil available phosphorus was decreases according to depth which was found to be maximum 16.70 kg ha^{-1} at 0-15 cm and 14.84 kg ha^{-1} at 15- 30 cm in 2020 and 16.93 kg ha^{-1} at 0-15 cm and 15.05 kg ha^{-1} at 15- 30 cm in 2021 in treatment T_{16} (RDF @ 100% + Zinc @ 20 kg ha^{-1} + Iron @ 7.5 kg ha^{-1}) and minimum 12.36 kg ha^{-1} at 0-15 cm and 9.60 kg ha^{-1} at 15- 30 cm in 2020 and 12.53 kg ha^{-1} at 0-15 cm and 8.72 kg ha^{-1} at 15- 30 cm in 2021 in treatment T_1 [Absolute control (RDF @ 0% + Zinc @ 0 kg ha^{-1} + Iron @ 0 kg ha^{-1})]. The soil available potassium was decreases according to depth which was found to be maximum 210.20 kg ha^{-1} at 0-15 cm and 198.52 kg ha^{-1} at 15- 30 cm in 2020 and 213.14 kg ha^{-1} at 0-15 cm and 201.30 kg ha^{-1} at 15- 30 cm in 2021 in treatment T_{16} (RDF @ 100% + Zinc @ 20 kg ha^{-1} + Iron @ 7.5 kg ha^{-1}) and minimum 195.82 kg ha^{-1} at 0-15 cm and 183.37 kg ha^{-1} at 15- 30 cm in 2020 and 198.56 kg ha^{-1} at 0-15 cm and 185.94 kg ha^{-1} at 15- 30 cm in 2021 in treatment T_1 [Absolute control (RDF @ 0% + Zinc @ 0 kg ha^{-1} + Iron @ 0 kg ha^{-1})]. Sahu *et al*., (2020) [19]; Singh *et al*., (2015) [21].

A ritical perusal of data pertaining in the table 4 and fig. 4 the effect of different levels of Zn and Fe on the soil in both the years 2020 and 2021 was found to be significant at C.D @ 5%. The soil available zinc was increases according to depth which was found to be maximum 0.435 mg kg^{-1} at 0-15 cm and 0.442 mg kg^{-1} at 15- 30 cm in 2020 and 0.453 mg kg^{-1} at 0-15 cm and 0.460 mg kg^{-1} at 15- 30 cm in 2021 in treatment T_{16} (RDF @ 100% + Zinc @ 20 kg ha^{-1} + Iron @ 7.5 kg ha^{-1}) and minimum 0.284 mg kg^{-1} at 0-15 cm and 0.292 mg kg^{-1} at 15- 30 cm in 2020 and 0.295 mg kg^{-1} at 0-15 cm and 0.304 mg kg^{-1} at 15- 30 cm in 2021 in treatment T_1 [Absolute control (RDF @ 0% + Zinc @ 0 kg ha^{-1} + Iron @ 0 kg ha^{-1})]. The soil available iron was decreases according to depth which was found to be maximum 8.64 mg kg^{-1} at 0-15 cm and 6.84 mg kg^{-1} at 15- 30 cm in 2020 and 8.90 mg kg^{-1} at 0-15 cm and 7.05 mg kg^{-1} at 15- 30 cm in 2021 in treatment T_{16} (RDF @ 100% + Zinc @ 20 kg ha^{-1} + Iron @ 7.5 kg ha^{-1}) and minimum 4.23 mg kg^{-1} at 0-15 cm and 3.14 mg kg^{-1} at 15- 30 cm in 2020 and 4.36 mg kg^{-1} at 0-15 cm and 3.23 mg kg^{-1} at 15- 30 cm in 2021 in treatment T_1 [Absolute control (RDF @ 0% + Zinc @ 0 kg ha^{-1} + Iron @ 0 kg ha^{-1})]. Choudhary *et al*., (2021) [5]; Sunil *et al*., (2017) [23].

Table 1: Effect of different levels of zinc and iron on bulk density (Mg m^{-3}), particle density (Mg m^{-3}), pore space (%) and water holding capacity (%) in soil at harvest.

Treatment	Bulk density (Mg m^{-3})				Particle density (Mg m^{-3})				Pore space (%)				Water holding capacity (%)			
	2020		2021		2020		2021		2020		2021		2020		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	1.276	1.282	1.278	1.286	2.438	2.442	2.458	2.462	47.66	47.50	47.83	47.75	48.65	47.12	49.04	47.50
T_2	1.283	1.289	1.284	1.293	2.461	2.465	2.481	2.485	47.87	47.71	48.04	47.95	49.72	48.34	50.12	48.73
T_3	1.282	1.287	1.281	1.292	2.453	2.458	2.473	2.478	47.74	47.64	47.95	47.84	49.52	48.18	49.92	48.57
T_4	1.278	1.284	1.278	1.288	2.445	2.448	2.465	2.468	47.73	47.55	47.90	47.79	48.82	47.62	49.21	48.00
T_5	1.281	1.285	1.279	1.291	2.448	2.453	2.468	2.473	47.67	47.62	47.92	47.78	49.38	47.90	49.78	48.28
T_6	1.287	1.292	1.286	1.297	2.528	2.532	2.548	2.552	49.09	48.97	49.30	49.17	50.24	49.06	50.64	49.45
T_7	1.290	1.294	1.288	1.300	2.560	2.564	2.580	2.585	49.61	49.53	49.85	49.69	50.84	49.52	51.25	49.92
T_8	1.287	1.291	1.285	1.297	2.471	2.476	2.491	2.496	47.92	47.86	48.17	48.02	50.54	49.86	50.94	50.26
T_9	1.296	1.301	1.294	1.306	2.548	2.551	2.568	2.571	49.14	49.00	49.35	49.20	50.32	49.28	50.72	49.67
T_{10}	1.285	1.288	1.282	1.295	2.571	2.575	2.592	2.596	50.02	49.98	50.30	50.10	51.35	50.16	51.76	50.56
T_{11}	1.290	1.295	1.289	1.300	2.550	2.554	2.570	2.574	49.41	49.30	49.62	49.49	50.43	49.62	50.83	50.02
T_{12}	1.301	1.305	1.298	1.311	2.581	2.586	2.602	2.607	49.59	49.54	49.84	49.69	51.64	50.42	52.05	50.82
T_{13}	1.289	1.293	1.287	1.299	2.559	2.563	2.579	2.584	49.63	49.42	49.74	49.71	49.60	48.70	50.00	49.09
T_{14}	1.294	1.303	1.296	1.304	2.572	2.576	2.593	2.597	49.69	49.55	49.84	49.77	51.40	50.24	51.81	50.64
T_{15}	1.296	1.304	1.297	1.306	2.575	2.578	2.596	2.599	49.67	49.52	49.76	49.73	51.51	50.31	51.92	50.71
T_{16}	1.302	1.306	1.299	1.312	2.582	2.588	2.603	2.609	49.57	49.54	49.82	49.69	51.82	50.60	52.23	51.00
F - test	NS	NS	NS	NS	NS	NS	NS	NS	S	S	S	S	S	S	S	S
CD @ 5%	-	-	-	-	-	-	-	-	1.58	1.87	2.15	2.19	1.69	1.91	2.48	1.75
S.Ed. (±)	-	-	-	-	-	-	-	-	0.77	0.92	1.05	1.07	0.83	0.94	1.21	0.86

Table 2: Effect of different levels of zinc and iron on bulk density (Mg m^{-3}), particle density (Mg m^{-3}), pore space (%) and water holding capacity (%) in soil at harvest.

Treatment	pH				EC (dSm^{-1})				Organic carbon (%)			
	2020		2021		2020		2021		2020		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
T_1	7.50	7.52	7.56	7.58	0.342	0.345	0.348	0.352	0.465	0.459	0.469	0.463
T_2	7.60	7.64	7.66	7.70	0.352	0.554	0.396	0.402	0.481	0.475	0.485	0.479
T_3	7.54	7.58	7.60	7.64	0.350	0.352	0.355	0.358	0.476	0.471	0.480	0.475
T_4	7.51	7.54	7.57	7.60	0.345	0.348	0.351	0.354	0.468	0.462	0.476	0.466
T_5	7.52	7.56	7.58	7.62	0.348	0.351	0.354	0.357	0.473	0.468	0.477	0.472
T_6	7.62	7.65	7.68	7.71	0.362	0.365	0.368	0.372	0.484	0.478	0.488	0.482
T_7	7.80	7.84	7.86	7.90	0.381	0.386	0.389	0.391	0.501	0.496	0.505	0.500
T_8	7.71	7.75	7.77	7.81	0.372	0.376	0.379	0.382	0.494	0.488	0.498	0.492
T_9	7.64	7.67	7.70	7.73	0.364	0.368	0.371	0.374	0.487	0.479	0.491	0.483
T_{10}	7.91	7.95	7.97	8.01	0.388	0.391	0.394	0.398	0.512	0.511	0.516	0.515
T_{11}	7.68	7.71	7.74	7.77	0.372	0.376	0.379	0.384	0.494	0.488	0.498	0.492
T_{12}	8.12	8.15	8.17	8.20	0.411	0.416	0.419	0.423	0.534	0.528	0.538	0.532
T_{13}	7.75	7.78	7.81	7.84	0.380	0.382	0.385	0.389	0.496	0.492	0.500	0.496
T_{14}	7.92	7.97	7.98	8.03	0.392	0.396	0.399	0.403	0.523	0.520	0.527	0.524
T_{15}	8.14	8.16	8.21	8.23	0.398	0.402	0.405	0.408	0.527	0.522	0.531	0.526
T_{16}	8.18	8.21	8.25	8.28	0.416	0.420	0.423	0.426	0.538	0.531	0.542	0.535
F - test	S	S	S	S	S	S	S	S	S	S	S	S
CD @ 5%	0.32	0.35	0.21	0.33	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.02
S.Ed. (±)	0.16	0.17	0.10	0.16	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table 3: Effect of different levels of zinc and iron on available nitrogen (kg ha^{-1}), available phosphorus (kg ha^{-1}) and available potassium (kg ha^{-1}) in soil at harvest.

Treatment	Available nitrogen (kg ha^{-1})				Available phosphorus (kg ha^{-1})				Available potassium (kg ha^{-1})			
	2020		2021		2020		2021		2020		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
T_1	218.06	196.50	221.11	203.58	12.36	9.60	12.53	8.72	195.82	183.37	198.56	185.94
T_2	220.35	203.78	223.43	205.91	13.18	10.62	13.36	10.77	197.62	186.82	200.39	189.44
T_3	222.18	206.08	225.29	207.77	12.84	10.48	13.02	10.63	196.78	187.15	199.53	189.77
T_4	219.34	198.60	222.41	204.88	12.52	9.72	12.70	9.86	196.08	183.78	198.83	186.35
T_5	221.08	203.16	224.18	206.65	12.73	10.14	12.91	10.28	198.37	185.42	201.15	188.02
T_6	225.50	206.45	228.66	211.14	13.47	10.86	13.66	11.01	198.55	187.08	201.33	189.70
T_7	224.55	203.50	227.69	210.19	14.86	12.68	15.07	12.86	205.45	193.62	208.33	196.33
T_8	222.08	202.18	225.19	207.68	14.28	11.92	14.48	12.09	203.18	191.78	206.02	194.46
T_9	221.88	202.36	224.99	207.47	13.54	11.18	13.73	11.34	201.19	188.18	204.01	190.81
T_{10}	225.76	204.76	228.92	211.44	15.32	13.38	15.53	13.57	206.34	194.45	209.23	197.17
T_{11}	222.08	202.18	225.19	207.68	14.28	11.92	14.48	12.09	203.18	191.78	206.02	194.46
T_{12}	228.36	208.52	231.56	214.09	16.32	14.62	16.55	14.82	208.67	196.38	211.59	199.13
T_{13}	223.62	202.76	226.75	209.25	14.75	12.15	14.96	12.32	204.76	192.50	207.63	195.20
T_{14}	226.95	205.16	230.13	212.65	15.64	13.53	15.86	13.72	207.82	195.96	210.73	198.70
T_{15}	227.34	206.43	230.52	213.05	15.81	13.78	16.03	13.97	208.52	195.78	211.45	198.52
T_{16}	230.52	212.30	233.75	216.28	16.70	14.84	16.93	15.05	210.20	198.52	213.14	201.30
F - test	S	S	S	S	S	S	S	S	S	S	S	S
CD @ 5%	4.34	4.65	4.46	3.45	0.46	0.52	0.64	0.42	4.93	4.16	4.21	3.64
S.Ed. (±)	2.13	2.79	2.21	2.02	0.22	0.25	0.31	0.21	2.42	2.67	2.51	1.72

Table 4: Effect of different levels of zinc and iron on available zinc (mg kg^{-1}) and available iron (mg kg^{-1}) in soil at harvest.

Treatment	Available zinc (mg kg^{-1})				Available iron (mg kg^{-1})			
	2020		2021		2020		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
T_1	0.284	0.292	0.295	0.304	4.23	3.14	4.36	3.23
T_2	0.328	0.334	0.341	0.347	5.10	4.16	5.25	4.28
T_3	0.288	0.296	0.300	0.308	4.65	3.52	4.79	3.63
T_4	0.321	0.329	0.334	0.342	4.96	3.90	5.11	4.02
T_5	0.331	0.338	0.344	0.352	5.36	4.38	5.52	4.51
T_6	0.337	0.342	0.351	0.356	5.78	4.76	5.95	4.90
T_7	0.35	0.361	0.364	0.376	6.28	5.07	6.47	5.22
T_8	0.349	0.358	0.363	0.372	6.06	4.92	6.24	5.07
T_9	0.345	0.353	0.359	0.367	5.86	4.85	6.04	5.00
T_{10}	0.367	0.375	0.382	0.390	6.95	5.56	7.16	5.73
T_{11}	0.356	0.362	0.370	0.377	6.45	5.14	6.64	5.29
T_{12}	0.406	0.411	0.422	0.428	7.93	6.08	8.17	6.26
T_{13}	0.384	0.389	0.400	0.415	7.38	5.82	7.60	5.99
T_{14}	0.395	0.404	0.411	0.420	7.52	5.96	7.75	6.14
T_{15}	0.423	0.436	0.440	0.454	8.36	6.42	8.61	6.61
T_{16}	0.435	0.442	0.453	0.460	8.64	6.84	8.90	7.05
F - test	S	S	S	S	S	S	S	S
CD @ 5%	0.02	0.02	0.02	0.02	0.34	0.23	0.33	0.28
S.Ed. (±)	0.01	0.01	0.01	0.01	0.17	0.11	0.16	0.13

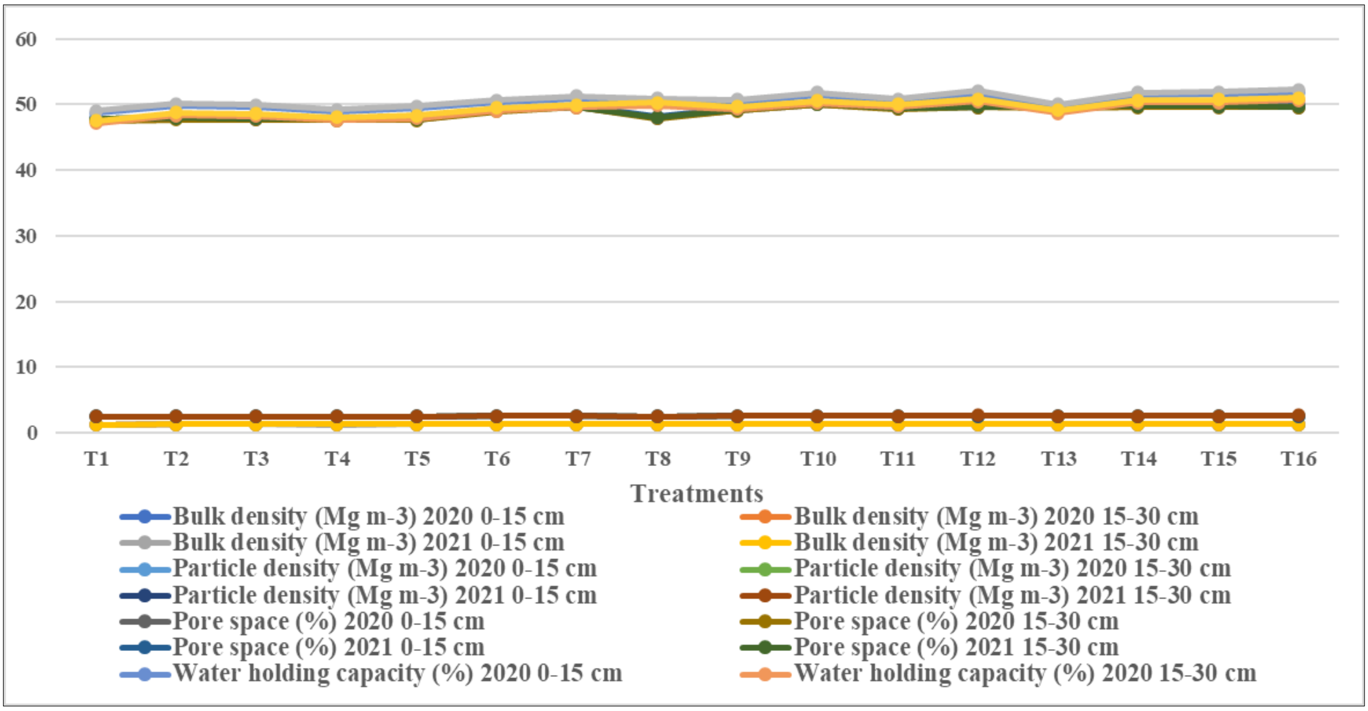

Fig 1: Effect of different levels of zinc and iron on bulk density (Mg m^{-3}), particle density (Mg m^{-3}), pore space (%) and water holding capacity (%) in soil at harvest.

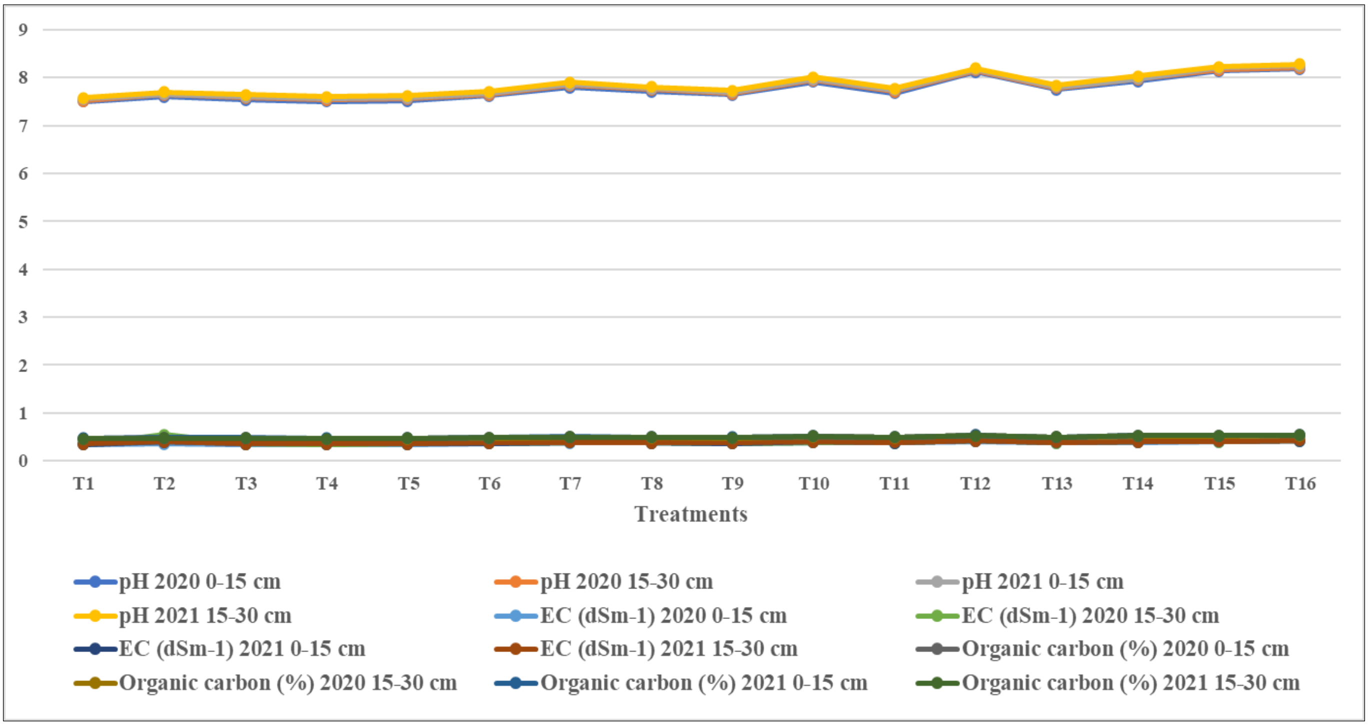

Fig 2: Effect of different levels of zinc and iron on bulk density (Mg m^{-3}), particle density (Mg m^{-3}), pore space (%) and water holding capacity (%) in soil at harvest.

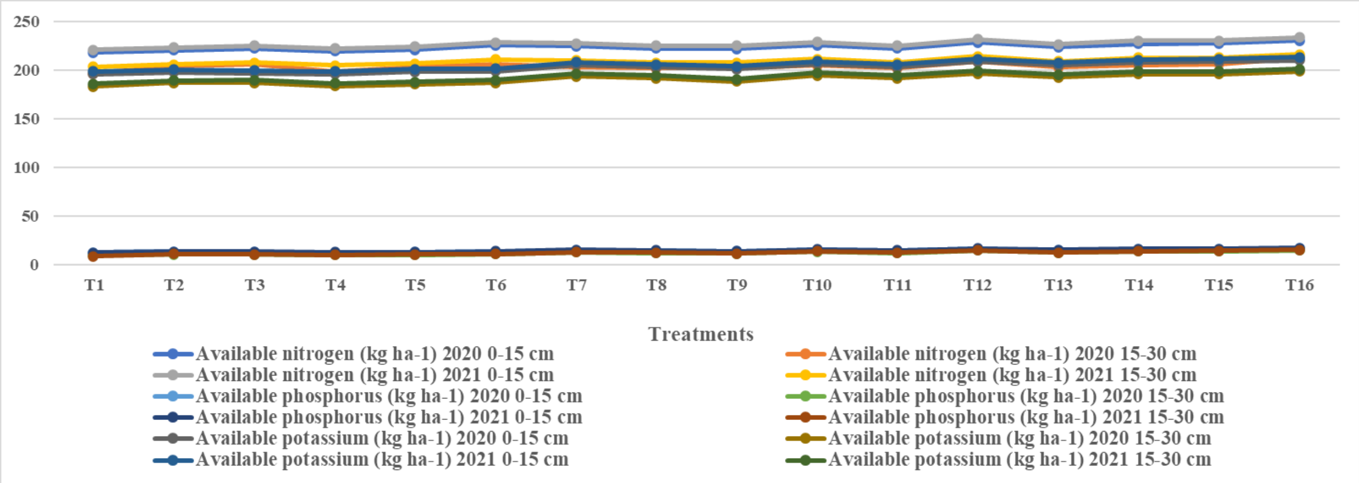

Fig 3: Effect of different levels of zinc and iron on available nitrogen (kg ha^{-1}), available phosphorus (kg ha^{-1}) and available potassium (kg ha^{-1}) in soil at harvest.

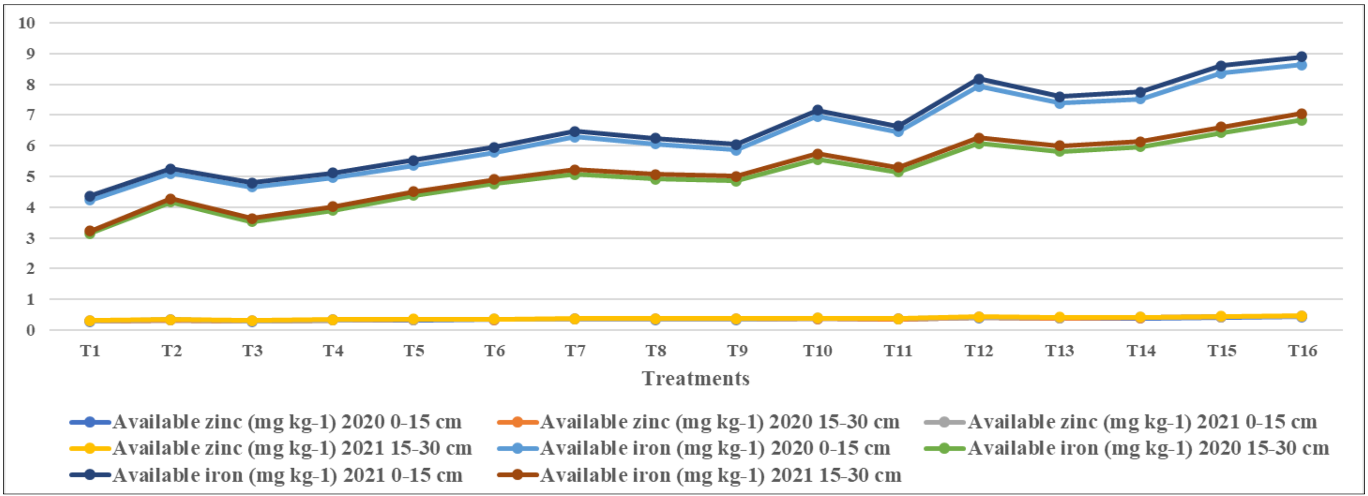

Fig 4: Effect of different levels of zinc and iron on available zinc (mg kg^{-1}) and available iron (mg kg^{-1}) in soil at harvest.

Conclusion

According to the results revealed the treatment T_{16} (RDF @ 100% + Zinc @ 20 kg ha^{-1} + Iron @ 7.5 kg ha^{-1}) was seen to be best for all the Physico-chemical parameters which is followed by treatment T_{12} (RDF @ 100% + Zinc @ 13.34 kg ha^{-1} + Iron @ 7.5 kg ha^{-1}) and treatment T_{15} (RDF @ 100% + Zinc @ 20 kg ha^{-1} + Iron @ 5 kg ha^{-1}) and the lowest treatment was T_1 [Absolute control (RDF @ 0% + Zinc @ 0 kg ha^{-1} + Iron @ 0 kg ha^{-1})]. Which proved that full dose of NPK, Fe and Zn are recommendable to the farmers.

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References

1. Anuradha Singh RK, Pareek B, Kumar D, Meena S, Dubey SK. Different Levels of Fertilizers on Growth and Yield of Cluster Bean (*Cyamopsis tetragonoloba* L.) in Rainfed Area of Uttar Pradesh, India. Int. J Curr. Microbiol. App. Sci. 2017;6(4):2029-2036.
2. Banjara GP, Majgahe SK. Effect of Biofortification of zinc and iron on yield attributes and yields of chickpea (*Cicer arietinum* L.) through agronomic intervention. The Pharma Innovation Journal. 2019;8(10):45-47.
3. Bouyoucos GJ. The hydrometer as a new method for the mechanical analysis of soils. Soil Science. 1927;23:343-353.
4. Chintha HB, Swaroop N, Thomas T, Barthwal A, Harit H, Amjad A. Effect of nitrogen, phosphorus, potassium, sulphur and zinc on soil health parameters of cluster bean (*Cyamopsis tetragonoloba* L.). The Pharma Innovation Journal. 2021;10(11):1955-1961.
5. Choudhary RS, Yadav BL, Jat R, Jat S. Effect of organic manures and mineral nutrients on growth, yield attributes and yield of Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.]. The Pharma Innovation Journal. 2021;10(7):526-529.
6. Deshlahare H, Banjara GP, Tandon A. Effect of bio fortification of zinc and iron on yields attributes of chickpea (*Cicer arietinum* L.) through agronomic intervention. International Journal of Chemical Studies. 2019;7(4):219-221.
7. Fisher RA. Statistical methods and scientific induction. Journal of the royal statistical society series. 1955;17:69-78.
8. Havlin JL, Beaton JD, Tisdale SL, Nelson WL. Soil fertility and fertilizer: An introduction to nutrient

management. Upper Saddle River, N. J. Pearson Education, Inc, 2010.
9. IPGA. Department of Agriculture in Indian Pulses and Grain Association. An annual progress reports, 2019.
10. Jackson ML. Soil chemical analysis Prentice Hall of India Ltd. New Delhi, 1958, 219-221.
11. Kasthurikrishna S, Ahlawat IPS. Effect of moisture stress and phosphorus, Sulphur and zinc fertilizer on growth and development of pea (*Pisum sativum*). Indian Journal of Agronomy. 2000;45:353-356.
12. Kumar MK, Patel IC, Shaukat A. Integrated nutrient management in cluster bean (*Cyamopsis tetragonoloba* L.). Legume Research. 2012;35:350-353.
13. Lindsay WL, Norvell WA. Development of DTPA soil test for zinc, iron, manganese and copper. Soil Science Society of America Journal. 1978;42:421-428.
14. Meena KR, Dhamma AK, Reager ML. Effect of phosphorus and zinc fertilization on growth and quality of cluster bean [*Cyamopsis tetragonoloba* (L.) Taub]. Ann. Agric. Res. New Series. 2006;27(3):224-226.
15. Munsell AH. Munsell's description of his colour system, from a lecture to the American Psychological Association. American Journal of Psychology. 1971;23(2):236-244.
16. Muthuvel P, Udayasoorian C, Natesan R, Ramaswamy PP. Introduction to Soil Analysis, Tamil Nadu Agricultural University Coimbatore-641002, 1992.
17. Olsen SR, Cole CV, Watanabe FS, Dean LA. Estimation of available phosphorus in soils by extraction with sodium bicarbonate ($NaHCO_3$), U.S.D.A. Circular. 1954;939:1-19.
18. Reddy K, Mohan GK, Satla S, Gaikwad S. Natural polysaccharides: Versatile excipients for controlled drug delivery systems. Asian J Pharma. Sci. 2011;6(6):275-286.
19. Sahu A, Swaroop N, David AA, Thomas T. Effect of Different Levels of NPK and Zinc on Soil Health Growth and Yield of Chickpea (*Cicer arietinum* L.) var. PUSA 362. Int. J Curr. Microbiol. App. Sci. 2020;9(10):591-597.
20. Singh B, Usha K. Nodulation and symbiotic nitrogen fixation of cowpea genotypes as affected by fertilizer nitrogen. J Plant Nutri. 2003;26(2):463-473.
21. Singh K, Singh AP, Mishra AK, Pandey M, Kumar P, Kumar A, *et al*. Growth dynamics, yield and nutrient uptake of fodder guar in relation to FYM and zinc fertilization. Eco. Env. & Cons. 2015;21(1):151-154.
22. Subbiah BV, Asiija EC. A rapid procedure for estimation of available nitrogen in soil. Current Science. 1956;25(8):259-260.
23. Sunil Dahiya S, Bhattoo MS, Khedwal RS. Effect of Zinc and Sulphur on Growth, Yield and Economics of Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.]. Int. J Curr. Microbiology. App. Sci. 2017;6(11):3744-3751.
24. Tandon HLS. Micronutrient hand book- from research to practical application. Fert. Dev. and Consultation org., New Delhi, India, 2009, 19-27.
25. Toth SJ, Prince AL. Estimation of cation exchange capacity and exchangeable Ca, K and Na content of soil by flame photometer technique. Soil Sci. 1949;67:439-445.
26. Walkley A, Black IA. Estimation of soil organic carbon by the chromic acid titration method. Soil Science. 1947;47:29-38.
27. Wilcox LV. Electrical conductivity Am. water work, Association. 1950;42:775-776.
28. Yadav R, Thomas T, Swaroop N, Kumar T. Response of different levels of phosphorus and zinc on soil health after harvesting Cluster bean (*Cyamopsis tetragonoloba* L.) *VAR*. Selection 220. The Pharma Innovation Journal. 2021;11(5):402-405.
29. Zaiter HZ, Clark RB, Lindgren DT, Nordquist PT, Stroup WW, Pavlish LA. Leaf chlorosis and seed yield of dry beans grown on high-pH calcareous soil following foliar iron sprays. Horti. Science. 1992;27:983-985.