The Pharma Innovation Journal 2022; 11(4): 1029-1034

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(4): 1029-1034

www.thepharmajournal.com
Received: 08-01-2022
Accepted: 27-02-2022

**Naveen Meena**
Research Scholar, Department of Soil Science and Agricultural Chemistry, NAI, SHUATS, Prayagraj, Uttar Pradesh, India

**Amreen Hasan**
Assistant Professor, Department of Soil Science and Agricultural Chemistry, NAI, SHUATS, Prayagraj, Uttar Pradesh, India

**Tarence Thomas**
Head and Professor, Department of Soil Science and Agricultural Chemistry, NAI, SHUATS, Prayagraj, Uttar Pradesh, India

**Raghu Nandan Singh Khatana**
Research Scholar, Department of Soil Science and Agricultural Chemistry, NAI, SHUATS, Prayagraj, Uttar Pradesh, India

**Corresponding Author:**
**Naveen Meena**
Research Scholar, Department of Soil Science and Agricultural Chemistry, NAI, SHUATS, Prayagraj, Uttar Pradesh, India

# Co-application effect of Zn and Fe on Physico-chemical properties of soil post cultivation of cow pea (*Vigna unguiculata* L.) *Var.* Pusa Komal in an inceptisol of Prayagraj

**Naveen Meena, Amreen Hasan, Tarence Thomas and Raghu Nandan Singh Khatana**

**Abstract**
A field trail was laid at Central Research Farm NAI, SHUATS, on the Co-application effect of Zn and Fe on Physico-chemical properties of soil post cultivation of cow pea (*Vigna unguiculata* L.) *Var.* Pusa Komal. The experiment analysed under RBD having nine treatments which were replicated thrice. The results reported that $D_b$ (Mg m$^{-3}$), $D_p$ (Mg m$^{-3}$), Precent Pore space (%), Water holding capacity (%) EC (dS m$^{-1}$) Organic Carbon (%), Available Nitrogen (kg ha$^{-1}$), Available Phosphorus (kg ha$^{-1}$), Available Potassium (kg ha$^{-1}$), Available Zinc (mg kg$^{-1}$), Available Iron (mg kg$^{-1}$) increased with Co-application of levels of Zn and Fe while pH of soil, decreased with increased Co-application of levels of Zn and Fe. The application of Zn and Fe significantly improved the soil Physico-chemical properties.

**Keywords:** Zn and Fe, Physico-chemical, cultivation, *Vigna unguiculata* L.

## Introduction
According to investigations, cowpea was one of the grain legumes cultivated at Harappa (Indus-Saraswati civilization; 3200–2000 BC) [15]. Cowpeas are a wonderful source of protein, fodder, vegetables, and certain treats [22] Pulses are particularly essential in Indian agriculture since they not only provide a rich source of protein for humans, but they also aid in the restoration of soil fertility. Pulses are planted over 25.26 million hectares in India, with a potential yield of 6.25 million tonnes and a production potential of 16.47 million tonnes. q ha$^{-1}$ [10].

Cowpea (*Vigna unguiculata* L. *Walp*.) is a vital legume for millions of people in underdeveloped nations. Cowpea is a multipurpose grain legume that grows well in arid and semiarid climates. Cowpeas are an excellent source of protein, fodder, vegetables, and a variety of delights [22]. Cowpea is a versatile crop that can be used as a grain, leaf, or fodder, and it has a good nutritional value and palatability. It can help in fixing atmospheric Nitrogen in the soil at a rate of 56 kg ha$^{-1}$ in optimal conditions when working with symbiotic bacteria. [14]. The mature cowpea seed contains 24.8 percent protein, 63.6 percent carbohydrates, 1.9 percent fat, 6.3 percent fibre, 7.4 parts per million thiamine, 4.2 parts per million riboflavin, and 28.1 parts per million niacin [1]. Green leaves have a protein concentration of 3 to 4%, immature pods have a protein concentration of 4 to 5%, and ripe seeds have a protein concentration of 25 to 30%.

Nitrogen is the most significant nutrient in plants. The plant can only use the nitrate (NO $^{-}$) and ammonium ($NH_4^+$) forms of nitrogen, despite the fact that the air contains 79 percent nitrogen. Nitrogen is contained in all proteins and enzymes and is involved in a variety of energy-transfer metabolic activities. Phosphorus is a macronutrient that is required for most growth processes. Among other organic components, it is required by nucleic acids, proteins, phospholipids, sugar phosphates, enzymes, and energy-rich phosphate compounds in plants. Although potassium (K) despite the fact that it is a crucial macronutrient for crop productivity, its economic benefits are often underestimated. The main reason for the Potassium deficiency is that farmers often overlook Potassium fertiliser because they believe it does not boost crop yields as much as N and P fertilisers. K is a crucial plant macronutrient involved in a variety of physiological tasks such as nutrition and water intake, nutrient transport, and growth, particularly in challenging conditions.

Plant metabolism, including the synthesis of auxin, glucose, phosphate, and nucleic acid, all require Zn [12]. Zinc (Zn) is a micronutrient that is required by both food crops and humans [8]. Despite recent gains in global food and energy sources, most underdeveloped countries still suffer from zinc deficiency [6]. Zinc (Zn) is an essential plant micronutrient with equivalent importance to key nutrients for agricultural productivity [19, 20]. Zinc is also essential for the production of proteins, RNA, and DNA. Iron has been discovered to be an activator of several enzymes, and it plays an important role in plant growth and production, such as chloroplast formation, protein synthesis, and chlorophyll synthesis [31-33]. Hemoglobin, the oxygen-carrying pigment, has iron as a component. Its lack causes difficulties in humans, including anaemia. Iron is a necessary component of all plants. Ferric ($Fe_3^+$) and Ferrous ($Fe_2^+$) are the two forms. Although $Fe_3^+$ is insoluble and difficult to absorb, $Fe_2^+$ is soluble and readily available to plants [21]. In photosynthesis, chloroplast formation, and chlorophyll biosynthesis, it plays a variety of critical biological activities. It is found in heme proteins like as cytochromes, catalase, and peroxidase, as well as Fe-S proteins such as ferredoxin, aconitase, and superoxide dismutase [3].

## Material and Method

**Experimental site:** The experiment was conducted at CRF NAI, SHUATS' Prayagraj, which is located at 25° 24′30″N latitude, 81° 51′10″ E longitude, and 98 metres above sea level (MSL) Prayagraj has a subtropical climate with summer and winter extremes. Winter temperatures, particularly in December and January, can drop to as low as 3-5 °C, while summer temperatures (May-June) can reach 45-48 °C.

Soil: Soil samples were collected from the experimental plot at random depths of 0-15 cm and 15-30 cm after the crop was harvested with a soil auger and khurpi. A wooden mallet was used to pulverise and combine these soil samples. Conning and quartering were used to reduce the amount of the soil sample, which was then passed through a 2 mm screen to prepare it for mechanical, physical, and chemical analysis.

Experimental Design and Treatments: A (RBD) was used for experiment by taking Zn and Fe with different levels. The plot size 2m x 2m. the treatments were $T_1$ Control (Absolute control), $T_2$ (50%Zn+0%Fe), $T_3$ (0%Zn+50%Fe), $T_4$ (100%Zn+0%Fe), $T_5$ (0%Zn+100%Fe), $T_6$ (50%Zn+100%Fe), $T_7$ (100%Zn+50%Fe), $T_8$ (50%Zn+50%Fe) $T_9$ (100%Fe+100%Zn). Sources of NPK were urea, SSP, MOP and Zn, Fe were Zinc sulphate, Iron chelates. Soil physical properties *i.e.* $D_b$, $D_p$, Percent Pore space and Water holding Capacity was determined by Graduated Measuring Cylinder and soil texture by hydrometer [17]. In terms of chemical characteristics, pH was assessed using a potentiometric approach using soil water suspensions, while EC was evaluated using a digital EC metre The method of wet-oxidation was employed to determine Organic Carbon. [25]. In an 800 mL kjeldahl flask, the alkaline permanganate method was employed to determine the amount of Available Nitrogen [23]. Using a colorimetric approach and a spectrophotometer, the amount of Available Phosphorus was estimated [18]. The amount of available Potassium and neutral ammonium acetate solutions [24]. Available Zn and Fe was estimated by DTPA extraction by using Atomic Absorption Spectrophotometer [13].

## Results and Discussion

**Table 1:** Effect of Zn and Fe on Physical properties of soil post harvest of cow pea

| Treatment/depth | $D_b$ (Mg m$^{-3}$) | | $D_p$ (Mg m$^{-3}$) | | Pore space (%) | | Water holding capacity (%) | |
|---|---|---|---|---|---|---|---|---|
| (cm) | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 |
| $T_1$ | 1.13 | 1.16 | 2.14 | 2.18 | 45.44 | 35.48 | 54.4 | 44.5 |
| $T_2$ | 1.14 | 1.17 | 2.15 | 2.20 | 48.43 | 38.3 | 57.6 | 47.6 |
| $T_3$ | 1.23 | 1.24 | 2.18 | 2.22 | 49.29 | 39.2 | 60.2 | 50.4 |
| $T_4$ | 1.17 | 1.21 | 2.14 | 2.19 | 47.3 | 37.4 | 55.6 | 45.7 |
| $T_5$ | 1.17 | 1.20 | 2.16 | 2.21 | 50.2 | 40.3 | 58.7 | 48.6 |
| $T_6$ | 1.26 | 1.29 | 2.18 | 2.22 | 53.26 | 43.2 | 62.2 | 52.4 |
| $T_7$ | 1.18 | 1.22 | 2.15 | 2.18 | 52.21 | 42.6 | 56.6 | 46.5 |
| $T_8$ | 1.21 | 1.25 | 2.17 | 2.24 | 55.37 | 45.4 | 59.3 | 49.6 |
| $T_9$ | 1.29 | 1.32 | 2.20 | 2.25 | 57.2 | 47.5 | 65.2 | 55.4 |
| F-test | S | S | S | S | S | S | S | S |
| S.E+M | 0.004 | 0.003 | 0.003 | 0.004 | 0.110 | 0.101 | 0.081 | 0.136 |
| C.D.@5% | 0.627 | 0.540 | 0.253 | 0.390 | 0.374 | 0.427 | 0.239 | 0.483 |

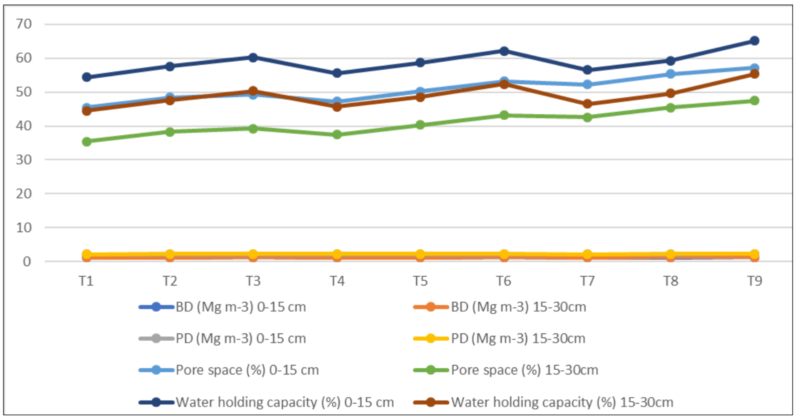


**Fig 1:** Fi Effect of Zn and Fe on Physical properties of soil after harvest of cow pea

The results revealed that with respect to depth the max. $D_b$ was found at treatment $T_9$ (1.29), (1.32) with the application of RDF along with 100% Zn and 100% Fe. With respect to depth Min. Bulk density was found at treatment $T_1$ (1.13), (1.16). Max. $D_p$ was found at treatment $T_9$ (2.20), (2.25) min. at treatment $T_1$ (2.14) (2.18), Max. Pore space was found at treatment $T_9$ (57.2), (47.5) and Min. at treatment $T_1$ (45.44), (35.48), Max. Water Holding Capacity was found at treatment $T_9$ (65.2), (55.4) and min. at treatment $T_1$ (54.4) at (45.5). This improvement in physical properties of soil in treatment $T_9$ might be attributed to application of 100% Zn + 100% Fe. The results were in accordance with [34, 32].

**Table 2:** Effect of Zn and Fe on Chemical properties of soil post harvest of cowpea

| Treatment/depth (cm) | pH | | EC (dS m$^{-1}$) | | OC (%) | |
|---|---|---|---|---|---|---|
| | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 |
| $T_1$ | 7.56 | 7.66 | 0.16 | 0.14 | 0.50 | 0.41 |
| $T_2$ | 7.54 | 7.63 | 0.17 | 0.16 | 0.54 | 0.45 |
| $T_3$ | 7.50 | 7.62 | 0.19 | 0.17 | 0.58 | 0.48 |
| $T_4$ | 7.48 | 7.57 | 0.17 | 0.15 | 0.52 | 0.42 |
| $T_5$ | 7.45 | 7.58 | 0.18 | 0.17 | 0.53 | 0.44 |
| $T_6$ | 7.44 | 7.56 | 0.21 | 0.19 | 0.59 | 0.50 |
| $T_7$ | 7.34 | 7.47 | 0.18 | 0.15 | 0.54 | 0.44 |
| $T_8$ | 7.35 | 7.45 | 0.22 | 0.19 | 0.57 | 0.48 |
| $T_9$ | 7.33 | 7.41 | 0.23 | 0.20 | 0.60 | 0.51 |
| F-test | S | S | S | S | S | S |
| S.E+M | 0.014 | 0.008 | 0.002 | 0.002 | 0.003 | 0.003 |
| C.D.@5% | 0.330 | 0.187 | 1.975 | 2.943 | 1.015 | 1.160 |

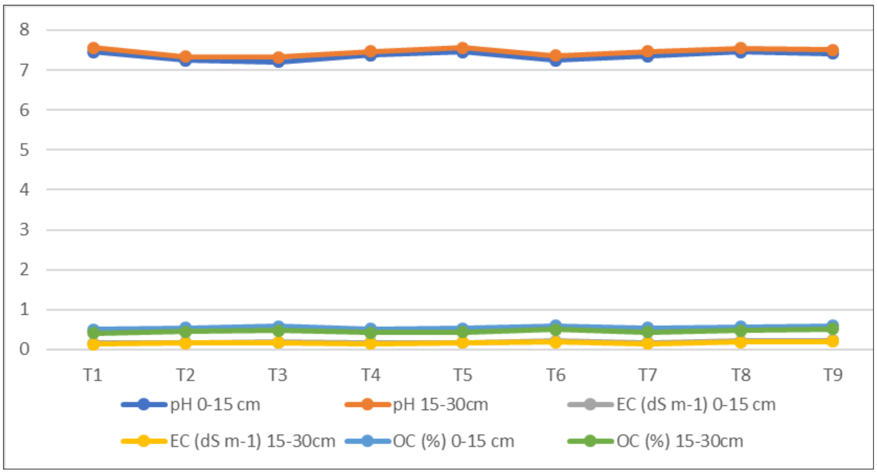


**Fig 2:** Effect of Zn and Fe on Chemical properties of soil post harvest of cowpea

Table 2 demonstrates that differing quantities of micronutrients have a substantial impact on soil pH. With respect to depth Max. pH was recorded in treatment $T_1$(7.56) (7.66) and min. was recorded in treatment $T_9$(7.33) (7.41). The pH influences crop growth as availability of nutrients is max. at pH 6.5-7.5. The ionic activity of Iron and Zinc might be the reason for the rise in pH. Furthermore, carboxylates exuded by cowpea roots as legumes were capable of lowering soil pH [26]. After crop harvest, various levels of micronutrients had a substantial impact on the EC of the soil. How-ever with respect to depth the max. EC was recorded in treatment $T_9$(0.23) (0.20) and min. was recorded in treatment $T_1$ (0.16) and (0.14). Max. percentage OC was found at treatment $T_9$ (0.60) (0.50) with the application of RDF along with 100% Zn and 100% Fe, Min. OC was found at treatment $T_1$ (0.50) (0.41) with the application of RDF along with 0%Zn and 0%Fe. The improvement in OC status of soil after crop harvest in treatment $T_9$ was to the extent of 11.89% over control. Similar results were shown by [35].

**Table 3:** Effect of Zn and Fe on Macronutrients on soil post harvest of cowpea

| Treatment /depth (cm) | Available Nitrogen (kg ha$^{-1}$) | | Available Phosphorus (kg ha$^{-1}$) | | Available Potassium (kg ha$^{-1}$) | |
|---|---|---|---|---|---|---|
| | 0-15 | 15-30 | 0-15 | 15-30 | 0-15 | 15-30 |
| $T_1$ | 231.1 | 161.3 | 22.1 | 21.2 | 189.6 | 149.3 |
| $T_2$ | 238.3 | 168.5 | 22.7 | 21.8 | 203 | 151.6 |
| $T_3$ | 243.3 | 173.2 | 23.5 | 22.6 | 205.3 | 153.6 |
| $T_4$ | 249.4 | 179.3 | 22.4 | 21.6 | 202 | 150.6 |
| $T_5$ | 250.3 | 180.5 | 22.6 | 21.7 | 198.6 | 147.3 |
| $T_6$ | 264.4 | 184.4 | 23.7 | 22.6 | 205.6 | 152.3 |
| $T_7$ | 258.4 | 176.5 | 22.4 | 21.6 | 208 | 155.3 |
| $T_8$ | 262.2 | 182.3 | 22.7 | 21.7 | 206.6 | 155.3 |
| $T_9$ | 271.3 | 191.3 | 23.9 | 22.7 | 210.3 | 157.3 |

| | | | | | | |
|---|---|---|---|---|---|---|
| F-test | S | S | S | S | S | S |
| S.E+M | 0.242 | 0.056 | 0.120 | 0.080 | 0.242 | 0.786 |
| C.D.@5% | 1.166 | 0.055 | 0.913 | 0.633 | 0.206 | 0.891 |

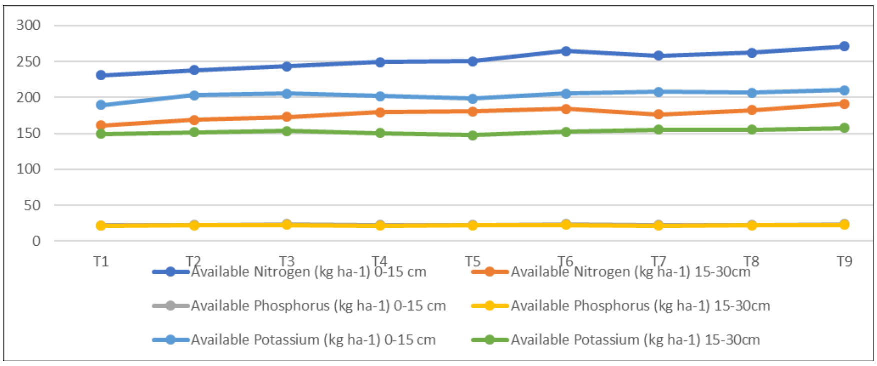


**Fig 3:** Effect of Zn and Fe on Macronutrients on soil after harvest of cowpea

According to the findings, with respect to depth the Max. amount of Available Nitrogen was found at treatment $T_9$ (271.3 kg $ha^{-1}$) (191.3 kg $ha^{-1}$) with the application of RDF along with 100% Zn and 100% Fe. Min. Available Nitrogen was found at treatment $T_1$ (231.1 kg $ha^{-1}$) (161.3 kg $ha^{-1}$) with the application of RDF along with 0%Zn and 0%Fe. Max. Available Phosphorus was found at treatment $T_9$ (23.9 kg $ha^{-1}$) (22.7 kg $ha^{-1}$) with the application of RDF along with 100% Zn and 100% Fe. Min. Available Phosphorus was found at treatment $T_1$ (22.7 kg $ha^{-1}$) (21.2 kg $ha^{-1}$) with the application of RDF along with 0%Zn and 0%Fe. The lower soil pH caused by the use of super phosphate in the soil experiment could be due to the gradual release of sulphate, which improved soil structure, chemical characteristics, and boosted the availability of important plant nutrients like N, P, and K, as well as some micronutrients like Fe and Zn, following application to soil. With respect to depth Max. Available Potassium was found at treatment $T_9$ (210.3 kg $ha^{-1}$) (157.3 kg $ha^{-1}$) with the application of RDF along with 100% Zn and 100% Fe. Min. Available Potassium was found at treatment $T_1$ (189.6 kg $ha^{-1}$) (149.3 kg $ha^{-1}$) with the application of RDF along with 0%Zn and 0%FeThe average values of N, P, K percent, Fe, and Zn are influenced by the addition of P to the soil at the rates shown in Table B. By increasing the rate of P application, the mean values of these parameters dramatically rose. It's possible that P-fertilization contributes to root system growth and, as a result, increases the root's ability to absorb additional nutrients. Such increases could also be attributed to similar increases in accessible N, P, K, Fe, and Zn in the soil under study. These findings are similar to [27-29].

**Table 4:** Effect of Zn and Fe on Micronutrients on soil after harvest of cowpea

| Treatment /depth | Available Zinc (mg $kg^{-1}$) | | Available Iron (mg $kg^{-1}$) | |
|---|---|---|---|---|
| | 0-15 cm | 0-15 cm | 15-30cm | 15-30cm |
| $T_1$ | 0.38 | 0.28 | 0.36 | 0.26 |
| $T_2$ | 0.40 | 0.29 | 0.38 | 0.29 |
| $T_3$ | 0.41 | 0.30 | 0.40 | 0.30 |
| $T_4$ | 0.43 | 0.32 | 0.43 | 0.32 |
| $T_5$ | 0.40 | 0.33 | 0.41 | 0.30 |
| $T_6$ | 0.44 | 0.34 | 0.44 | 0.35 |
| $T_7$ | 0.46 | 0.36 | 0.47 | 0.32 |
| $T_8$ | 0.47 | 0.37 | 0.49 | 0.41 |
| $T_9$ | 0.49 | 0.39 | 0.54 | 0.43 |
| F-test | S | S | S | S |
| S.E+M | 0.004 | 0.026 | 0.026 | 0.021 |
| C.D.@5% | 1.871 | 0.608 | 0.608 | 0.582 |

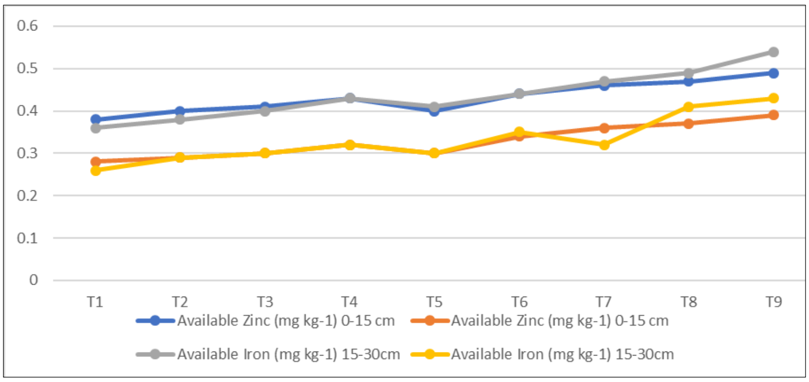


**Fig 4:** Effect of Zn and Fe on Micronutrients on soil post harvest of cowpea

The results revealed that with respect to depth the max. Available Zinc was found at treatment $T_9$ (0.49 mg $kg^{-1}$) (0.39 mg $kg^{-1}$) with the application of RDF along with 100% Zn and 100% Fe. Min. Available Zinc was found at treatment $T_1$ (0.38 mg $kg^{-1}$) (0.28 mg $kg^{-1}$) with the application of RDF along with 0%Zn and 0%Fe. Max. Available Iron was found at treatment $T_9$ (0.49) (0.39) with the application of RDF along with 100% Zn and 100% Fe. Min. Available Iron was found at treatment $T_1$ (0.38) (0.28) with the application of RDF along with 0%Zn and 0%Fe The lower soil pH caused by the use of super phosphate in the soil experiment could be due to the gradual release of sulphate, which improved soil structure, chemical characteristics, and boosted the availability of important plant nutrients like N, P, and K, as well as some micronutrients like Fe and Zn, following application to soil. Because the pH of the soil is important for Iron solubility, the pH of the soil tended to fall below 7.5, resulting in the solubilization of Iron, which made it available to plants while simultaneously lowering the available Iron concentration in the soil.

## Conclusion

Recent research on yield, physical, and chemical parameters of soil following cowpea harvest has concluded that the application of macro and micro nutrients played a critical role in the creation of higher yields and the availability of macro and micro nutrients in soil. The foregoing results demonstrated that soil addition of NPK, Zn, and Fe boosted yield, physical, and chemical characteristics of soil after harvest of cowpea plants. The treatment $T_9$ of (100%Fe+100%Zn) following the harvest of cowpea, the highest yield components, as well as physical and chemical parameters of soil, were obtained. Zinc concentrations are highest on the surface of the soil and decrease with depth. The reason for this is that plants absorb zinc from the subsoil and transport it to the leaves. Zinc is liberated from plant tissues and fixed in the surface soil as leaves fall and decay.

## References

1. Ahlawat IPS, Shivakumar BG. Kharif Pulses. In Textbook of Field Crops Production (R. Prasad, Ed.) ICAR, New Delhi, India, 2005.
2. Ali M, Gupta S. Carrying capacity of Indian Agriculture: pulse crops. Current Science. 2012;102:874-881.
3. Baruah KK, Bharali A. Physiological basis of Iron toxicity and its management in crops. In: Recent advances in crop physiology. Singh, A.I. (Ed). Daya Publishing House, New Delhi, 2015, 203-224.
4. Black CA. Methods of soil analysis vol.2, Am. Soc. Agraon., Madison, Wisconsin, U.S.A, 1965.
5. Bouyoucos GJ. The hydrometer as a new method for the mechanical analysis of soils. Soil Sci. 1927;23:393-395.
6. Cakmak I, Kutman UB. Agronomic biofortification of cereals with zinc: A Review. 744 European Journal of Soil Science, 2017. DOI: 10.1111/ejss.12437
7. Elwell WT, Grindley JAF. Atomic Absorption Spectrophotometry Pergam on Press Press Ltd, London, W-1, 1967.
8. FAO/WFP. Crop and food supply assessment mission to Zimbabwe. Special Report. FAO, Global Information and Early Warning System on Food and Agriculture Food, 2002, 763.
9. Fisher RA. Technique of Analysis of Variance. Hand book of Agricultural Statistics B-29-110, 1950.
10. GOI (Government of India). Agricultural Statistics at a glance, 2019.
11. Jackson ML. Soil chemical analysis, Second edition Indian Reprint, prentice hall of India, New Delhi. 1958, 498.
12. Latef AAH, Abu Alhmad MF, Abdelfattah KE. The possible roles of priming with ZnO nano particles in mitigation of salinity stress in Lupine (*Lupinus termis*) plants. J Plant Growth Reg. 2017;36:60-70.
13. Lindsay WL, Norvell WA. Development of a DTPA soil test for Zinc, Iron, Manganese and Copper. Soil Science of American Journal. 1978;42:421-428.
14. Mandal MK, Pati R, Mukhopadhyay D, Majumdar K. Maximizing yield of cowpea through soil test based nutrient application in Terai alluvial soils. Better Crops. 2009;3:28-30.
15. Mehra KL. Agricultural foundation of Indus-Saraswati civilization. In: Agricultural Heritage of India: Proc. of the Nat. Conf. 10–13 February. Rajasthan College of Agriculture, Udaipur, India (Nene, Y.L. and Choudhary, S.L., eds.). Maharana Pratap University of Agriculture & Technology, Udaipur 313 001, Rajasthan, India, 2002, 1-21.
16. Munsell AH. Munsell's description of his colour system, from a lecture to the American Psychological Association. American journal of psychology. 1921;23:236-244.
17. Muthuval P, Udaysoorian C, Natesan R, Ramaswami PP. Introduction to Soil Analysis, Tamil Nadu Agricultural University, Coimbatore-641002, 1992.
18. Olsen SR, Cole CV, Watanhe FS, Dean LA. Estimation of Available Phosphorus in soils by extraction with sodium bicarbonate U.S. Deptt. Agr. Circ., 1954, 939.
19. Padbhushan R, Kumar D. Influence of soil and foliar applied boron on green gram in calcarous soils. International Journal of Agriculture, Environment and Biotechnology. 2014;7:129-136.
20. Rattan RK, Patel KP, Manjaiah KM, Datta SP. Micronutrients in soil, plant animal and human health. Journal of the Indian Society of Soil Science. 2009;57:546-558.
21. Santos RSD, Junior ATA, Pegoraro C, Oliveria DCA. Dealing with Iron Metabolism in rice from breeding for stress tolerance to biofortification. Genet. Mol.Bio. 2017;40(1):312-325.
22. Singh AK, Bhatt BP, Sundaram PK, Kumar S, Bahrati RC, Chandra N, *et al*. Study site specific nutrient management of cowpea seed production and their effect on soil nutrient. Journal of Agricultural Sciences. 2012;4:191-198.
23. Subbiah BV, Asija GL. A rapid procedure for the estimate of Available Nitrogen in soil current sciences. 1956;25:259-263.
24. 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.
25. Walkely A, Black IA. Critical examination of rapid method for determining Organic Carbon in soils, effect of variance in digestion conditions and of inorganic soil Constituents. Soil sci. 1947;632:251.
26. Tunya BA, Lelei JJ, Ouma JP, Ombui PN, Onwonga RN.

Changes in Soil Chemical Properties in Response to Application of Phosphorus Sources in Legume Sorghum Cropping Systems. J Agric. and Enviro. Sci. 2014;3(4):151-168.
27. Sakara HME. Study on the effect of phosphorus fertilization and salt stress on faba bean plant (*Vicia faba* L.). Thesis of MSc. Fac. Agric. Mans. Univ. Egypt, 2009.
28. Oseni TO. Growth and Zinc Uptake of Sorghum and Cowpea in Response to Phosphorus and Zinc Fertilization. World J Agric. Sci. 2009;5(6):670-674.
29. Benvindo RN, De R, Prado M, Nóbrega JCA, Flores RA. Phosphorus Fertilization on the Nutrition and Yield of Cowpea Grown in an Arenosols. American-Eurasian J Agric. & Environ. Sci. 2014;14(5):434-439.
30. Bhuiyan MMH, Rahman M, Afroze F, Sutradhar G, Bhutyan S. Effect of phosphorus, molybdenum and rhizobium inoculation on growth and nodulation on mung bean. J Soil and Nature. 2008;2(2):25-3.
31. Deb R, Poddar P, Banerjee S. Effect of various modes of application of molybdenum on nodulation yield and economics of groundnut cultivation under Terai region of West Bengal. Environment and Ecology. 2006;24S(4):1081-1084.
32. Pingoliya KK, Dotaniya ML, Lata M. Effect of iron on yield, quality and nutrient uptake of chickpea (*Cicer arietinum* L.). African J Agric. Res. 2014;9(37):2841-2845.
33. El-Azab ME. Effects of Foliar NPK Spraying with Micronutrients on Yield and Quality of Cowpea Plants. Asian J Applied Sci. 2016;4(2):526-533.
34. Kuldeep PD, Kumawat Vipen, Bhadu HK, Sumeriya, Vinod Kumar. Effect of Iron and Zinc Nutrition on Growth Attributes and Yield of Chickpea (*Cicer arietinum* L.). International Journal Current Microbiology and Applied Science. 2018;7(8):2837-2841.
35. Kumawat N, Singh RP, Kumar R, Yadav TP, Om H. Effect of integrated nutrient management on productivity, nutrient uptake and economics of rainfed pigeon pea (*Cajanus cajan* L.) and black gram (*Vigna mungo* L.) intercropping system. Indian Journal of Agricultural Science. 2015;85:171-76.