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Testing of iron fertilizer use efficiency in vertisol

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Abstract
The experiment was conducted with eight treatments viz., T_1 - control, T_2 - only RDF, T_3 - $FeSO_4$ foliar 3 sprays @ 0.5%, T_4 - $FeSO_4$ @20kg ha^{-1}+ Vermicompost @40kg ha^{-1}, T_5 -Fe-EDTA (Soil application @2.5 kg ha^{-1}), T_6 - $FeSO_4$ @20kg ha^{-1}+ DAP @40kg ha^{-1}, T_7 - $FeSO_4$ @20kg ha^{-1}+ 10:26:26 @40kg ha^{-1} and T_8- $FeSO_4$ @20kg ha^{-1} + Urea @40kg ha^{-1}. The experiment was laid out in complete randomized design with three replications. The results emerged out indicated the significant increase in soil organic carbon (0.73%) and grain yield (14.27 gm/pot), DTPA extractable soil micronutrients (Fe, Zn, Cu and Mn) and iron fractions (Exchangeable iron, Dilute acid soluble iron, Water soluble iron and Reducible iron) were found increased in treatment T_8 ($FeSO_4$ @20kg ha^{-1}+ Urea @40kg ha^{-1}) followed by treatment T_7 ($FeSO_4$ @20kg ha^{-1} + 10:26:26 @40kgha^{-1}) which was found to be at par with each other and Significantly highest fertilizer use efficiency of iron fertilizers (19.92%) was found in treatment T_5 -Fe-EDTA (Soil application @2.5 kg ha^{-1}).

Keywords: iron fertilizer, vertisol, FUE

1. Introduction
Low dietary diversity and inadequate daily intake are the main reasons for the widespread occurrence of Fe deficiency in human populations, especially among children and women living in developing world. Impairments of cognitive function, immune system and work capacity and increases in infant and maternal mortality represent major health complications associated with Fe deficiency (Hunt 2005; Carter *et al*. 2010) [5, 1]. Iron is an essential micronutrient for almost all living organisms because of it plays critical role in metabolic processes such as DNA synthesis, respiration, and photosynthesis. Further, many metabolic pathways are activated by iron, and it is a prosthetic group constituent of many enzymes. Iron deficiency has increased from 30% in the 1960s to 40% in the 1990s among the world population (Welch and Graham, 2002) [13]. An imbalance between the solubility of iron in soil and the demand for iron by the plant are the primary causes of iron chlorosis. Iron plays a significant role in various physiological and biochemical pathways in plants. It serves as a component of many vital enzymes such as cytochromes of the electron transport chain, and it is thus required for a wide range of biological functions. In plants, iron is involved in the synthesis of chlorophyll, and it is essential for the maintenance of chloroplast structure and function. Iron is involved in N fixation, electron transfer and respiratory enzyme systems as a part of cytochrome and hemoglobin. Flooding and compaction reduce soil aeration and oxygen level, which decrease or increase Fe availability depending on soil condition. Iron deficiencies usually occur early in the growth season when soils tend to be wetland cool and root growth and microbial activity are limited. As soils warm, microbial activity and root growth increase, allowing plants to absorb more Fe (Rout and Sahoo, 2015) [12]. Iron is primarily absorbed by plants, and it solubilizes Fe^{3+} and then reduces it to Fe^{2+} for absorption or transport into the root. The ability of iron to donate and accept electrons means that if iron is free within the cell, it can catalyze the conversion of hydrogen peroxide into free radicals. Free radicals can cause damage to a wide variety of cellular structures, and they can ultimately kill the cell (Crichton *et al*., 2002) [3].

2. Material and Methods
A pot culture experiment was conducted in *Kharif* season of 2015 at Department of Soil Science and Agricultural Chemistry, College of Agriculture, VNMKV, Parbhani. The experimental soil is characterized by deep black color (Malewar, 1976) [8] dominated by montmorillonite clay with high coefficient of expansion and

shrinkage in summer which leads to deep cracking. This pot culture experiment was laid out by using completely randomized design (CRD) with three replications and eight treatments. The experimental soil is of pH 8.14, EC 0.32 dS m^{-1}, Organic Carbon 0.44%, $CaCO_3$ 5.12%, Fe (3.55mg kg^{-1}), Mn (4.14 mg kg^{-1}), Zn 0.28(mg kg^{-1}) and Cu (1.32 mg kg^{-1}). Iron fractions viz., Exchangeable iron (1.11 mg kg^{-1}), Dilute acid soluble iron (2.10 mg kg^{-1}), Water soluble iron (0.13 mg kg^{-1}) and Reducible iron (1.25 mg kg^{-1}). The treatments T_1 - control, T_2 - only RDF, T_3 - $FeSO_4$ foliar 3 sprays @ 0.5%, T_4 - $FeSO_4$ @20kg ha^{-1}+ Vermicompost @40kg ha^{-1}, T_5 -Fe-EDTA (Soil application @2.5 kg ha^{-1}), T_6 - $FeSO_4$ @20kg ha^{-1}+ DAP @40kg ha^{-1}, T_7 - $FeSO_4$ @20kg ha^{-1}+ 10:26:26 @40kg ha^{-1} and T_8- $FeSO_4$ @20kg ha^{-1} + Urea @40kg ha^{-1}. The soybean was sown by dibbling method with five to six seeds per pot. Nutrients, N, P, K and S @ 30:60:30:20 kg ha^{-1} were applied through urea (46%), Diammonium phosphate (18%), Muriate of potash (60%), Elemental Sulpher (20%) and $FeSO_4$ @20kg/ha, Fe-EDTA @2.5 kg ha^{-1} and Vermicompost @40kg ha^{-1} as per treatment. Observations on the crop characteristics indicating growth of the crop i.e. plant height at the interval of 30, 60 and 90 DAS, number of branches per plant, pod per plant and nodules per plant were recorded. The soil samples were collected at the time of harvest and analyzed for pH, EC, organic carbon, calcium carbonate, DTPA extractable micronutrients (Fe, Zn, Mn, Cu), iron fractions (Exchangeable iron, Dilute acid soluble iron, Water soluble iron and Reducible iron) and fertilizer use efficiency of iron fertilizers were calculated by the formula proposed by Rehman and Farukh (2011) [11].

$$\text{FUE (\%)} = \frac{\text{Yield of fertilized pot (Kg) – Yield of unfertilized pot (Kg)}}{\text{Amount of fertilizer applied (Kg)}}$$

3. Result and Discussion

3.1 Physico-chemical properties of soil after harvest of Soybean

The range of soil pH at harvest stage of soybean in different treatments was varied from 7.78 to 7.97 and the electrical conductivity of soil varied from 0.30 to 0.35 dSm^{-1}. The calcium carbonate content was varied from 4.43 to 4.98 per cent. The soil pH, EC and calcium carbonate value did not influence significantly due to application of different iron fertilizer combinations. The significantly highest soil organic carbon content at harvest stage (0.73 per) cent was observed under treatment T_8- $FeSO_4$ @20kg/ha +Urea @40kg ha^{-1} which was at par with T_7- $FeSO_4$ @20kg/ha + 10:26:26 @40kg ha^{-1} and lowest organic carbon (0.55 per cent) was recorded in treatment T_1 (control).

Table 1: Effect of application of iron fertilizer combinations on physico- chemical properties of soil after harvest of Soybean

Treatments	pH	EC (dSm^{-1})	Organic carbon (%)	$CaCO_3$ (%)
T_1- Control	7.78	0.35	0.55	4.98
T_2- Only RDF	7.86	0.33	0.60	4.64
T_3- $FeSO_4$ foliar 0.5% (50 gm 10 lit water	7.82	0.33	0.68	4.57
T_4- $FeSO_4$ @20kg/ha + Vermicompost @40kg ha^{-1}	7.86	0.31	0.69	4.73
T_5- Fe-EDTA (Soil application @2.5 kg ha^{-1})	7.81	0.30	0.70	4.43
T_6- $FeSO_4$ @20kg/ha + DAP @40kg ha^{-1}	7.87	0.32	0.65	4.95
T_7- $FeSO_4$ @20kg/ha +10:26:26 @40kg ha^{-1}	7.97	0.32	0.72	4.61
T_8- $FeSO_4$ @20kg/ha + Urea @40kg ha^{-1}	7.94	0.34	0.73	4.73
SE(m)	0.091	0.015	0.018	0.263
CD (0.01)	NS	NS	0.056	NS
Initial value	8.14	0.32	0.44	5.12

3.2 DTPA extractable micronutrient status after harvest

The DTPA extractable micronutrients Zn, Fe, Cu, and Mn status after harvest of soybean as influenced by various treatments is presented in Table 3. The DTPA-Fe, Zn, Cu, and Mn in soil were significantly increased (5.98, 0.45, 1.63 and 4.11 mg kg^{-1}, respectively) in treatment T_8- $FeSO_4$ @20kg/ha +Urea @40kg ha^{-1} which was at par with treatment T_7- $FeSO_4$ @20kg/ha + 10:26:26 @40kg ha^{-1}. Increase in DTPA-extractable Zn, Fe, Cu and Mn content with $FeSO_4$ soil application might be due to formation of different stable complexes with organic ligands. This has decreased their susceptibility for adsorption or fixation or precipitation reaction in soil, which has helped in keeping micronutrient elements soluble and consequently more available to plants for longer period. Mimmo *et al*., (2014) [9] reported that an enhanced release of inorganic (such as protons) and organic (organic acids, carbohydrates, amino acids, phytosiderophores, siderophores, phenolics and enzymes) compounds to increase the solubility of poorly available Fe pools, Kamble *et al.* (2014) [6] in turmeric on Vertisol in Maharashtra and Durgude *et.al* (2013) [4] also reported that application of RDF + $FeSO_4$ @20kg/ha increase the Fe content in soil in onion growth on Entisol.

Table 2: Effect of application of iron fertilizer combinations on DTPA extractable soil micronutrients after harvest of Soybean

Treatments	DTPA-Soil micronutrients (mg kg^{-1})			
	Fe	Zn	Cu	Mn
T_1- Control	3.88	0.33	1.40	3.38
T_2- Only RDF	4.69	0.36	1.42	3.47
T_3- RDF + $FeSO_4$ (foliar) 0.5% (50 gm 10 lit water).	5.33	0.41	1.48	3.75
T_4- RDF + $FeSO_4$ @20kg/ha + Vermicompost @40kg ha^{-1}	5.69	0.39	1.51	3.98
T_5- RDF + Fe-EDTA(Soil application @2.5 kg ha^{-1})	5.77	0.40	1.55	3.81
T_6- RDF + $FeSO_4$ @20kg/ha+ DAP @40kg ha^{-1}	4.81	0.37	1.43	3.51
T_7- RDF + $FeSO_4$ @20kg/ha + 10:26:26 @40kg ha^{-1}	5.83	0.43	1.59	4.09
T_8- RDF + $FeSO_4$ @20kg/ha +Urea @40kg ha^{-1}	5.98	0.45	1.63	4.11
SE(m)	0.30	0.022	0.041	0.17
CD (0.01)	0.90	0.067	0.12	0.51
Initial value	3.55	0.28	1.32	4.14

3.3 Soybean yield and fertilizer use efficiency of iron fertilizers

Data presented in Table 3 indicate that, the influence of iron fertilizer combinations on yield of soybean and fertilizer use efficiency were significantly influenced due to variation in fertilizer combinations. The significantly highest grain yield (14.27gm pot^{-1}) was recorded in treatment T_8- RDF + $FeSO_4$ @20kg/ha + Urea @40kg ha^{-1}and the significantly highest fertilizer use efficiency (19.92%) was recorded in treatment T_5- Fe-EDTA (Soil application @2.5 kg ha^{-1}). Increase in fertilizer use efficiency with the application of Fe-EDTA might be due to the organic compounds are able to stabilize the metal ions and increase solubility and availability of elements to the plant. Similar results were close conformity with chibba *et al*. (2007) [2] who reported that the foliar and soil application of Fe significantly increased yield of Fenugreek. Kumbhar and Deshmukh (1993) [7] also reported the response of Tomato cv. Rupali to soil application of $FeSO_4$ @ 80 kg ha^{-1} for increasing the yield of tomato.

Table 3: Effect of application of iron fertilizers on yield and fertilizer use efficiency of iron fertilizers

Treatments	Yield (gm/pot)	FUE (%)
T_1- Control	11.32	----
T_2- Only RDF	11.39	----
T_3- RDF + $FeSO_4$ foliar 0.5% (50 gm 10 lit water).	13.98	2.48
T_4- RDF+ $FeSO_4$ @20kg/ha + Vermicompost @40kg ha^{-1}	13.88	2.39
T_5- RDF+ Fe-EDTA(Soil application @2.5 kg ha^{-1})	13.91	19.92
T_6- RDF+ $FeSO_4$ @20kg/ha + DAP @40kg ha^{-1}	12.88	1.45
T_7- RDF+ $FeSO_4$ @20kg/ha + 10:26:26 @40kg ha^{-1}	14.11	2.60
T_8- RDF+ $FeSO_4$ @20kg/ha +Urea @40kg ha^{-1}	14.27	2.75
SE(m)	0.491	0.03
CD (0.01)	1.436	0.09

3.4 Iron fractions (mg kg^{-1}) in soil after harvest of soybean

Data presented reported in Table 4 indicated that, the influence of iron fertilizer combinations on Iron fractions (Exchangeable iron, dilute acid soluble iron, Water soluble iron and Reducible iron) were significantly influenced due to variation in fertilizer combinations. Iron fractions (Exchangeable iron, dilute acid soluble iron, Water soluble iron and Reducible iron) in soil were significantly increased (1.98, 3.68, 0.92 and 2.87 mg kg^{-1}, respectively) in treatment T_8- $FeSO_4$ @20kg/ha +Urea @40kg ha^{-1} which was at par with treatment T_7- $FeSO_4$ @20kg/ha + 10:26:26 @40kg ha^{-1}.

Table 4: Effect of application of iron fertilizer combinations on iron fractions after harvest of Soybean

Treatments	Iron fractions (mg kg^{-1})			
	Exchangeable Fe	Water soluble Fe	Dilute acid soluble Fe	Reducible Fe
T_1- Control	1.10	0.11	2.13	1.36
T_2- Only RDF	1.22	0.19	2.24	1.46
T_3- RDF + $FeSO_4$ foliar 0.5% (50 gm 10 lit water).	1.43	0.36	2.89	1.98
T_4- RDF + $FeSO_4$ @20kg/ha + Vermicompost @40kg ha^{-1}	1.88	0.73	3.11	2.45
T_5- RDF + Fe-EDTA (Soil application @2.5 kg ha^{-1})	1.90	0.65	3.25	2.58
T_6- RDF + $FeSO_4$ @20kg/ha + DAP @40kg ha^{-1}	1.65	0.54	2.95	2.10
T_7- RDF + $FeSO_4$ @20kg/ha+ 10:26:26 @40kg ha^{-1}	1.93	0.84	3.45	2.66
T_8- RDF + $FeSO_4$ @20kg/ha + Urea @40kg ha^{-1}	1.98	0.92	3.68	2.87
SE(m)	0.076	0.027	0.028	0.057
CD (0.01)	0.222	0.079	0.084	0.167
Initial value	1.11	0.13	2.10	1.25

4. Conclusions

From the studies it can be concluded that combinations of iron fertilizers with organic and inorganic sources resulted in highest grain yield and increased iron fractions (exchangeable Fe, water soluble Fe, dilute acid soluble Fe and reducible Fe, DTPA-extractable soil micronutrients (Fe, Zn, Cu and Mn) were obtained with the application of $FeSO_4$ @20kg ha^{-1} + Urea @40kg ha^{-1} The Fe, Zn, Cu and Mn content in plant increased significantly with application of $FeSO_4$ foliar spray 0.5% (50 gm 10 lit water). Highest fertilizer use efficiency was obtained with application of Fe-EDTA (Soil application @2.5 kg ha^{-1}).

5. References

1. Carter RC, Jacobson JL, Burden MJ, Armony SR, Dodge NC, Jacobson SW. Iron deficiency anemia and cognitive function in infancy. Pediatrics. 2010; 126:427-434.
2. Chibba IM, Nayyar VK, Kanwar JS. Influence of mode and source of iron on Fenugreek in a typic Ustocherpt in Punjab. International Journal of agri. and biology. 2007; 9(2):254-256
3. Crichton RR, Wilmet S, Legssyer R, Ward RJ. Molecular and cellular mechanisms of iron homeostasis and toxicity in mammalian cells. Journal of Inorganic Biochem. 2002; 91:9-18.
4. Durgude AG, Palwe CR, Sawale DD, Kadam SR. Response of onion to soil and foliar application of iron on entisols. The Asian Journal Of Horticulture. 2013; 8(2):754-757.
5. Hunt JR. Dietary and physiological factors that affect the absorption and bioavailability of iron. Int Journal of Vitam Nutrition Res. 2005; 75:375-84
6. Kamble BH, Kadam GJ, Kathmal DK. Effect of Iron Application on Yield of Turmeric (*Curcuma longa*) in Maharashtra. International Journal of Bio-resource and Stress Management. 2014; 5(4):502-506.
7. Kumbhar VS, Deshmukh SS. Effect of soil application of ferrous sulphate on the uptake of nutrients, yield and

quality of tomato (cv. Rupali South). Indian J. Hort. 1993; 41(3):144-147.
8. Malewar GU. Placement of black soils of Marathwada in comprehensive system of soil classification. J Maharashtra agric. Univ. 1976; 1:195-199.
9. Mimmo T, Del Buono D, Terzano R, Tomasi N, Pinton R. Rhizosheric organic compounds in the soil microorganism plant system: their role in iron availability. European journal of soil science. 2014; 10:1111-1115.
10. Rajamani P, Shanmugasundaram R. Influence of FeEDDHA on Iron–Manganese Interaction in Soybean Genotypes in a Calcareous Soil. Journal of Plant Nutrition. 2014; 26(9):1815-1823.
11. Rehman A, Farukh S. Grain quality, nutrient use efficiency and bioeconomics of maize. Chelean Journal of Agril. Reasc. 2011; 71(4):586-590.
12. Rout G, Sahoo S. Role of iron in plant growth and metabolism. Reviews in Agricultural Science. 2015; 3:1-24.
13. Welch RM, Graham RD. Breeding crops for enhanced micronutrient content. Plant Soil. 2002; 245:205-214.