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Organically Complexed Iron and Inorganic Nutrition of Sorghum CSH. 5 in Two Kinds of Soils

HONORA J. FRANCIS[1] and C.K. RAJAGOPAL[2]

Experiments were conducted in pots using sorghum CSH 5 and inorganic iron complexed with organic matter. Two soils, one black calcareous and other red, were used for conducting the experiments. Highly beneficial effects on uptake of iron and other nutrients and on yield of straw and grain were observed due to the application of complexed iron to the soils. Iron uptake was highly correlated with the uptake of N, P, K, Ca, Mg, Zn, Cu and Mn at seedling, flowering and maturity stages of growth. Uptake of iron by resorting to application of complexed iron in the soil was highly significant.

One of the greatest obstacles for proper plant growth and yield in calcareous soils are the condition of lime induced iron-chlorosis. As application of inorganic iron to the soil is of little benefit, the usual method of tackling this problem is by foliar application of iron. However, this also is not very effective, unless frequent applications involving much labour and expenses are resorted to. Another method is by applying synthetic iron chelates to the soil or plant. The high price of these substances in market hinders their large scale application. Therefore the need for some alternative methods of providing iron to the plants growing in calcareous soils has arisen. The present investigations were planned to study the effect of organically complexed iron salts on uptake and translocation of iron by the plant.

MATERIAL AND METHODS

Preparation of complex of organic amendment and iron : Three kg of green cotton leaves and 3 kg of soil were mixed well and transferred to a glazed pot. One gram ammonium phosphate was added, moistened with water and allowed to incubate for one month. The partially decomposed organic material was divided into four portions. One portion was kept as such and this is referred to as the organic amendment in the treatments. To the other three portions calculated quantities of $FeSO_4$ at the rates of 15, 30 and 45 ppm Fe were added and put in different pots and mixed well and allowed to remain as such for one month. This is referred to as the iron-organic complex in the treatments. The organic amendment, the complex and Fe alone were then applied

1. Assistant Professor, 2. Professor.
Department of Soil Science and Agricultural Chemistry,
Tamil Nadu Agricultural University, Coimbatore-641003

to the soils in the different treatments as needed.

Pot experiment : The treatment combinations were as shown below.

In the treatment F_1, M_0, F_2, M_0 and F_3 M_0 the iron was applied in such a way that the soil ultimately contained 15, 30 and 45 ppm Fe. The iron-organic complexes were prepared in such a way that they contained 15, 30 and 45 ppm Fe. The experiment was replicated twice and simultaneously conducted in the two soils, red and black. For the experiment, 6 kg. of soil was weighed and tranferred to each pot, the sides of which are coated with wax inside and it was further covered with a polythene sheet to prevent leaching. Six seeds of sorghum CSH 5, were sown in the soil in each pot. Watering was done using demineralised water. Plant samples were collected after 30 days, 60 days and at maturity. Plant samples were analysed for N, P, K, Ca and Mg using the standard procedures. Plant micronutrients were estimated in the triacid-digested extract using variation Techtran A.A. 120 atomic absorption Spectrophotometer.

RESULTS AND DISCUSSION

A persual of the results of chemical analysis pertaining to the different concentration of macro and micro elements in the plants revealed that only in the case of iron there was difference due to treatments. The treatments F_3 M_3 which supplied the highest amount of iron as well as the organic amendment registered the highest concentration of iron in the plant at all stages of growth.

The spectacular increase in drymatter yield (grain + straw) as a result

F_0 M_0 — Control (Soil without organic amendment or iron but mixed with NPK as per the recommended dose)

F_0 M_1 — Soil as above + organic amendment at 5 tonnes/ha

F_0 M_2 — Soil as in (1) + organic amendment at 10 tonnes/ha

F_0 M_3 — Soil as in (1) + organic amendment at 20 tonnes/ha

F_1 M_0 — Soil as in (1) + 15 ppm Fe without organic amendment

F_1 M_1 — Soil as in (1) + 15 ppm Fe with organic amendment at 5 tonnes/ha

F_1 M_2 — Soil as in (1) + 15 ppm Fe with organic amendment as 10 tonnes/ha

F_1 M_3 — Soil as in (1) + 15 ppm Fe with organic amendment at 20 tonnes/ha

F_2 M_0 — Soil as in (1) + 30 ppm Fe without organic amendment

F_2 M_1 — Soil as in (1) + 30 ppm Fe with organic amendment at 5 tonnes/ha

F_2 M_2 — Soil as in (1) + 30 ppm Fe with organic amendment at 10 tonnes/ha

F_2 M_3 — Soil as in (1) + 30 ppm Fe with organic amendment at 20 tonnes/ha

F_3 M_0 — Soil as in (1) + 45 ppm Fe without organic amendment

F_3 M_1 — Soil as in (1) + 45 ppm Fe with organic amendment at 5 tonnes/ha

F_3 M_2 — Soil as in (1) + 45 ppm Fe with organic amendment at 10 tonnes/ha

F_3 M_3 — Soil as in (1) + 45 ppm Fe with organic amendment at 20 tonnes/ha

TABLE I. Influence of treatments on the dry matter yield of 30 and 60 days plants and on grain and straw yield (g/pot).

Treatment		Black Calcareous soil				Red Soil			
		30 days old plants	60 days old plants	Grain	Straw	30 days old plants	60 days old plants	Grain	Straw
F_0	M_0	1.70	9 70	6.75	30.85	2.50	9.75	7.10	29.55
	M_1	1.70	10.70	8.70	32.10	2.50	11.20	9.00	33.50
	M_2	1.70	11.75	10.50	35.15	2.10	12.10	11.15	35.55
	M_3	2.00	12.35	13.05	37.15	2.90	13.10	13.45	39.00
F_1	M_0	2.20	12.10	14.25	39.30	3.30	12.85	15.35	41.00
	M_1	2.50	13.30	17.60	51.75	3.50	13.55	17.85	52.85
	M_2	2.80	14.20	19.25	58.00	4.10	14.20	19.75	59.50
	M_3	2.95	15.40	25.00	64.75	4.10	15.05	26.05	67.75
F_2	M_0	2.90	13.80	26.95	69.85	4.10	15.90	27.60	74.05
	M_1	3.75	15.00	27.35	13.45	4.20	16.70	28.40	84.50
	M_2	3.50	15.35	29.10	88.30	4.60	16.70	29.55	88.90
	M_3	4.00	16.50	36.00	96.00	5.10	18.05	38.00	94.95
F_3	M_0	4.10	17.15	39.50	108.80	5.30	18.30	40.50	97.70
	M_1	4.60	17.60	42.25	111.90	6.20	19.80	42.05	117.05
	M_2	5.70	18.15	44.45	115.90	7.25	19.45	44.15	121.55
	M_3	6.10	19.05	46.40	129.00	7.50	21.00	48.10	136.80

of incorporation in the soil through organic complex can be observed from Table I. Both red and black soils behaved similarly in this respect. A dry-matter increase of 200 per cent was observed at the maximum level of iron-organic matter combination. The possibility ot the production of water soluble complexes of iron with organic matter as envisaged by Bloomfield(1955)seems to be a valid reason for obtaining such consistent results in all cases of iron-organic matter complex application. Coulso *et al*. (1960) reported that leaf leachets formed water soluble complexes with iron got easily translocated in soil solution. Another reason for the greater growth and yield in the treatments in which the cotton leaf-iron organic complex was applied might well be due to the better translocation of iron within the plant effected as a result of absorption by the plant roots of the organic ligands involved in the formation of organic complex. Tiffin (1970) in his investigations on iron exudates and translocation of iron within the soybean plant attributed a vital role for citrate ions in the translocation of iron within the plant. According to him iron moved within the plant in the form of iron citrate and also got exuded from the roots in the same form. The citrate content of cotton leaves is quite high.

Ramanathan *et al.* (1975) recorded a citrate content of 3.5 per cent in leaves of cotton grown in Coimbatore.

When iron is limiting in the plant it exerts a constraint on the metabolic functions of other nutrients many of which depend on the physiological action of iron for their proper functioning. The plant is thus, forced to limit its growth proportionate to the amount of active iron obtaining in its system.

There was increased N uptake by the plant as the level of iron-organic complex in the soil increased. The mean values were 17.90 mg/pot in the case of control and increased to 68.70 mg/pot at the highest level of iron-organic complex addition in the case of 30 day old plants raised in the black calcareous soil. Similar trend was observed in the red soil and also in other stages of growth. Results obtained by Oertli *et al.* (1965), Dalap (1970) and Chew *et al.* (1976) agree with this finding.

The same trend was also observed with uptake of phosphorus and potassium. Thg mean uptake values for P and K were 2.50 and 32.35 mg/pot in the control and increased to 9.70 and 112.5 mg/pot at the highest level of iron-organic complex treatment. The correlation between iron uptake and P uptake was significant in the plants grown in both the soils. Jain and Singh (1967) obtained similar results working with rice. The results of Matocha and Thomas (1969) and Tadano and Tanaka (1970) who found increased K content of potato was associated with response to iron, also agree with the results of the studies now reported.

The iron uptake and calcium uptake were found to be significantly correlated (Table II) at all the stages of plant growth studied. This was also found to be the case with magnesium except in the 60 days plants. As alreedy stated these relationships reveal the vital role played by iron in the plant's metabolism at all stages of growth.

Iron in relation to other Micronutrient nutrition : The other micronutrients uptake was also found to be highly related (Table II) to iron uptake by the plant. Manganese, zinc and copper uptake were found to be positively correlated with iron uptake. The relationships were found to be highly significant in the mature plant and grain.

The effect of iron in producing increased drymatter and grain and the high positive correlation between iron uptake and the uptake of other nutrient ions point to the key metobolic role being played by iron. It is presumed that there is an optimum concentration of iron at every stage of plant growth which results in highly positive interaction with other nutrients and leads to better plant health and the capacity to yield increased grain. Any concentration below or above this index may result in decreased yield. Although no attempt has been made in these investigations to find out their critical value, the results obtained give ample indication that the determination of such values may be very great use as guidelines in the iron fertilization of crops and in future, attempts have to be made to identify the conditions which promote optimum iron values in the plant and also quantitatively determine these op-

TABLE II. Relationship between iron uptake and other nutrient uptake at 30 and 60 day old plants and grain and straw yields (n=32 pairs)

30 Day old plants

Relationship between X Y	Correlation coefficient	Regression equation
Fe uptake Vs. Drymatter yield		
a. Black calcareous soil	0.962**	Y = 1.515 + 0.630 X
b. Red soil	0.927**	Y = 1.662 + 0.923 X
Fe uptake Vs. N uptake		
a. Black calcareous soil	0.910**	Y = 16.120 + 6.566 X
b. Red soil	0.827**	Y = 17.893 + 17.101 X
Fe uptake Vs. P. uptake		
a. Black calcareous soil	0.772**	Y = 2.854 + 1.224 X
b. Red soil	0.658**	Y = 2.846 + 0.869 X
Fe uptake Vs. K. uptake		
a. Black calcareous soil	0.650**	Y = 35.092 + 12.950 X
b. Red soil	0.782**	Y = 23.569 + 7.897 X
Fe uptake Vs. Ca uptake		
a. Black calcareous soil	0.828**	Y = 15.862 + 8.076 X
b. Red soil	0.409*	Y = 30.280 + 7.536 X
Fe uptake Vs. Mg uptake		
a. Black calcareous soil	0.690**	Y = 133.807 + 6.063 X
b. Red soil	0.710**	Y = 119.776 + 3.886 X
Fe uptake Vs. Mn uptake		
a. Black calcareous soil	0.894**	Y = 1.379 + 0.083 X
b. Red soil	0.853**	Y = 2.248 + 0.076 X
60 day old plants		
Fe uptake Vs. Dry matter yield		
a. Black calcareous soil	0.058**	Y = 9.312 + 0.438 X
b. Red soil	0.962**	Y = 9.902 + 0.563 X
Fe uptake Vs. N uptake		
a. Black calcareous soil	0.504**	Y = 83.465 + 3.594 X
b. Red soil	0.901**	Y = 74.155 + 4.665 X
Fe uptake Vs. P. uptake		
a. Black calcareous soil	0.654**	Y = 14.859 + 0.816 X
b. Red soil	0.432*	Y = 9.235 + 0.432 X
Fe uptake Vs. K. uptake		
a. Black calcareous soil	0.726**	Y = 213.578 + 10.156 X
b. Red soil	0.802**	Y = 219.796 + 13.626 X
Fe uptake Vs. Ca. uptake		
a. Black calcareous soil	0.562**	Y = 121.353 + 5.075 X
b. Red soil	0.484**	Y = 136.181 + 4.147 X
Fe uptake Vs. Mg. uptake		
a. Black calcareous soil	0.558**	Y = 19.014 × 6.160 X
b. Red soil	0.097 NS	

Fe uptake Vs. Mn. uptake		
a. Black calcareous soil	0.615**	$Y = 1.003 + 0.068 X$
b. Red soil	0.447**	$Y = 1.234 + 0.049 X$
Sorghum grain		
Fe uptake Vs. Grain yield		
a. Black calcareous soil	0.892**	$Y = 13.280 + 2.234 X$
b. Red soil	0.938**	$Y = 11.282 + 2.696 X$
Fe uptake Vs. N. uptake		
a. Black calcareous soil	0.862**	$Y = 169.108 + 27.959 X$
b. Red soil	0.909**	$Y = 135.991 + 32.174 X$
Fe uptake Vs. K. uptake		
a. Black calcareous soil	0.896**	$Y = 14.282 + 3.267 X$
b. Red soil	0.888**	$Y = 14.282 + 3.724 X$
Fe uptake Vs. Ca. uptake		
a. Black calcareous soil	0.758**	$Y = 42.650 + 8.145 X$
b. Red soil	0.472**	$Y = 24.899 + 3.718 X$
Fe uptake Vs. P. uptake		
a. Black calcareous soil	0.896**	$Y = 17.237 + 3.267 X$
b. Red soil	0.888**	$Y = 14.282 + 3.724 X$
Fe uptake Vs. Mg uptake		
a. Black calcareous soil	0.758**	$Y = 42.650 + 8.145 X$
b. Red soil	0.472**	$Y = 24.899 + 3.718 X$
Fe uptake Vs. Mn uptake		
a. Black calcareous soil	0.588**	$Y = 142.681 + 32.581 X$
b. Red soil	0.492**	$Y = 126.888 + 31.858 X$
Straw Yield		
Fe uptake Vs. Straw yield		
a. Black calcareous soil	0.997**	$Y = 26.971 + 1.294 X$
b. Red soil	0.975**	$Y = 28.931 + 1.332 X$
Fe uptake Vs. N uptake		
a. Black calcareous soil	0.040**	$Y = 187.253 + 8.799 X$
b. Red soil	0.870**	$Y = 205.948 + 8.194 X$
Fe uptake Vs. P uptake		
a. Black calcareous soil	0.855**	$Y = 30.005 + 1.014 X$
b. Red soil	0.740**	$Y = 7.436 + 0.690 X$
Fe uptake Vs. K uptake		
a. Black calcareous soil	0.950**	$Y = 596.002 + 27.360 X$
b. Red soil	0.945**	$Y = 596.133 + 24.312 X$
Fe uptake Vs. Ca. uptake		
a. Black calcareous soil	0.960**	$Y = 223.828 + 12.171 X$
b. Red soil	0.910**	$Y = 238.292 + 9.633 X$
Fe uptake Vs. Mg uptake		
a. Black calcareous soil	0.690**	$Y = 133.807 + 6.063 X$
b. Red soil	0.710**	$Y = 119.776 + 3.866 X$
Fe uptake Vs. Mn uptake		
a. Black calcareous soil	0.894**	$Y = 1.379 + 0.083 X$
b. Red soil	0.853**	$Y = 2.248 + 0.076 X$

timum values. This will go a long way in overcoming not only iron deficiency as exhibited by deficiency symptoms but also the latent iron deficiencies present in many plants under different agroclimatic conditions which can only be found out when the yield obtained becomes very low.

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