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Science Behind Iron Deficiency in Sugarcane

Sugarcane is an important cash crop which produces higher biomass and therefore its nutrient requirement is also high. Intensive cane cultivation and inadequate supply of organic matter has led to some micronutrient deficiency. Iron is an important micronutrient which aids in photosynthesis. The occurrence of iron chlorosis is very common in Tamil Nadu. Excessive calcium influences iron chlorosis and hence it is frequently noticed in calcarious soils and is referred as lime induced chlorosis. Application of ferrous sulphate as basal fertilizer or foliar spray leads to correction of iron deficiency and paved the way for increasing cane yield.

INTRODUCTION

Sugarcane is one of the important cash crop which is the main source for sugar production in India and the byproducts generated from the sugar industries are the main source for alcohol and chip board manufacturing. Millions of people get employment directly or indirectly through sugar industries. The major reasons attributed for low productivity in cane and sugar were low plant population, imbalanced nutrient application, continuous mono cropping with high yielding and nutrient exhaustive varieties, low micronutrient content in soil and burning of sugarcane trashes after harvest. The low micronutrient availability to the crop affects various enzymatic pathways and uptake of other nutrients. Among the various micronutrients, iron and zinc has major role in productivity of sugarcane.

IRON AND SUGARCANE

Iron is one of the most abundant elements in the soil and present in the form of iron oxides and iron silicates in most of the soil types. The presence of various forms of iron oxides in the soil reflects various

colour gradients as yellow, orange, red and brown. The occurrence of iron chlorosis in sugarcane is most common in India. Iron chlorosis in sugarcane can be considered to be a physiological disorder. Iron becomes physiologically inactive in the chlorotic leaves and its relation with the higher uptake of phosphate results in the imbalance of mineral iron. The iron level in sugarcane leaves is not an indicator of iron deficiency in the crop. The iron status in soil was measured as a ratio of total phosphorus to total iron rather than total iron content alone. Iron deficiency in sugarcane is generally appears due to anyone of the following three reasons,

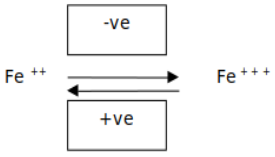
1. Presences of inadequate amount of iron in soil/plants
2. Lack of its mobility in plants
3. Unfavorable iron: Manganese ratio

NORMAL DISTRIBUTION OF IRON IN SUGARCANE PLANT

In general, iron showed relatively little mobility in the plant system and plays an important function in the chlorophyll pigments production and takes an active part in respiration, constitute of many enzymes and active biological oxidation. In sand culture, the young tissues were low in Fe. Thus, the bottom, middle and upper thirds of the leaves increased in Fe as the leaves aged with dead leaves containing most of all. The same general trends although less marked, applied to the sheaths. On the dry- weight basis, the stem had a decreasing Fe content from the meristem to the old cane. On a green weight basis, this trend would be reversed, but because of increasing dry weight as the cane ages and matures, these appears to be trend of decreasing Fe from meristem to cane.

FUNCTIONS OF Fe IN PLANTS

The importance of Fe to living things is in its oxidation- reduction characteristics. Thus, Fe^{++} with an added electron gives Fe^{+++} and reducing Fe^{+++} returns the iron to the $Fe^{+\ +}$ form and the released electron to some other ion or reaction. In the meantime, there has been a two-way change of energy the first one is up and second on down.



In the plant chloroplast, Fe is combined with an organic compound thought at one time to be a protein. The combination is known as ferredoxin and is considered to be a very powerful reductant in the chloroplast. It is very dominant in the initial stages of photosynthesis (photosystem II) causing the oxidation of the reduced form of a nicotinamide adenine dinucleotide phosphate oxidase (NADPH) to nicotinamide adenine dinucleotide phosphate (NADP), which accepts electron from light energy activated chlorophyll. It is considered that ferredoxin direct the oxygen into the NADPH to form NADP. In plants as noted earlier, the green pigment is a mixture of the compound chlorophyll a, b, c, d and e. Chlorophyll a has the empirical formula $C_{55}H_{72}O_5N_4Mg$. The pertinent point here is that although Fe is not a part of any of these, it is indispensable in the early stages of chlorophyll manufacture by the chloroplast and thus accounting for chlorosis as a symptom of Fe deficiency. It is of interest that while Mg is the element in Chlorophyll that needs Fe for its formation. In addition to these fundamental functions, the $Fe^{++}\leftrightarrow Fe^{+++}$ mechanism is equally important in the reverse of photosynthesis. Iron aids in the accumulation of energy by organic compounds and then aids in the releases of that energy in respiration, resulting in the formation of many other compounds and in the transfer of the energy, motivating other processes.

CAUSES OF IRON DEFICIENCY IN SOILS

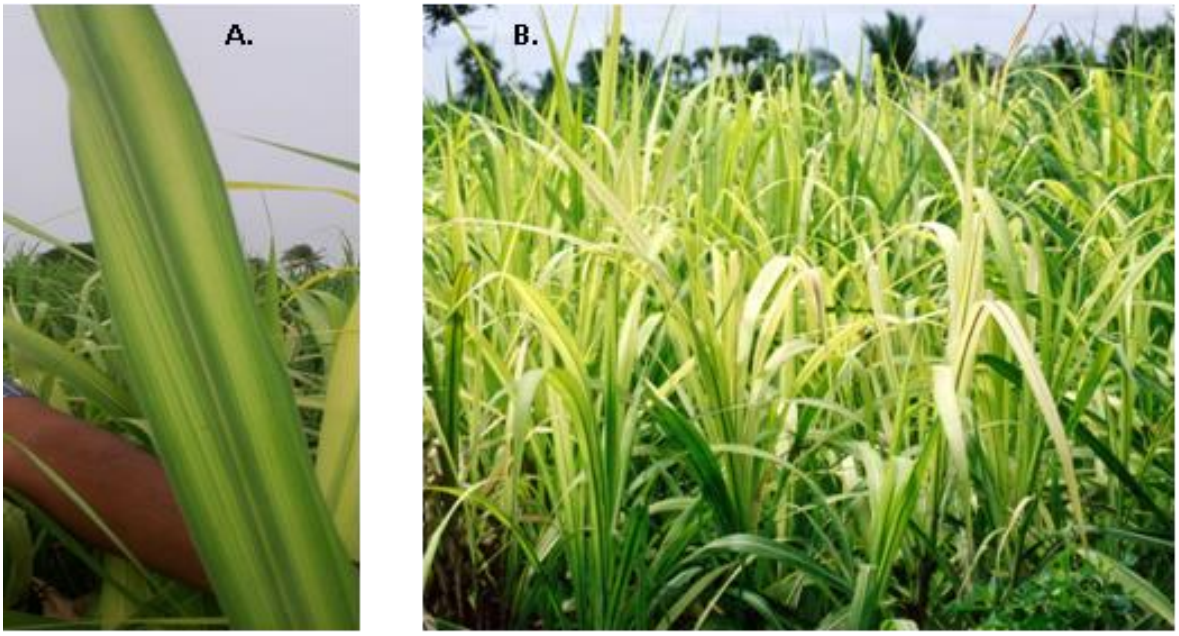
Iron essentiality was first established by E. Gris in 1844 AD. Sufficient Fe is available in the setts for the growth of cane during early stages and hence true iron deficiency was rare. But the expression of Fe chlorosis in young crop was due to induced iron deficiency by the excessive presence of lime, carbonate, phosphorus and heavy metal in the soil. Normal cane contains Fe:Mn ratio of 15:1 or more and during Fe deficiency the ratio is 1:1 or less. During iron deficiency the plants accumulate Fe in the nodal region. The iron deficiency occurs in varied soil conditions *viz.,*

1. Light sandy soils
2. Low lying areas where the lime nodule appears on the surface or which contain enough of calcium carbonate or available phosphate and potash
3. Upland fields in the vicinity of village where large amount of human excreta are added daily or fresh cow dung is applied in sufficient quantity
4. In the factory area where large amount of press mud is applied as manure and
5. Over limed soils

The occurrence of iron deficiency is mainly due to the availability of this element to sugarcane for its proper nourishment rather than the level of iron in the soil. The concentration of heavy metals like copper, zinc, cobalt and manganese has a direct impact on the occurrence of chlorosis. The deficiency of iron is also coupled with poor aeration, high content of copper or manganese, excessive usage of phosphate and application of undecomposed compost/fresh cow dung. A heavy dose of green manuring in calcareous soil also causes chlorosis. High concentration of calcium in the soil solution decreases adsorption of iron and this is worsened by addition of phosphorus. Bicarbonate in soil precipitates iron to insoluble forms and causes chlorosis. Lime induced iron chlorosis is very common in different areas. If the ratio of Fe:Mn other than 15:1 is conducive for the occurrence of iron deficiency. The high pH and cool temperature also induce iron deficiency. The calcareous clay soil with maximum leaching grew dark green plants in spite of low Fe- DTPA (diethylene triamine penta acetic acid) and increased the pH of the soil. The application of saline water to sugarcane crop induces chlorosis. The presence of salinity in the soil decides the iron chlorosis even though high saline water is used for irrigation. The native Mg supplying capacity of soil as well as cumulative Mg supplied to the soil through irrigation water appeared to be the causal factor in decreasing leaf Fe and chlorophyll Fe concentration. The soil salinity and chlorosis are the two closely related and important factors responsible for significant reduction in cane yield. The roots of sugarcane are more severely affected by Mg salts rather than the tops. The excessive calcium influences iron chlorosis and hence it is of frequent occurrences in calcareous soils and referred as lime induced iron chlorosis. Under such unfavorable conditions, the availability of iron gets reduced and thus deficiency is exhibited by interveinal chlorosis in leaves. Due to limited mobility of Fe in the plant system the Fe chlorosis appears in the young leaves. The critical level in the leaf blade is 20 ppm. The chlorotic leaf tissues show higher concentration of total iron than a normal green leaf indicating inactivation of iron due to other factors. The major and micronutrient *viz.,* K, P, Zn, Cu and Mn in higher contractions causes precipitation of ferrous compound leading to lack of available iron mobility in plants.

DEFICIENCY SYMPTOMS OF IRON IN SUGARCANE

An iron chlorosis symptom was visualized in young leaves. Interveinal chlorosis was appearing in the leaves from the base of the leaves to the tip. In severe cases the entire leaf become chlorotic and eventually the whole plant become pale yellow to white in colour. There is new root development in the young stubble shoots. The ratoon and young crops are



Symptoms: A. Interveinal chlorosis of the leaves, B. Advanced stage entire leaf may be bleached and entire plant may become chlorotic

severely affected by Fe chlorosis. Chlorosis leads to stunted growth of the cane and even drying of the entire clump.

PACKAGE OF PRACTICES TO CORRECT IRON DEFICIENCY

Several method have been recommended to overcome the iron deficiency

1. Foliar application of ferrous sulphate@250 – 500 g in 100 lit of water/soil application of ferrous sulphate@25 $kgha^{-1}$
2. Soil application of ferrous sulphate@100 $kgha^{-1}$ along with 12.5 tonnes of farmyard manure
3. Foliar spraying of ferrous sulphate@5 $kgha^{-1}$ along with 2.5 kg of urea dissolved in 500 liters of water. Depending upon the severity of Fe chlorosis foliar application may be repeated at 7 – 10 days interval.

CONCLUSION

Sugarcane is a C4 plant and produces high biomass and exhaust high amounts of macro and micro nutrients from the soil. Due to ratooning practice the sugarcane remains in the field for more than three years and continuously removes the nutrients from the soil. The macro nutrients are only applied in the soil during cultivation without the application of micronutrients. The requirements of micronutrients are low but they are the important constituents of enzymes or co-enzymes which are involved in various physiological processes of plant growth and development. Deficiencies of micronutrients in the plants are expressed as characteristic deficiency symptoms resulting in the loss of crop productivity. Fe induced chlorosis are frequent in sugarcane in the young and ratoon crops. Proper application of Fe results in the optimum growth and development of sugarcane for maximizing the productivity.

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