IS IRON TOXICITY IN RICE ONLY ONE ASPECT OF A MULTIPLE NUTRITIONAL DISORDER?

K.L. Jayatissa - Subject Matter Speialist
(Crop Protection)
In-Service Training Institute,
Gannoruwa, Peradeniya.

A physiological disorder known as bronzing, or iron toxicity is observed in tropical and sub-tropical rice growing areas. In Asian countries (such as India, Indonesia and Sri Lanka) and in sub-tropical countries (such as Italy, Japan and Spain) this physiological condition is referred to , by various terms (implying different meanings). While While one term indicates a "deficiency" another term expresses a "toxic effect" or a 'disease'.

Whatever the term used in Sri Lanka we experience this condition in rice plants in the wet zone areas. The effected extent is several thousand of acres. Therefore, the economic loss caused by this condition should not be underestimated.

Location where this problem is most frequently observed in Sri Lanka, are -

(i) Paddy fields situated in association with highland, the soil being generally rich in iron compounds.

(ii) 'Deniya' like narrow paddy fields.

(iii) Acidic soil.

(iv) Poor soil structure and drainage.

(v) The soil solution has a higher Fe ion concentration (50-500 ppm)

(vi) Usually these soils are low in plant nutrients. The cation exchange capacity (CEC) is low. The soils are particularly very low in P, Ca and K.

(vii) Soil mineral matter is very much degenerated.

(viii) Where the scum and reddish brown ferric hydroxide layer is seen on the water surface.

(ix) These soils are continuously saturated with water. Drainage is very poor.

(x). Seepage and spring water continously bring iron to the site thus adding excess iron and thus aggrevating the situation.

Research findings indicate that this problem called iron toxicity is not necessarily associated with high soil iron concentration and continous flow of soluble iron compounds to the site through seepage. The symptoms of this condition have been observed where the Fe^{++} ion concentration is very high as well as in places with low and moderate Fe^{++} ion concentrations in soil. Even the healthy looking rice plants may carry very high levels of Fe ion within its tissues.

In view of these, it is clear that this problem called 'iron toxicity' can not be solely attributed to the Fe ion concentration. Plants growing in such places exhibit symptoms, such as:-

(i) Leaves yellowish with discolouration or small brown spots starting from the leaf tip and spreading down-wards.

(ii) Weak plant growth - indicated by poorly development of shoots and roots.

(iii) Plants showing these symptoms are highly localised.

(iv) Such plants indicate a poor state of K.P., and Ca nutrition as shown up in analytical studies. Even Zn, and Si deficiencies too have been noticed Also excessive Mn and Fe have been observed inside tissues.

Intensity of these symptoms will vary with the cultivater, soil characteristics and irrigation status.

However, merely on the excessive Fe ion content found in plant tissues, it is difficult to assume that this condition is brought about by excessive inflow of iron from iron rich highland soils nearby, when everything else is alright. Root system of a plant controls entry of iron into the system under normal circumstances. But, it does not seem to happen here. "Why it does not happen here" is what one has to find out.

Iron is taken into a plant in reduced or ferrous form. Oxidised or ferris form is not taken in. Entry of iron through the root system of a healthy plant is controlled by a bio chemical process taking place at the rhyzosphere of such a plant.

Oxygen absorbed through the shoot system of the plant is sent down to the rhyzosphere to exidise the ferrous compounds in the layer of soil lying just in contact with the outer layer of the root and convert them to ferric compounds. These ferric compounds being more water soluble than ferrous compounds are taken away from the root through the squeous medium. As a result, less iron is left at the rhizosphere in absorbable form, ie: ferrous form. Outside layer of a healthy root looks brownish, because of this process taking place continuously. Brownish colour indicates the activeness of the root system.

Iron compounds subject to oxidation reduction process under special physicochemicl conditions.

$$\text{(Ferric) } Fe^{+3} \underset{\text{high eh}}{\overset{\text{Low eh}}{\rightleftharpoons}} Fe^{+2} \text{ (Ferrous)}$$

The forward reaction takes place under a pH range of (5.0 - 5.5) Also it is governed by the redox-potential of the soil. Usually, with a high redox-potential of the soil. Usually, with a high redox potential (550-500 mv), backword reaction, ie, oxidation process takes place. This, generally happens only in an environment where drainage is good. For the forward reaction ie; reduction to occur, a low redox potential (about 150 mv) should be there. Soils with good drainage characteristics and those that subject to intermitant drying up will have higher redox potentials where as soils with poor drainage characteristics and which are subject to continous innudation will have low redox potentials.

On the other hand, what causes uncontrolled or poorly controlled entry of iron compounds in to the system?

The mechanisms that controls entry of iron compounds into a healthy plant, may be broken down under diseased conditions. If so, what could be the course to it?

One hypothesis put forward to explain this suggests thatit is linked with the state of K, Ca, and P, nutrition. We know that K, being a metabolic enzyne activator, if deficient in a plant can lead to many things such as Ca, matabolism being disturbed, accumulation of more soluble nitrogenous compounds, and accumulation of sugars of low molecular weight, weakening permeability of cell membrane and affecting the respiratory and photo-synthetic activities. Especially with weakened permeability of the cell membrane, out flow of some accumulated compounds will take place in a uncontrolled manner. As a result of this microbial activity on the outside layer of the root is increased, espeically that of iron reducing bacteria, which thrive on the medium found on the outer surface of the root. In this process, iron compounds produced, leading to increased concentration of ferrous compounds in the rhysosphere and in turn increased inflow of iron compounds into the system.

In the event respiratory inhibitors such as hydrogen sulphaide are present this process is further aggrevated.

Under such circumstances, aiming at increased yields how could these processes be controlled?

Following remedial action could be suggested as a strategy on the basis of key points discussed above.

1. Maintain redox potential of the soil at a higher level (above 150 mv) by improving soil structure and drainage.

2. Improve cation exchange capacity in the soil.

3. Bring the soil reaction to natural or alkaline state.

4. Improve the ability of the plant to withstand stresses under these circumstance.

(1) Increasing rodox potential:-

Rodox potential of the soil is linked with the Oxygen supply to the soil, which in turn, is governed by drainage pattern of the same. Soil that this been inundated continuously will have a low oxygen supply, hence a low rodox potential too. Thus, what one has to do is to dry the soil on and often. This could be achieved through,

- a deeper edge cannal.
- controlling water entering from highland quantitatively and qualitatively.
- maintain the drainage system properly - by having an efficient, permanent drainage cannal system and also by facilitating drainage with in the liyadde at the time of planting. 'Kivul ela' traditionally made by farmers, has a significant effecat on the growth of the young seedling.

(2) Increased cation exchange capacity (CEC) -

CEC of a soil is a function of ion concentrations of metals such as Ca, Na, K, etc These soils inherently lack in such ions. Thus, the way ata improve CEC of the soil is to supply such compound in the form of fertilizers. In supplying them it is important to supply the required quantity in the form plants could utilize easily. Also it may not be adequate supplying such compound in the same quality and same quantities that it would be given to a normal soil. Instead, it should be supplied in greater quantities and easily avilable forms.

[illegible]

The pH of a soil is again linked with the content of certain anions or cations in the soil solution. What is commonly done to increase pH of a soil or shift soil reaction from acidic to alkaline, is adding lime. Depending on the level of acidity in the soil quantity to be added may vary from few to may tons. Also this is something one has to repeat rather regularly .

(4) Ability to withstand stresses - varietal reaction:-

Through breeding it may be possible to improve the ability of cultivars to perform satisfactorily under such conditions. Better performance under strained conditions may also be facilitat4d through improved dranage, improved plant nutrition, selecting proper varieties, choosing the suitable method of planting - broadcasting instead of transplanting and eventually better results may be achieved.