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Editorial

Iron Stress in Crop Plants and Ways to Overcome it

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Abstract

Iron (Fe) stress is encountered by many crops in calcareous soils with pH above 8.0, which are abundant in India. Most of the times Fe stress goes unnoticed however anyway it affects yield. Aerobic rice and upland rice nurseries also exhibit Fe stress. In many cases frequent adequate irrigation solves the problem. In Fe deficient areas adequate organic manures must be applied, while preparing the field. Application of elemental S and S-containing fertilizers also helps in overcoming Fe stress in plants. In case of serious Fe-stress, ferrous sulphate or Fe-EDTA solution can be sprayed, which effectively overcome the Fe stress problem.

Description

Iron stress or deficiency in crops has become a serious problem in many parts of the globe including India and is one of the factors limiting yields of many crops. The list of crop species affected by this problem is long, and includes those which were hitherto not known to be susceptible. In India sugarcane, groundnut and sorghum crop are mostly affected in Maharashtra, rhizome crops like turmeric and flower crops like jasmine suffer from Fe chlorosis in Tamil Nadu (Kannan, 1988). About 12% of the soils in India are Fe deficient (Singh, 2008, 2009). Grain sorghum is considered as the indicator plant for iron deficiency in plants. Singh and Dayal (1992) reported that, the yield increases were 13 to 19, 12 to 18, and 11 to 18% over the control with iron sulphate, iron citrate and Fe-EDTA sprays, respectively in groundnut. Splitting the application dose of 2 kg Fe ha^{-1} in two sprays @ 1 kg Fe ha^{-1} each at 50 and 70 days after emergence (DAE) or in four sprays at 0.5 kg each at 30, 45, 60, and 75 DAE, resulted in higher recovery from chlorosis, and in the highest pod and haulm yields of groundnut. Manjappa and Rao (2001) from Raichur (Karnataka) reported more bolls/plant and heavier bolls and increased seed cotton yield with 0.5% spray of ferrous sulphate.

Iron is an important micronutrient element involved in the several metabolic and enzymatic activities in plants. Iron is present in plants as haeme pigments and ferrodoxins. Haeme pigments are mostly (~90%) present in chloroplasts, while ferrodoxins are involved in photosynthesis, nitrate and sulphate reduction and nitrogen fixation (Prasad, 2007). Fe is also involved in the formation of ALA (omega amino laenolenic acid, which makes up the structure of chlorophyll (Prasad, 2007). This is why Fe deficiency leads to less chlorophyll in plants leading to pale or white bleached leaves. Fe also imparts some disease resistance in plants

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(Graham and Webb, 1991).

Earth's crust has about 5% iron and most soils, especially tropical soils are fairly rich in iron (Prasad and Power, 1997; Fageria et al., 2011; Shivay and Mandi, 2020), but its availability to crop plants is a problem, because most of it is present in Fe^{3+} form, which is not water soluble. Plants absorb iron as Fe^{2+} (soluble in water) after reducing Fe^{3+} to Fe^{2+} using several mechanisms. Legumes and other non-poaceae plants excrete organic acids to lower soil solution pH for absorbing Fe (Marschner, 1974; Schmidt, 2006). On the other hand roots of poaceae plants produce phytosiderophores (Bowen, 1981; Romheld, 1991), such as, avenic acid (Fushiya et al., 1982) mugineic acid (Kawai et al., 1988) to chelate and absorb Fe. Available (DTPA-extractable) Fe contents ranged between 21 and 352, 14.4 and 371, and 5.9 and 386 mg kg^{-1} in calcareous (Orthent) soils of Bihar, alluvial (Ochrept) soils of West Bengal and alluvial (Psamment) soils of Uttar Pradesh and Punjab, respectively (Singh, 1998; Takkar et al., 1990). The critical limit for Fe varies from 3.50 to 7.00 mg kg^{-1} soil in different types of soils in India (Shukla et al., 2014).

Interveinal chlorosis in top leaves in upland crops is the main symptom of iron stress in plants, On the other hand, under lowland conditions as obtained in rice paddies (Fageria et al., 2011) the excess availability of Fe^{2+} iron may create iron toxicity in plants, which is known as bronzing disease (Inada, 1965).

Iron in aqueous solutions is surrounded by six molecules of water and is present as $Fe(OH)_6^{3+}$ at pH 1, as $Fe(OH)_2^{+}$ at pH 6 and $Fe(OH)_3$ at pH 8 and Fe $(OH)_4^{-}$ at pH 10 (Baes and Mesmer, 1976). A soil with pH 8.0 in equilibrium with solid Fe phase has mostly $Fe(OH)_3^{0}$ and soluble Fe concentration of $10^{-10.4}$ M, while most plants need a soluble Fe concentration of 10^{-8} M (Schwab and Lindsay, 1989).

According to Tanaka and Yoshida (1970), 70 mg kg^{-1} DM Fe is critical deficiency limit in rice, for most crops the deficiency limit is 30-50 mg kg^{-1}. Furthermore, Fe chlorosis is more due to the content of Fe^{2+} than the total Fe. The chlorotic leaves may contain 27-34 mg kg^{-1} DM Fe^{2+} even though total iron may be 200-270 mg kg^{-1} DM.

The ways to overcome Fe stress in plants are as follows:
(i) Since in aqueous solution Fe is soluble, application of water in upland crops is the easiest solution. Upland rice nurseries, which frequently show iron stress with bleached leaves, respond well to irrigation.

(ii) Addition of large amounts of organic manures at the time of land preparation in Fe deficient areas (Shenker and Chen, 2005). Organic manures produce humic and other complex organic acids, which chelate Fe and make it available to crop plants.

(iii) Application of elemental sulphur or sulphur containing fertilizer, because acidity developed the conversion of Fe^{3+} to Fe^{2+}.

(iv) Soil application of 5-10 kg ferrous sulphate ha^{-1} or spraying of 0.5% ferrous sulphate solution on foliage. Furthermore, Astolfi et al. (2006) reported that sulphur deficiency in soils reduces phytosiderophores release by Fe-deficient barley plants. Application of nitrogen fertilizers also helps in increasing Fe availability.

Iron deficiency occurs in many crops in India on calcareous soils having a pH of 8.0 or above and affects crop yields. Application of adequate organic manure, while preparing the field, frequent and adequate irrigation and application of elemental S or S-fertilizers is an easy way to overcome Fe stress in crop plants. If needed then ferrous sulphate or Fe-EDTA can be sprayed on crop plants.

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