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Physiological and molecular facets of plant iron nutrition and interactions in global scenario

Akhouri Hemantaranjan

Banaras Hindu University, India, E-mail: hemantaranjan@gmail.com

Abstract

Understanding the physiological and molecular aspects of iron (Fe) nutrition and interactions in plants is critical for the development of long-term agricultural methods in the face of iron deficiency. In major agricultural crops, iron interactions with zinc, nitrogen, boron, aluminium, and vanadium were favourable. Following that, significant progress was made in understanding the function of transport proteins in plant Fe homeostasis. The action of FRO proteins reduces iron in symplast to $Fe2+$, whereas the FDR3 gene plays a key role in Fe transport. The new physiological and molecular understandings of Fe absorption and translocation in grains also point to the buildup of some hazardous metals, which requires further research. Plant leaves, in addition to these functions, are crucial sink tissues for iron in plastids and mitochondria, as well as essential for photosynthesis and other cellular metabolic activities. Fe shortage reduces symbiotic nitrogen fixation through reducing rhizobial species' growth and survival, nodule formation, and nodule function, because $Fe2+$ is a component of nitrogenase, leghaemoglobin, and ferredoxin, all of which are regulated by nodulin-like genes. Fe plays an important role in the host-rhizobium relationship in Phaseolus vulgaris. The remarkable role of 24-Epibrassinolide in preserving physiologically active iron, which is stored in vacuoles or ferritin of various crop species, was recently investigated. Greater insights are needed under changing climate conditions to improve the judicious use and efficiency of iron in plants through sensible researches at molecular levels.

Plant nutrient imbalances are a global challenge for crop productivity. Traditionally, visual symptoms have been used to diagnose nutritional problems. Iron (Fe) is one of the most necessary and difficult micronutrients for living organisms to obtain.

Fe is involved in a wide range of biological processes, but its bioavailability in well-aerated and calcareous soils is extremely low. Many enzymatic reactions require it in both heme and non-heme forms. Fe administration increased photosynthetic CO2 fixation rates by 96 percent within the first 10 days of treatment per unit leaf area. Fe shortage in legumes reduces symbiotic nitrogen fixation through reducing the growth and survival of rhizobia, Rhizobium phaseoli, and other rhizobial species, nodule formation, nodule function, and host plant development. The introduction of nitrogen-fixing nodules into non-nodule-forming French beans using iron and zinc fertilisation revealed a key role for Fe in the host-rhizobium relationship. Different crop plants with different Fe acquisition mechanisms could have a similar impact on the rhizosphere microbial community through releasing root exudates. Iron-zinc, iron-nitrogen, iron-boron-zinc, and iron-zinc-vanadium interactions examined in a variety of agricultural crops yielded a wealth of information about Fe's physiological activities in plants. Chlorosis is caused by a significant Fe deficit, which results in a multiple-fold decrease in nitrate reduction to ammonia. To carry out the many metabolic activities that occur within chloroplasts and mitochondria, substantial amounts of Fe are required. Fe is necessary for the formation of iron-sulfur (FeS) clusters in mitochondria and the appropriate functioning of the respiratory electron transport chain. Last but not least, the overall research by our own and international scientists enriches our knowledge in one of the most important fields of physiological and biochemical aspects of iron nutrition and interactions in plants, which is relevant for the development of sustainable agricultural practises aimed at addressing this nutritional stress, which is one of the major constraints for the limited agricultural resources.

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