Iron (Fe) is fourth most abundant element in the earth’s crust and is an essential nutrient for almost all organisms. Its solubility and availability are very changeable depending on soil pH and Eh and as a result, iron can be deficient under alkaline and oxidative conditions, whereas it can be present in excess under acidic and submerged conditions: both situations can generate serious nutritional disorders. Iron deficiency or difficulties in iron uptake or absorption cause anaemia in mammals and chlorosis in plants, whilst iron overload and pathologically increased iron uptake – surpassing the extracellular iron binding capacity as well as the intracellular iron storage capacity – leads to oxidant stress and permanent cell and tissue damage. In the long process of evolution plants have developed various physiological and molecular mechanisms to enhance uptake from iron-deficient soils, and have evolved tight regulatory control of iron homeostasis. Although impressive progress has been made in understanding the complex mechanisms involved in iron uptake and in the regulation of iron homeostasis, many questions still remain unanswered. This collection of papers related to plant iron nutrition highlights the role of nitric oxide, ferritin, frataxin and the ClpC1 gene in iron homeostasis, and the interactions between plant root exudates and microbes in the rhizosphere and their possible function.

Nitric oxide (NO) is a signalling and physiologically active molecule in animals, plants and bacteria. It has been shown to be an emerging and potent signal molecule in plant growth, development and stress physiology. It has also been implicated as a central component in maintaining iron bioavailability in plants. Ramirez et al. (2010) give an overview of the functions of NO in iron metabolism in animals and discuss how NO production constitutes a key response in plant iron sensing and availability. In plants, NO drives downstream responses to both iron deficiency and iron overload. NO-mediated improvement of iron nutrition in plants growing under iron-deficient conditions represents a powerful tool to cope with soils displaying low iron availability. An interconversion between different redox forms based on the iron and NO status of plant cells might be the core of a metabolic process driving plant iron homeostasis. Frataxin, a recently identified protein in plants, plays an important role in mitochondria biogenesis and in maintaining mitochondrial iron homeostasis. Evidence regarding the interaction between frataxin, NO and iron from analysis of frataxin knock-down Arabidopsis thaliana mutants is reviewed and discussed.

Ferritins are generally considered as a kind of iron-storage protein; however, with an increasing knowledge of these proteins in the plant developmental process, their putative function of furnishing iron during various development stages appears unlikely to be essential. Beginning with a general introduction of bacterial and mammalian ferritin synthesis and functions, Briat et al. (2010) summarize our knowledge of (a) the specific features of plant ferritins; (b) the regulation of their synthesis during development and in response to various environmental cues; and (c) their function in plant physiology, with special emphasis on the role that both bacterial and plant ferritins play in plant–bacteria interactions. It is becoming clear that there are strong links between these proteins and protection against oxidative stress. Ferritins, by buffering iron, exert a fine tuning of the quantity of metal required for metabolic purposes, and help plants to cope with adverse situations, the deleterious effects of which would be amplified if no system had evolved to take care of free reactive iron.

In the research paper by Wu et al. (2010), the authors try to uncover a gene involved in Fe homeostasis in mesophyll cells in Arabidopsis. In their study, a spontaneous mutant irm1, which shows typical Fe-deficiency chlorosis, was found from Arabidopsis thaliana. Using map-based cloning, the gene responsible for the altered phenotype of irm1 was cloned, and Wu et al. found that a point mutation from G to A at nucleotide 2317 of ClpC1 on chromosome V of Arabidopsis is responsible for the irm1 phenotype. The leaf chlorosis of the mutant irm1 and clpC1 (a T-DNA-inserted null mutant of ClpC1) could be restored to green by watering the soil with Fe solution. The expression intensity of ferric reductase FRO8 in irm1 and clpC1 was disordered (significantly higher than that of wild type). Thus, the glycine residue at amino acid 773 of ClpC1 is proved to be essential for its functions, including leaf Fe homeostasis, presumably via chloroplast translocation of some nuclear-encoded proteins that function in Fe transport.

Strategy I plants (belonging to dicots and non-graminaceous monocots) respond to iron deficiency by inducing root ferric chelate reductase (FCR) in the plasma membrane, releasing protons to acidify the rhizosphere soil and secreting organic acids or reductants such as phenolic compounds. But the function of these phenolic compounds in relation to plant iron nutrition is still unclear. By growing red clover in a calcareous soil, Jin et al. (2010) collected rhizosphere soils with (Fe-sufficient)
or without (Fe-stressed) foliar FeEDTA spraying. They found that in rhizosphere soil, the number of microbes that secreted siderophores quickly was greater in the Fe-stressed treatment than in the Fe-sufficient one, while the number of microbes that did not secret siderophores showed the opposite pattern. A significantly higher concentration of phenolics was detected in the rhizosphere soil of Fe-stressed plants. In addition, the siderophore produced by a rhizospheric microbe isolated from the Fe-stressed treatment was well able to solubilize iron oxides/hydroxides, and utilization of the siderophore-solubilized Fe by the plant was even more efficient than that of EDTA-Fe. The authors propose that iron-deficiency stress of red clover can alter the composition of siderophore-secreting microbes in the rhizosphere, probably as a result of the secretion of phenolics by the root, and this may in turn help to improve the solubility of Fe in the soil and the Fe nutrition of the plant via elevated microbial siderophore secretion.

LITERATURE CITED


