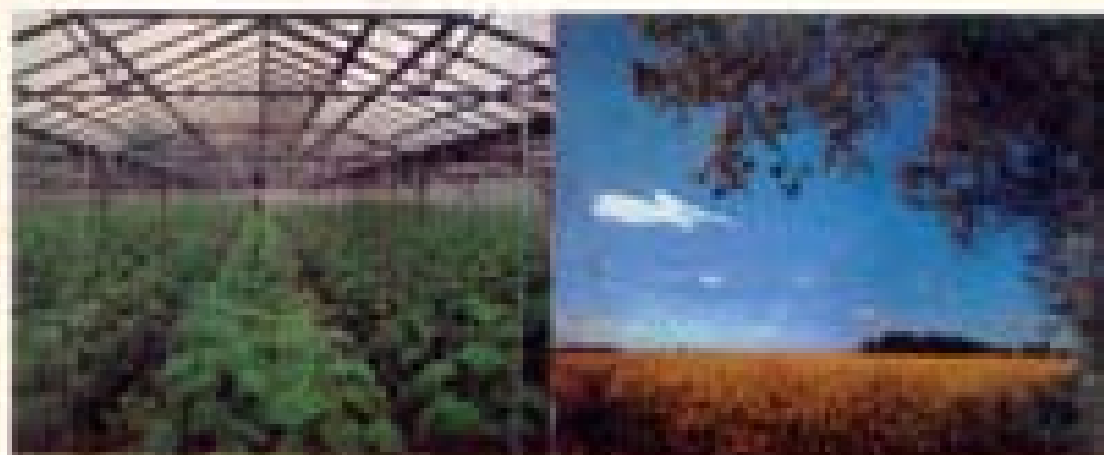


Advancements in Iron Nutrition Research

Edited by : A. Hemantaranjan



Scientific Publishers, Jodhpur

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PREFACE

The book "Advancements in Iron Nutrition Research" has been designed with a view to a thorough appreciation and precise acceleration of the multilateral researches in an exciting and expanding area of Agriculture, the iron nutrition. In fact, iron nutrition in higher plants is an extremely complex process. Impressive progress has been achieved during the last decade in our understanding of the mechanisms of iron uptake and their functions in plant metabolism, simultaneously with corresponding advances made in increasing crop yields by the supply of micronutrient iron. As a result of a display of interdisciplinary interest in Fe at an international symposium on trace elements of ICLA in 1979, a symposium was sponsored on Fe by the Chinese Institute of English Young University, Peking, China, in 1981. Disciplines represented there included horticulture, genetics, plant physiology, plant biochemistry, soil science, plant breeding, microbiology, plant pathology and animal science. The 42 papers presented were published in the *Journal of Plant Nutrition* (Vol. 5, 1982).

Six equally successful International Iron Symposia followed: Logan, Utah (1985), Lincoln, Nebraska (1987), Albuquerque, New Mexico (1987), Jerusalem, Israel (1989), Logan, Utah (1991), Zaragoza, Spain (1993) with an average of over 80 research papers published in different volumes of the *Journal of Plant Nutrition*, 1986, 1986, 1988, 1990, 1994, and *Plant and Soil*, 1990. All these symposia since 1980 have been, indeed, a great driving force and acted as an impetus to the conception of this extremely useful book for the scientific community, in general, and Agricultural Scientists, in particular, on the subject of iron utilization by plants.

More progress was considerably made in the 1990s in understanding and management of Fe chlorosis in plants than during the previous 150 years when it became known that Fe deficiency was involved in the chlorosis. A solid foundation was prepared for use of plant breeding and biotechnology to develop plant cultivars with improved resistance to Fe chlorosis. A great example, but as yet not full, understanding was developed of the mechanisms of Fe metabolism and uptake by plants. The mechanisms differ greatly according to species and cultivars. Although obviously not too simple, plants have so far been divided into two groups according to their ability to obtain Fe when it is poorly available. Some of Strategy I plants elaborate reducing reactions, develop specialized cells that release protons and sometimes siderophores. Roots of Strategy II plants, grasses in particular, produce and excrete phytosiderophores, which chelate Fe, and the whole molecule is available.

especially to the plants that produce them. Fe^{2+} is essential for Strategy I and Fe^{3+} for Strategy II plants. Microorganisms produce siderophores, some of which can make Fe available to higher plants, their direct role in practical control of Fe chlorosis and in transgenerating has promise.

There is a wide range of variability within cultivars of a given species for both Strategy I and Strategy II plants. Some germplasm has a high degree of Fe efficiency that can be used in breeding programmes. There is much variability among the microorganisms also, and many different kinds of siderophores are involved. Information concerning the specialised reactions involving the rhizosphere leads the way to improved methods for control of Fe chlorosis. Synthetic chelating agents can be more effectively used, soil pH control in microsites can be an efficient procedure for improved Fe uptake, Fe in organic amendments in microsites can become an effective control measure.

Even though the decade of 1980 saw tremendous strides in understanding of Fe, there is much yet that can be done. Horticulturists and plant physiologists need to become more involved in these matters. Dr. Arthur Wallace of the University of California, the real midwest and leader of the team of researchers in this field, is of the opinion that there can be many rewards when researchers from several disciplines and from several nations work closely together for a number of years in an area of common interest. Therefore, it has been very important to review the researches on iron nutrition carried out from different disciplines and to assemble them in different chapters of a book to probably go ahead in this direction and hence this endeavour.

The book is a summary of important new findings on iron nutrition and interactions, and of basic and applied work in Fe nutrition. It is nearly impossible to compile all new data and ideas in iron nutrition researches carried out during the last few decades, but, this book, may provide a useful perspective of important progress and fruitful research opportunities. For new workers in this field, a specialised book on iron nutrition consisting of manifold information and references has been realised to be extremely important to quickly learn about the whole area of iron nutrition and obtain help (including genetic materials needed for research).

The book entitled "Advancements in Iron Nutrition Research" is a medium for interdisciplinary exchange of information which is a valuable contribution to the understanding of iron nutrition in plants. As can be seen from the chapters, the approach to the topic ranges from theoretical to applied, molecular to organismic, and single to multivariable systems. In the first two chapters of this book a number of soil and plant procedures to control iron deficiency as well as to remedy the lime-induced chlorosis in peanuts by iron chelates have been elaborated. Physiological and environmental stresses limiting the acquisition of Fe by selected genotypes are discussed in chapter three to gain a better understanding of the significance of the energy budget on Fe

assimilation by plants. The biochemistry and physiology of iron nutrition related to different strategies in higher plants in nitrification and uptake of iron and its function in chloroplast, nitrogen fixation, enzyme and protein structure are discussed in the fourth chapter. The symbiotic nitrogen fixation with reference to iron nutrition is separately discussed as an excellent material in the fifth chapter. In the sixth chapter of this book, emphasis has been laid on the effects which iron deficiency has on the structure and regulation of one component of the photosynthetic electron transport system (PS I), along with a focus on cyanobacterial responses to iron nutrition, as a model for (yet contrast with) plastid morphology and the regulation of PS I within the chloroplasts of higher plants. After this follows a chapter in which a direct physical contact between plant roots and Fe-containing rooting substrate (perl) which is essential for the mobilization of sparingly soluble Fe has been beautifully and originally reviewed.

Nevertheless, special care has been taken in reviewing the recent advances in phytonitrification production and activity with reference to epiphytic, bacterial and fungal siderophores, transport mechanisms, physiological aspects of mugonic acid (MA), molecular genetics and methods for detection and quantification which are elaborated in three consecutive chapters eight, nine and ten. The ninth chapter gives adequate place of sideration needed for research with phytonitrifiers in the future whereas the tenth chapter judiciously describes the siderophore-mediated iron uptake in nitrogen-fixing cyanobacteria. Apart from these, various techniques in iron nutrition researches have been exhaustively dealt in chapter twelve, without which this book, can not be considered complete.

Although this book has been edited by one person, it is nevertheless the product of co-operation at various levels. I am unable to mention that my interest in iron nutrition and my scientific career in this field are due to the consistent encouragement and inspiration of esteemed Dr. S.C. Agarwala, Lucknow, Dr. O.K. Gang, Varanasi; Dr. M.M.R.E. Adail, Algiers; Dr. D.N. Tyagi, Varanasi (at present, Professor & Head, Department of Plant Physiology, Institute of Agricultural Sciences, Banarus Hindu University); Dr. R. Kannan, Bombay and above all Dr. Arthur Wallace and Dr. R.B. Clark of the United States of America. I am gratefully thankful to them. My sincere thanks are also due to the Director and the Dean of the Faculty of Agriculture, Institute of Agricultural Sciences, Banarus Hindu University for providing opportunities to exchange thoughts with scientists in India and abroad as well as perfect academic milieu to create novel piece of work in the form of this book, at this University.

Hopefully, this book has to be mutually helpful for researchers in the various fields of agricultural, biological and environmental sciences, who already have a profound knowledge of plant physiology, plant biochemistry,

soil science and genetics. In the literature, preference has been given to more recent publications in addition to representative examples of classical contributions cited in various sections apart from a number of beautiful photographs, tables, graphs and figures.

Last but not the least, I am thankful from the core of my heart to various eminent scientists and co-authors who have been actively engaged in their respective researches in India, U.S.A., Japan, Australia, Switzerland and West India for taking enormous pains in the fulfillment of this objective by contributing relevant chapters, in addition to my own, of this book. Their vast cooperation, indeed, has enabled me to accomplish this gigantic task of instructional importance. In the end, I have my special thanks to my all learned colleagues in this Department for their good wishes, moral support and kind help as and when required for this academic work.

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August 15, 1989.

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Arthur Wallace grew up on a general purpose farm in Utah. In 1943, he graduated from Utah State University with a B.S. degree in Chemistry. After serving in the army during World War II where he directed a medical laboratory, he attended Rutgers University and earned a Ph. D. degree in Soil and Plant Nutrition in 1949.

Dr. Wallace's academic career was entirely at the University of California-Los Angeles in various departments as agriculture involved and changed-Subtropical Horticulture, Horticultural Science, Plant Biochemistry, Agricultural Sciences, and Environmental Science. His interests include all of these and more.

Dr. Wallace is best known for his work on the iron nutrition of plants, and he is probably the world's leading authority on this subject. Among his most important accomplishments has been his leadership in starting and perpetuating the International Symposiums on Iron Nutrition and Interactions in Plants, a symposium that has been held seven times.

Besides his participation in more than 40 international symposia and conferences, Dr. Wallace has produced several whole issues for various journals, such as *Soil Science*, the *Journal of Plant Nutrition*, and so on. During his professional career, Dr. Wallace has published a total of almost 400 journal articles and papers, covering a wide range of topics related to soil and plant nutrition. His publications now span six decades beginning with two papers he co-authored with professors while he was an undergraduate student at the Utah State University in the early 1940s.

Dr. Wallace is a Fellow of the American Society of Agronomy, Soil Science Society of America, Crop Science Society of America, and the American Society for Horticultural Science.

Arthur Wallace retired from the University of California-Los Angeles in 1989 as Professor Emeritus, and since then, he and his son, Gary Wallace, have developed two businesses related to soil science.

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He was invited to present one of his research papers in the Third International Iron Symposium at Lincoln, Nebraska, U.S.A.

Dr. Gang was awarded prestigious J.I. Chetty Gold Medal, 1967 for his outstanding work in Plant Physiology by the Indian Society for Plant Physiology, New Delhi. He served the Indian Society for Plant Physiology as the President in the year 1966. His research contributions have been duly cited and discussed in books and publications of international standard. He is the Fellow of the Indian Society of Plant Physiology and life member of important Indian and overseas learned bodies in biology and agriculture.

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