第一版序

矿质营养是植物生长发育所必需的。植物的矿质营养学对基础科学和应用科学都非常重要。过去几十年中，我们对矿质元素的吸收机理及其在植物代谢中的功能理解不断加深。同时，在通过施肥提供矿质养分来增加作物产量的研究方面也取得了长足进步。本书的主要目的是根据我们现有的知识来阐述植物矿质营养的基本原理。尽管栽培作物是主要对象，但为了能更好地阐明矿质营养的基本原理，无论在细胞水平或是对逆境土壤化学条件适应性的特殊机理方面，也引述了一些包括低等植物在内的非栽培植物的典型例子。

植物营养学是一门与土壤学、植物生理学和生物化学等其他学科密切相关的学科。本书对土壤中矿质元素的介绍，是为了帮助理解植物根系如何从土壤中获取矿质养分，以及根系如何改变根—土界面上的土壤化学性质。关于光合作用和呼吸作用等植物生理生化基础过程的论述，主要是介绍它们如何以及在多大程度上受矿质元素的影响或调控。作物生理学的内容也有所涉及，因为它是农学和园艺学的基础并具有重要应用价值，尤其是关于矿质元素和植物激素对源—库关系的影响。

植物矿质营养所涉及的面很广，不可能面面俱到。本书对某些方面做了详尽论述和讨论，这或是由于相关内容对我们理解矿质营养特别重要，或是由于近年来的研究有了很大进展。当然，作者个人的研究兴趣也是影响选材内容的重要因素之一。其中特别强调了矿质元素的短距离和长距离运输、源—库关系，以及植物—土壤的相互作用。本书也力求使读者更好地了解植物对逆境土壤化学条件的适应机理，强调了矿质营养的遗传学基础，也介绍了在热带和亚热带地区“使作物适应土壤”的可能性和局限性。

本书是为具有植物生理、生物化学和土壤学渊博学识的农学、生物学和环境科学等学科的研究生和工作者所著。书中着意运用典型的表、图和图解来说明矿质营养的各种问题，而不作基本过程的详尽解释。这类覆盖范围广泛的教材，一般化是不可避免的。但书中引用了大量参考文献，供进一步详细阅读。在所列的参考文献中，优先推荐了最新研究结果。但在许多章节也引用了具有代表性的经典例子和文献。本书虽然由我一人所写，但却是在不同层面多方合作的结晶。我对植物营养学的兴趣以至献身这一科学是受到了G. Michael 博士的鼓励。没有两名优秀同事 V. Roemheld 博士和 Ernest A. Kirkby 博士的支持，本书就不能以现在的面目呈现在大家面前。我非常感谢他们。V. Roemheld 博士不仅参与了制图工作，而且对表格排列和文字改进提出了宝贵建议。我的老朋友 Ernest A. Kirkby 对稿件提出了很好的建议，并修改和润色了文字，使本书的第一稿有了很大改进。本所同事 P. Martin 博士，J. Horst 博士和 B. Sattelmacher 博士对本书各章节都做了

有价值的讨论，并帮助完成教学和管理工作以使我有更多时间用于写作，对本书出版做出了很大贡献。如有关图注所示，我的朋友们无私地提供了各自的原始照片。

本书手稿的打印需要技术熟练的秘书。我特别感谢 H. Hoderlein 女士所做的手稿的打字输入工作。最后，我还要感谢我的家人鼓励我写这本书，以及在写作过程中从始至终的支持和耐心。

Horst Marschner

于斯图加特-霍恩海姆大学

1985 年 8 月

第二版序

如第一版序中所提到，本书的主要目的是在现有知识基础上阐述植物矿质营养的基本原理。为了达到这一目标，教材就必须经常补充最新研究进展，这正是本书再版的目的。新版的结构没有变动，各章节也保持不变。但每章的内容有了较大改动，更新了约半数的图、表及参考文献。新进展的介绍基于以下原则：优先选择新结果和参考文献，其质量至少相当于被代替的内容。第一部分重点放在根—冠相互作用、胁迫生理、水分关系和微量元素的功能。考虑到大家对植物—土壤相互作用的兴趣不断增加，第二部分有较大变动和延伸，包括在第十四章关于内外因素对根系生长的影响，第十五章根—土界面（根系分泌物，根际微生物，菌根）等部分，增加了新内容。

第二版是在许多同事、朋友的支持和帮助下完成的。特别感谢 Ismail Cakmak 博士、Alrecht Jungk 博士，Volker Roemheld 博士及 Alexander Hansen 博士。我的老朋友 Ernest A. Kirkby 教授再次给予了大力支持，包括文字修改及提出了许多有益的建议，使新版不断完善。我十分感谢 Eckhard George 博士及其研究小组的精美绘图，感谢我女儿 Petra 和 Ulrich Grauer 博士通读全文及校对，感谢 Helga Hoderlein 女士的技术支持，特别是手稿的文字输入。

Horst Marschner
于斯图加特-霍恩海姆大学
1993 年 12 月

Preface to First Edition

Mineral nutrients are essential for plant growth and development. Mineral nutrition of plants is thus an area of fundamental importance for both basic and applied science. Impressive progress has been made during the last decades in our understanding of the mechanisms of nutrient uptake and their functions in plant metabolism; at the same time, there have also been advances in increasing crop yields by the supply of mineral nutrients through fertilizer application. It is the main aim of this textbook to present the principles of the mineral nutrition of plants, based on our current knowledge. Although emphasis is placed on crop plants, examples are also presented from noncultivated plants including lower plants in cases where these examples are considered more suitable for demonstrating certain principles of mineral nutrition, either at a cellular level or as particular mechanisms of adaptation to adverse chemical soil conditions.

Plant nutrition as a subject is closely related to other disciplines such as soil science, plant physiology and biochemistry. In this book, mineral nutrients in soils are treated only to the extent considered necessary for an understanding of how plant roots acquire mineral nutrients from soils, or how roots modify the chemical soil properties at the soil-root interface. Fundamental processes of plant physiology and biochemistry, such as photosynthesis and respiration, are treated mainly from the viewpoint of how, and to what extent, they are affected or regulated by mineral nutrients. Crop physiology is included as an area of fundamental practical importance for agriculture and horticulture, with particular reference to source-sink relationships as affected by mineral nutrients and phytohormones.

Mineral nutrition of plants covers a wide field. It is therefore not possible to treat all aspects with the detail they deserve. In this book, certain aspects are covered in more detail, either because they have recently become particularly important to our understanding of mineral nutrition, or because many advances have been made in a particular area in the last decade. Naturally, personal research interests and evaluation are also factors which have influenced selection. Particular emphasis is placed on short- and long-distance transport of mineral elements, on source-sink relationships, and on plant-soil relationships. It is also the intention of this book to enable the reader to become better acquainted with the mechanisms of adaptation of plants to adverse chemical soil conditions. The genetical basis of mineral nutrition is therefore stressed, as well as the possibilities and limitations of "fitting crop plant to soils", especially in the tropics and subtropics.

I have written this textbook for graduate students and researchers in the various fields of agricultural, biological and environmental sciences, who already have a profound knowledge of plant physiology, biochemistry and soil science. Instead of extensive explanations of basic processes, emphasis is placed on representative examples—tables, figures, schematic presentations—illustrating the various aspects of mineral nutrition. In a textbook of such wide scope, generalizations cannot be avoided, but relevant literature is cited for further and more detailed studies. In the literature, preference has been given to more recent publications. Nevertheless, representative examples of classical contributions are also cited in the various sections. Although this book is written by one person, it is nevertheless the product of cooperation at various levels. My interest in plant nutrition and my scientific career in this field are due to the inspiration of Dr. G. Michael. The book as it is presented here would not have been accomplished without the excellent support of two colleagues. Dr. V. Roemheld and Mr. Ernest A. Kirkby. I am very much indebted to both of them. Dr. Roemheld not only prepared the drawings but also gave highly valuable advice regarding the arrangement of the tables and improvements to the text. My old friend Ernest A. Kirkby corrected the English and improved the first draft considerably by valuable suggestions and stimulating criticism. My colleagues in the institute, Dr. P. Martin, Dr. W. J. Horst and Dr. B. Sattelmacher helped me greatly, both by valuable discussions in various subject areas treated in this book and by keeping me free for some time from teaching and administrative responsibilities. Many colleagues were kind enough to supply me with their original photographs, as indicated in the legend of the corresponding figures.

The preparation of such a manuscript requires skilful technical assistance. I would especially like to thank Mrs. H. Hoderlein for typing the manuscript.

Last but not least, I have to thank my family for encouraging me to write the book and for their assistance and patience throughout this time-consuming process.

Stuttgart-Hohenheim
August 1985

Horst Marschner

Preface to Second Edition

As mentioned in the first edition the main aim of this textbook is to present the principles of the mineral nutrition of higher plants, based on current knowledge. This ambitious aim requires that the content of the book has to be updated regularly to take into account new developments in the subject as has been done in this second edition. The structure of the textbook has not been altered and the subject matter and number of chapters remains the same. The contents of the chapters, however, have been revised and on average about half the figures, tables and references replaced. The introduction of these more recent findings was based on the principle that newer examples and references are given priority, provided the quality of the information is at least similar to that which is being replaced. In Part I more emphasis has been placed on root-shoot interactions, stress physiology, water relations, and functions of micronutrients. In view of the worldwide increasing interest in plant-soil interactions, Part II has been considerably altered and extended. This is particularly true for Chapter 14 on the effects of external and internal factors on root growth, and Chapter 15 on the root-soil interface (root exudates, rhizosphere microorganisms, mycorrhizae).

The second edition would not have been accomplished without the support of many colleagues, friends and coworkers. Of these colleagues I am particularly grateful to Dr. Ismail Cakmak, Dr. Albrecht Jungk, Dr. Volker Roemheld and Dr. Alexander Hansen. And again my old friend Ernest A. Kirkby took the most difficult task not only of correcting the English but also of improving the presentation by valuable suggestions and detailed, constructive criticism. I am also highly indebted to Dr. Eckhard George and his team for skilfully drawing the figures, to my daughter Petra and Dr. Ulrich Grauer for critically reading the text and the proofs, and to Mrs. Helga Hoderlein for the high quality of her technical assistance, especially in preparing the manuscript.

Stuttgart-Hohenheim
December 1993

Horst Marschner