Water and Plant Life

Problems and Modern Approaches

Edited by
O. L. Lange L. Kappen E.-D. Schulze

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The picture on the cover is a modified version of Fig. 5 on p. 81.

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Introduction

Water is essential for life and without water no life exists. The liquid surrounding of an aqueous solution is the conditio sine qua non for most of the physiological responses and as such, water is as decisive for the occurrence of a single enzymatic reaction as it is for the global zonation of world vegetation. It is no wonder that scientists since early times have made every effort to describe and understand the functional interrelationships between water and the phenomenon of life. During the past half of this century, these endeavours in the field of botany have been marked by steps which might be symbolized by a series of books such as "The plant in relation to water" (J. Maximov, 1929), and "Die Hydratur der Pflanze in ihrer physiologisch-ökologischen Bedeutung" (H. Walter, 1931), then "Pflanze und Wasser" (Vol. III of the Encyclopedia of Plant Physiology, edited by O. Stocker, 1956), and "Plant-water relations" (R. O. Slatyer, 1967), or the treatment of "Displacement of water and its control of biochemical reactions" (S. Levin, 1974).

Recently, general interest in the different aspects of water relations in plants has increased greatly all over the world. It is realistic to assume that now at least three new publications in this field are appearing every day. There are two reasons for this currently very high scientific activity. On the one hand our growing biochemical and biophysical knowledge and capability sets a scientific challenge to gain closer insights into the fundamental processes of plant-water interrelationships. On the other hand, mankind has more and more to face and to solve practical problems which are connected with water physiology and water ecology of plants. We are forced to enlarge the food production of a world which to a great extent is limited by lack of water. In addition it has become obvious that man's obligation is to manage the water resources within the ecosystems of the globe. This is no longer simply a matter of having "nice clean" water but a requirement for continuing human existence. All this has also led to the increasing interest in problems concerning plant existence in relation to water in the subdisciplines of applied botany, such as agronomy, forestry, and land management.

It is nearly impossible to cover the immense bulk of information which has been presently accumulated in these fields of biology. The task is rendered more difficult because experimental scientific work today is essentially the work of specialists. The separation of their limited areas of investigation handicaps the understanding of the function of whole plants and systems. However, a synthesis is necessary, because the ultimate aim of botany must remain the explanation of plant life in all its complexity.

It is perhaps ecology which increasingly stimulates the cooperation and integration of the different disciplines in biology. In order to explain the existence and behavior of the different plant types and plant communities in their environment, the various aspects of plant structure and plant function must be analyzed. This knowledge needs to be integrated in order to draw ecological conclusions, therefore, analysis as well as synthesis characterizes the task of ecological biology. We try to accomplish this in the present volume by presenting, from an ecological point of view, an analytical as well as a synoptic survey of the large field of "Water and plant life". We have not tried to summarize all known facts in this book. However, we will describe the level that our knowledge has reached, point out the problems which have recently arisen, and provide recommendations for future research. We hope that the obvious gaps in our understanding will stimulate and facilitate further work.

In September 1974 two scientific conferences were held at Würzburg where biophysicists, biochemists, physiologists, ecologists and geobotanists from all over the world came together to discuss amongst other subjects the problems of plant-water relations. Within its first meeting, the International Association of Plant Physiologists organized a symposium on Plant Productivity and Water Relations. At the same time the Deutsche Botanische Gesellschaft devoted a section of its biennial congress to the subject Pflanze und Wasser. We took the opportunity of these meetings to invite scientists representing the different fields of water-relations research to collaborate in producing this book. The authors were asked to integrate their results into a broad discussion covering the entire field of their chapters. In this way, the reader should obtain the most comprehensive picture possible of actual problems in plant-water research.

The scope of the volume, consequently, is the importance of water for plant life throughout the different levels of plant existence, from the molecular level of the cytoplasm to cells and tissues, and from the entire plant organism to ecosystems and vegetation zones. The text is divided into seven parts. Short prefaces for each part provide a brief summary of the chapters included and attempt to show the interrelationships between them as well as links between the different parts. In the first Part of the book the fundamentals of water relations are discussed, and special attention is paid to the definition and description of water status within the plant tissues and within the soil-plant-atmosphere continuum. Parts 2 and 3 consider the processes of water uptake and water loss and their regulation. In Part 4 the interrelationships between water stress and the metabolic activity of the plants are discussed especially in respect to ultrastructural, biochemical and hormonal aspects. The subjects of Part 5 are the different types of the photosynthetic CO_2 pathways which are known to be adaptive biochemical responses of plants to water supply and temperature under different environmental conditions. Part 6 is devoted to water status as a determinant in the productivity of plants and plant communities including aspects of artificial irrigation of plant cultures. The importance of the water factor for plant distribution and vegetation pattern is demonstrated exemplarily in Part 7 of this volume.

The editors are indebted to their author colleagues for their understanding cooperation in preparing the chapters of this book. Thanks are due also to Mr. M. Englert for his valuable assistance in preparing the English edition of many of

the manuscripts and Mrs. I. Urlaub for her careful help during the editorial work. Last, but not least, we gratefully acknowledge the agreement of Dr. K. F. Springer to publish this book as a volume of Ecological Studies. His continuing support has been invaluable. Within this series specially selected aspects of water relations of plants have already been considered. The physics of soil and salts in ecosystems is treated in Vol. 4 (ed. Hadas et al.). The special ecological and physiological problems of plants in saline environments are discussed in Vol. 15 (ed. Poljakoff-Mayber and Gale). Volume 5 (ed. Yaron et al.) deals with arid-zone irrigation and its physiological implications. Methods of studying plant-water relations are critically reviewed by Slavík in Vol. 9 of Ecological Studies. Certain aspects of these foregoing volumes have been summarized and included in the present book, which aims to outline an overall view of plant-water relations. This book is primarily intended to serve as a source of information for scientists such as biologists and agronomists. However, we hope that it will be found suitable also for use as a textbook for advanced students in biology, and will thus stimulate young people to discuss and consider the various ecological aspects of water in biological systems.

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