

**Controlled  
Environment  
Guidelines  
for  
Plant  
Research**

**Editors**

**T. W. Tibbitts**

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# CONTROLLED ENVIRONMENT GUIDELINES FOR PLANT RESEARCH

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## PREFACE

This volume brings together information presented at the Controlled Environments Working Conference held in Madison, Wisconsin, March 12-14, 1979. The conference arose from the realization that progress in understanding the effects of environmental factors on plant growth has been greatly impeded because of the lack of uniformity in measuring and reporting environmental conditions in controlled environment facilities. This lack has made it nearly impossible for different investigators to compare their research findings. Furthermore, the lack of guidelines has led to the production of a variety of monitoring instruments with variable specifications. Publication of research papers has often been delayed because opinions of reviewers and editors have differed widely on what constitutes appropriate environmental measurements and reporting units.

The guidelines proposed include recommendations for regulating and measuring such environmental factors as radiation, temperature, carbon dioxide, atmospheric moisture, soil moisture, and air movement in controlled environment facilities. They suggest how measurements can be made accurately and in ways that can be repeated by other investigators.

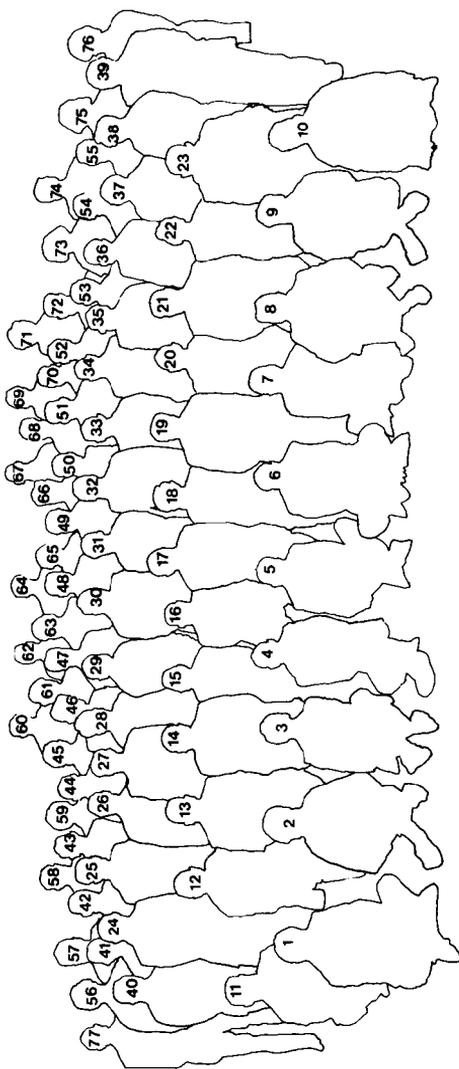
The book is intended for biologists and engineers using controlled environments with a view toward ensuring precise and reproducible research. It should also be useful for investigators undertaking environmental measurement and control in greenhouses and in the field.

The papers were presented by invited plant physiologists, physicists, and engineers of demonstrated competence. We thank each contributor for his scholarly contribution as well as for his patience and cooperation during the production phases of this volume.

The conference was initiated by the North Central Regional Growth Chamber Committee of the U.S. Department of Agriculture-Science Education Agency. This conference was cosponsored by the conference by the University of Wisconsin Biotron, the Growth Chamber Working Group of the American Society for Horticultural Sciences, and the Committee on Environment and Plant Structures of the American Society of Agricultural Engineers. Representing these organizations on the conference planning committee were T.

W. Tibbitts (Chairman), T. T. Kozlowski, J. C. McFarlane, and R. L. Prince, respectively. Members of the local arrangements committee included L. C. Anderson, C. O. Cramer, T. T. Kozlowski, B. H. McCown, L. E. Schrader, C. B. Tanner, and T. W. Tibbitts. The help of Barbara A. Jungheim, Gay W. Stauter, and Susan Higgins in typing the manuscript is appreciated.

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# CONTROLLED ENVIRONMENT GUIDELINES FOR PLANT RESEARCH

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The development of equipment for growing plants in controlled, reproducible environments is widely recognized as an extremely important contribution to research in plant science. Controlled environments have been advantageously used not only for producing uniform plants for biochemical studies but also for a variety of studies including those on: (1) effects of environmental factors on growth, (2) adaptation and acclimation, (3) screening plant material for special phenological characteristics, (4) interactions

between plants and other organisms, (5) effects of various biocides under different environmental conditions, and (6) determination of environmental factors that are likely to be significant in influencing growth in the field (Kramer, Slatyer, and Hellmers, 1972). Unfortunately, however, progress in extending knowledge has been significantly slowed because of the lack of accepted standardized procedures for characterizing and measuring both above-ground and below-ground factors of the environment within growth chambers.

Detailed and complete measurements are needed because of the large variations in environmental conditions in different laboratories and chambers, even though attempts are made to maintain similar controls. These differences occur because of variations in the direction of air flow, reflectivity of surfaces, carbon dioxide concentrations of makeup air, size of chambers, and various other reasons.

Precision could be greatly improved with guidelines and uniformity in relation to: (1) sensors (types, accuracy and precision, calibration procedures), (2) measurement (locus of measurement for different species and stages of plant growth, time of taking measurements, spacing of measurements, etc.), and (3) reporting (appropriate units, conciseness and format, etc.).

With few notable exceptions, there has been little organized effort by plant scientists to standardize measurement and reporting of environmental parameters in growth chambers. One of the earliest efforts by plant scientists to provide guidelines for measuring and reporting was that of the Committee of Plant Irradiation of the Netherlands Stichting voor Verlichtingskunde in 1953. This committee recommended that irradiance for purposes of practical plant irradiation be characterized with the aid of several different spectral regions. The committee recognized certain limitations in these broad categories and suggested