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PREFACE OF 1st EDITION

After plastic films were invented, covering technique became popular for crop protection. Mulching, row covers, floating mulch and greenhouses are classified differently, but in principle they are more or less the same technique. As far as the physical environment for plant growth is concerned, the main sub-systems are the soil layer and the boundary air layer above it. Covering the soil surface with film changes these environments drastically. Air space between the cover and the soil surface is very limited in mulching. If this space is enlarged and crops are grown under the film, the floating mulch, row cover and plastic house systems can be utilized.

Therefore, insofar as the physical environment itself is concerned, air space between the cover and the soil surface is the key to the classification. The same mechanism governs environments produced by the various covers. Therefore, in this book we will analyze all of the different environments from mulching to greenhouses. In order to analyze the physical environment, the relationship between plants and environment is of course another important topic.

Stress is placed on the link between quantitative phenomena and qualitative analyses, although not all simulation results are verified experimentally. Selection of adequate parameter values is for verification of the simulation. Most phenomena involved are non-linear and non-steady state. For this reason, the approach which is called System Dynamics is used and simulation models developed in a simulation language CSMP (Continuous System Modeling Program) are fully used. Simulation languages for continuous systems work on the same principles as analog computers and are problem-oriented. It is very easy to understand. There are several languages, such as micro-CSMP, ACSL, SYSL, and PCSMP which are run on computers ranging from mainframes to IBM PCs, and each is slightly different. The first three are available commercially. The last, PCSMP (CSMP for IBM PCs) has been developed by the Department of Theoretical Production Ecology, Agricultural University, Wageningen, the Netherlands. These simulation languages are much more powerful than BASIC or FORTRAN; they can be run on IBM PCs, and they satisfy engineers' nostalgia for analog computers.

This book was written for a computer simulation class at the graduate level at the University of Tokyo. The author assumes that readers have some basic background in differential equations, numerical analysis, and FORTRAN programming. He will be more than satisfied if the digital simulation technique using CSMP described in this book becomes widely used as a research tool as well as an educational tool in student laboratories. All models in this book are written in micro-CSMP and are available on request (a request card is attached to this book).

There are already some good English books for students majoring in agricultural structures and environments. However, they are mostly for animal environments and as far as the author knows simulation technique has not yet been well documented in the area of plant growth, although it is a very powerful methodology. The author started greenhouse simulation as a graduate student, using FORTRAN on mainframes. He became acquainted with digital simulation

techniques during his post-doctoral study (1968-1969) at the University of Minnesota after having some difficulty in simulating his models using both hybrid and analog computers. Dr. L. L. Boyd, head of the department at that time, offered the author a chance to study there, and Dr. K. A. Jordan taught him how to use hybrid and analog computes. The first model developed at that time was made using FORTRAN (Takakura et al., 1971), and it has been referred to by many researchers on greenhouse environments since then. As is indicated in Takakura and Jordan (1970), the second model was in MIMIC (a similar simulation language as CSMP), which was only available at Minnesota. After the author started simulation work using CSMP in Japan, he had a chance to work in the Department of Theoretical Production Ecology (which was headed by Prof. Dr. C. T. de Wit at that time) at Agricultural University, Wageningen in the Netherlands in 1973, and also had an excellent opportunity to discuss digital simulation in CSMP with other members of his department. They cooperated with the staff of the computer science department at the same university to develop PCSMP later.

The writing of this book began when the author visited the Department of Biological and Agricultural Engineering, Rutgers University in 1987. A simulation model was developed for floor heating greenhouses with Prof. W.J. Roberts, the chairman of the department, and his young staff members. In the summer 1991, the author offered a one-week short course at Rutgers using the first draft of this book. All 15 attendants were eagerly discussed the contents of this book and gave many suggestions for its completion; especially helpful was Dr. Wei Fang, National Taiwan University. Dr. Ken Jordan, now in the University of Arizona ran the most of the models in ACSL and gave many suggestions. Nancy K. Okamura, research fellow in our department and Susan Schmidt, University of Tokyo Press read the manuscript carefully and made corrections. There are many others who contributed by giving suggestions and preparing the manuscript. This book would not have been possible without their help. The author would like to thank all who have contributed in many ways. Last but not the least, he would like to express his appreciation to Dr. Luweis, Editor in Chief, Kluwer Academic Publishers, who agreed to publish this book.

In Tokyo
October 1992

Tadashi Takakura

PREFACE OF 2nd EDITION

Since the first edition was published almost ten years ago and computer software has changed drastically. As far as the authors know, any of CSMP group is not supported for recent WINDOWS system. On the other hand, general mathematical software such as MATLAB has been taught in many engineering courses. Since we left Rutgers, we have been working at different institutions in different countries but in the same research area. Recent computer software development has forced us to learn mathematical software and both of us selected MATLAB. We have met at several occasions such as international symposium and one time we discussed to renew the first edition by using some new language which is more powerful and suitable in the present WINDOWS environment. This is the main reason we selected MATLAB. It has also very powerful toolboxes such as SIMULINK, which is very suitable for dynamic simulation. First we planned to involve all models in MATLAB and SIMULINK, but because of the limit of the volume, we have decided to have MATLAB models with one SIMULINK model as an example. It is not difficult to develop SIMULINK models if the readers understand MATLAB models. All models in the first edition have been converted in MATLAB with its explanation by Dr. Wei Fang. All models listed in this book can be downloaded from Dr. Wei Fang's home page. The URLs of the web sites are as follow:

http://ecaaser3.ecaa.ntu.edu.tw/weifang/cuc/index.htm
http://ecaaser5.ecaa.ntu.edu.tw/weifang/cuc/index.htm

Both of us hope all readers can run all models in the new computer environment.

In Nagasaki and Taipei
January 2002

Tadashi Takakura and Wei Fang