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Nota di contenuto	1 Introduction -- 1.1 Levels of understanding of crop growth -- 1.2 Growth factors and production situations -- 1.3 CO <sub>2</sub> assimilation as a basis -- 1.4 Some general modelling considerations -- 1.5 Outline of the book -- 2 The main seasonal growth pattern -- 2.1 Introduction -- 2.2 The growth phases -- 2.3 Exponential-linear growth: one equation -- 2.4 A special case: $r_m$ , $c_m$ , $p_1$ and $s$ are constant -- 2.5 Application for variable weather conditions -- 2.6 Generalization on approaching the senescence phase -- 2.7 A term for losses due to maintenance respiration -- 2.8 Additional exercises -- 2.9 Solutions to the exercises -- 2.10 Symbols and acronyms used in Chapter 2 -- 3 Climatic factors -- 3.1 Importance of the diurnal course -- 3.2 The daily progress of the incident global radiation -- 3.3 Temperature -- 3.4 Humidity -- 3.5 Wind speed -- 3.6 Annual temperature course -- 3.7 Additional exercises -- 3.8 Solutions to the exercises -- 3.9 Symbols and acronyms used in Chapter 3 -- 4 Assimilate flow and respiration -- 4.1 Introduction -- 4.2 Growth and respiration -- 4.3 Short-circuiting the assimilate pool on the long-term -- 4.4 Growth respiration and chemical composition -- 4.5 Maintenance respiration -- 4.6 Additional exercises -- 4.7 Solutions to the exercises -- 4.8 Symbols and

acronyms used in Chapter 4 -- 5 Development and growth -- 5.1 Introduction -- 5.2 Development stages -- 5.3 Development rate and environmental factors -- 5.4 Distribution of dry matter and development stage -- 5.5 Leaf area growth -- 5.6 Solutions to the exercises -- 5.7 Symbols and acronyms used in Chapter 5 -- 6 Radiation in crops -- 6.1 Introduction -- 6.2 A model crop with black horizontal leaves -- 6.3 Black leaves that are not horizontal -- 6.4 Horizontal leaves that are not black -- 6.5 Scattering leaves, non-horizontal -- 6.6 Scattering by leaves and soil -- 6.7 Distribution of absorption of light over the leaf canopy -- 6.8 Clustering -- 6.9 Additional exercise -- 6.10 Solutions to the exercises -- 6.11 Symbols and acronyms used in Chapter 6 -- 7 Leaf energy balance and transpiration -- 7.1 Introduction -- 7.2 Energy balance of a non-transpiring leaf -- 7.3 Thermal ('long-wave') radiation:  $3 - 20 \mu\text{m}$  -- 7.4 Evaporation from a wet surface -- 7.5 Leaf transpiration -- 7.6 Units of conductance:  $\text{m s}^{-1}$  or  $\text{mol m}^{-2} \text{s}^{-1}$  -- 7.7 Notation with the coupling factor  $\Omega$  -- 7.8 Additional exercises -- 7.9 Solutions to the exercises -- 7.10 Symbols and acronyms used in Chapter 7 -- 8 Analysis of leaf  $\text{CO}_2$  assimilation -- 8.1 Introduction -- 8.2 The photosynthesis-light response curve -- 8.3 The light and dark processes in  $\text{CO}_2$  assimilation -- 8.4 Limitation by low  $\text{CO}_2$  -- 8.5 Maximal photosynthetic capacity (at both high light and high  $\text{CO}_2$ ) -- 8.6 Limitation by low light -- 8.7 The  $\text{C}_3$  cycle, photorespiration and the  $\text{CO}_2$  compensation point -- 8.8 Temperature -- 8.9 Additional exercises -- 8.10 Solutions to the exercises -- 8.11 Symbols and acronyms used in Chapter 8 -- References -- Appendix 1 Richards and Gompertz functions -- A1.1 Richards function -- A1.2 Gompertz function -- Appendix 2 Gaussian integration in simulation modelling -- A2.1 Introduction -- A2.2 Canopy photosynthesis -- A2.3 Solution to the exercise -- Appendix 3 SUCROS1 — A crop growth model for potential production -- A3.1 Introduction -- A3.2 Initial conditions -- A3.3 Crop development (Chapter 5) -- A3.6 Carbohydrate production (Chapter 4) -- A3.7 Maintenance (Chapter 4) -- A3.8 Dry matter partitioning (Chapter 5) -- A3.9 Growth of plant organs and translocation (Chapters 4 and 5) -- A3.10 Leaf and ear development (Chapter 5) -- A3.11 Dry matter production -- A3.12 Weather data (Chapter 3) -- A3.13 Carbon balance check (Chapter 4) -- A3.14 Run control -- A3.15 Structure and listing of the model -- A3.16 Definition of the abbreviations used in SUCROS1 -- Appendix 4 SUCROS1 — adapted for soil reflection -- Appendix 5 The FORTRAN Simulation Translator (FST), a simulation language -- A5.1 Introduction -- A5.2 The structure of the model -- A5.3 FST example program simulating logistic growth -- A5.4 Comment lines and FST statements -- A5.5 Rules for FST keywords, variable names and values -- A5.6 Definition of input values of the model (PARAMETER, INCON, CONSTANT, FUNCTION) -- A5.7 Hierarchy of operations in expressions, and the use of FST functions and FORTRAN functions -- A5.8 FST keywords for output (TITLE, PRINT, OUTPUT) -- A5.9 FST run control keywords (TRANSLATION\_GENERAL, TRANSLATION\_FSE, TIMER, FINISH) -- A5.10 Weather data in FST programs (WEATHER) -- A5.11 Rerun facility, the END keyword -- A5.12 FORTRAN subroutines with FST, the STOP keyword -- Appendix 6 Derivation of the equations for exponential extinction of horizontal, non-black leaves (after Goudriaan (1977), pg 13–14).

## Sommario/riassunto

We dedicate this book to professor C. T. de Wit (1924 - 1993) who initiated Production Ecology as a school of thought at the Wageningen Agricultural University (see Rabbinge et al., 1990). To acknowledge the leading role of C. T. de Wit, a recently formed graduate school at

this university in Production Ecology was named after him. Production Ecology is the study of ecological processes, with special attention to flows of energy and matter as factors that determine the productivity of ecological systems. Agro-ecosystems are a special case of ecosystems which are much better suited for the productivity approach than natural ecosystems are. This is the reason for the strong role of agricultural research in production ecology. On the other hand, it must be recognized that the spatial heterogeneity of natural ecosystems and their species richness may alter some ecophysiological relationships. However, the basic physical, chemical and physiological processes will be the same. De Wit introduced the state variable approach as the basis for simulation modelling. In this approach the floating character of nature is schematized into a series of snapshots over time in which the states are frozen at each separate moment. The current state determines how the rates of change will lead to the next snapshot. This way of thinking enables a clear and workable representation of interacting simultaneous processes, without compromising on the mathematics.

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