5.1 Introduction

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In the preceding chapters of this book, three production situations have been discussed that differ with respect to the number of land qualities that influence plant performance. In each situation, the influence of the land quality or land qualities concerned (i.e. intercepted solar radiation, water availability, nutrient status) on plant performance is described in a number of functional relations. All functional relations that play a role in a given production situation are included in the crop production model for that situation. It is important to realize that a model cannot predict crop production. The production estimate that is computed is entirely determined by the user of the model who defines the crop characteristics and the production environment in a set of basic data; a model merely makes the consequences of the user's data selection visible.

It follows that the quality and reliability of the generated production estimates cannot surpass the quality of the available basic data and therefore basic data must be sufficiently accurate and complete. Basic data used in the present model can be grouped into four categories:

- basic weather data
- basic plant data
- basic soil/land data
- basic management data.

These same headings are used in Tables 48, 49, and 50, in which the minimum basic data requirements for production calculations under Production Situations 1, 2 and 3 are summarized.

Data within one category are not necessarily all of the same nature. Three different types of data can be distinguished. The first type concerns data that are characteristic for a certain location or land use. Such data do not change in the course of a crop cycle. They are 'CONSTANTS'. Examples of these are such soil physical characteristics as total pore space and saturated hydraulic conductivity, and plant characteristics such as the threshold temperature for development or the maximum rate of CO_2 assimilation of single leaves. The second type pertains to data that do vary with time, but their variation is independent of the crop production process. The variables themselves do, however, influence system behaviour. They are therefore called 'FORCING VARIABLES'. Rainfall, temperature and irradiance are examples of forcing variables. The third type are again variables, but variables of this type change in value in an endogenous way, i.e. as a result of the calculations. Their values must be initialized by the user at the beginning of the computations, after

Table 48. Basic data requirements for the simulation of crop performance in Production Situation 1. Variety, location and crop calendar must be known.

Symbol	Description	Source
Weather data		
H_g	total radiation on clear day ($J\ m^{-2}d^{-1}$)	Table 2
H_a	measured total radiation ($J\ m^{-2}d^{-1}$)	Meteorological Serv
T_a	measured air temperature (°C)	Meteorological Serv
Plant data		
k_e	extinction coefficient for visible light	normally $k_e = 0.8$
SLA	specific leaf area ($m^2\ kg^{-1}$)	Table 51
F_{cl}	gross assimilation rate on clear day ($kg\ CO_2 ha^{-1}d^{-1}$)	Table 1
F_{ov}	gross assimilation rate on overcast day ($kg\ CO_2 ha^{-1}d^{-1}$)	Table 1
F_g	maximum rate of gross CO_2 assimilation of a single leaf ($kg\ CO_2 ha^{-1} h^{-1}$)	C_3 crops: $F_g = 40$ C_4 crops: $F_g = 70$
E_g	conversion efficiency kg dry matter ($kg^{-1}CH_2O$)	Table 4
R_m	relative maintenance respiration rate ($kg\ CH_2O\ kg^{-1}$ dry matter d^{-1})	Table 4
TU_{pre}	temperature sum before anthesis (d °C)	This volume and a mic literature
TU_{post}	temperature sum after anthesis (d °C)	This volume and a mic literature
T_O	threshold temperature (°C)	Table 7 and agronc terature
WLVI	leaf dry weight at beginning of the first interval ($kg\ ha^{-1}$)	This volume and agı
WI	total dry weight at beginning of the first interval ($kg\ ha^{-1}$)	nomic literature

which they remain invariate for the duration of one time interval. Thus they reflect the state of the system at any moment, which explains why they are termed 'STATE VARIABLES'. Examples of state variables are the soil — moisture content and the weight of the leaf mass. A rate of change calculated for one time interval is used to update the variable value at the end of the calculations. The updated value is then used as an input for the calculation of system behaviour during the next interval.

Table 49. Additional basic data requirements for the simulation of crop performance in Pı Situation 2.

Symbol	Description	Source
Weather data		
P	gauged rainfall rate (cm d^{-1})	Meteorological service
E_0	potential evaporation rate (cm d^{-1})	Meteorological service Section 2.1
ET_0	potential evapotranspiration rate (cm d^{-1})	Meteorological service Section 2.1
Plant data		
p	soil water depletion factor	Table 20
RDI	rooting depth at beginning of first time interval (cm)	This volume and agron literature
Soil/land data		
$\varnothing$	slope angle of the land (°)	Contour maps
$z_t(i)$	groundwater depth at beginning of first time interval (cm)	This volume and maps/ surements
$SS_t(i)$	surface storage at beginning of first time interval (cm)	This volume and field c servations
SM_0	total pore space (cm^3 cm^{-3})	Table 16 + soil reports
γ	texture-specific geometry factor (cm^{-2})	Table 16 + soil reports
S_0	standard sorptivity (cm $d^{-1/2}$)	Table 18 + soil reports
A	transmission zone permeability (cm d^{-1})	Table 18 + soil reports
k_0	saturated hydraulic conductivity (cm d^{-1})	Table 17 + soil reports
a	texture-specific constant ($cm^{2.4}$ d^{-1})	Table 17 + soil reports
α	texture-specific constant (cm^{-1})	Table 17 + soil reports
ψ_{max}	texture-specific suction limit (cm)	Table 17 + soil reports
$\psi(i)$	matric suction at beginning of first time interval (cm)	This volume and field observations
Management data		
I	rate of water release at headworks	User-defined/ Irrigation authority
E_d	field application efficiency factor	Table 19
E_f	field canal efficiency factor	Table 19
E_i	conveyance efficiency factor	Table 19
d	surface roughness (cm)	User defined/this volume
σ	clod/furrow angle (°)	normally: $\sigma = 30$
DD	drain depth (cm)	Irrigation authority
L_d	drain spacing (cm)	Irrigation authority
r_d	drain radius (cm)	Irrigation authority

Table 50. Minimum basic data set, needed for estimation of the nutrient requirement (Production Situation 3).

Symbol	Description	Source
Plant data		
N_Y	minimum nitrogen concentration in marketable product (kg kg^{-1})	This volume and agronomic literature
$N_{(P-Y)}$	minimum nitrogen concentration in crop residue (kg kg^{-1})	This volume and agronomic literature
N_A	actual nitrogen concentration in plant tissue (kg kg^{-1})	Chemical analysis
Management data		
Y_c	control yield of fertilizer experiment (kg ha^{-1})	Agronomic literature
Y_{Ax}	yield obtained on experimental plot fertilized with A kg ha^{-1} of nutrient x	Agronomic literature
A_x	application of nutrient x in fertilizer (kg ha^{-1}).	Agronomic literature

Exercise 64

Carefully examine the input data listed in Tables 48 and 49 and specify for each entry whether it is a constant, a forcing variable or a state variable.
Explain why the input data listed in Table 50 (for Production Situation 3) cannot be classified in constants, forcing variables and state variables. Read once more the introduction to Section 4.1 before attempting to answer this question.

It has been argued before that the quality of the model results cannot be better than the quality of the input data. If complete, accurate and sufficiently detailed basic data are lacking, even the most sophisticated simulation exercise becomes futile. Perfect basic data sets are rarely available. In most practical situations, data sets are incomplete or partly of unknown quality.The gaps must then be filled with approximate data or 'default values'. In some instances, standard values can be used that are, for all practical purposes, not too far from the truth. Examples have been presented in the preceding chapters (e.g. F_g for a C_3 crop equals 40 kg ha^{-1} h^{-1}; all texture – related soil parameters). Where indicative standard data cannot be used, approximate data must be estimated by the user of the model. This can, in some instances, be done with an interpolation or extrapolation routine (e.g. weather data for areas between meteorological stations). In other cases, the help of a specialist with local experience, who can make reliable estimates by interpreting a qualitative or semi – quantitative description of the production environment, is required. Soil survey reports are examples of such descriptions from which semi – quantitative information can be inferred.

The models presented so far are essentially mathematical descriptions of processes that take place in plant production and the effects of specific environmental conditions on these processes. Clearly plant production is a complex affair and an in – depth analysis of all factors and processes involved is beyond the scope of this book. Attention has therefore been focussed on only the most important aspects of plant production, which have been described in a number of necessarily simple mathematical relations. (Gross simplification is not the exclusive hallmark of the approach presented here; some aspects of plant production are still poorly understood and must be described in an oversimplified fashion in any model). These necessary simplifications are another reason why the fit between observed and simulated plant performance is normally less than perfect. However, such structural imperfections are likely to become less disturbing in the future as better methodologies are developed.

There is also a possibility that the generated production figures deviate from observed figures for reasons that cannot be attributed to inaccuracies in the data base or the model itself. Production could be affected by factors that are not considered in the simulation procedure. The possible occurrence of extreme temperatures, storms, specific soil disorders or endemic diseases are but a few examples. For this reason it is prudent to apply the suggested production calculations only to the regions where the crop concerned is actually grown. Even then, the calculation results should not be regarded as an accurate prediction of crop yields but rather as a useful quantitative approximation of the productive capacity of land under conditions as defined.

In the following sections, the availability, determination and relevance of a number of important weather, soil and plant data will be discussed. In addition, some attention will be given to major environmental disorders that might affect plant performance or preclude production altogether.