

Contents

Acknowledgment	1
1 Introduction	3
I Theory of field water use	7
2 Basics of water flow in unsaturated soils	9
2.1 Soil water potential	9
2.2 Soil moisture characteristic and hydraulic conductivity curve	10
2.3 Soil water flow	14
3 Water uptake by plant roots	16
3.1 Mathematical description	16
3.2 Limitation of uptake by potential transpiration	21
4 Numerical approximation of flow in soil-root systems	31
4.1 Initial and boundary conditions	31
4.2 Finite difference approximation	35
II Theory of crop production	41
5 Mathematical description of growth	43
6 Water and actual production	52
7 Calculation of potential production	56
III The programs	65
8 Program for field water use, SWATR	67
8.1 General description	67
8.1.1 Coding of the program	67
8.1.2 Soil physical properties	69
8.1.3 Discretization of the soil profile	70
8.1.4 Initial and boundary conditions	72
8.1.5 Sink term	76

8.1.6	Compilation of subroutines	78
8.2	Field experiments	80
8.2.1	Red cabbage on sticky clay	80
8.2.2	Potatoes on loamy sand	81
8.3	Experimental verification	82
8.3.1	Red cabbage on sticky clay	82
8.3.2	Potatoes on loamy sand	96
8.4	Numerical experiments	100
8.5	Conclusions	108
9	Program for crop production, CROPR	109
9.1	General description	109
9.2	Field experiments	114
9.2.1	Red cabbage on sticky clay	114
9.2.2	Potatoes on loamy sand	114
9.2.3	Grass on silty clay	114
9.3	Experimental verification	115
9.3.1	Red cabbage on sticky clay	115
9.3.2	Potatoes on loamy sand	118
9.3.3	Grass on silty clay	121
9.4	Numerical experiments	123
9.4.1	Influence on potential yield Q_{pot}	123
9.4.2	Influence on actual yield Q_{act}	124
9.5	Conclusions	125
10	Execution of SWATR	126
10.1	Listing of program	126
10.2	Instructions for input	143
10.3	Example of input	162
11	Execution of CROPR	165
11.1	Listing of program	165
11.2	Instructions for input	170
11.3	Example of input	177
Appendix A	List of used symbols	179
References		183