CROP–SOIL SIMULATION MODELS

Applications in Developing Countries

Edited by
R.B. Matthews and W. Stephens

NRSP
DFID Natural Resources Systems Programme

CABI Publishing

Contents

Contributors ix

Abbreviations x

Preface xiii

1 Introduction 1
Robin Matthews

Part 1: Models as tools in research 7

2 Models as Research Tools 9
Robin Matthews

3 Crop Genotype Improvement 13
Robin Matthews
3.1 Identification and Evaluation of Desirable Plant Characteristics 14
3.2 Environmental Characterization 19
3.3 G×E Interactions 22

4 Crop Management 29
Robin Matthews
4.1 Yield Gap Analysis 29
4.2 Soil Surface Management 33
4.3 Planting 33
4.4 Water Management 37

4.5 Nutrient Management 41
4.6 Pest and Disease Management 47
4.7 Weed Management 49
4.8 Harvesting 53

5 Cropping and Farming Systems 55
Robin Matthews
5.1 New Crops and Cropping Systems 55
5.2 Evaluating Sustainability 58
5.3 Farm Household Models 63

6 Regional and National Planning 69
Robin Matthews
6.1 Linear Programming Approaches 70
6.2 Dynamic Simulation Approaches 74
6.3 Limitations 76
6.4 Impact 77

7 Global Level Processes 79
Robin Matthews and Reiner Wassmann
7.1 Impact of Climate Change on Rice Production 80
7.2 Greenhouse Gas Production 86
7.3 The El Niño-Southern Oscillation 90

Part 2: Models as decision-support tools **93**

8 Decision Theory and Decision Support Systems 95
William Stephens
8.1 Decisions, Decisions, Decisions 95
8.2 Characteristics of Decision Making 95
8.3 Definitions of Decision Support Systems 97
8.4 Spatial and Temporal Scale 101
8.5 Application 102

9 Tools to Support Operational Decision Making 105
William Stephens and Tabitha Middleton
9.1 Pest Management 105
9.2 Irrigation Scheduling 109
9.3 Optimizing Fertilizer Application 112
9.4 Multiple Decision Support 113
9.5 Deciding whether to Implement Emergency Relief 114

10 Tools to Support Strategic Decision Making 117
William Stephens and Tabitha Middleton
10.1 Land-use Planning 117

10.2 Planning for Climate Change 120
10.3 Crop Forecasting 121
10.4 Irrigation Planning 123
10.5 Assessing the Benefit of Proposed New Technologies 124
10.6 Planning Optimum Farm Management Strategies in Collaboration with Extension Services and Farmers 125

11 Why has the Uptake of Decision Support Systems been so Poor? 129
William Stephens and Tabitha Middleton
11.1 Model Construction Constraints 132
11.2 Marketing and Support Constraints 136
11.3 Technical and Operational Constraints 141
11.4 User Constraints 143
11.5 Other Constraints 144
11.6 Criteria for Success of Decision Support Systems 145
11.7 Risks Associated with using Decision Support Systems 146

Part 3: Models as tools in education and training 149

12 Using Models as Tools in Education and Training 151
Anil Graves, Tim Hess and Robin Matthews
12.1 Introduction 151
12.2 Using Existing Simulation Models 152
12.3 Model Building 163
12.4 Transferring the Systems Approach to Less-developed Countries 165
12.5 Considerations for Education and Training 173
12.6 Limitations and Constraints of Models in the Educational Context 178

Part 4: Have crop models been useful? 183

13 Who are Models Targetted at? 185
Robin Matthews
13.1 Researchers 186
13.2 Consultants 187
13.3 Educators and Trainers 188
13.4 Policy Makers 189
13.5 Extensionists 190
13.6 Farmers 191

14 Impacts of Crop–Soil Models 195
Robin Matthews, William Stephens and Tim Hess
14.1 Limitations to Use 195

14.2 Constraints to the Uptake of Crop Models 196
14.3 Characteristics for Impact 198
14.4 Concluding Remarks 205

Part 5: The way forward **207**

15 Where to Now with Crop Modelling? 209
Robin Matthews
15.1 Modelling Rural Livelihoods 211
15.2 Contribution to Crop Improvement Programmes 217
15.3 Making Information Available – Decision Support Systems 219
15.4 Integrating Model Use into Research and Extension Projects 221
15.5 Environmental Research 224
15.6 Building Modelling Capacity 226
15.7 Further Crop–Soil Model Development 227
15.8 Summary 229

16 Concluding Remarks 231
Robin Matthews and William Stephens

References 235

Appendix: Personal Communications 267

Index 271