Contents

Preface xi

Part I Farming systems and their biological components 1

1 Agricultural systems 3
   1.1 On the nature of agriculture 3
   1.2 Unifying themes 8
   1.3 Maintenance of agricultural systems 20
   1.4 Review of key concepts 21

2 Trophic chains 23
   2.1 Plant production 23
   2.2 Trophic systems in agriculture 27
   2.3 Animal and human nutrition 30
   2.4 Carrying capacity 39
   2.5 Review of key concepts 42

3 Community concepts 44
   3.1 Community change 44
   3.2 Biomass accumulation 45
   3.3 Responses to crowding in monocultures 53
   3.4 Competition in polycultures 58
   3.5 Community response to limiting factors 66
   3.6 Review of key concepts 69

4 Genetic resources 71
   4.1 Genetic diversity in agriculture 71
   4.2 Change in genetic structure 74
   4.3 Cultivar development 81
   4.4 Genetic advance and maintenance of diversity 88
   4.5 Review of key concepts 94
## Contents

### Part I Development

5 Development  
5.1 Developmental time 96  
5.2 Developmental switches 100  
5.3 Quantifying phenological response 106  
5.4 Seed germination and dormancy 112  
5.5 Crop improvement 118  
5.6 Review of key concepts 121

### Part II Physical and chemical environments

6 Aerial environment  
6.1 Radiation concepts 125  
6.2 The SW source 128  
6.3 Sun–Earth geometry 129  
6.4 SW penetration of the atmosphere 131  
6.5 Radiation balance 134  
6.6 Energy balance 137  
6.7 Turbulent transport 142  
6.8 Advection 146  
6.9 Microclimate 148  
6.10 Climate and weather 150  
6.11 Key concepts 156

7 Soil resources  
7.1 Soil chemistry 159  
7.2 Soil formation 162  
7.3 Soil types and uses 171  
7.4 Soil properties 173  
7.5 Water and air components 181  
7.6 Soil temperature relations 187  
7.7 Review of key concepts 190

### Part III Production processes

8 Nitrogen processes  
8.1 The nitrogen cycle 195  
8.2 Decay and immobilization 200  
8.3 Mineralization and nitrification 202  
8.4 Loss of nitrogen 203  
8.5 Assimilation of mineral nitrogen by plants 207  
8.6 Nitrogen fixation 208  
8.7 Example nitrogen cycles 214
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.8</td>
<td>Farming with organic sources of nitrogen</td>
<td>219</td>
</tr>
<tr>
<td>8.9</td>
<td>Review of key concepts</td>
<td>226</td>
</tr>
<tr>
<td>9</td>
<td>Water relations</td>
<td>229</td>
</tr>
<tr>
<td>9.1</td>
<td>Flow of water through a crop</td>
<td>229</td>
</tr>
<tr>
<td>9.2</td>
<td>Evapotranspiration</td>
<td>232</td>
</tr>
<tr>
<td>9.3</td>
<td>Collection of water by root systems</td>
<td>237</td>
</tr>
<tr>
<td>9.4</td>
<td>A model of crop water balance</td>
<td>241</td>
</tr>
<tr>
<td>9.5</td>
<td>Responses of crops to water shortage</td>
<td>243</td>
</tr>
<tr>
<td>9.6</td>
<td>Adaptation to drought</td>
<td>244</td>
</tr>
<tr>
<td>9.7</td>
<td>Water-use efficiency</td>
<td>257</td>
</tr>
<tr>
<td>9.8</td>
<td>Review of key concepts</td>
<td>260</td>
</tr>
<tr>
<td>10</td>
<td>Photosynthesis</td>
<td>262</td>
</tr>
<tr>
<td>10.1</td>
<td>Photosynthetic systems</td>
<td>262</td>
</tr>
<tr>
<td>10.2</td>
<td>Leaf photosynthesis</td>
<td>265</td>
</tr>
<tr>
<td>10.3</td>
<td>Canopy photosynthesis</td>
<td>276</td>
</tr>
<tr>
<td>10.4</td>
<td>Modeling canopy photosynthesis</td>
<td>280</td>
</tr>
<tr>
<td>10.5</td>
<td>Canopy structure for productivity and competitiveness</td>
<td>283</td>
</tr>
<tr>
<td>10.6</td>
<td>Review of key concepts</td>
<td>289</td>
</tr>
<tr>
<td>11</td>
<td>Respiration and partitioning</td>
<td>292</td>
</tr>
<tr>
<td>11.1</td>
<td>Carbon use in respiration and synthesis</td>
<td>292</td>
</tr>
<tr>
<td>11.2</td>
<td>Growth respiration and growth yield</td>
<td>296</td>
</tr>
<tr>
<td>11.3</td>
<td>Seasonal patterns of crop respiration</td>
<td>300</td>
</tr>
<tr>
<td>11.4</td>
<td>Morphological aspects of partitioning</td>
<td>302</td>
</tr>
<tr>
<td>11.5</td>
<td>Ideotype concepts</td>
<td>314</td>
</tr>
<tr>
<td>11.6</td>
<td>Review of key concepts</td>
<td>317</td>
</tr>
<tr>
<td>Part IV</td>
<td>Resource management</td>
<td>321</td>
</tr>
<tr>
<td>12</td>
<td>Soil management</td>
<td>323</td>
</tr>
<tr>
<td>12.1</td>
<td>Spatial variability</td>
<td>323</td>
</tr>
<tr>
<td>12.2</td>
<td>Plant nutrition</td>
<td>325</td>
</tr>
<tr>
<td>12.3</td>
<td>Management of soil fertility</td>
<td>330</td>
</tr>
<tr>
<td>12.4</td>
<td>Fertilizer practices</td>
<td>334</td>
</tr>
<tr>
<td>12.5</td>
<td>Tillage systems</td>
<td>341</td>
</tr>
<tr>
<td>12.6</td>
<td>Drainage</td>
<td>346</td>
</tr>
<tr>
<td>12.7</td>
<td>Erosion</td>
<td>348</td>
</tr>
<tr>
<td>12.8</td>
<td>Land value and capability</td>
<td>354</td>
</tr>
<tr>
<td>12.9</td>
<td>Review of key concepts</td>
<td>356</td>
</tr>
</tbody>
</table>
# Contents

## 13 Strategies and tactics for rainfed agriculture

13.1 Agriculture in wet regions

13.2 Principles for efficient use of water

13.3 Patterns of water shortage and crop types

13.4 Optimum patterns of water use

13.5 Cultivars and sowing time

13.6 Crop rotations and fertilizer

13.7 Density and planting arrangement

13.8 Fallow

13.9 Simulation models and analyses of cropping strategies

13.10 Review of key concepts

---

## 14 Water management in irrigated agriculture

14.1 Irrigation and world food supply

14.2 Water and salt – an inescapable combination

14.3 Salinity and alkalinity

14.4 Efficiencies of water use in irrigation

14.5 Water use and productivity

14.6 Irrigation methods

14.7 Irrigation scheduling

14.8 Management of water supply and drainage

14.9 Selection of areas for irrigation schemes

14.10 Review of key concepts

---

## 15 Energy and labor

15.1 Sources and utilization of energy

15.2 Energy in food production

15.3 Improving efficiency of energy use

15.4 Low-input farming

15.5 Crops for energy

15.6 Review of key concepts

---

## Part V Farming past, present, and future

## 16 Evolution of wheat production systems in southern Australia

16.1 The wheat belt of Northwest Victoria

16.2 Evolving systems

16.3 Initial development (1840 to 1900)

16.4 An early recovery (1900 to 1950)

16.5 Ley-farming (1950 to 1985)

16.6 Intensification and diversification (1985 to present)

16.7 Searching for new designs
## Contents

16.8 Role of society 455
16.9 Review of key concepts 456

17 Technological change in high-yield crop agriculture 458
17.1 Common features of high-yield systems 458
17.2 Maize–soybean cropping systems in the North American Corn Belt 459
17.3 Intensive rice cropping systems of Asia 470
17.4 Soybean-based cropping systems in Northern Mato Grosso, Brazil 476
17.5 The future of high-yield crop agriculture 481
17.6 Review of key concepts 482

18 The future of agriculture 484
18.1 Population and need for food 484
18.2 Food production since 1940 490
18.3 Immediate challenges 493
18.4 The importance of a technological agriculture 497
18.5 Improving technology 501
18.6 Review of key concepts 508

Species list  511
Conversions and constants useful in crop ecology  514
References  516
Index  546