

Contents

Preface

page 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

5	Development	96
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		123
6	Aerial environment	125
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	159
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		193
8	Nitrogen processes	195
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

8.8	Farming with organic sources of nitrogen	219
8.9	Review of key concepts	226
9	Water relations	229
9.1	Flow of water through a crop	229
9.2	Evapotranspiration	232
9.3	Collection of water by root systems	237
9.4	A model of crop water balance	241
9.5	Responses of crops to water shortage	243
9.6	Adaptation to drought	244
9.7	Water-use efficiency	257
9.8	Review of key concepts	260
10	Photosynthesis	262
10.1	Photosynthetic systems	262
10.2	Leaf photosynthesis	265
10.3	Canopy photosynthesis	276
10.4	Modeling canopy photosynthesis	280
10.5	Canopy structure for productivity and competitiveness	283
10.6	Review of key concepts	289
11	Respiration and partitioning	292
11.1	Carbon use in respiration and synthesis	292
11.2	Growth respiration and growth yield	296
11.3	Seasonal patterns of crop respiration	300
11.4	Morphological aspects of partitioning	302
11.5	Ideotype concepts	314
11.6	Review of key concepts	317
Part IV	Resource management	321
12	Soil management	323
12.1	Spatial variability	323
12.2	Plant nutrition	325
12.3	Management of soil fertility	330
12.4	Fertilizer practices	334
12.5	Tillage systems	341
12.6	Drainage	346
12.7	Erosion	348
12.8	Land value and capability	354
12.9	Review of key concepts	356

13	Strategies and tactics for rainfed agriculture	358
13.1	Agriculture in wet regions	358
13.2	Principles for efficient use of water	360
13.3	Patterns of water shortage and crop types	360
13.4	Optimum patterns of water use	361
13.5	Cultivars and sowing time	365
13.6	Crop rotations and fertilizer	367
13.7	Density and planting arrangement	369
13.8	Fallow	371
13.9	Simulation models and analyses of cropping strategies	374
13.10	Review of key concepts	382
14	Water management in irrigated agriculture	384
14.1	Irrigation and world food supply	384
14.2	Water and salt – an inescapable combination	385
14.3	Salinity and alkalinity	386
14.4	Efficiencies of water use in irrigation	391
14.5	Water use and productivity	391
14.6	Irrigation methods	393
14.7	Irrigation scheduling	401
14.8	Management of water supply and drainage	404
14.9	Selection of areas for irrigation schemes	408
14.10	Review of key concepts	409
15	Energy and labor	411
15.1	Sources and utilization of energy	411
15.2	Energy in food production	413
15.3	Improving efficiency of energy use	419
15.4	Low-input farming	423
15.5	Crops for energy	425
15.6	Review of key concepts	433
Part V	Farming past, present, and future	437
16	Evolution of wheat production systems in southern Australia	439
16.1	The wheat belt of Northwest Victoria	439
16.2	Evolving systems	441
16.3	Initial development (1840 to 1900)	442
16.4	An early recovery (1900 to 1950)	443
16.5	Ley-farming (1950 to 1985)	444
16.6	Intensification and diversification (1985 to present)	446
16.7	Searching for new designs	451

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
	<i>Species list</i>	511
	<i>Conversions and constants useful in crop ecology</i>	514
	<i>References</i>	516
	<i>Index</i>	546

