Index

Abbreviations used in this index: CAM, plants with crassulacean acid metabolism; \( E_t \), transpiration; \( E_s \), evaporation from soil; \( E_{o, ref} \), reference evapotranspiration; \( ET \), evapotranspiration; \( P_V \), production value; \( R_n \), net radiation; \( R_e \) and \( R_n \), growth-related and maintenance respiration, respectively; \( T_r \) and \( T_u \), temperature of air and soil, respectively; and \( Y_u \), true growth yield.

The symbol "'" may be read as and, or, or versus.

acetylene
assay for N fixation, 210
production by nitrogenase, 207
acid rain and soil pH, 182
acid soil see soil acidity
adaptation
drought, 240–52
temperature, 56, 71, 264–5, 270
adiabatic processes, 149, 157
advection, atmospheric, 153–4
agricultural chemicals
concerns, 485, 486–7
soil incorporation, 335
see also biocides, fertilizer, herbicides, pests
agriculture
continuum of society, 5
energy and labor, 600–22
land use, 83, 481, 482
nations compared, 481–4
food supply, 481
soil resources, 482, 484
workers in agriculture, 481
objectives of, 409
potential for increase, 483–4
recent changes, 478–82
relation to population, 31, 475–84
soils used, 176
sufficiency of, 475, 487
technological/social change, 8, 64–6, 213–15, 450, 473, 487–92
urban conflict, 484
world statistics, 82–4, 479, 481
agricultural systems, 3–10
competing regions, 451
human resources, 79
important attributes, 4–6
maintenance of, 78–9
modern agriculture, 492–3
alternatives to, 221–2, 485–7
see also low-input agriculture, organic farming
agroforestry, 287, 447

air see atmosphere, CO₂
air temperature (\( T_r \))
dew point, 148
diurnal pattern, 145–6
global trend, 162
plant response, 55–6
C3/C4 photosynthesis, 264–5
diurnal, 189, 304–5
flowering, 106–8, 112–14
growth/photosynthesis, 264
respiration, 292–3
species classified, 56
profile in canopy, 155
sensible heat flux (\( H_f \)), 145–7
wet bulb, 149
albedo, 144
alfalfa
as feed, 24
composition, 15
energy content of irrigation, 391, 392
N nutrition, 210–11
photosynthesis, 273–4, 276
respiration, 298
satiety tolerance, 383
seed production, 98, 309
synthetic cultivars, 92
trap crop for lygus, 74
alkaline soil, 379–85, 398–7
allopathy, 43
aluminum toxicity, 180, 448
amaranth, 84
ammonia, in human diet, 26, 27
ammonification, 201–2
deposition, 206
fertilizer, 207, 329–30
volatilization, 205–6
from leaves, 206, 260
from animal manures, 215, 219, 220, 466–7, 471
animal manures, 218–21
animal parasites, 216, 219
application to fields, 212–13, 214–6, 220–1, 222, 466–9
decay series, 221, 468
Dutch dairies, 214–16
medieval farm, 212–13
yield variation, 66
collectible supply, 218, 467
energy source, 421, 422
handling and composition, 218–20
Iowa farm, 466–9
nitrate leaching, 181, 204–5, 216
weed seed, 219
see also ammonia volatilization
animal nutrition, 19–26
digestive systems, 19–20
feeds and feeding, 21–4
beef cattle, 24, 463–5
C3/C4 grasses, 265
concentrate/roughage, 23–4, 25–6
dairy cattle, 26, 29
sheep, 439
net energy concepts, 21–3
TDT concept, 21, 463–5
animal power, 23, 25
energy efficiency, 23, 401
feed requirements, 23, 25
compared with tractors, 401–2, 488
animal yield, 21–2, 24–6, 463, 466
ammonia exchange in soil, 178
antagonism (polyculture), 49
arable land, world, 83
potential, 383–4
assimilate supply
control of growth, 246, 304–7
limit to photosynthesis, 269–70
mobilization, 247–8
preassimilation assimilate, 353, 355
sources/sinks, 303
transport as sucrose, 269, 289
use in respiration/growth, 302
associative N fixation, 208
atmosphere
absorption of radiation, 138–42
atmospheric window, 141, 160–1
circulation and climate, 157–8
general circulation model (GCM), 76
inversion, 158
LW emission, 142
atmospheric transport, 150–6
advection, 153–4
buoyancy, 146–7, 150
Bowen ratio, 145
convective heat flux, 146–7
in canopy, 155–6
mixing height, 147–8, 152–3
photosynthesis, 152, 272
vapor dilution, 147
see also wet and dry deposition
autonomy of farming, 5, 487
available water (soil) (AW), 185, 186, 191
models of water use, 236–7, 374, 375
avoidance of stress, 240–1
Azolla, N fixation, 208
barley
CO₂ exchange, 299, 300
composite crosses, 88–9
genetic shift, 91
mulchlines, 96
salt tolerance, 381, 382, 383
basal metabolism, 21–2, 27
bean, field
determinate/determinate, 311
flowering, 108
mixed cropping, 287
overlap crop, 54, 285
photosynthesis, 274, 276
salt tolerance, 382, 383
temperature response, 56
yield components, 307–8, 311, 312
beef cattle
breeds, 462
feeds and feeding, 24–6, 463–5
grazing management, 461–2
N budget, 466
export of N, 445, 466, 471
N loss in manure, 466–7
production practices, Iowa, 462–5
Beet’s Law, 37
biocides, 416–17, 491–2
integrated pest management (IPM), 74, 491–2
problems/alternatives, 76–9, 485–8, 490–2
stabilizing effects, 65
substitute for land/labor, 491
see also herbicides, pests
biological control, 490–1
biomass, 11
accumulation by crops, 34–6
effect of density, 43–4
effect of N, 323
forages, 39
bulk density, 420
composition, 15, 297, 321, 445, 455
energy crops, 420–4
soil fauna, 171
soil microbes, 171, 199
biotechnology, 97
black body radiation, 131–3
bluegrass pasture, 461–2
blue-green algae, 198
border effects, fields, 154
Bouger-Lambert Law, 36–7, 274
Bowen ratio (θ), 153–4
buoyancy of air, 146–7, 150
burning
crop residues, 201, 333, 437
effect on
seed banks, 127
succession, 33, 454
soil pH, 181–2

522 Index

C3/C4 photosynthesis, 259–60, 269–71
in CAM, 260–1
leaf N, 265–6, 271
leaf structure, 267–8
phloem respiration, 262
production rates, 40–2
temperature relations, 264–5
transpiration efficiency, 254–5, 358
calcium
plant composition, 321, 445
soil solution, 180
soil structure, 177
CAM see crassulacean acid metabolism
cancer, risk from biocides, 76–8

canopy
acclimation to crowding, 276, 279
aerodynamic roughness, 150–1
analytical model, 274, 277
CO2 exchange profiles, 276–8
diffusive resistance, 225, 249–50
dynamics, 280–3
effects of water stress, 245–6
light interception, 36–8, 274–5
direct/diffuse radiation, 278–80
grass/clover, 37, 285–6
light profile, 37, 276–7
microclimate, 155–7
R, exchange, 157
temperature, 155, 156
irrigation scheduling, 392
canopy photosynthesis
barley, 299–300
canopy architecture, 275–83
crop respiration, 276–9
relation to interception, 274–5
canopy structure, 37–9, 257, 275–83
diversity, 37, 285–6
radiation-use efficiency, 262
trellis, 284–5
capeweed, 440, 441
carbohydrate see assimilate supply, composition of plant material
carbon
in biomass, 10, 320, 321
in soil, 172, 173
isotopes, 267, 269
oxidation-reduction levels, 295
soil acidification, 180
carbonic anhydrase, 260
carboxylase enzymes, 13, 259–60, 265
cardinal temperatures, 56, 107
carrying capacity, 28–9; see also
human carrying capacity, stocking rate
cassava
C3–C4 intermediate, 261
drought resistance, 352
leaf diffusive resistance, 249
overlap cropping, 54
stability of cultivars, 64
cation-anion balance
in biomass, 180–1
transfer in manure, 218
cation exchange capacity (CEC), 177–8
cattle, see beef cattle or dairy cattle
digestive system, 19–20
cedar, 19–20
cellulase enzymes, 19
cellulose see wall material
cereal cyst nematode, 359, 360, 442
cereals, see also specific crops
trade, 481, 484
world production, 82–4
change, 478–9
per capita, 479–81
channel analogy, partitioning, 303
chemical activity, 104–5
of water, 183
chilling injury, 264
clay minerals, 168, 170–1
stability diagrams, 170, 179
surface properties, 176
climate, 157–62
Australian wheat–sheep zone, 428, 430–1, 432
classification of, 158–60
crop substitution, 71–2, 76, 350–2
dependence on energy balance, 145
drought, 238–40
general circulation models, 76
Iowa, 453
Mediterranean, 428
modified by topography, 158
soil properties, 172–3
climate change, 76, 159–62
effects on agriculture, 76, 162
historic patterns, 160
Milankovich theory, 159–60
volcanos, 160
climate vegetation, 33
cloonal lines, 85, 92, 102
clothesline effect, 361
cloudiness and solar radiation, 140
clover
generic shift, 92–3
light interception, 37, 285–6
N carry-over, 217
N fixation, 444, 448
photosynthesis, 282
red clover, 461
salinity tolerance, 383
subterranean clover, 440
soil seed bank, 127, 442
C:N of microbrial biomass, 199
residues/manure, 171, 200–1
effect on N immobilization, 200, 333
soil organic matter, 171–4
CO2 assimilation, 10–11, 153
atmospheric–ocean equilibrium, 161
atmospheric transport, 152–3, 156
isotope discrimination, 267
mixing height, 152–3
concentration, [CO2], 161
atmospheric trend, 161
diurnal over maize, 152
Index

523

greenhouse effect, 141–2, 161
in leaves (C), 258, 260, 264
photosynthetic response, 264, 265, 271
profile in canopy, 155–6
soil, 287
coefficient of economic yield, 11
coefficient of variation (CV), 62
companion crop, 54, 434, 460
competition, 42–52
additive effects, 49
direct/indirect effects, 43
exclusion hypothesis, 47
importance of, 48
monoculture, 42–7

effect of density, 43–6, 307–9, 361
monoculture/poly culture, 59
N supply, 285–6
water supply, 33, 244–5
complementation, polyculture, 49, 50–2
composition of plant material
elemental, 296–7, 320, 321, 445, 455
methods of analysis, 13–14, 296, 326–8
proximate, 13–15, 293–5
concentrate, animal feed, 23, 25–6, 463–5
conductivity
leaf diffusive resistance (rL), 241, 248–9, 258
soil hydraulic, 186–7, 232–3
soil thermal, 188–9
Conservation Law, 28
assimilate use, 302, 315–16
energy balance, 145
hydrologic balance, 225
radiation balance, 142–3
conservation reserves, 456, 478
conservation tillage, 334, 457, 470
constants, 518–19
consumers (trophic web), 17
contour cropping, 342–3, 455, 470
conversion of units, 518–19
coordinated of growth, 300–4

corn see maize
Corn Belt (USA), 450–2
climate, burning, 127, 181–2, 301, 333, 437
decay, immobilization, 171–2, 199–201, 333
effect on fallow, 363–4, 366
effect on T, 336
erosion prevention, 333, 340–2, 345, 374–5
incorporation, 333–4
nitrogen content, 217, 422
source of energy, 421–3
use by livestock, 219, 333, 437, 463, 464–5

crop rotation
Australian farm, 429, 431, 436–7, 442–5
economics of, 428
erosion prevention, 374, 375, 455
fallow, 212–13, 361–8
Iowa farm, 456, 459–61, 468
non-uniformity principle, 212, 362, 429
pest/disease control, 74–5, 359, 360, 442–3, 458

soil temperature, 188, 336
water use, 245–6, 359–60, 360–1
cover crop, 221

crassulacean acid metabolism (CAM)
drought response, 230
photosynthesis, 261
critical nutrient concentration
plant (CNC), 326–7
safe level, 328
soil (CNC), 325–6, 472
crop(s)
area/production, world, 82–4
distribution, 6–8

Australian wheat–sheep zone, 428–9
rainfall transect, 71–2, 430
Thuenen zones, 7
US Corn Belt, 450–1
ecology, integrative discipline, xiii
new, 85
products of, 259
see also specific crops
crop growth rate (CGR), 34–6, 37–8, 39–42, 458, 460
crop improvement, 87, 91–7
biotechnology, 97, 487–8
breeding methods, 91–7
inbreeding species, 94–5
outbreeding species, 92–4
for limited water, 240–5, 356, 371–3, 375
generic advance, 98–100
identities for, 312–15
phenology, 114–15
photosynthesis, 263, 271
selection, 86–9
see also specific crops
cropping systems, 3
attributes of, 4–6

dominant crops, 72–3
crop management, 1
in-season tactics, 349–50, 374–7
optimum, 9
see also specific crops
crop residues
burning, 127, 181–2, 301, 333, 437
decay, immobilization, 171–2, 199–201, 333
effect on fallow, 363–4, 366
effect on T, 336

© Cambridge University Press www.cambridge.org
crop rotation (cont.)
relay cropping, 54
risk control, 74, 75
soil organic matter, 145, 217–18
solar variations, 429, 430–7
use of water, 358, 361, 372–3, 375
weeds, 434–5, 440–2, 458–9

crop substitution
balancing water use/erosion, 373–4, 375
limited rainfall, 71–2, 351–2
salinity, 384
wet years, 350
with climate change, 76

crude fiber (CF), 13–14
crude protein (CP), 13–14
cultivars, 85–6, 91–7
blends, 95
desirable traits, 312–15, 356–8
genetic base, 85, 101–2
ideotypes, 312–15, 371–3, 490
inbreeding species, 95
multilines, 95–7
outbreeding species, 92–4
stability, 63–4, 67–8
water use, 356–8

cultivation, 335; see also weed control
cyanobacteria, 198, 208
cycling of elements, 196–8
role of decomposers, 17
soil formation, 171

dairy cattle
N cycle, grazing, 214–16
trough efficiency, 26, 29
daylight, 138
role in flowering, 109–11
decay, 17, 171, 199–200, see also crop residues
influence on T, 188
degree-days, see thermal units, photothermal units, development
demographic transition, 476, 482
dentrification, 196, 197, 203–4
Iowa farm, 468, 471
isotope discrimination, 210
determine crops, 107–8
drought resistance, 242–3, 352
development, 104–26
coordination with growth, 300
developmental rate, 56, 106–7
model of, 116
under drought, 241
influence of temperature, 56
photothermal units, 119–20
thermal units, 116–19, 123, 124
phenostages, 125
photoperiodism, 109–11
physiological age, 106
scapes, 105–6
seed dormancy, 123–5
seed germination, 122–3
traits for limited water, 356–8
vernalization, 98, 112–14
sensitivity to drought, 384–5
see also specific crops
dew formation, 156
dew point, 148
dietary requirements see animal nutrition,
human nutrition, food supply
dietary energy see energy
diffusion
atmospheric transport, 150
leaf-air, 248–50, 258–9
digestible energy of feed (DE), 21–2, 25–6, 29
digestive systems, 19–20
disease see plant disease
diversity of crops, 6–8, 82–5
burden on farmers, 73
labor distribution, 8, 74, 459
risk management, 71–5
diversity-stability hypothesis, 70
domestic animals
digestive systems, 19–20
role in food supply, 16–17, 20, 25, 29, 82, 417–18, 479
trophic efficiency, 25–6, 29, 463, 465
use of ‘human-edible’ feeds, 25
see also beef cattle, dairy cattle, sheep, horse
dominance, community, 33
double-cropping, 54, 374, 375
Iowa farm, 456–6, 469
nitrates in, 204–5, 241, 471–2
salinity control, 378–9, 381–4, 392–3, 394–7, 398, 446–7
salt balance, 397
use for irrigation, 394–5

drip irrigation, 390–1
DRIS (nutrient diagnosis), 328
drought 238–40
adaptations to, 240–52, 351–2
flowering, 242–3, 352
physiological traits, 248–52, 268
production/survival, 241
ecape, 240–1, 256
resistance to, 238, 240–1, 256
avoidance/tolerance, 240–1
duplex soils, 175, 430

economics, 5–7
analysis of fallow-wheat, 367–8
Australian farm, 432–3
balancing supply–demand, 479–81
choice of crops, 6, 414–15, 450
commodity prices, 8, 61, 71, 481
cost of irrigation, 6, 390–1, 393
government roles, 5, 61–2, 67, 79–80
Iowa farm, 456
labor and capital, 4, 40
labor and energy, 410–11
of energy crops, 424
of fuels from biomass, 420, 424
of sustainability, 9
Index

526  Index

farming systems (cont.)
technological level, 10, 473–4, 482–3
farm management, 8–10
decision process, 3, 9, 58, 350–1
economic risk, 61, 71–3, 351
intensity, 10, 30, 420, 477–8
optimal, 9, 473
response farming, 374–7
sophistication of, 473–4
see also economics
farm size, 452–3, 473
erosion control, 343–4
inheritance customs, 482
in Iowa, 451–2
intensity of farming, 7
energy use, 412
modern agriculture, 485
feed see animal nutrition
feedback
exponential growth, 34
photosynthesis, 268–70
fermentation
biomass to fuel, 421–3
denitrification, 204
digestion, 19–20
ethanol/methane, 421–3
fertilizer, 328–32
application, 330–2
Australian farm, 440–1, 444–5
carryover, 332
effect on stability, 62, 65–6
efficiency, 322–3, 328–9, 350–1, 413–16, 489
energy cost, 207, 404, 413–14
excess, 332, 333, 422
historic trends, 65, 214–15, 478–82
importance, 198, 484
Iowa farm, 468, 471–2
materials, 328–30
replacement fertilization, 332
slow-release, 205
substitutes for land/inputs, 413, 477–8
yield sensitivity, 55, 62, 322–3
Field Capacity, (FC), 485
field management, 6, 8–10, 317
efficient use of water, 350–1
fallow, 362–3
grazing, 9, 68, 360
nutrient supply, 331–2
polycultures, 52–3
spatial variability, 319–20
see also specific crops
fire see burning
fitness
individual/community, 88
seed size, 309
flowering, 107–14
control, various species, 115
determinate/indeterminate, 107–8, 242–3, 352
growth substances, 302
optimal switch, 108
photoperiodic control, 109–14
winterness in wheat, 356
see also specific crops
foliage see canopy, cover
food supply
developed/developing nations, 478–82
dietary energy, 481
potential, 477–8, 483–4
Standard Nutritional Unit, 29, 479
forage crops
Australian farm, 434, 435, 441
composition, 15, 321, 445, 455
erosion prevention, 342
importance, 417
Iowa farm, 456, 460–1
variable water supply, 351
yield accumulation, 39
see also alfalfa, clover, grass
free energy, 166, 184
frost, 156
fuel requirements
farm machines, 403–5
for energy crops, 422–4
riple systems, 412–13, 414
fuel sources, 407–9
functional equilibrium (roots/shoots), 246,
306–7
fungicides, 78; see also biocides
gasification (pyrolysis), 421
Gas Law, 146
general circulation model (GCM), 76, 161
genetic advance, 98–100; see also specific crops
genetic diversity/stability, 70–5, 95–7
 genetic resources, 82–103
cultivar development, 91–7
germplasm collections, 101–2
structure, 86–7
genetic shift, 88–91
composite crosses, 88–9
seed production, 98
synthetic cultivars, 92
weeds, 89
see also selection
germplasm, 82, 101–2
global change see climate change, technology
change, human population

glucose
cost of
N fixation, 207
nitrate reduction, 206
osmotic adjustment, 251
electron yield, 195
equivalent (GE), 206
heat of combustion, 16
requirement (GIR), 294–9
influence of N source, 297–8, 299
various seeds, 297–9
government, see economics
grain see cereals, seed (grain), and specific crops
grain equivalent, human diet, 29, 477–8, 481,
483–4
grain legumes, world production, 83
see also lupin, soybean
grass
bluegrass pasture, 461–2
canopy structure, 37, 285–6
competition in mixture, 63, 285–6
composition, 15, 455
conservation reserves, 456
reference (ETL), 228
response to temperature, 56
see also forage crops, ryegrass
grazing
animal pests, 443
crop residues, 457, 457, 463, 464
management, 9, 68–9, 360, 438–9, 440–1, 461–2
rotation, 443
stocking rate, 9, 29, 215, 432, 438–9
medieval example, 212
N transfer to grass, 218
nitrate leaching, 204–5
of commons, 80
pasture productivity, 39
refuging, 212, 221
soil acidification, 181, 462, 447–8
supplemental feed, 431
see also pasture
greenhouse effect, 141–2
in climate change, 76
green manure, 177, 217–18
green revolution, 478
gross energy (GE) of feed, 21–2
gross heat content, 15
ground heat flux (G), 145, 188
growth
assimilate response, 303–4
coordination of, 300–4
operational rules, 302
link to transpiration, 238, 251–4
temperature response, 56, 189, 305
see also crop growth rate, morphological plasticity, partitioning of assimilate
growth analysis, 38
growth/differentiation balance, 305–6
growth duration, 58–9
drainage, 337, 446, 465–6, 472
efficient use of water, 356–7, 361
growth respiration (R), 289, 290–1, 292–8
growth substances, 301–2
growth yield (Y), 292–8
biological classes, 293–5
effect of N source, 297–8, 299
elemental analyses, 299–7
sink capacity, 304
gypsum, soil reclamation, 178, 394–5
Haber–Bosch NH3 process, 207
H2 and N fixation, 207
harvest index (HI), 11
for N, 39
yield advance, 99
harvesting
fuel costs, 405
maize, 459
time requirements, 400–2
hay production see forage crops
H-bonding in water, 182–3, 184
heat of combustion (J/kl), 14–16
farm fuels, 404
glucose, 16
plant material, 15, 404
see also enthalpy
heliotropic leaf movements, 246
herbicides, atrazine, 472
Australian farm, 433–4, 441–2
cancer risk, 76, 78
chemical fallow, 365, 433–4
energy cost, 403, 404, 417
Iowa farm, 459, 460, 472–3
pasture management, 441–2, 462
pollution by, 472
stability, 65
weed tolerance, 89, 472
with tillage systems, 334, 413, 416–17
see also weed control
heterosis (hybrid vigor), 93–4
homestead grant, 451
horse
digestion, 20
feed requirement, 23, 25
versus tractors, 25, 401–2, 488
horticultural crops, 7
farm size, 6–7, 412
forcing, 336
importance of, 83–4
irrigation of stone fruits, 393
treatment, 7
trellising, 284–5
human carrying capacity
dependence on energy, 424–5
global, 483–4
influence of N fertilizer, 216
dairy cattle, 29
of Iowa farm, 470
of tropical soils, 484
of wheat crop, 28
human population, 475–7
proportion in agriculture, 480–2
nutrition
dietary requirements, 25–7
grain equivalents (SNE), 28–9, 477, 481, 483–4
humus, 171–2, 197
role in structure, 177
surface properties, 178
hybrid vigor (heterosis), 93–4
hydraulic conductivity, soil, 186–7
drainage, 338
soil evaporation, 232
water uptake, 233
hydrologic balance, 224
Index

hydrologic balance (cont.)
change with farming drainage, 337
dryland salinity, 446–7
Iowa crops, 465–6
measurement of ET, 228–9
ideotypes, 312–15
efficient use of water, 371–3
erect leaf habit, 279–80, 281–2
models for, 315, 371–3
with N fixation, 416, 490
see also crop improvement
immobilization of N, 200–1, 333
indeterminate crops, 68, 107–8
drought resistance, 352
variable environments, 68, 242–3
infiltration, 185, 186–7, 333, 341, 358, 363
irrigation, 380, 386–7, 388
information in farming, 6, 10, 317, 473–4, 482–3, 487–8
insects see pests
integrated pest management (IPM), 74, 491–2
intensity of farming, 10, 30, 482–4, 487
conservation of soil/inputs, 420, 477–8
maize, USA, 479–80
yield-area relationship, 29–30, 477–8
see also low-input agriculture
intercropping, 54
interference, 43; see also competition
ion exchange by soil, 177–8
Iowa farm, 450–70
crops and yields, 455
efficiency, 470
N budget, 471
irrigation, 132
global distribution, 136, 140–1
inclined surfaces, 133–4, 158, 159
irrigation, 378–99
choice of land, 397–8
conflicts in water use, 394–5
costs of, 390–1, 392
drainage, 381–4, 394–7
energy use, 414
humidity regions, 398
influence of soil type, 386–7
land leveling, 387
management, 388–9, 395–6, 393–5
methods, 386–91
microsystems, 391–2
sprinklers, 388–91
surface irrigation, 386–8
salinity, 379–84, 389
scheduling, 391–3
sunflower, 253–4
isotope discrimination
C in photosynthesis, 267
N in denitrification, 210
Kirá plot, 44–5
Krichhoff’s Law, 133
Köppen climate systems, 159, 160
labor
Amish farms, 418–19
child, 482
embodied energy of, 403, 488
energy efficiency, 401
increase in productivity, 481
proportion in agriculture, 480–2
return from, 10
requirements
Australian farm, 432
distribution of, 8, 74
farm tasks, 401–2
Iowa farm, 456
land capability, 345–7
value, 6, 345
degree of risk, 61, 345, 478
land equivalent ratio (LER), 50, 286–7; see also
relative yield total
landrace, 85
late blight of potato, 69–70
latent heat flux (LE), 144–5, 147–9
laterite in soil, 176
leaching, 168, 170–1, 204–5
nitrification, 214, 215, 216
requirement in irrigation, 382, 384
soil formation, 168, 170–1
soil reclamation, 396–7
leaf
area duration (LAD), 38
area index (LAI), 36–9
diffusive resistance (r), 248–50, 258, 261, 266
growth under water stress, 245
initiation, 106, 245
unit of canopy, 257
water potential see plant water potential
legumes
adaptation, 56, 209, 415
composition, 15, 321, 445, 455
energy savings, 414–16, 489–90
mineral nutrition, 209, 441
mixed cropping, 51–3, 285–7
N carry-over, 217
N fixation, 207–11, 212–13, 215, 217–18, 445, 468
scavenge N, 210
soil acidification, 181
symbiosis with rhizobia, 208–9
temperature response, 56
tolerance to salinity, 382, 383
see also specific crops
Leguminosae, 287
Liebig response, 55, 57
light
compensation point, 261–2, 278
intereception, 36–8
relation to productivity, 37–8, 274–5
profile in canopy, 36–7, 286
see also canopy, photosynthesis, radition
lime, soil acidity, 182, 446, 462
limiting resources, 54–8
properties of land area, 1, 58
interactions, 56–8
Index

limited by rainfall, 71–2
nitrogen
fertilizer response, 322–3, 328, 329, 415, 416
optimal for canopy, 283
required in production, 468
methods used in Iowa, 457–9
response farming, 375–6
world, 83
yield advance
Minnesota, 102
USA, 479–80
manganese toxicity, 180, 448
manure see animal manures, green manure
mating systems, 85–6
medieval farm, 212–13
melon, partitioning, 314
meristems, 104, 106, 107
apical dominance, 302
role in partitioning, 300–5
sensitivity to stress, 245
metabolizable energy of feed, (ME), 21–2
methane
anaerobic soils, 200
from organic material, 421, 422, 423
greenhouse gas, 161
rice residues, 333
methanol production, 421, 422, 423
methemoglobinemia, 205
microclimate, 155–6, 361, 335–6
microorganisms, in digestion, 19; see also soil
microorganisms, plant disease
millet, 41, 83
mineralization, 172, 195, 197, 201–2
Iowa farm, 468, 469
nitrate, loss 203
priming, 202, 322
under fallow, 214–15, 362
mixed cropping (polyculture), 32
companion cropping, 54, 434, 460
competition in, 47–52
for light, 48–9, 50, 285–7
grass/legume, 53, 285–6, 440, 600–1
intercropping, 54
maize–bean, 51–2, 287
management, 52–3
soil-borne diseases/pests, 70–1
tree crops, 287
mixing height, atmosphere, 147, 150–1, 152–3
mobilization (assimilate), 12, 247–8, 289, 291,
303, 353, 355
model
canopy photosynthesis, 275–82
development, 116–20
etosha, 341–2, 345
general circulation of atmosphere (GCM), 76,
161
N cycle, 196, 466–70, 471
partitioning of assimilate
peanut, 310
potato, 299, 301, 304–5
potential photosynthesis, 40–1
respiration, 299, 301
530 Index

model (cont.)
  sorghum crop, 371–3
  state-variable systems, 11
trellised canopy, 284–5
water stress, 385
water transport in plants, 226
water use, 236–8, 368–77
  wheat crop, 368–71, 373–4, 375
moisture equivalent (ME), 185
moisture stress see drought, and specific crops
molybdenum, N fixation, 207
monoculture, 32
  advantages of 52–3, 244–5
  competition in, 42–7
  morphological plasticity, 45–6, 307–9
  use of water, 245, 251
Montgomery effect, 49
morphogenesis, 104
  morphological plasticity, 45–6, 59, 300–12; see also partitioning of assimilate
mortality
  in crowded stands, 44–5
  of humans, 475–6
multiple cultivars, 95–7

nature reserves, 478
net assimilation rate (NAR), 38
net energy of feed (NE), 21–2, 24
Netherlands pastures, 214–16
net primary production, 16–17, 40
net radiation (R), 142–4
daily/annual patterns, 144, 146
dew or frost formation, 195
partitioning, 144–5
  profile within canopy, 155
neutral detergent fiber (NDF), 13–15
niches concepts, 47
niche differentiation, 47–8, 50–2
nitrates, 205
nitrates drainage, 468, 469–70, 471
treatment of, 472
drinking water standards, 205
branching from manure, 214–15, 216
branching from soil, 204–5
plant/soil analyses, 325–8, 472
reduction, 195, 206
nitrification, 196, 202
inhibitors, 202, 205
nitrate, 203, 205
nitrogen
  content in plants, 197, 321, 323, 445, 455
  C3/C4 leaves, 265, 271
distribution in canopy, 283
  harvest index of, 39
  immobilization, 200–1
  in soil solution, 179–80
mineralization, 201–2
  mobilization to grain, 39, 353, 355
  oxidation–reduction states, 195–6
  nitrogen cycle, 195–9
  Iowa farm, 466–70, 471
leaks see nitrogen loss
medieval farm, 212–13
pastures, 214–16, 468
soil acidification, 181
nitrogen fertilizer
  crop response, 322–3, 326–8, 329, 415–16
  energy cost, 207, 404, 411, 415–16
  Haber–Bosch process, 207
  immobilization, 200
  loss from, 203, 330
  luxury consumption, 323
  materials, 329–30
  optimum amounts, 333–3
  placement, 204, 330, 331, 471
  priming of mineralization, 202, 322
  response farming, 375–7
  time of application, 380–1
  trends in, 99–100, 214–15, 480
nitrogen fixation, biological, 196, 197, 207–11
  Australian farm, 444–5
for non-legumes, 416, 490
free-living systems, 207–8
  Iowa farm, 468, 469, 471
legume–rhizobia symbiosis, 208–11
  estimates of fixation, 210–11, 444–5, 468
  facultative nature, 201–10, 211
  glucose cost, 207
  rhizobia inoculation 208–9, 442, 459
  luxus, 187
  Mo requirement, 207, 448
  repression by mineral N, 207, 209–10, 211
nitrogen-free extract (NFE), 13
nitrogen loss, 202–6, 212–16 passim, 466–70, 471–2
ammonia volatilization, 205–6, 215, 219, 220, 260, 466–7, 471
nitrate leaching, 204–5, 214–15, 216
denitrification, 196, 197, 203–4, 322, 468
  sources of material, 203, 216, 471
nitrogen supply
  cover/water use, 359–60
functional equilibrium, 307
  pasture management, 215, 285–6
  poverty systems, 213
  yield response, 99–100, 322–3
  yield variation, 62
  nitrogen-use efficiency, 283, 415–16
  Iowa farm, 470, 471
  nitrogenase, 207
non-structural materials, 12–14
non-uniformity principle, 9
concentration of water, 351, 361–2
mixed cropping, 50–1
nitrogen transfers, 212
no-till system, 334, 363
nutrient cycling, 198
Australian farm, 444–5
effect of tillage, 334
soil formation, 171
see also nitrogen cycle
nutrient transfer
  animal manure, 212, 214–16, 218, 220–1
Australian farm, 444–5
Iowa farm, 466–7, 468
organic farms, 212, 221, 419
nutrition see animal nutrition, human nutrition
nutritional control, plant growth, plant nutrients
O3
anoxic (viable) soil, 165, 187–8, 203, 337
effects on C3/C4, 260, 270–1
exchange in soil, 187–8
out
companion crop, 434, 460
fodder crop, 434, 435
multifibres, 96
nutrient content, 445, 455
oceans
effect on climate, 157
salt sink, 171, 198
oil-seeds
gross heat content, 15
source of fuel, 421
optimization
canopy N, 283
crop improvement, 315
in farming, 9, 471
organic farming, 216–22, 419
authors’ perspective on, 486–7, 492
autonomy of, 487
by Aminsh, 418–19
dependence upon price, 222, 419
energy efficiency, 418–20
nitrate loss, 203, 212
nutrient transfer, 419–20
rule-based systems, 221–2
sufficiency of, 478, 484
weed disease control, 222
organic matter see biomass, soil organic matter
osmotic adjustment, 12, 186, 251
to enhance water supply, 251, 372–3
overlap cropping, 54, 285
oxidation-reduction
carbon, 293
in soil, 105
nitrogen, 195–6
pan evaporation, 229
Panicum grasses, 261
partitioning of assimilate, 11, 289, 300–16
conservation of mass, 302, 315, 316
determinate/indeterminate, 311, 312
functional equilibria, 246, 306–7
ideotypes, 312–15, 371–3
vine crops, 285
partitioning of \( R_c \), 144–5
pasture
ammonia volatilization, 206
Australian farm (winter annual), 440–4
N fixation, 444, 445
productivity, 438–9, 443–4
relation to rainfall, 444
seed bank, 433, 442
Dutch farms, 214–16
erosion, 342, 349, 360
graz–legume mixtures, 53, 215, 218
high rainfall, 342, 349
Iowa farm, 461–2, 468
irrigation, 394
N cycle, 214–16
nitrate leaching, 181, 204–5
seasonal production, 438–9, 461–2
seed banks, 227
soil acidification, 181, 447–8, 462
with limited water, 351–2
world area, 83
see also grazing
pathogens, see plant disease
pea
medieval farm, 212–13
sensitivity to drought, 385
peanut partitioning, 310
Penman equation, 129
PEP carboxylase, 260
perseverance, 33, 60, 71–3
pests
biological control
crop rotation, 52, 70, 429, 458
integrated pest management (IPM), 74, 491–2
host resistance, 84, 89, 91, 99, 458, 491, 499
trap crops, 74
cereal cyst nematode, 359
European corn borer, 457, 458
pesticides, 76–8, 417, 458; see also biocides
pest adaptation to, 492
lygus, 74
rootworm of maize, 52, 457, 458
pH, plants, 180–1, 206
pH, soil, see soil acidity, soil alkalinity
phenology, 105; see also development
phenotype, 310–15
selection, 87–9, 94
phosphorus
availability of, 178–9, 189, 191
ecology, 198, 444–5
fertilizer, 222, 328–9, 441, 444
fixation in soil, 178–9, 444
mineral stability, 179
legume nutrition, 209, 428, 441
plant content, 179, 321, 445, 455
soil analysis, 326
photoassimilation, 263–4
photoperiodism, 109–12; see also flowering
phorespiration, 260, 162, 271
photosynthesis, 11, 257–288
diffusion model, 258–9
gross photosynthesis (P) 162
in energy balance, 145
light/dark reactions, 258
measurement, 273
net photosynthesis, (P), 258
systems (C3, C4, CAM), 259–61
photosynthesis, crops, 271–87
C3/C4, 273–4
canopy resistance, 271

© Cambridge University Press www.cambridge.org
Index

photosynthesis, crops (cont.)
  CO₂ requirement, 152–3
models, 275–82, 285
  potential, 40–1
  radiation-use efficiency, 40, 274–5, 276
  relation to transpiration, 252
  response to light, 273–4
seasonal patterns
  barley, 300
  potato, 301
  wheat, 272–3
photosynthesis, leaves, 261–71
  [CO₂] response, 264, 265, 271
  end-product inhibition, 268–70
  light response, 261–4
  N content, 265–6
  nitrate reduction, 206
  photoinhibition, 263–4
  quantum relations, 40–2, 258, 262–3
  specific leaf mass (SLM), 267–8
  sun/shade, 267–8
  temperature response, 264–5, 270
photosynthetically active radiation (PAR), 41, 133
  fraction in sunlight, 140
photothermal units, 116, 119–21
  physiological age, 106
phytochrome, 109
pineapple, 230, 261
plant breeding see crop improvement
plant community, 1
  agricultural climax, 446
  dominance, 33
  succession, 32–4
plant density, 42–7
  biomass accumulation, 43–4
  competition with neighbors, 42–3
  optimal in crops, 44, 261–2
  yield components, 45–6, 307–9
plant disease affecting water use, 359
  control
    fallow, 359, 360, 362
    multilines, 95–7
  rotation, 74–5, 429, 442–3
  suppressive soil, 74–5
  early top of sugarbeet, 87
disease progress curve, 96
host resistance, 84, 87, 89, 95–7
  horizontal/vertical, 96
late blight of potato, 69–70
mosaic virus of soybean, 97
potato scab, 75
rhizoctonia root rot, 359
soil-borne, 74–5
stem rust of cereals, 96
take-all of wheat, 74, 442–3
yellow rust of sugarbeet, 97
plant hormones see growth substances
planting
  methods, 46–7, 335
  optimal time, 61, 369–70
  pattern, 46–7, 361–2
plant nutrients, 320–3
  availability in soil, 178–80
  diagnosis of need, 325–8
  nitrate/ammonium, 206
  plant analysis, 326–8
  plant content, 320–1, 323, 445, 455
  soil analysis, 325–6, 472
plant spacing, 46–7, 361–2
plant water see water in plants
plasticity see morphological plasticity, partitioning of assimilate
plastochron, 106
poling, 333–4
pollution, agricultural, 6, 339, 345, 471, 485
polyculture, 32
  competition in, 47–52
  types of, 54
  see also mixed cropping
pollynge, 87, 316
potassium
  cycling, 198, 444–5
  leaching, 180
  plant content, 321, 445, 455
  requirement of legumes, 109
  soil solution, 180
potato
  crop growth rate, 41
  late blight, 69–70
  partitioning, 299, 301, 304–5
  respiration/photosynthesis, 304–5
  potential ET (ETₚ), 227–31, 236
  relation to ET, 228–30
potential production, 40–1
  Priestley–Taylor equation, 229, 236, 237
primary production, 16–17, 34–42
  annuals/perennials, 36
  function of cover, 36, 58
  model of potential, 45–1
  record rates, 40–2
production processes, 193
  production value (PV), 294–5, 296, 297, 298, 304
  see also growth yield
productive structure of crops, 38–9
productivity of farming, 4
protein
  animal diet, 24, 29
  human diet, 26–7
  N content, 13
  plant content, 14–15, 298
  effect on respiration, 291–2, 297
  effect on yield, 298, 299
proximate analysis, 13
  maize/soybean grains, 297–8
Pseudomonas
  denitrification, 203–4
  suppressive soil, 74–5
psychrometric constant (γ), 149, 229, 236
pure lines, 94
Index

Q, 292
quantum efficiency (requirement), 40, 258, 262–3, 268
radiation, 131–4
atmospheric absorption, 138–42
black body, 131–2
irradiance, 132
inclined surface, 133–4, 158, 159, 336
measurement, 132–3
photosynthetically active, 133
quantum theory, 133, 139–40
short-wave (SW)/long-wave (LW), 131, 132, 133
see also light, solar radiation
radiation balance, 141–4
radiation-use efficiency, 38, 262–3, 274–5
lowa crops, 458, 460, 470
potential, 40–1
rainfall
dominant crop, 71–2
effectiveness, 450–1
infiltration, 186, 341, 358, 363
intensity, 340–1
mineral content, 378; see also wet and dry deposition
need for shelters, 350
orographic effects, 158
rainfed farming, 349–77
use by crops, 244, 361
rapeseed
Australia, 428, 436, 443
flowering, 112
recommended daily allowances (RDA), 26–7
reference ET (ETr), 228–30
refuging, N transfer, 212, 222
relative growth rate (RGR), 35; see also specific growth rate
relative humidity, 148
relative yield total (RYT), 50–3, 95; see also land equivalent ratio (LER)
relay cropping, 54
replacement experiments, 49, 90
reproduction;
abortion, 108, 308
mobilised assimilate, 12, 247–8, 289, 291, 303, 353, 355
relative rate, 89–90
medieval wheat, 212
relative to vegetative growth, 108, 128
see also flowering, yield reserves, 12; see also assimilate supply
resistance see diffusion, drought, pests, plant disease
resources
limitations on crops, 54–8
requirements of plants, 47–8
respiration, 11, 40, 289–302
acclimation to crowding, 276–7, 279
effect of plant composition, 291–2, 295, 297
efficiency, 290
in energy balance, 145
in soil, 187
light compensation point, 261–2, 278, 291
profile in canopy, 276–8
R and Rm, 291, 299, 301
seasonal pattern, 298–300, 301
selection for low R, 292
source of CO2, 156, 187
response farming, 374–7
Reynold’s analogy, 152
rhizobia, legume symbiosis, 208–10
faculative nature, 205
incorporation of legumes, 208–9, 442, 459
see also nitrogen fixation
rice
basin irrigation, 387
energy from straw, 422
labor requirement, 401
methane from residue, 333
N fixation, 208
N placement, 204, 330, 331
peristence as a crop, 72–3
sensitivity to drought, 385
soil structure, 177
weeds, 89
ridge culture, 335, 336, 363
risk in cropping
annuals/perenials in pasture, 68, 71
variable rainfall, 349–51
risk management, 66–8, 71–5, 349–51
crop diversity, 8, 71–5
crop rotation, 74–5
effect of price, 61
exposure of capital, 69
grazing, 68
intensive farming, 420, 477–8
tactical variations, 350–1, 374–7
timeliness, 74, 349, 402, 412, 456, 457
rooting depth, 372–3, 375
root/leaf ratio, 246–7, 306–7
root length density (L), 232–4
near soil surface, 244
sunflower, 247
root systems
basis for complementation, 50–1
collection of water, 232–4
control of water use, 361–2
drought resistance, 244–5
fraction of biomass, 34
soil contact, 233
root/tuber crops, 311, 352; see also cassava, potato, sugarbeet
rotation see crop rotation
roughness length, 151
rubisco, 259–60, 365
rumen, 20
ruminants, 417–18; see also beef cattle, dairy

runt, 225, 363, 456–7;
control of, 337, 342–4, 345
see also hydrologic balance
Index

534  rye
     genetic shift in, 88-9
     long-term experiment, 324-5

ryegrass
     energy balance and ET, 146, 154
     flowering, 109, 111
     light interception, 37, 285-6
     N use in pasture, 215
     selection for low respiration, 292
     weed in wheat, 434-5

saltiness, 164, 379-84
     dryland seepage, 446-7
     irrigation/drainage, 378, 380-1, 394-6
     measures of, 379-80
     plant tolerance, 381, 382, 383
     not a solution, 384
     soil reclamation, 396-7

seed (grain)
     composition, 13, 15, 321, 445, 455
     control of number/site, 307-9, 311-12
     dormancy, 123-5, 126
     hard seed, 124, 127
     germination, 121-3
     production, 92-3, 97-8
     certification, 98
     soil seed bank, 125-7, 442
     storage, 101, 121-2
     seed bed, 334, 336
     seedling seed planting
     selection
     competitive ability, 49, 88
     individual/community, 88, 316
     low maintenance, 292
     pasture species, 95
     photosynthesis, 263, 271
     transplantation efficiency, 267
     yield/composition, 298

self-thinning, 44-5
    sensible heat fluxes (IH), 145-7
    sheep, Australia, 430, 432, 437, 438-40
    short day plants (SDP), 109
    similarity principle, 152
    sink capacity/activity, 304-5
    small farms see farm size
    smectite clay, 170, 178
    sodium adsorption ratio (SAR), 178, 380
    sodium toxicity, 178, 380
    soil, 164-92; see also following headings:
      aeration, 165, 187-8, 203, 337
      alkalinity, 178, 379-80, 396-7
      analysis, 325-6, 472
      lime requirement, 182
      bulk density, 164
      chemistry, 164-7
      classification, 174-6
      duplex, 175, 430
      USDA taxonomy, 175
      zonal/azonal soils, 175
    erodibility, 340, 341
    fertility, 323-4; see also organic farming
    nutrient availability, 178-180, 322, 326, 472
    maps, 175, 346, 347
    porosity, 177, 183
    problems with high rainfall, 349
    profile (horizons), 168-9
    salinity, 164, 379-80, 396-7
    seed bank, 125-7, 442
    texture, 167, 168
    use in agriculture, 176
    soil acidity, 180-2, 191, 447-8
    correction with lime, 181-2, 187, 191
    influence of cropping, 181-2, 187, 191
    K* leaching, 182
    legumes, 180, 447-8
    tolerance, 182
    not a solution, 448
    toxic ions, 182, 448
    wheat-pasture rotation, 447-8
    soil evaporation, (E), 224, 231-2
    cover, 230-1, 359, 363-4
    in water-use efficiency, 353
    model of water use, 236-7
    stages in, 231-2, 237
    soil formation, 167-73
    Iowa, 454-5
    influence of vegetation, 33, 171, 173
    rate and erosion, 339
    soil management, 319-48
    drainage, 337-8, 446-9, 455
    with irrigation, 378-9, 381-4, 392-3, 394-7
    erosion, 338-45
    fertility, 324-32
    spatial variability, 319-20, 412
    tillage, 332-7, 349-50
    soil microorganisms, 195-6, 198-9
    biomass, 171, 199
    contrast to ruminants, 223
    denitrification, 202-3
    free-living N fixation, 207-8
    mineralization, 172, 201-2
    N immobilization, 208-10
    role in decay, 17, 199-200
    see also plant disease
    soil minerals, 167-71
    particles sizes, 167-8
    surface properties, 176
    weathering, 168
    soil organic matter, 171-4, 196-7
    activity of components, 196-7
    climate effects, 172-3
    composition, 171-2, 196-7
    C/N 172-4
    crop rotation, 174, 436
    distribution in profile, 171, 172
    equilibrium level, 172-4
    fauna biomass, 171
    influence of farming, 173-4
    mineralization, 172, 201-2
    properties of, 177-8
    soil–plant-atmosphere continuum, 224
    soil structure, 176-7
Index

535

effect of sodium saturation, 177
effect of tillage, 177, 349
green manures, 177, 217–18
infiltration, 187
wheat–pasture sequences, 436
soil temperature (T.), 188–9
effect of tillage, 334, 335–6
effect of water, 188–9
ground heat flux (Q) 145
patterns, 188–9, 190
residue cover, 336
soil type, 174–6
fuel cost of tillage, 405
irrigation, 386–7, 388
soil drying, 231
soil water (θ), 182–8
effect of deficit, 186, 238
fallow management, 362–7
hydraulic conductivity, 186–7, 233
infiltration of water, 185, 186–7, 333, 358, 363, 380, 386–7, 388
influence on ET, 233–5, 236–8
plant-available, 185–6, 191, 235
release curve, 185
salinity, 379–84
water potential (Ψ), 183–6, 232–5
drying cycle, 226–7
water table, 337, 383–4, 388
solar altitude, 137
Solar Constant, 136
solar declination (δ), 137
solar radiation, 134–41
direct/diffuse, 140, 141
humidity effects, 140–1, 350
irradiance of Earth, 136, 140–1
penumbra, 135
see also light, radiation
solstice, 136
solute water potential (Ψs), 184, 251
sorghum
composition, 15, 207
crop model, 372
flowering, 112
growth yield, 297
stubble mulch, 335
with limited water
ideotypes, 371–2, 375
row spacing, 362
source–sink relations
assimilate, 303–5
microclimate, 156
sowing see planting
soybean
composition, 15, 298, 321, 455
crop growth rate, 38, 460
distribution with rainfall, 71–2
flowering, 110–11, 112
growth yield, seed, 197–8
Iowa, 450, 451, 452
phenology, 458
production methods, 459–60
radiation-use efficiency, 458
weed control, 460
light interception, 38
meal as concentrate, 463, 465
multilines, 97
sensitivity to drought, 385
space relations in stands, 46–7, 361–2
spatial variability in fields, 319–20
acidity, 182
drainage, 337
field size, 319, 343–4
legume rotations, 217
species diversity
agriculture, 82–5
natural communities, 33–4, 70
risk in farming, 71–5
species, scientific names, 515–7
specific growth rate, (α), 35
human population, 476–7
specific heat of air, 146
of soil, 188–9
specific leaf mass (SLM), 39, 267–8
stability of crops, 4–5, 50–81
buffering by multilines, 95
cultivar traits, 63–4, 67, 71
dependence on nutrients, 446
determinate/deteterminate, 68
diversity–stability hypothesis, 70
dryland salinity, 446–7
Finlay–Williamson test, 63–4
grass–clover mixture, 285–6
relation to yield, 63, 68
sensitivity to resources, 62
soil acidification, 447–8
stability coefficient (β), 63–4
stimulate crops, 352
fallow, 68, 367–8
see also yield variation
stability of soil minerals, 168, 170, 179, 180
stand establishment, 123, 124
Standard Nutrition Unit (SNU), 29, 479
standard of living
embodied energy of labor, 403, 488
developed/developing nations, 478, 481
influence on farming systems, 5
Sefam–Boltzmann Law, 132
stocking rate
beef, 9, 461
dairy, 29, 215
sheep, 438–9
stomates
leaf diffusive resistance (rL), 241, 248–9, 258
optimal control, 367
transpiration efficiency, 266–7
Storrie Index, 347
strategy of agriculture, 1, 8
strip cropping, 342–3
structural material of plants, 12
stubble–mulch system, 334, 345, 366
Index

substance agriculture, 4, 5, 6
crop failure, 69
ergy efficiency, 409–10
substrate see assimilate
succession, 32–4
agricultural fields, 446, 462
decay organisms, 198, 199
diversity-stability, 70
individuation theory, 33
nudiegrass

crop growth rate, 41
ergy balance and advection, 154
sufficiency of agriculture, 5, 420, 475
with low input, 478, 484
sugar beet
canopy, 283
crop growth rate, 41
new crop, 85
partitioning, 306–7, 311
plant analysis for N, 326–7
seed production, 96
tolerance to salinity, 383
sugar cane
clonal lines, 85
energy from bagasse, 423

sulphur

cycling, 198
soil amendment, 178, 396
Sun, 134–5
Sun-Earth geometry, 135–8
and climate change, 76, 159–60
see also solar, radiation
sunflower
acclimation of leaves, 268
flowering, 111
leaf diffusive resistance, 249
model of water use, 236, 239
phenology, 116–17
photosynthesis, 274, 275, 276
pre-anthesis assimilate, 247–8
root length density, 247
transpiration efficiency, 253–4
water-use efficiency, 353, 354
sustainable agriculture, 5, 486
sustainability of agriculture, 4–5
depends on inputs, 486–7
economic constraints, 9
erosion, 339
importance of plant breeding, 102
is not enough, 475
medieval farming, 213
optimal management for, 9
relationship to stability, 60, 71–3
soil characteristics for, 319
with low input, 324–5
swidden agriculture, 181
swine, 20, 25, 26, 451
take-all disease, 74–5, 442–3
technological change, 8, 64–6, 213–15, 450, 473, 487–92

getic advance, 98–101
mate production, 66, 100, 214, 479–80
N fertilizer, 214, 215
rate of, 75–6, 450
wheat production, 65, 67, 214, 478
temperature, see air temperature, soil temperature
terraces, erosion control, 342–3, 490
thermal radiation, 131–3
thermal units, 117–9
flowering in wheat, 120
seed germination, 123–4
thermodynamic concepts, 166–7
Thunen zones, 7

tillage, 332–6
conservation tillage, 334, 457
plant disease, 451
effect on soil formation, 339
organic matter, 173–4
structure, 177, 337
temperature, 334, 335–6
seed banks, 126
fallow, 370–1, 372
for weed control, 335, 370–1, 372
fuel requirement, 403, 405, 411, 413, 414
implements for, 333–4
systems defined, 334
need for herbicide, 334, 413
timeliness, 456, 457
time requirements, 401–2
tilling, 45–6, 307; see also partitioning of assimilate


timeliness
high rainfall, 349–50, 456
machines, 74, 337, 334, 401–2, 411, 412
time required for farm tasks, 401–2, 411
tobacco
optimal canopy, 283–4
photosynthesis, 274, 276
tolerance, 56
acid soil, 182, 448
dehydration, 251–2
salinity, 381, 382, 383, 447
shade, 33, 50
stress, 240–1
topography, 158–9, 337
erosion, 341–4

Total Digestible Nutrients (TDN), 21, 461, 463–5

toxic ions, 178, 180, 322, 380, 448
toxic substances in food, 76–8, 485

tractors
advantageous size, 74, 401–2, 412, 456
see also machines
traditional agriculture see organic farming
translocation of assimilates, 289, 303
transpiration (E), 224, 226
by crops, 233–6
efficiency (TE)
wheat, 355–6
C3/C4, 254, 255, 358

effect of water supply, 253–4
deficit, 226–7, 238
leaf water potential (Ψp), 224
drying drying cycle, 226–7
stomate control, 248–9
osmotic adjustment, 251
pre-dawn values, 186
water supply
effect on stability, 67, 71–2
for livestock, 360, 431, 455
tactical dropping, 370–7
quality
health standard for nitrate, 205
drainage, 394–6, 397, 471
irrigation sources, 378, 380–1, 397
water table, 337, 383–4, 388
water use by crops
affected by disease, 359, 396
conserved use, monoculture, 244–5
low farm, 465–6
influence of fertility, 359–60, 375–7
influence of weeds, 358–9, 370–1, 372
management for efficient use, 350–1
optimization, 266–7, 352–5
relation to productivity, 384–6
wheat, 353, 355–6
water use efficiency (WUE), 252–4, 350–1, 470
regional differences, 398
weeds, 18
adaptation to technology, 65, 472
annual pasture, 440
ryegrass in wheat, 434–5
seed banks, 125
seed in manure, 219
water use by, 358
weed control
buring, 437
competition by crops, 39, 44, 48, 54
crop rotation, 75, 433–4, 458–9
economic threshold, 491
fallow, 212, 358–9, 363, 370–1, 372, 433–4
in polyculture, 53
management of seed bank, 491
tillage, 333–4, 335
with high rainfall, 350
see also herbicides
Wein’s Displacement Law, 132
wet and dry deposition, 198, 206, 378
Dutch farms, 215
low farm, 468–9
medieval farm, 212–13
wheat
cereal cyst nematode, 359, 396, 442
composition, 15, 321, 445
crowding response, 46, 307
cultivars
for limited water, 356–7
ideotype, 312–13
types, 113–14
winter hardiness, 71
development, 118, 120
model, 369–70
Index

538  Index

wheat (cont.)
  scale 105–6
  thermal units, 118
disease control, 74–5, 96, 359, 360, 442–3
flowering, 112–14, 118, 120
  vernalization, 112–14
  genetic advance, 99–100
  mobilisation of assimilate, 247, 353, 355
  photosynthesis, 269, 272–3
  reproductive rate, 112, 397
  sensitivity to drought, 67, 242, 243
  yield components, 307
  wheat production
    Australian farm, 428–9, 433–4
crop models, 368–71, 373–4, 375
distribution with rainfall, 71–2
efficient use of water, 353, 355–6
  fallow efficiency, 364–6
humans supported, 28
medieval farm, 212–13
  stability, 67–8, 367–8
  with limited water, 368–75
world, 83
  yield variation, 67–8, 355–6, 367–8
wilting point (WP), 185–6
wind
  erosion, 344–5
  fetch, 155
  profile, 150, 155
turbulent transport, 150–3
  windbreaks, 345
world
  agricultural production, 82–3, 479, 481
  yield variation, 65–6
human population, 475–9
  carrying capacity, 483–4
N supply, 211
yield
  actual, attainable, potential, 10
  advance, 98–101
  and relative ET, 384–5
  effect of weeds, 434–5
  mobilized material, 247–8, 353, 355
  influence of composition, 298
  influence of spacing, 46, 307–9, 361–2
  intensity of farming, 10, 30, 479–82, 482
  potential of new lands, 482
  relation to photosynthesis, 10–11, 263, 283–4
  response to N, 322–3
  see also specific crops
yield–area relation, 30, 479–80
yield components, 307–9, 311, 312
yield variation, 60–9
  accommodations to, 66–9
  effect of drainage, 337
  measures of, 62–4
  sensitivity to
    drought, 244, 243, 384–5
    resources, 55, 62
salinity, 383
  wheat in Australia, 68, 437–8
  see also famine, stability
zero plane displacement, 151