

Index

- 2PG 135
- Abamectin 341
- acceptable risk 172–3
- access and benefit sharing 40, 42, 43–4
- accessions 3–10, 11–12, 26–7, 37, 38, 39, 52–3, 56, 57, 226, 227
- acetylated starches 122
- active sensors 370
- Aegilops tauschii* 22, 26
- aerobic methane oxidisers 283
- Afghanistan 454
- Africa, agricultural input markets 451–2
- agricultural labour composition 457–8
 - agricultural potential 446–59
 - agricultural subsidies 452–4
 - agricultural technology 448–50
 - agro-dealers 87, 450, 451–3
 - climate change 458–9
 - fertiliser use 224, 258, 452, 453
 - Green Revolution 447–8, 449, 462–3
 - land markets 457
 - land tenure security 457
 - public investment 458
 - rural input markets 451–2
 - small holder farmers 448
 - staple crop processing zones 455–7
 - transformational policies 451–9
 - see also* sub-Saharan Africa
- Africa Fertiliser Summit 452
- African Development Bank 449, 450, 454, 455, 456, 457, 459
- African Orphan Crop Consortium 401–4
- agricultural diversification, India 431, 432
- agricultural education 87, 261–2, 263–4, 329, 331, 469, 470
- agricultural input markets, Africa 451–2
- agricultural insurance, India 437
- agricultural intensification, India 432–4
- agricultural investment, China 418–19, 425
- agricultural labour composition, Africa 457–8
- agricultural markets, policy 513
- agricultural policies, India 432–4, 435
- and pest management 324–41
 - post-war 164–5
- agricultural regulation 162–79
- agricultural subsidies 269–70, 424–5, 452–4
- Africa 452–4
 - China 424–5
- agricultural sustainability, China 423
- agricultural technology, Africa 448–50
- side effects 165
- Agricultural Technology Management Agency (ATMA) 432
- agricultural transformation, in Asia 419–20
- agricultural universities, USA 149
- agriculture, China 411–26
- India 429–42
 - technological innovation 164–5
 - use of remote sensing 376–7
 - water management 352–64
- agri-food industry, and RS 123–4
- agri-ppps 399–400
- agro-dealers, Africa 87, 450, 451–3
- agronomic biofortification 68
- alfalfa 152
- alleles for breeding 8
- allelic diversity 4, 5, 6, 7, 8
- Alliance for a Green Revolution in Africa (AGRA) 262, 403, 449, 450, 453, 462
- allopolyploids 16, 17
- α -linolenic acid 102, 104
- alternate-wetting-and-drying, in rice 375–6
- amiRNA 108
- ammonia xv, xvii–xviii, 521
- amphiploids 25, 26, 27
- amylopectin 123
- amylose 123
- anaerobic systems 278–95

- Anaeromyxobacter* 288
aneuploid analysis 24
Angola 456
annotation 52, 203, 206
apple germplasm 9
apples 11, 169, 311
Aquattra™ 105
Arabidopsis thaliana 18, 25, 105, 129, 134, 135, 137, 207, 212, 213, 215
arachidonic acid 102
Arctic® apples 169, 311
artificial micro RNA 108
Asia, agricultural transformation 419–20
aubergine *see* eggplant
autopolyploids 17, 24
Avena sativa 19, 148
avirulence (AVR) effectors 303
AVR effector genes 303–9, 310–11, 312
Azospirillum 286
- Bacillus thuringiensis* (*Bt*) 167, 340–1
bacteria, endophytic 289
heterotrophic 286–7
bacterial blight 304
bananas 7, 97, 167, 169, 449
Bangladesh 83, 85, 86, 91, 167, 225, 230, 233, 235, 236, 238, 264, 304, 342, 374, 420, 480, 488
banker system 340
BAPPENAS (Badan Perencanaan Pembangunan Nasional) 330, 331, 332
barley 18, 19, 21, 24, 123, 148, 312
BARLEYmax 123
beans, high-iron 71, 85, 86
Beauveria bassiana 341
Beijerinckia 286, 287
Benin 454
beriberi 116–17
β-carotene *see* provitamin A
Bethma 361
Bhutan 226, 239
Bill and Melinda Gates Foundation 90, 230, 289, 315, 449, 450, 451, 462
BIMAS 328–9
biofortification 64, 67–70, 73–4, 76
transgenic breeding 88–93
biofortified crop delivery 82–93
biofortified crops, communication 88
efficacy 71–3
sub-Saharan Africa 83–9
biological insecticides 340–1
biological pesticides 162, 168, 340, 341
biosafety 40, 44–6, 91
biotechnology, and disease control 303–12
Biotechnology and Biological Sciences Research Council (BBSRC) 289
black bird drongo 342
blast disease 304–5, 309
blast fungus 304, 305, 309, 315
blood glucose 120, 121
Borlaug, Norman xv, 495
bottlenecks, genetic 21–2, 23, 26–8, 133, 134, 208, 214, 373
Bph genes 327, 337
BPH resistance 327, 328, 337
Bradyrhizobium 288
Brassica juncea 100
Brassica napus 20, 100, 105
see also canola
Brazil 264, 269, 270, 313, 482, 487, 490, 512, 522
bread, white 116
bread basket cases 251, 252, 264
Breeding in Africa for Africa program 83
breeding targets 69, 151
Bringing Green Revolution to Eastern India program 230, 434
brown planthopper 325–8, 329, 330, 332, 333, 334, 336–42, 343
Bt brinjal 167, 435
Bt cotton 267, 417, 435
Bt cowpea 167
Bt crops 167, 170
Bt gene 337
Bt mustard 435
Bt toxins 167, 267, 341
Burkholderia 288
Burma xviii
see also Myanmar
butyrate 119–20, 122, 123
butyrylated starches 122
Byer, Peter 89
- C3 crops 129, 130, 136, 138
C4 plants 130, 136
Cambodia 238, 239, 420
Camelina sativa 104, 105
Cameroon 458
cancer, colorectal 118, 120, 121
canola 20, 100, 104, 105, 108

- canopies, soybean 138
 carbohydrates, dietary 117
 carbon storage, plant 130
 Cartagena Protocol 40, 45, 46
 cassava, yellow 20, 69, 72, 83, 84–5, 135, 169, 258, 259, 448, 451, 454, 455
 Centre for Genetic Resources (CGN) 8
 cereals, blast disease on 304–5, 309
 Chad 458
 chemically modified starches 122
 child mortality 64–5, 66
Chilo medinalis 337, 341
Chilo suppressalis 337, 341
 China, agricultural investment 418–19, 425
 agricultural policies 415–19, 423–6
 agricultural subsidies 424–5
 agricultural sustainability 423
 agricultural transformation 412–23
 agriculture 411–26
 diabetes 116
 fertiliser usage rates 267–8
 groundwater overdraw 423
 market interventions 424, 425
 market reform 417–18
 national food security 423
 nitrogen use 338–9
 pest trapping 341
 rural infrastructure 270
 technological changes 416–17
 Zhanghe Irrigation System 358–9
 cholera 115, 282
 cholesterol 98, 100
Chrysopogon zizanioides 340
 cisgenics 311, 316
 citrus greening 167, 316
 climate change xx, 114, 225, 234, 440, 458–9, 511, 516
 Africa 458–9
 climate-change policy, India 440
 closing yield gaps, sub-Saharan Africa 260–2
Clostridium 287, 288
Cnaphalocrocis medinalis see rice leaf folder
 cocoa production 455
 codeine poppy 107
Coffea arabica 10
 collections, *ex situ* 4–5, 7–8, 12, 26, 36
 colorectal cancer 118, 120, 121
 command economies 482
 commodity prices 171, 418, 455
 Commodity Technology Delivery Compact (CRDC) 450
 communication technology 335–6
 communication, and food supply chain transformation 482–3
 with farmers 334–5
 compositional analysis study 174–5
 Comprehensive African Agricultural Development Program (CAADP) 458
 conservation, *in situ* 4–5, 26, 28, 36
 conservation security, *ex situ* 9–11
 in situ 10–12
 Consortium of International Agricultural Research Centers (CGIAR) xv, 23, 43, 57, 148, 262, 447, 449, 522
 constipation 117, 118
 consumers, food supply chain transformation, impact on 490
 contract farming, India 439
 Convention on Biodiversity (CBD) 37, 39, 40, 42, 43, 44, 45
 Copernicus program 373
 corruption, irrigation systems 361
 Cote d'Ivoire 455, 472
 cotton 18, 20, 167, 267, 360, 413, 424
 Bt 267, 417, 435
 cottonseed 100
 cowpea 167, 358, 455
 CRISPR 166, 312–13, 338, 520
 crop canopy modification, photosynthetic efficiency 138
 crop delivery mechanisms 88
 crop development framework 188
 crop diversification, India 434
 crop growth simulation models (CGSM) 375
 crop improvement, for
 biofortification 69–71, 74
 crop intensification, and yield gap closing 255–7
 crop intensity 374–5
 Crop Ontology 37, 38
 crop plants, domestication 18–21
 hybridisation 22–6
 crop protection, nanotechnology 168
 regulations 169–77
 crop species, origins 15–22
 Crop Trust 23
 crop wild relatives 10–11, 12, 28, 36, 39, 40
 crop yield estimation 375
 crop yield gaps 250–71

- crop yield, policies 269–71
- crops, GE herbicide-tolerant 167
- genetic diversity 21–2
 - high-iron 71–2
 - high-provitamin A 72, 76, 88
 - high-zinc 72–3
 - self-pollinated 85–6
 - vegetatively propagated 9, 17, 83–5
- crossovers, chromosomal 25–6, 28
- cryptic gene transfer 25–6
- cyanobacteria 136, 284, 285
- Cyrtorhinus lividipennis* 326, 341
- cytogenetics 16, 17
- data aggregation 39
- data availability 39–40
- data banks, digital 52, 55, 56
- data linking 215–16
- data management, rice genome 52–3
- declared quality seed 86
- Democratic Republic of Congo 84, 85, 86
- demonstration trials 88
- Derxia* 287
- Desulfotomaculum* 283
- Desulfovibrio* 283
- developing and emerging economies 479–90
- and food supply chain transformation 485–90
- developing countries, biofortified crop delivery 82–93
- micronutrient deficiencies 66–7
- diabetes 116, 120, 124
- diazotrophs 285–8
- diazotrophic microbiome, engineering 294
- Dicrurus adsimilis* 342
- diet, and fibre content 117–18
- change 499, 501–2
 - and food supply chain transformation 484–5
 - and market policies 503
 - and socio-economic inequalities 503
 - and trade policies 503
- diet quality, differences 503
- dietary carbohydrates 117
- dietary deficiencies, global 64–6
- dietary fibre 66, 113–14, 117, 118–19
- diet-related non-communicable diseases 116–18
- digital phenotyping platforms 206–14
- disease control, and biotechnology 303–12
- genome editing 312–13
- disease management 313–14
- diseases, diet-related 116–18
- infectious 115
 - non-communicable 115–18
- DNA clocking 21
- docosahexaenoic acid 102–5
- domestication syndrome 22
- domestication timelines 19–21
- double strand break 312
- double-stranded RNA 167, 168
- drought-tolerant rice 231–3, 235
- dryland cropping 257, 265, 447
- ducks, in pest control 342
- Durable Rust Resistance in Wheat 315
- economic growth 511–13
- effector binding elements 309–10, 311, 312, 313
- effector-triggered immunity 303
- eggplant 167, 435
- Egypt 267, 356, 357
- eicosapentaenoic acid 102–5
- Ejeta, Gebesa 262
- electronic wallet 454
- embryo rescue techniques 25
- Emerging Green Revolution 448
- endophytes, in rice 287–8
- endophytic bacteria 289
- Enterobacter cloacae* 286
- Escherichia coli* 282, 293
- estimated average requirement 69, 88
- Ethiopia 259, 356, 480, 483, 490
- crop yields 261–2
- eukaryotic algae 137
- evaluation phase, of plant breeding 154
- ex situ* collections 4–5, 7–8, 12, 26, 36
- ex situ* conservation, security 9–11
- Fad2* genes 100, 101
- FAIR principles 38
- fall armyworm 335, 449–50
- famine xvi, xviii, 114
- Farm Radio Trust 335
- farm yield 250–3, 255, 256, 258, 261–2, 266, 267, 268, 269, 271
- Farmer Field Schools 331–4
- farmer welfare, India 435–7
- Farmers Input Support Programme (FISP) 87
- FatB* gene 100, 101
- fatty acids, plant 97

- polyunsaturated 101–5
- short chain 118, 119, 120–4
- trans 98, 99
- fermentable fibre 120, 121, 122, 123, 124
- fermentation, large bowel 119, 121
- starch 119–21
- fertiliser management, in pest management 338–9
- fertiliser use, Africa 224, 258, 452, 453, 466–7
- China 267–8
- fibre content, and diet 117–18
- food preparation 119
- fibre, dietary 66, 113–14, 117, 118–19
- fermentable 120, 121, 122, 123, 124
- laxative effect 124
- finance, access to 454–5
- finance schemes 400–1
- financial incentives 394, 502
- fish, in pest control 342
- Five Farming Efforts system 328
- Flaksberger, Konsanton 16
- Flavr Savr™ tomato 169
- flooded rice systems 279–88
- flood-tolerant rice 227–8, 229–31, 235, 433
- fluorescence imaging 212–13
- focused identification of germplasm strategy 7, 39
- food consumption, transformation 494–504
- trends 497, 499
- food preparation, and fibre content 119
- food security, global xiv–xxi, 508
- food supply chain transformation 479–90
- and diet 484–5
- and urbanisation 483–4
- in developing and emerging economies 485–90
- impact on consumers 490
- impact on small farmers 490
- food system, modern 114–15
- transformation 490, 495–7
- food trade, policy implications 516–17
- policy reform 509–10
- food waste 169
- food, nutritional value 168–9
- Ford Foundation xv, 353, 447
- foreign direct investment 481, 482, 483, 486, 487
- Forum for Agricultural Research in Africa (FARA) 82
- fungal and bacterial resistant GE crops 167
- fungi, as pest control 340–1
- Galanthus nivalis* agglutinin (GNA) 337–8
- GE crops, approval 174–5
- fat content 169
- fungal and bacterial resistant 167
- policy decisions 176–7
- regulatory approvals 171, 177
- risk assessment 163, 170–1
- GE herbicide-tolerant (GEHT) crops 167
- GE seeds, conditions of use 162, 164
- gene bank accessions 6, 7–8
- gene banks 3–5, 8–9, 11–12, 26, 28, 36, 37–8, 39–40, 45, 46, 227
- digital 52, 55, 56
- rice 52, 55, 56
- gene editing, rice 338
- gene jockeys 177
- gene parks *see in situ* conservation
- gene pools 22, 23, 26–7
- gene silencing 25, 100–1
- oleic acid 100–1
- Genesys 6, 9, 38
- genetic bottlenecks 21–2, 23, 26–8, 133, 134, 208, 214, 373
- genetic diversity, assessment 5–6, 10–11
- crops 21–2
- future 28
- future conservation 11–12
- genetic erosion 3, 10, 11, 23
- genetic recombination 25–6
- genetic resource utilisation 40–5
- genetic suppression 25, 100, 108
- genetic variance 5
- genome editing 108, 131, 150, 152, 163, 166, 167–8, 174, 312–13, 316, 338, 520
- genome sequencing 18, 35, 51, 203–7, 215, 313–14
- genome wide association studies (GWAS) 7, 216
- genome-wide markers 152, 154
- genomic estimated breeding values 8, 153, 154
- genomic selection 7–8, 153, 154, 216, 239
- genomic-enabled prediction 8
- genomics 6, 7, 8, 203–6, 314
- genotyping 7, 18, 21, 26
- genotyping-by-sequencing 6
- geometric resolution *see* spatial resolution
- germplasm, apple 9
- soybean 129
- germplasm exchange 149, 156, 157, 158
- Germplasm Vocabulary 37
- Ghana 455, 469

- Glh10* gene 327
 global food security xiv–xxi, 508
 global food supply, and trade 507–17
 and yield gaps 252–5
 Global Rice Array 56
 global trade, spread of pathogens 314–15
 Global Yield Gap Atlas 251
 glycaemic index 120–1
Glycine max see soybean
 GMOs 45–6, 91, 93, 311, 435
 GNA 337–8
 goatgrass 22
 Golden Rice 88–93, 97, 169, 522
Gossypium species see cotton
 grain production 413, 418, 423, 429, 430–1, 463
 grain yield, sub-Saharan Africa 464–8
 green leafhopper 329, 337
 green leafhopper resistance 327
 Green Revolution xvi, 67, 115, 128, 224, 225–6, 263, 264, 266–7, 324, 325, 329, 352, 389–91, 393, 395, 420, 430–4, 446, 447–8, 455, 461, 462, 465, 467, 469, 471
 Africa 447–8, 449, 462–3
 India 430–1
 groundwater, for irrigation 362–3
 groundwater overdraw, China 423
 growth enhancement support, Africa 452–3
 gut function 119–21
 gut health 124

 habitat management, in pest management 339–40
 harvest index 128
 HarvestPlus 68, 73, 76, 82, 86, 87, 88
Heading date-1 locus 52
 health risks, life style 501–2
 heterotrophic bacteria 286–7
 hexaploid wheat 22, 26, 204
 hidden hunger 64–5, 115, 188
 high-amylose barley 123
 high-amylose maize starch 123
 high-amylose wheat 123
 high-iron beans 71, 85, 86
 high-iron crops 71–2
 high-oleic safflower 100–1
 high-provitamin A crops 72, 76, 88
 high-RS foods 124
 high-zinc crops 72–3, 85, 86
 high-zinc rice 85, 86

 high-zinc wheat 85
 highly time resolved phenotyping 213
 Himalaya 292, 123
 homoeologous pairing promotor (*Hpp-5M⁸*) gene 28
 homology 205
 Hong Kong 511
Hordeum vulgare see barley
 household responsibility system 415
 hybrid crops 87
 hybridisation, crop plants 22–6
 barriers 25–6
 hybridisation programs 23–5
 hyperspectral imaging 210–12, 216, 371, 375

 icosapentaenoic acid 102–5
 image-based plant phenotyping 207–9
 imaging, fluorescence 212–13
 hyperspectral 371, 375
 multispectral 211–12, 371, 372, 373, 376
 thermal 212–13, 376
 import restrictions 514
in silico plant breeding 131, 216–17
in situ conservation 4–5, 26, 28, 36
 security 10–12
 inbreeding 153
 indebtedness, India 435
 India pest trapping 341–2
 India, agricultural diversification 431, 432
 agricultural insurance 437
 agricultural intensification 432–4
 agricultural policies 432–4, 435
 agriculture 429–42
 biofortified crops 71–2, 85, 87
 climate-change policy 440
 contract farming 439
 crop diversification 434
 crop income 437
 farmer welfare 435–7
 GMOs 435
 Green Revolution 430–1
 indebtedness 435
 intellectual property rights 439
 iron deficiency 71–2
 irrigation system 361
 irrigation 430, 434
 land ownership 441
 land tenancy 441
 livestock 434
 market reforms 439

- marketing innovations 432
- milk marketing 432
- nutrition security 440
- pearl millet 87
- potato cold storages 488–9
- poverty alleviation 431
- pre-Green Revolution 430
- private sector partnerships 438–9
- risk mitigation 435–7
- rural transformation 438
- rural–urban continuum 438–9
- second Green Revolution 432–4
- soil management 434
- Sustainable Development Goals 439–41
- urbanisation 438
- water management 434
- women in agriculture 440
- youth in agriculture 440–1
- Indian Council of Agricultural Research (ICAR) 232, 289, 430, 433, 439, 440, 441
- Indonesia 264, 324, 339, 343, 361, 401, 404–5, 419, 420, 484, 514
 - IPM and food security 328–34
- induction speed, wheat 137
- Indus Waters Treaty 356–7
- infant mortality 64–5, 66
- infectious diseases 115
- information and communications
 - technology 334, 335–6
- infrared spectrometers 211
- infrastructure investment, and food supply chain transformation 482
- inhibitors, bioavailability 75
- Innate™ potatoes 169, 311
- insecticides 267, 325–8, 336, 339–43
 - biological 340–1
 - and brown planthopper 326–7
 - non-chemical 335–8
- insulin 120, 121
- integrated pest management (IPM) 324
 - and food security in Indonesia 328–34
 - in rice systems 324–5, 334–43
- intellectual property, and plant breeding 146, 156–9
- intellectual property rights 37, 38, 39, 40, 43
 - India 439
- International Center for Maize and Wheat Improvement (CIMMYT) xv, 23, 24, 148, 237–8, 353
- International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) 87
- International Fund for Agricultural Development (IFAD) 230, 450, 453
- International Institute of Tropical Agriculture (IITA) 457
- International *Oryza* Map Alignment Project (IOMAP) 51
- International Plant Protection Convention (IPPC) 40, 44–5, 314
- International Rice Research Institute (IRRI) xv, 23, 52, 55, 56, 90, 91, 92, 93, 148, 158, 226, 227, 231–4, 237, 238, 289, 325, 337, 353, 362, 390, 433, 447, 461
- International Treaty on Plant Genetic Resource for Food and Agriculture (ITPGRFA) 37, 39, 40, 42, 43–4
- International Undertaking on Plant Genetic Resources 40
- introgression libraries 24, 26, 27
- inulin 75
- investment, and food supply chain transformation 482, 483
- iron absorption 75–6
- iron deficiency 65–6, 71–2
- iron nutrition 71–2
- iron oxidation, in rice soils 283
- iron-biofortified crops 71–2
- iron-pearl millet 69, 71, 72, 87
- irrigation 352, 353, 356–64, 389, 430, 434, 447, 459, 466, 469
 - groundwater for 362–3
 - India 430, 434
- irrigation systems, corruption 361
 - India 361
 - inequity of supply 360–1
 - maintenance 359–60
 - management 357–61
 - Pakistan 361
 - resilience 358–9
 - Sri Lanka 361
 - water capture 358
 - sub-Saharan Africa 264, 466, 469
- Japan 116–17, 227, 264, 269, 325, 511
- Jennings, Peter 89
- Kafa Biosphere Reserve 10
- karnal bunt, in wheat 314

- Kenya 72, 259, 260, 262, 448, 451, 453, 454, 455, 458, 469, 471
maize yield 259, 471–2
- Kilimo Biashara program 453
- Klebsiella oxyloca* 286
- Klebsiella pneumoniae* 293
- Korea 435, 510
- Lake Chad Basin 458–9
- Land Institute 149
- land markets, Africa 457
- land ownership, India 441
- land tenancy, India 441
- land tenure security, Africa 457
- Laos 228, 239, 420
- large bowel fermentation 119, 121
- laser line scanning 209
- laser ranging 209–10
- late blight 167, 311
- laxative effect, of fibre 124
- leaf folder, rice 337, 339, 341
- leaf rust resistance 23
- leafhopper, green 329, 337
- legumes xvii, 3, 10, 265, 289–92, 293, 374
- LiDAR 209–10, 216, 370, 371–2
- life style, health risks 501–2
- light curtains 209
- light detection and ranging 209–10
- linoleic acid 102, 104
- livestock, India 434
- lobbyists 177, 333
- Lolium* pathotype 304
- London, sewage system 115
- long chain polyunsaturated fatty acids 102, 104, 105
- low density lipoprotein 98, 100
- Lr34 gene 23
- Lycopersicon peruvianum* 27
- Lycosa pseudoannulata* 326
- Magnaporthe oryzae* 304, 305, 310, 311, 313, 314, 316
- Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) 431, 435, 436
- maintenance breeding 225
- maize 20, 21, 72, 76, 123, 130, 148, 152, 167, 207, 237–8, 258–62, 266, 284–5, 424, 448, 459, 489–90
biofortified 72, 87
prices 418, 424
transgenic 91
vitamin A 87
water-efficient 448
Zambia 87
- maize-feed-chicken, Nigeria 489–90
- maize starch, high-amylose 123
- maize yields 251–2, 259, 260, 261, 264, 267, 268, 289, 464–8, 471–2
- Malawi 259, 260–1, 262, 335, 448, 451, 452, 454
- malnutrition 64, 66–7, 76, 168, 401, 446, 503
- Malus* species 11
- management data, PGR 37–8
- marker-assisted backcrossing 227, 228, 233, 236, 238, 239
- marker-assisted selection, in rice 337
- market interventions, China 424, 425
- market policies, and diet 503
- market reform, China 417–18
India 439
- marketing innovations, India 432
- mass media campaigns 335
- mating disruption 341–2
- Medicago sativa* 152
- Mekong River Basin 355–6
- Metarhizium anisopliae* 341
- methanotrophs 283, 288
- Methylosinus* 283, 288
- Mexico 21, 71, 360, 486, 488
- microbiome, in flooded rice soils 278–95
- micronutrient deficiencies 66–7
- micronutrient fortification 168–9
- micronutrient status, of crops 71
- Milaparvata lugens* see brown planthopper
- milk marketing, India 432
- Millennium Villages Project (MVP) 260, 264
- millet 20, 258, 260, 455, 464, 468
iron-pearl 69, 71, 72, 87
proso 148
- milling 116, 122
- Minimum Support Price 437
- MinION 205, 206
- Mission for Integrated Development of Horticulture (MIDH) 434
- mlo* wheat 312
- mobile phones 266, 335–6, 454, 482–3
- modern food system 114–15
- molecular markers 6, 69, 70, 227, 311, 337
- morphinan alkaloids 105–6, 107
- morphine pathway 105–8

- mortality, infant 64–5, 66
 Mozambique 72, 83
 multi crop passport descriptors 37
 multispectral imaging 211–12, 371, 372, 373, 376
 Myanmar 228, 232, 239
- Nagoya Protocol 40, 42–3, 44
 nanotechnology, and crop protection 168
 Napier grass 259
 National Accelerated Agricultural Input Access Program (NAAIAP) 453
 National Agricultural Research Systems (NARES) 450
 National Dairy Development Board (NDDB) 432
 National Food Security Act (India) 436
 National Food Security Mission (NFSM) 433
 National Livestock Mission (NLM) 434
 National Mission for Sustainable Agriculture (NMSA) 434
 National Plant Diagnostic Network (NPDN) 315
 National Rural Livelihoods Mission (NRLM) 431, 437, 441
 National Skill Development Mission 437, 441
 Nepal 232–3, 235, 238, 480, 484
Nephotettix virescens 329, 337
 NERICA 468, 473
 new agricultural technologies, regulation 172–7
 new plant-breeding technologies 166–7
nif genes 287–8, 289, 292–4
 Niger 458
 Nigeria 83, 84, 259, 450, 458, 453–4, 457, 589
 Nigeria Incentive-Based Risk Sharing for Agricultural Lending (NIRSAL) 450, 454
 Nile River Basin 356
 nitrogen fertiliser xvii–xviii, 166, 268, 287–8, 295, 338
 nitrogen fixation 279, 284–5, 287–9, 292, 293, 294–5
 and bioengineered rice 288–94
 nitrogen-fixing bacteria 285–8
 nitrogen use, China 338–9
 nitrogenase 292–3
 nitrogenase gene 287, 288, 289
 no early spray 339–40
 noble cane 23
nod genes 289
- non-chemical insecticide technologies 335–8
 non-communicable diseases 115–18
 non-GM crops, trade 510
 non-homologous end joining pathway 312
 non-photochemical quenching 134–5, 137
 normalised difference vegetative index 210, 371
 nucleotide-binding-site/leucine-rich-repeat proteins 303
 Nuseed 105
 nutrient supplementation 65–8, 73
 Nutriterra™ 105
 nutrition security, India 440
 nutritional bioavailability 71–3
- oats 19, 148
 oilseeds, breeding for EPA and DHA 104–5
 sources of EPA and DHA 103
 omega-3 long chain polyunsaturated fatty acids 102, 105
 omega-6 polyunsaturated fatty acids 102
 ~omics data, PGR 38
 One Acre Fund 260
 Operation Flood 432
 opium poppy 105–8
 orange sweet potato 69, 72, 73, 82, 83–4, 189, 449
 oranges 167
Oryza genome diversity 49–57
Oryza longistaminata 49, 287
Oryza sativa 18, 19, 24, 25, 49, 51, 52, 337, 468
Oryza species 18, 19, 21, 22, 24–5, 49–51, 52, 226–7, 287, 290
 oxygen gradient 282, 283
 oxygen transfer, in rice 283
- PacBio 51, 205, 206
 Pakistan, irrigation system 361
Panicum miliaceum 148
Papaver somniferum 105–8
 papaya 167
 passive sensors 370
 passport data 5, 9, 37, 38, 39
 pathogen management 303–16
 pathogen-associated molecular pattern 303
 pathogens, engineering resistance 310–13
 research 315
 spread by global trade 314–15
 pattern recognition receptors 303, 310
 pectin 118, 169

- pest control, ducks 342
 - fish 342
 - mating disruption 341–2
- pest management, and agricultural policies 324–41
 - biointensive strategies 338–40
 - fertiliser management 338–9
 - habitat management, in 339–40
 - rice 324–41
- pest management strategies, sustainable 335–8
- pest monitoring 335
- pest trapping 341–2
- pesticides 162, 163, 165, 166, 168, 169, 170, 324, 329, 330, 331, 332–4, 336, 340–3, 389, 393
 - biological 162, 168, 340, 341
- pharmamolecules 105–8
- phenomics, data analysis 214–15
- phenotypic characterisation 5–6, 174–5
- phenotypic data 38
- phenotyping 150, 153, 154, 206–16
 - rice 55–7
- phenotyping data, analysis 214–15
- phenotyping methods 206–14
- pheromone mass trapping 341–2
- Philippines 91, 92, 93, 228, 230, 288, 363, 390, 420, 510
 - water use 357, 363
- phosphoenolpyruvate 136
- photorespiration 135–7
- photosynthesis, redesign 128–38
- photosynthetic capacity 129, 130, 211
- photosynthetic efficiency,
 - bioengineering 130–1
 - crop canopy modification 138
 - sun-shade transitions 134–5, 137
- Phytophthora infestans* xviii
- phytosanitary certificates 45, 314
- phytosanitary regulation 40, 44–5
- pineapples 169
- plant breeders' rights 156, 157, 163, 170
- plant breeding, for biofortification 69–71, 74
 - evaluation phase 154
 - intellectual property 146, 156–9, 439
 - methods 151–6
 - private 151–6
 - regulation 166–7
 - selection phase 153
 - US public sector 148–59
- plant fatty acids 97
- plant genetic resources 36–46
- plant oils, composition 97–8
 - functional attributes 98–9
 - nutritional attributes 98–9
 - reconfiguring 99–100
- plant phenotyping, metadata 216
- plant quarantine 314–15
- plant variety protection 156, 157
- planthopper, brown 325–8, 329, 330, 332, 333, 334, 336–42, 343
 - whitebacked 337, 339
- Plantwise program 336
- Plenish® soybeans 169
- PODD 216
- policy, and food supply chain transformation 482, 483
- politicisation, of regulatory systems 173–4, 177
- polyploidiation 22
- polyploids 16–17, 18, 22
- polyunsaturated fatty acids 101–5
 - omega- 102, 105
- population growth xiv
- population resequencing 205–6
- populations, rural 270
- porridge 119
- potato cold storages, India 488–9
- potatoes xviii, 20, 24, 42, 136, 167, 169, 311, 483, 485, 488–9
- potential yield 250–2, 253, 255, 262, 265, 266–8, 270
- Potrykus, Ingo 89
- poverty alleviation, India 431
- prebiotics 74, 75–6
- predators, non-arthropod 342
- Prime Minister Agriculture Irrigation Scheme 434
- private investment, and food supply chain transformation 483
- private sector 76, 85, 86, 87, 88, 148–53, 156–7, 230, 237, 238, 267, 391, 392, 397–9, 403, 406–7, 438–9, 441, 452, 453–4, 521, 522, 524
- private sector partnerships, India 438–9
- process-based regulation 162
- processed foods 115, 122, 484–5, 486–7, 490, 502
- processing sector transformation 486–8
- promoter substances 73–4
- propionylated starches 122

- proso millet 148
 proteobacteria 282–3, 287, 288
 provitamin A 65, 67, 69, 70, 71, 72, 76, 82, 83, 85, 97
Pseudomonas species 286, 289
 public investment, Africa 458
 public–private partnerships (PPP) 399–406
 public sector 398, 399, 403, 406, 521–2
Puccinia graminis f. sp. *tritici* *see* wheat stem rust
 pudding 280, 294
 PUFA, long chain 102, 104, 105
 pull system 340
 pulses 122, 261, 433
Pyricularia graminis tritici 314
- quantitative trait locus 7, 223–36, 239, 337
 quarantine restrictions 314–15
 quarantine, plant 314–15
- R* genes 303, 304, 309, 311–12, 313
 radio 335
 ranking lines 151
 raw starches 122
 recombination barriers 27–8
 reference-guided assembly 205–6
 Regional Technology Delivery Infrastructure (RTDI) 450
 regulations, agricultural 162–79
 - crop protection 169–77
 - of new agricultural technologies 172–7
 - phytosanitary 40, 44–5
 - plant breeding 166–7
 - process-based 162
 regulatory approvals, of GE crops 171, 177
 regulatory systems (GE plants),
 - politicisation 173–4, 177
 remote sensing 210, 212, 215, 236, 266, 369–82
 - and agricultural management 373–6
 - data costs 372–3
 - use in sustainable agriculture management 376–7
 - use in sustainable food systems 380–2
 remote sensing, wavelengths 210–11, 370, 371–2, 376
 resequencing 51–2, 56, 205–6
 resistant starch 119–24
 resolution, in remote sensing 209, 212, 371–2, 373
- retail transformation 486
 retinol *see* Vitamin A
 retrogradation 119, 122–3
 rhizosphere, bacteria 286
 rice, alternate-wetting-and-drying 375–6
 - blast disease on 304–5, 309
 - brown 116, 122
 - brown planthopper resistance 327–8
 - climate-smart varieties 433
 - drought-tolerant 231–3, 235
 - flood-tolerant 227–8, 229–31, 235, 433
 - gene banks 51–2
 - gene editing 338
 - genetic diversity 22
 - genome 49–57
 - Golden 88–93, 97, 169, 522
 - high-zinc 85, 86
 - insect-resistant varieties 337
 - marker-assisted selection 337
 - new advances in IPM 334–43
 - nifH* gene 287–8, 292–4
 - nitrogen fixation 288–94
 - origin 18, 21
 - oxygen transfer 283
 - pest management 324–41
 - phenotyping 55–7
 - resequencing 51–2, 56
 - salt-tolerant 234, 235
 - seed policy agreements 238–9
 - semi-dwarf varieties 226
 - soil microbiome 278–95
 - stress-tolerant 227, 236–9, 433
 - transgenic 88–93
 - transgenic resistance 337–8
 - white 116, 117, 122
 Rice Biotechnology Network 89
 rice breeding 226–36
 rice growing, sub-Saharan Africa 461–73
 rice leaf folder 337, 339, 341
 rice milling 116
 rice policy reforms 238–9
 rice price policy, Indonesia 329
 rice production, management programs 469
 rice rhizosphere, sulphate reduction 283
 rice soils, iron oxidation 283
 - microbiome 278–95
 - soil bacteria 286–7
 rice species 18, 19, 21, 22, 24–5, 49–51, 52, 226–7, 287, 290
 rice stem borer 339, 340, 341, 342

- rice systems, flooded 279–88
 integrated pest management (IPM) 324–5
- rice wetlands, properties 279
- rice yield, sub-Saharan Africa 467, 468–71
- rice-rhizobia symbioses 289–92
- risk, acceptable 172–3
- risk assessment, GE crops 163, 170–1
- risk assessment–policy gap 170–1
- risk mitigation, India 435–7
- river basins, water utilisation 355–7
- RNAi 100, 107, 108, 163, 167, 168
- Rockefeller Foundation xv, 89, 90, 353, 447, 449, 451, 443, 462
- root knot nematode resistance 27
- root microbiome 287–8, 294
- roughage model 117
- Rubisco 136–7
- RubP 135
- rural infrastructure, China 270
- rural input markets, Africa 451–2
- rural populations 270
- rural poverty reduction, Asia 420
- rural transformation, India 438
- rural–urban continuum, India 438–9
- Rwanda 71, 85, 86
- rye 19, 24
- Saccharum officinarum* 19, 23
- safflower, high-oleic 100–1
- Sakamura, Tetsuo 16
- Saltol 234, 235
- salt-tolerant rice 234, 235
- SAR sensors 370, 372
- Schultz, Theodor W. 495
- Scirphophaga incertulas* 337, 341
- Scotinophara* species 341
- second meal effect 121
- sedoheptulose-1:7-bisphosphatase (SbPase) 131, 133–4
- seed abortion 25
- seed oils, high oleic 100–1
- seed policy agreements, rice 238–9
- SeedNet 86
- selection phase, of plant breeding 153
- self-pollinated crops 85–6
- Sen, Amartya 495
- sensor networks, distributed 213–14, 380, 381
- sensors 370
- sequencing, genome 18, 35, 51, 203–7, 215, 313–14
- sequencing platforms 205–6
- sequencing technologies 205–6, 215
- sewage system, London 115
- Shannon-Weaver Diversity Index 5
- short chain fatty acids 118, 119, 120–4
- Singapore 511
- single nucleotide polymorphism 51, 52–3, 206, 216, 217
- small farmers, impact of food supply chain transformation 490
- small holder famers Africa 448
- snowdrop lectin gene 337
- societal acceptance, of GE plants 177–8
- socio-economic inequalities, and diet 503
- software, for genome assembly 205
- Sogatella furcifera* see whitebacked planthopper
- soil bacteria, in rice soils 286–7
- soil conservation, monitoring 375
- Soil Health Management and Soil Health Card Scheme 434
- soil management, India 434
- soil microbiome, and rice 278–95
- sorghum 5, 19, 169, 258, 260, 449, 455, 464, 468
- South Africa 458, 464, 485, 488, 512
- soybean 8, 19, 100, 130, 134, 135, 137, 138, 148, 169, 264, 268, 418
- soybean canopies 138
- Soybean Free Air Concentration Enrichment facility (SoyFACE) 134, 138
- soybean germplasm 129
- soybean isoflavone synthase (GmIFS) 289
- spatial resolution 209, 212, 370, 371, 32, 373, 375, 376
- spectranomics 210–11, 212
- spectrometers, infrared 211
- squash 167
- Sri Lanka, irrigation system 361
- Standard Material Transfer Agreement (SMTA) 42, 43, 158
- staple crop processing zones, Africa 455–7
- starch, high-amylose maize 123
- resistant 119–24
- starch fermentation 119–21
- starches, acetylated 122
- butyrylated 122
- chemically modified 122
- propionylated 122
- raw 122

- stem borer, rice 339, 340, 341, 342
 striped 337, 341
 yellow 337, 341, 342
- stem rust, wheat 311, 314, 315
- stress-tolerant rice 227, 236–9, 433
- Stress-Tolerant Rice for Africa and South Asia (STRASA) 230
- striped stem borer 337, 341
- SUB* gene 228, 235, 236
- sub-Saharan Africa, biofortified crops 83–9
 closing yield gaps 260–2
 grain yield 464–8
 irrigation 264, 466, 469
 maize yield 259, 464–5, 471–2
 policy implications 263–4
 rice growing 461–73
 rice yield 467, 468–71
 yield constraints 258–60
 yield gaps 257–64
see also Africa
- subsidies, agricultural 269–70, 424–5, 452–4
- sugarcane 20, 23, 43
- Suharto 328, 329, 330–1, 333
- sulphate reduction, in rice rhizosphere 283
- sunflower 20
- sun-shade transitions, photosynthetic efficiency 134–5, 137
- surface water, management 361–2
- sustainable agriculture management, use of remote sensing 376–7
- sustainable development goals 376–7, 405
 India 439–41
- sustainable food systems, use of remote sensing 380–2
- sustainable pest management strategies 335–8
- Sustainable Rice Platform 392–5
 financial incentives 394–5
- SWEET* genes 309–10, 312
- sweet potato, orange 69, 72, 73, 82, 83–4, 189, 449
- Sweetpotato for Profit and Health Initiative (SPHI) 82, 84
- synthetic pesticides 162, 163, 169
- systems of rice intensification 433
- T1B.1R translocation 24
- Taiwan 358
- TALEN 312, 313
- Tanzania 451, 453, 469
- target population of environments 237
- tariffs xviii, 270, 418, 510, 513, 514
- Tasman (poppy) 107
- Technologies for African Agricultural Transformation (TAAT) 449–50
- technology, access to 502
- temporal resolution 371, 373
- Thailand 92, 115, 227, 286, 267
- thebaine oripavine poppy 1 107
- thermal imaging 212–13, 376
- Tilletia indica* 314
- TILLING 108, 166
- tobacco 133–4, 135, 136, 138, 293
- Togo 454, 455, 456
- tomatoes 20, 21, 24, 27–8, 134, 169
- Top1 106–7
- total factor productivity 415, 417
- trade policies, and diet 503
- trade, and global food supply 507–17
 non-GM crops 510
 openness 508, 516
 policy reform 509–10
 in water 363
- trans-fatty acids 98, 99
- transgenic breeding, for biofortification 88–93
- transgenic plant breeding 68, 88–93
- transgenic poppy 107
- transgenic resistance, in rice 337–8
- transgenic rice 88–93
- triacylglycerols 97
- Triticum* pathotype strains 313, 314
- Triticum* species 16–17, 18, 19, 21, 26, 134
- Tropical Landscape Finance Facility 404–6
- T.T. Chang Genetic Resources Center 226
- Uganda 72, 73, 83, 259, 468, 469, 471
- undernutrition 64–5, 501
- United States Agency for International Development (USAID) 90, 230, 331
- unmanned aerial vehicles 55, 56, 370, 373, 376, 381
- urban life style, health risks 501–2
- urbanisation, food supply chain transformation 483–4
 India 438
- USDA Soybean Collection 8
- value added processing 455–6
- Vavilovian Centres of Origin 15

- vegetatively propagated crops 9, 17, 83–5
- vetiver grass 340
- Vietnam 92, 228, 239, 336, 342, 355, 395, 419, 420, 482, 484, 486
- violaxanthin de-epoxidase 135
- virtual phenome 216–17
- virtual water 363
- vitamin A 65, 69, 72, 83, 84, 88, 89, 91, 92–3
- vitamin A deficiency 65, 72, 76, 89, 92–3
- vitamin A-maize 87

- Warabandi 361
- water, Philippines 363
 - trade, in 363
 - virtual 363
- water agreements 356
- water allocation 357
- water capture, in irrigation systems 358
- water conservation, monitoring 375–6
- water index 210
- water losses 357
- water management, agricultural 352–64
 - farm level 361–3
 - India 434
 - system level 357–61
- water saving 357
- water-limited potential yield 250, 255
- wavelengths, in remote sensing 210–11, 370, 371–2, 376
- welfare costs 513
- wheat, bread 18, 19, 22, 24, 26, 28
 - genetics 16–17
 - gluten-free 169
 - hexaploid 22, 26, 204
 - high-amylose 123
 - high-zinc 85
 - induction speed 137
 - karnal bunt, in 314
- wheat blast 304, 309, 313–14, 315
- wheat germplasm enhancement 26
- wheat milling 116
- wheat species 16–17, 18, 19, 21, 26, 134
- wheat stem rust 311, 314, 315
- Wheat Workers Material Transfer Agreement (WWMTA) 157–8
- wheat yield 266, 268, 468
 - Australia 268–9
 - Kansas 268
- whitebacked planthopper 337, 339
- women in agriculture, India 440
- World Bank 356, 448, 450, 453, 454
- WTO Sanitary and Phytosanitary Agreement (WTO-SPS) 40, 44–5, 314

- Xanthomonas citri* ssp. *citri* 313
- Xanthomonas oryzae* pv. *oryzae* 304, 309–10
- Xanthomonas oryzae* pv. *oryzicola* 304, 309
- Xanthomonas* wilt 167

- Yayu Biosphere Reserve 10
- yellow cassava 20, 69, 72, 83, 84–5, 135, 169, 258, 259, 448, 451, 454, 455
- yellow stem borer 337, 341, 342
- yield, farm 250–3, 255, 256, 258, 261–2, 266, 267, 268, 269, 271
 - maize 251–2, 259, 260, 261, 264, 267, 268, 289, 464–8, 471–2
 - potential 250–2, 253, 255, 262, 265, 266–8, 270
 - water-limited potential 250, 255
 - wheat 266, 268, 468
- yield constraints, sub-Saharan Africa 258–60
- yield gaps, constraints 265–6
 - crop 250–71
 - global food supply 252–5
 - smaller 264–71
 - sub-Saharan Africa 257–64
- yield gap closing 255–7
- Youth Employment in Agriculture Program (YEAP) 457
- youth in agriculture, India 440–1
- Yun Lin Irrigation System, Taiwan 358

- Zambia 72, 87, 448
- zeaxanthin epoxidase 135
- Zhanghe Irrigation System, China 358–9
- Zimbabwe 260, 448–9, 451, 457, 458
- zinc deficiency 66, 89
- zinc, biofortified crops 72–3, 85, 86