Chapter 1

OLIVE GROWING IN THE WORLD AND IN SPAIN, 15

1. Geographic distribution of olive groves, 17
   1.1 Olive trees in the world, 17
   1.2 Olives trees in Spain, 17
   1.3 Spain’s olive growing areas, 21
2. Olive oil, 23
   2.1 Global overview, 23
   2.2 Olive oil overview in the EU, 25
   2.3 Spanish production, 26
3. Table olives, 28
   3.1. Global overview, 28
   3.2. Table olives in Spain, 30
4. Future prospects, 30
5. Bibliography, 31

Chapter 2

BOTANY AND MORPHOLOGY, 33

1. Introduction: Taxonomy, 35
2. Plant structure, 35
   2.1. The tree, 35
   2.2. The leaves, 36
   2.3. The roots, 37
3. Reproductive structures, 40
   3.1. Inflorescence, 40
   3.2. The flower, 42
   3.3. Pollination and fertilisation, 46
   3.4. The fruit, 48
   3.5. The seed and the embryo, 53
4. Bibliography, 57
Chapter 3

VARIETIES AND ROOTSTOCKS, 59

1. Introduction, 61
2. Characteristics of plant material in Spain, 61
   2.1. Spanish varieties, 63
      2.1.1 Oil and double purpose varieties, 67
      2.1.2 Table olive varieties, 72
   2.2 Rootstock use, 73
      2.2.1 Selecting root stocks, 74
   2.3 Outlook and improvement plan, 75
3. Other country varieties, 77
   3.1. Italy, 77
   3.2. Tunisia, 78
   3.3. Greece, 79
   3.4. Turkey, 80
   3.5. Syria, 80
   3.6. Morocco, 81
   3.7. Portugal, 81
4. Bibliography, 82

Chapter 4

PROPOGATION METHODS, 83

1. Introduction, 85
2. Basic concepts, 86
3. Traditional methods of plant propagation, 87
4. Drawbacks of propagation by rooting hardwood cuttings, 91
5. Propagation by rooting softwood cuttings under mist, 93
   5.1. Method, 93
      5.1.1. Rooting, 93
      5.1.2. Hardening, 97
      5.1.3. Growing, 98
   5.2. Environmental conditions needing for rooting, 100
      5.2.1. Bottom heat, 100
      5.2.2. Rooting media, 102
      5.2.3. Mist, 102
      5.2.4. Environmental surrounding the cuttings, 102
   5.3. Rooting and grafting in closed benches, 103
   5.4. Advantages of olive propagation by rooting softwood cuttings under mist, 105
6. Seed propagation, 108
7. Certified plants, 109
8. Bibliography, 111
Chapter 5

FRUITING AND PRODUCTION, 113

1. Introduction, 115
2. Photosynthesis and partitioning of assimilates, 116
   2.1. Photosynthesis and production, 116
   2.2. Distribution and storage of assimilates, 119
3. The biennial cycle, 121
   3.1. Shoot growth, 122
   3.2. Floral induction, 122
   3.3. Flower initiation and bud dormancy, 123
   3.4. Inflorescence and flower development, 125
   3.5. Flowering, pollination and fertilisation, 126
   3.6. Fruit set and abscission, 127
   3.7. Fruit growth and development, 129
4. Control of fruit production, 131
   4.1. Optimising photosynthesis, 131
      4.1.1 irrigation, 131
      4.1.2. Soil management, 132
      4.1.3. Plant density, 132
      4.1.4. Pruning, 132
   4.2. Improving harvest index, 133
      4.2.1. Girdling, 133
      4.2.2. Pollinators, 135
   4.3. Improving harvest quality, 139
      4.3.1. Chemical thinning, 140
   4.4. Regulating the harvest, 141
5. Bibliography, 144

Chapter 6

RIPENING, 147

1. Introduction, 149
2. Composition of fruit, 152
3. Ripening, 152
   3.1. Maturity indices, 152
4. Physiological and biochemical changes associated with ripening, 155
   4.1. Hormones, 155
   4.2. Respiration, 156
   4.3. Photosynthesis, 156
   4.4. Carbohydrates, 156
   4.5. Lipids and lipogenesis, 157
   4.6. Pigments, 162
   4.7. Phenolic compounds, 163
   4.8. Tocopherols and tocotrienols, 163
   4.9. Fruit retention force, 164
5. Changes in the composition and characteristics of oil during the fruit ripening process, 165
6. Bibliography, 166
Chapter 7

PLANTING, 171

1. Introduction, 173
2. Climate requirements, 174
3. Assessment and correction of soil properties for olive groves, 175
   3.1. Physical soil limitations, 176
   3.2. Chemical soil limitations, 183
   3.3. Nutrient availability, 186
   3.4. Correction of physical soil properties, 190
   3.5. Correction of chemical soil properties, 190
4. Designing the grove, 191
   4.1. Selecting varieties, 192
   4.2. Types of groves, 192
   4.3. Planting density and layout in the field, 194
   4.4. Increasing density in traditional plantings, 200
5. Planting out, 201
   5.1. Planting and opening holes, 201
   5.2. Type of tree and its placement, 202
   5.3. Tutoring and protecting young trees, 204
6. Later care of the grove, 206
   6.1. Training pruning, 206
   6.2. Irrigation and fertilisation, 207
   6.3. Pests and diseases, 208
7. Bibliography, 209

Chapter 8

SOIL MANAGEMENT SYSTEMS, 211

1. Introduction, 213
2. Olive grove management systems, 216
   2.1. Tillage, 216
   2.2. No-tillage on bare soil, 219
   2.3. Semi-tillage, 221
   2.4. Minimum tillage, 221
   2.5. Management systems with ground cover, 223
      2.5.1. Inert ground covers, 223
      2.5.2. No-tillage with weed cover during winter, 224
      2.5.3. Cereal or vetch crops in crop inter rows, 230
3. Changes in the soil after applying systems other than tillage, 233
   3.1. Changes in chemical properties of the soil, 234
   3.2. Changes in physical properties of the soil, 237
   3.3. Moisture balance in the soil, 242
4. Erosion and crop management systems, 247
5. Crop management systems and olive grove fauna, 251
6. Cost considerations, 251
7. Herbicide use in olive groves, 252
8. Best practice in herbicide use, 260
   8.1. Best practice for herbicide treatments, 260
Chapter 9  

FERTILISATION, 267

1. Introduction, 269
2. Essential elements, 271
3. Determining olive grove nutritional needs, 272
   3.1. Soil testing, 273
   3.2. Leaf analysis, 273
      3.2.1. Leaf sampling timing, 275
      3.2.2. Sampling procedure, 277
      3.2.3. Use and interpretation of foliar tests, 278
4. Developing an annual fertilisation programme, 279
5. Correcting common deficiencies and excesses, 281
   5.1. Nitrogen, 281
   5.2. Potassium, 284
   5.3. Phosphorus, 285
   5.4. Calcium, 285
   5.5. Magnesium, 286
   5.6. Iron, 286
   5.7. Manganese, zinc and copper, 287
   5.8. Boron, 288
   5.9. Sodium and chlorine, 288
6. Fertiliser application, 289
   6.1. Soil application, 289
   6.2. Foliar fertilisation, 291
      6.2.1. Factors affecting foliar nutrient uptake, 292
   6.3. Injecting tree trunks, 293
7. Bibliography, 296

Chapter 10  

IRRIGATION, 299

1. Introduction, 301
2. Olive water interactions, 303
3. Irrigation requirements for maximum production, 305
4. Scheduling irrigation, 310
   4.1. Low frequency irrigation, 313
   4.2. Drip irrigation programmes, 313
5. Irrigation interaction with other cultivation practices, 316
6. Deficit irrigation, 317
7. The need for research, 321
8. Bibliography, 322
Chapter 11

**FERTIGATION, 325**

1. Introduction, 327
2. Advantages and disadvantages of fertigation, 327
3. Nutrient movement in the wetted area, 328
4. Quality of irrigation water, 329
5. Types of fertilisers for fertigation, 333
   5.1. Precautions in the use of fertilisers, 336
6. Fertigation management, 336
   6.1. Fertiliser storage, 337
   6.2. Fertiliser injection systems, 339
       6.2.1. Fertiliser solution tank, 339
       6.2.2. Venturi injector, 340
       6.2.3. Fertiliser doser, 341
6.3. Preventing blockages in the irrigation system, 342
   6.3.1. Filtration, 343
   6.3.2. Water treatment, 343
   6.3.3. Cleaning the system, 346
7. Fertigation programming, 347
8. Bibliography, 348

Chapter 12

**PRUNING, 349**

1. Introduction, 351
2. Training pruning, 360
   2.1. Training pruning in traditional orchards, 362
   2.2. Training pruning in intensive orchards, 364
   2.3. Training pruning in the nursery, 366
   2.4. Pruning after planting, 369
3. Production pruning, 373
   3.1. Production pruning in irrigated orchards, 375
   3.2. Production pruning for table olives, 377
4. Renewal pruning, 381
5. Mechanical pruning, 387
6. Bibliography, 390

Chapter 13

**MECHANISATION, 393**

1. Introduction, 395
2. Mechanical tasks, 396
3. Soil management equipment, 396
   3.1. Preparing the soil for planting, 396
   3.2. Soil maintenance, 398
       3.2.1. Tillage, 398
3.2.2. No tillage, 400
3.2.3. Green cover, 400
3.3. Preparing the soil for harvest, 400
4. Pruning and residue treatment machinery, 402
4.1. Mechanical pruning, 402
4.2. Eliminating pruning residue, 403
   4.2.1. Logs, 404
   4.2.2. Twigs, 404
5. Spray application of agrochemicals, 407
   5.1. Spraying principles, 407
   5.1.1. Pressurised liquid spraying, 407
   5.1.2. Air spraying, 408
   5.1.3. Centrifugal spraying (ULV applications), 408
5.2. Herbicide application, 408
5.3. Nozzles, 410
5.4. Drop size, 412
5.5. Nozzle range for herbicide application, 412
5.6. Canopy treatment equipment. Mist blowers, 413
5.7. Regulation, use and maintenance, 416
6. Olive grove soil fertilisation equipment, 417
   6.1. Solid organic fertiliser (manure) spreaders, 417
   6.2. Liquid organic fertiliser (slurry) spreaders, 417
   6.3. Solid mineral fertiliser spreaders, 418
   6.4. Liquid mineral fertiliser spreaders, 418
7. Mechanical harvesting, 419
   7.1. Olive removal, 421
   7.1.1. Factors impacting on olive removal, 422
   7.1.2. Types of shakers, 424
   7.1.3. Shaker operation, 431
   7.2. Collecting the olives, 433
   7.2.1. Mechanical net movement, 433
   7.2.2. Simultaneous fruit falling and catching, 435
   7.2.3. Collecting olives from the ground, 436
   7.3. Cleaning and transport, 439
8. Super dense olive groves, 440
9. Costs and yields, 442
10. Bibliography, 447

Chapter 14

PESTS, 449
1. Introduction, 451
2. Olive fruit fly, 453
   2.1. Biological cycle, 454
   2.2. Damage, 457
   2.3. Regulating population, 458
   2.4. Monitoring methods, 459
   2.4.1. Monitoring adult populations, 460
   2.4.2. Monitoring eggs and larvae, 461
2.5. Application techniques, 461
3. Prays or olive moth, 462
   3.1. Biological cycle, 463
   3.2. Damage, 465
   3.3. Regulating population, 466
   3.4. Control methods, 467
4. Scales, 468
   4.1. Black scale, 468
   4.2. Olive parlatoria scale or olive scale, 472
   4.3. Mussel scale, 475
5. Olive borer or olive bark beetle, 477
6. Black olive borer, 483
7. Jasmine moth or palpita, 485
8. Olive pyralid moth, 489
9. Acariosis, 492
10. Olive psyllid, 496
11. Apple weevil or broad-nosed weevil, 499
12. White grub or cockchafer, 502
13. Olive thrips, 504
14. Olive bark midge, 507
15. Cicadas, 510
16. Leopard moth, 514
17. Vertebrates, 517
   17.1. Birds, 517
   17.2. Rodents, 519
   17.3. Rabbits and hares, 519
18. Bibliography, 520

Chapter 15

DISEASES, 521

1. Introduction, 523
2. Peacock spot, 525
   2.1. Symptoms, 526
   2.2. Etiology, 529
   2.3. Epidemiology, 530
   2.4. Control, 534
3. Verticillium wilt, 535
   3.1. Symptoms, 535
   3.2. Etiology, 537
   3.3. Epidemiology, 540
   3.4. Control, 541
4. Olive knot, 544
   4.1. Symptoms, 545
   4.2. Etiology, 546
   4.3. Epidemiology, 547
   4.4. Control, 548
5. Anthracnose, 549
   5.1. Symptoms, 550
Chapter 16

VIRGIN OLIVE OIL PRODUCTION, 579

1. Introduction, 581
2. Basic process, 582
3. Preliminary operations, 584
4. Preparation, 588
   4.1. Crushing, 588
   4.2. Malaxing, 589
5. Solid-liquid separation, 591
   5.1. Selective filtration, 592
   5.2. Pressing, 592
   5.3. Centrifugation, 593
6. Liquid-liquid separation, 601
   6.1. Decantation, 602
   6.2. Centrifugation, 602
7. Oil storage, 603
8. Organoleptic characteristics, 606
9. HACCP, 608
10. Olive oil refining, 608
   10.1. Refining methods, 609
      10.1.1. Chemical refining, 610
      10.1.2. Physical refining, 612
   10.2. Olive pomace oil, 613
   10.3. Conclusions, 615
11. Bibliography, 616
Chapter 17

OLIVE OIL QUALITY, 619

1. Introduction, 621
2. Different quality criteria
   2.1. Regulatory quality, 622
   2.2. Nutritional and therapeutic quality, 627
   2.3. Culinary quality, 628
   2.4. Commercial quality, 628
3. Factors that impact on olive oil quality, 628
   3.1. Agricultural factors, 628
      3.1.1. Intrinsic agricultural factors, 629
      3.1.2. Extrinsic agricultural factors, 635
   3.2. Industrial factors, 640
4. Conclusions, 643
5. Bibliography, 644

Chapter 18

PROCESSING OLIVES, 647

1. Introduction, 649
2. Processing green olives, 650
   2.1. Table varieties, 651
   2.2. Fruit harvesting, transport and grading, 651
      2.2.1. Transport in liquid, 653
   2.3. Debittering, washing and brining, 653
      2.3.1. Influence of variety, 655
   2.4. Fermentation and bulk storage. Alterations, 655
      2.4.1. Bulk storage (fourth phase), 656
      2.4.2. Fermentation control, 657
      2.4.3. Alterations, 657
   2.5. Conditioning operations, 658
   2.6. Fast-track processing of green olives, 659
   2.7. Preparing the packaged product, 660
      2.7.1. Preserving conditions, 660
      2.7.2. Seasoned olives, 661
      2.7.3. Organoleptic evaluation. Application of standards, 663
3. Processing black (ripe-type and naturally mature) olives, 665
   3.1. Processing ripe-type olives, 666
      3.1.1. Harvesting, 667
      3.1.2. Transport, selection and grading of olives, 667
      3.1.3. Washing, 667
      3.1.4. Placement in brine or other solutions, 668
      3.1.5. Grading and selection, 671
      3.1.6. Darkening process, 671
      3.1.7. Other considerations in the darkening process, 672
      3.1.8. Fixing the colour and salt balance, 674
      3.1.9. Selection, grading, preliminary operations, packaging and sterilisation, 674
      3.1.10. Alterations, 675
3.2. Untreated naturally black olives in brine (shrivelled or not), 676
   3.2.1. Harvesting, transport, selection and grading, 677
   3.2.2. Washing and brining, 678
   3.2.3. Fermenting systems, 678
   3.2.4. Selection, grading and packaging, 682
   3.2.5. Alterations of untreated black olives, 683
3.3. Other processes, 683

4. Waste water, 684
   4.1. Waste water from green olives, 684
   4.2. Actions to reduce the amount of green olive effluent, 685
   4.3. Waste water from ripe-type olives by oxidation, 686
   4.4. Waste water from untreated naturally black olives in brine, 687
   4.5. Method to eliminate waste water from black olives, 688

5. Bibliography, 689

Chapter 19

OLIVE OIL IN HUMAN DIET AND HEALTH, 693
1. Introduction, 695
2. Importance of fat in human nutrition, 695
3. Olive oil as a dietary fat. Nutritional value, 696
4. Dietary fats and health, 698
5. Olive oil and health, 700
   5.1. The gastrointestinal system, 701
   5.2. Cardiovascular diseases, 702
   5.3. Oxidation damage, 705
   5.4. Inflammatory diseases, 708
   5.5. Cancer, 710
6. Bibliography, 711

Chapter 20

THE ECONOMICS OF OLIVEOIL, 713
1. Introduction, 715
2. Olive oil supply and demand in Spain, 715
   2.1. Regulation of the olive sector: common market organisation for fats and oils in the European Union, 716
   2.1.1. From traditional CAP to 1998 reform, 716
   2.1.2. The intermediate CAP reform in 2003, 720
   2.2. Olive oil supply, 721
      2.2.1. Production input prices, 721
      2.2.2. Price to the grower, 724
      2.2.3. Assistance received by the sector, 725
      2.2.4. Grower income, 727
      2.2.5. Business structure of the sector, 728
   2.3. Olive oil demand, 729
3. Employment rates in the olive growing sector, 734
   3.1. Ploughing and hoeing, 736
3.2. Fertilising, 737
3.3. Phytosanitary foliar treatments, 738
3.4. Disk harrows work, 738
3.5. Soil preparation, 739
3.6. Conventional cultivation, a summary, 740
3.7. Herbicide treatments, 742
3.8. Irrigation, 742
3.9. Removal of water shoots
3.10. Pruning, 744
3.11. Harvesting, 746
4. Economic study of the olive grove, 747
   4.1. Income 748
   4.2. Expenses, 749
   4.3. Labour costs, 751
   4.4. Profits per area unit, 752
5. Bibliography, 755