

# Table of Contents

<b>PREFACE .....</b>	<b>i</b>
INTRODUCTION .....	i
WE WANT YOUR HELP.....	i
HOW TO USE THIS GUIDE.....	ii
A WORD ABOUT MEASUREMENTS .....	ii
A WORD ABOUT SCIENTIFIC NAMES .....	iii
ACKNOWLEDGEMENTS .....	iii
<b>CHAPTER ONE THE HISTORY OF TEA CULTIVATION .....</b>	<b>1</b>
1.1 THE TEA PLANT AND ITS ORIGIN .....	1
1.2 TEA PRODUCTION AND CONSUMPTION IN THE WORLD .....	1
1.3 TEA PRODUCTION IN VIET NAM .....	2
<b>CHAPTER TWO THE TEA ECOSYSTEM.....</b>	<b>3</b>
2.1 PARTS OF THE ECOSYSTEM, AND THEIR RELATIONSHIPS .....	3
2.2 THE FUNCTIONS OF LIVING THINGS IN THE ECOSYSTEM .....	5
2.2.1 <i>The ecological pyramid</i> .....	5
2.2.2 <i>Food chains and life cycles</i> .....	7
2.3 MANAGING THE TEA ECOSYSTEM .....	9
<b>CHAPTER THREE THE LIVING SOIL.....</b>	<b>10</b>
3.1 WHAT IS SOIL? .....	10
3.1.1 <i>Soil includes living things</i> .....	10
3.1.2 <i>Soil includes non-living components</i> .....	11
3.2 WHAT SOIL PROPERTIES ARE MOST SUITABLE FOR TEA? .....	12
3.2.1 <i>Soil depth</i> .....	13
3.2.2 <i>Soil nutrient content</i> .....	13
Macro and micronutrients .....	14
Soil testing .....	14
3.2.3 <i>Ability of soil to store nutrients</i> .....	15
3.2.4 <i>Soil acidity (pH)</i> .....	16
1. Adding organic matter is the longest-lasting solution to extreme pH.....	18
2. To raise the pH of very acidic soils, add lime.....	18
3. To lower the pH of very alkaline soils, add sulfur .....	20
3.2.5 <i>Water entry and storage</i> .....	21
3.2.6 <i>Drainage and depth of underground water</i> .....	23
3.2.7 <i>Ease of working the soil</i> .....	24
3.2.8 <i>Soil health</i> .....	24
Preventing soil diseases .....	24
Antagonists (natural enemies of pathogens).....	25
Soil sterilization .....	27

3.3	HOW TO MANAGE YOUR SOIL .....	27
3.3.1	<i>The role of organic matter and microorganisms.....</i>	27
1.	Organic matter increases the biological activity of soil.....	27
2.	Organic matter stores and slowly releases nutrients.....	28
3.	Organic matter improves water movement, aeration, and ease of working the soil.....	28
4.	Organic matter promotes soil health .....	28
3.3.2	<i>Some principles of soil conservation and fertilization.....</i>	28
1.	Keep the soil covered.....	28
2.	Feed the soil a regular supply of organic material .....	28
3.	Maintain vegetation on field or farm boundary areas.....	28
4.	Eliminate the use of pesticides on soil .....	29
5.	Reduce the use of chemical fertilizers; use organic fertilizers instead .....	29
6.	Build terraces on steep slopes.....	29
7.	Plant along the gradient of the slope .....	29
<b>CHAPTER FOUR GROWTH AND PHYSIOLOGY OF THE TEA PLANT.....</b>		<b>30</b>
4.1	WHAT IS HAPPENING INSIDE A GROWING PLANT.....	30
4.1.1	<i>The leaves breathe in air, breathe out water, and make sugars from sunlight.....</i>	30
4.1.2	<i>The twigs and branches contain tubes that transport water, fertilizer, and sugar .....</i>	32
4.1.3	<i>The buds grow new tissue to make new leaves and shoots .....</i>	32
4.1.4	<i>When a bud “builds” a new shoot, not all the leaves are alike.....</i>	32
4.1.5	<i>The roots store starch, and absorb fertilizer and water.....</i>	34
4.2	GROWTH STAGES OF THE TEA PLANT .....	34
4.2.1	<i>Seedling stage .....</i>	34
4.2.2	<i>Branch formation stage .....</i>	35
4.2.3	<i>Commercial stage .....</i>	35
4.2.4	<i>Degraded tea .....</i>	36
4.3	ROOT GROWTH.....	36
<b>CHAPTER FIVE PLANTING A NEW TEA CROP.....</b>		<b>38</b>
5.1	PLANNING THE WORK .....	38
5.2	CHOOSING WHICH TEA VARIETY TO PLANT .....	40
5.3	CHOOSING A METHOD FOR PRODUCING NEW TEA PLANTS (SEEDS, SEEDLINGS, OR CUTTINGS) .....	43
5.4	HOW TO PRODUCE NEW TEA PLANTS FROM SEEDS .....	44
5.4.1	<i>Collecting seeds .....</i>	44
5.4.2	<i>Choosing seeds .....</i>	45
5.4.3	<i>Saving seeds.....</i>	45
5.4.4	<i>Planting seeds directly into field.....</i>	46
5.4.5	<i>Planting seeds in a nursery.....</i>	47
1.	Location of the nursery.....	47
2.	Shade for the nursery .....	47
3.	Use of net houses .....	48
4.	Collecting soil for the nursery.....	48
5.	Filling the containers.....	50
6.	Planting the seeds.....	50
7.	Taking care of the seedlings .....	50

5.5	HOW TO PRODUCE NEW TEA PLANTS FROM CUTTINGS .....	50
5.5.1	<i>Preparing mother bushes</i> .....	50
5.5.2	<i>Making cuttings</i> .....	51
5.5.3	<i>Planting cuttings in a nursery</i> .....	52
5.5.4	<i>Taking care of the cuttings</i> .....	53
5.6	PREPARING THE NEW FIELD FOR TEA.....	54
5.6.1	<i>Ringing and cutting down trees</i> .....	54
5.6.2	<i>Planting green-manure bushes or grass</i> .....	54
5.6.3	<i>Improving the soil</i> .....	55
5.7	PLANTING THE TEA INTO THE NEW FIELD .....	55

**CHAPTER SIX MANAGING THE TEA CROP .....56**

INTRODUCTION .....	56
--------------------	----

6.1	MANAGING THE SEEDLING STAGE .....	56
6.1.1	<i>Mulching</i> .....	56
6.1.2	<i>Shade trees or green manure plants between rows</i> .....	57
6.1.3	<i>Other weed management</i> .....	57
	What is the best way to kill weeds?.....	58
6.1.4	<i>Other water management</i> .....	58
6.1.5	<i>Fertilizer, manure, and compost</i> .....	59
6.1.6	<i>How to make compost</i> .....	60
6.1.7	<i>How much fertilizer should you use?</i> .....	62
	Manure and compost .....	62
	Chemical fertilizer .....	62
	What method should you use to apply fertilizers?.....	63
6.1.8	<i>Folding the tips of spindly seedlings</i> .....	64
6.2	MANAGING THE BRANCH FORMATION STAGE.....	65
6.2.1	<i>Mulching</i> .....	65
6.2.2	<i>Green manure plants between rows</i> .....	65
6.2.3	<i>Other weed management</i> .....	65
	Some helpful effects of weeds:.....	65
	Some harmful effects of weeds:.....	65
6.2.4	<i>Other water management</i> .....	67
6.2.5	<i>Fertilizer, manure, and compost</i> .....	67
6.2.6	<i>Pruning</i> .....	67
	When is the best time to prune? .....	70
	How should pruning be done?.....	70
6.2.7	<i>Plucking</i> .....	71
6.3	MANAGING THE COMMERCIAL STAGE.....	72
6.3.1	<i>Mulching</i> .....	72
6.3.2	<i>Shade trees within rows</i> .....	72
6.3.3	<i>Other weed management</i> .....	72
6.3.4	<i>Other water management</i> .....	72
6.3.5	<i>Fertilizer, manure, and compost</i> .....	72
6.3.6	<i>Foliar fertilizers</i> .....	73
	Should I apply foliar fertilizers?.....	74
	What is the best way to apply foliar fertilizers? .....	75
6.3.7	<i>Growth stimulants</i> .....	75
	Should I apply growth stimulants? .....	75
	What is the best way to apply stimulants? .....	75

6.3.8	<i>Plucking</i> .....	77
	When to pluck: time of year.....	77
	When to pluck: time of day and type of weather.....	78
	What to pluck.....	78
	What to pluck: recommendations from other countries:.....	80
	What to harvest.....	80
	How many times to pluck:.....	81
6.3.9	<i>Pruning</i> .....	82
	How often should you prune?.....	82
	Light prunings.....	83
	Medium prunings.....	84
	Heavy pruning.....	84
	Pruning recommendations from other countries.....	84
	In what month should you prune?.....	84
6.4	MANAGING DEGRADED TEA.....	86
6.4.1	<i>Steps in rejuvenating</i> .....	87

## **CHAPTER SEVEN MANAGING OTHER PLANTS IN THE TEA FIELD ..... 88**

7.1	GROWING OTHER PLANTS <u>BETWEEN</u> THE TEA ROWS.....	88
7.1.1	<i>Planting green-manure plants between rows</i> .....	90
	Advantages and disadvantages of green-manure plants.....	90
	What type of green-manure plant should you grow?.....	90
	Planting and care of green-manure plants.....	91
7.1.2	<i>Intercrops that can be eaten or sold (cassava, beans, etc.)</i> .....	92
7.2	GROWING SHADE TREES <u>WITHIN</u> THE TEA ROWS.....	93
7.2.1	<i>Advantages of shade trees</i> .....	93
7.2.2	<i>Disadvantages of shade trees</i> .....	94
7.2.3	<i>What type of shade tree should you grow?</i> .....	94
7.2.4	<i>Planting and care of shade trees</i> .....	96

## **CHAPTER EIGHT ECOLOGY OF INSECT PESTS AND NATURAL ENEMIES ..... 97**

8.1	INSECT ANATOMY: WHAT IS AN INSECT?.....	98
8.2	INSECT LIFE CYCLES.....	99
8.2.1	<i>Life cycles with 3 forms</i> .....	99
8.2.2	<i>Life cycles with 4 forms</i> .....	100
8.3	WHY LEARN ABOUT INSECT ECOLOGY?.....	102
8.4	HOW CAN AN INSECT DAMAGE A PLANT?.....	103
8.5	A PEST OR NOT A PEST INSECT: HOW TO FIND OUT!.....	103
8.6	NON-CHEMICAL METHODS FOR MANAGING PEST INSECTS.....	105
8.6.1	<i>Regular field observation and analysis</i> .....	105
	Use of traps for sampling and control.....	106
8.6.2	<i>Protecting and helping natural enemies</i> .....	107
8.6.3	<i>Purchase and Release of Natural Enemies</i> .....	108
8.7	NATURAL ENEMIES: THE FRIENDS OF THE FARMER.....	109
8.7.1	<i>Major groups of natural enemies</i> .....	109
8.7.2	<i>What kind of natural enemies are most efficient?</i> .....	110

8.8	SOME IMPORTANT NATURAL ENEMIES IN TEA.....	111
8.8.1	<i>Predators</i> .....	113
	Lady Beetles - Coccinellidae.....	113
	Ground beetles - Carabidae.....	115
	Lacewings - Chrysopidae.....	116
	Hover flies - Syrphidae.....	119
	Spiders - Araneae.....	120
	Praying mantids - Mantidae.....	121
	Predatory Ants.....	122
	Predatory mites.....	123
	Rove beetles.....	125
8.8.2	<i>Parasitoids</i> .....	126
	Parasitoids that attack aphids.....	128
	Parasitoids that attack caterpillars.....	130
	Parasitoids that attack eggs.....	131
8.8.3	<i>Insect Pathogens</i> .....	132
	Bacillus thuringiensis (Bt).....	133
	Fungi.....	136
	Viruses.....	139
	Nematodes.....	143
8.8.4	<i>Other natural enemies: Birds</i> .....	145

## **CHAPTER NINE MAJOR INSECT PESTS OF TEA IN VIET NAM ..... 146**

9.1	HOW TO DETERMINE WHICH INSECT PEST IS DAMAGING THE CROP.....	146
9.2	SMALL SUCKING INSECTS ON LEAVES OR BUDS.....	147
9.2.1	<i>Tea green leafhopper</i> .....	147
	Description and Behavior.....	147
	Life cycle.....	148
	Plant damage and plant tolerance.....	149
	Natural enemies.....	149
	Management practices: prevention and control.....	150
	a. Prevention.....	150
	b. Field monitoring and decision making.....	151
	c. Control methods.....	151
9.2.2	<i>Mosquito bug</i> .....	152
	Description and Behavior.....	152
	Life cycle.....	154
	Plant damage and plant tolerance.....	154
	Natural enemies.....	154
	Management practices: prevention and control.....	154
	a. Prevention.....	154
	b. Field monitoring and decision making.....	156
9.2.3	<i>Mites (including Red spider mite)</i> .....	156
	Description and Behavior.....	157
	a. Identification based on symptoms.....	157
	b. Identification based on shape and behavior.....	160
	Life cycle.....	162
	Plant damage and plant tolerance.....	163
	Natural enemies.....	163
	Management practices: prevention and control.....	164
	a. Prevention.....	164
	b. Field monitoring and decision making.....	166
	c. Control methods.....	167

9.2.4	<i>Thrips</i> .....	168
	Description and Behavior .....	168
	Life cycle .....	168
	Plant damage and plant tolerance .....	169
	a. Feeding inside rolled-up buds .....	169
	b. Feeding on young open leaves .....	169
	c. Feeding on young stems .....	170
	Importance of thrips feeding .....	171
	Natural enemies .....	171
	Management practices: prevention and control .....	171
	a. Prevention .....	171
	b. Field monitoring and decision making .....	172
	c. Control methods .....	172
9.2.5	<i>Aphids</i> .....	172
	Description and Behavior .....	172
	Life cycle .....	173
	Plant damage and plant tolerance .....	173
	Natural enemies .....	174
	Management practices: prevention and control .....	174
9.2.6	<i>Scale insects</i> .....	174
	Description and Behavior .....	174
	Life cycle .....	175
	Plant damage and plant tolerance .....	176
	Natural enemies .....	176
	Management practices: prevention and control .....	176
9.3	CATERPILLARS ON LEAVES OR BUDS .....	177
9.3.1	<i>Bud rollers, leaf tiers, and leaf folders</i> .....	177
	Description and Behavior .....	177
	Life cycle .....	177
	Plant damage and plant tolerance .....	177
	Natural enemies .....	177
	Management practices: prevention and control .....	178
9.3.2	<i>Case worms and bag worms</i> .....	178
	Life cycle .....	178
	Natural enemies .....	178
	Management practices: prevention and control .....	178
9.3.3	<i>Nettle caterpillars and saddleback caterpillars</i> .....	179
	Description and Behavior .....	179
	Life cycle .....	179
	Natural enemies .....	180
	Management practices: prevention and control .....	180
9.3.4	<i>Cluster caterpillars</i> .....	180
	Life cycle .....	180
	Management practices: prevention and control .....	180
9.4	RED BORER IN BRANCHES OR STEMS .....	181
	Description and Behavior .....	181
	Life cycle .....	181
	Plant damage and plant tolerance .....	182
	Natural enemies .....	182
	Management practices: prevention and control .....	182
9.5	TERMITES ON ROOTS AND STEMS .....	182
	Description and Behavior .....	182
	Life cycle .....	183
	Plant damage and plant tolerance .....	183
	Management practices: prevention and control .....	183

<b>CHAPTER TEN DISEASE ECOLOGY .....</b>	<b>184</b>
10.1 PATHOGENS AND OTHER MICRO-ORGANISMS.....	185
10.2 WHERE DO PATHOGENS LIVE BEFORE THEY INFECT YOUR TEA BUSHES? .....	186
10.3 HOW PATHOGENS MOVE TO NEW PLANTS .....	187
10.4 HOW PATHOGENS GET INSIDE A PLANT.....	188
10.5 A DISEASE OR NOT A DISEASE...? HOW TO FIND OUT!.....	189
10.6 CONTROL OR MANAGEMENT?.....	192
10.7 WHEN CAN A PATHOGEN ATTACK A PLANT? THE DISEASE TRIANGLE. ....	194
10.8 DISEASE MANAGEMENT: WHERE TO START?.....	196
10.9 ANTAGONISTS: THE NATURAL ENEMIES OF PATHOGENS .....	198
10.9.1 <i>Trichoderma for root diseases and pruning wounds</i> .....	198
10.9.2 <i>Other antagonists</i> .....	199
10.10 WHAT ABOUT FUNGICIDES...?.....	201
<b>CHAPTER ELEVEN MAJOR DISEASES OF TEA IN VIET NAM.....</b>	<b>202</b>
11.1 HOW TO DETERMINE WHICH DISEASE IS DAMAGING THE CROP.....	202
11.2 LEAF DISEASES .....	204
11.2.1 <i>Blister blight</i> .....	204
Importance .....	204
Symptom that is easiest to recognize .....	204
Symptoms over time.....	204
Disease cycle.....	205
Conditions that make the disease worse.....	205
Natural enemies .....	205
Management practices: Prevention and control .....	205
a. Prevention .....	205
b. Field monitoring and decision making .....	206
c. Control methods.....	206
11.2.2 <i>Gray blight and brown blight</i> .....	206
Importance .....	206
Symptoms over time.....	206
Disease cycle.....	206
Conditions that make the disease worse.....	206
Natural enemies .....	206
Management practices: Prevention and control .....	207
11.2.3 <i>Wet leaf blight</i> .....	207
Importance .....	207
Symptoms over time.....	207
Disease cycle.....	208
Conditions that make the disease worse.....	208
Natural enemies .....	208
Management practices: Prevention and control.....	208

11.3	BUD AND BRANCH DISEASES (SHOOT DIE-BACK AND/OR BRANCH CANKERS).....	209
11.3.1	<i>Horse hair blight</i> .....	209
	Importance.....	209
	Easiest symptom to recognize.....	209
	Symptoms over time.....	209
	Disease cycle.....	209
	Conditions that make the disease worse.....	209
	Natural enemies.....	209
	Management practices: Prevention and control.....	209
11.3.2	<i>Bud decay or Bud blight (sometimes called anthracnose)</i> .....	210
	Importance.....	210
	Symptoms over time.....	210
	Disease cycle.....	211
	Conditions that make the disease worse.....	211
	Natural enemies.....	211
	Management practices: Prevention and control.....	211
	a. Prevention.....	211
	b. Field monitoring and decision making.....	211
	c. Control methods.....	211
11.3.3	<i>Dead twig diseases / die-back diseases</i> .....	211
	Importance.....	212
	Symptoms over time.....	212
	Disease cycle.....	213
	Conditions that make the disease worse.....	213
	Natural enemies.....	213
	Management practices: Prevention and control.....	213
11.3.4	<i>Bacterial shoot blight</i> .....	213
	Importance.....	213
	Easiest symptom to recognize.....	214
	Symptoms over time.....	214
	Disease cycle.....	214
	Conditions that make the disease worse.....	215
	Natural enemies.....	215
	Management practices: Prevention and control.....	215
11.3.5	<i>Swollen trunk disease, or club-branch disease</i> .....	215
	Symptom that is easiest to recognize.....	215
	Symptoms over time.....	216
	Disease cycle.....	216
	Conditions that make the disease worse.....	216
	Natural enemies.....	216
	Management practices: Prevention and control.....	216
11.4	ROOT DISEASES.....	217
11.4.1	<i>Root rots</i> .....	217
	Importance.....	217
	Symptoms over time.....	217
	Disease cycle.....	218
	Conditions that make the disease worse.....	218
	Natural enemies.....	218
	Management practices: Prevention and control.....	218
11.4.2	<i>Nematodes</i> .....	219
	Symptoms over time.....	219
	Disease cycle.....	219
	Conditions that make the disease worse.....	220
	Natural enemies.....	220
	Management practices: Prevention and control.....	220
	a. In nurseries.....	220
	b. Before planting a new field.....	221
	c. In established (mature) fields.....	221

11.5	NUTRIENT DEFICIENCIES AND PHYSIOLOGICAL DISORDERS .....	222
11.5.1	<i>Nutrient deficiencies</i> .....	223
11.5.2	<i>Too much fertilizer</i> .....	225
11.5.3	<i>Misuse of pesticides</i> .....	225
11.5.4	<i>Physiology and weather (including “white leaf” and “yellow leaf virus”)</i> .....	226
<b>CHAPTER TWELVE PESTICIDES.....</b>		<b>227</b>
12.1	HOW TO DECIDE WHETHER YOU NEED TO APPLY A PESTICIDE: ECONOMIC INJURY LEVELS VERSUS AGRO-ECOSYSTEM ANALYSIS.....	227
12.2	TYPES OF PESTICIDES .....	229
12.2.1	<i>Botanical pesticides</i> .....	229
12.2.2	<i>Mineral-based pesticides</i> .....	233
12.2.3	<i>Soaps</i> .....	234
12.2.4	<i>Biopesticides</i> .....	234
12.2.5	<i>Compost teas</i> .....	235
12.2.6	<i>Synthetic pesticides</i> .....	235
	Fungicides .....	235
	Insecticides .....	236
12.3	HOW TO CHOOSE THE MOST SUITABLE SYNTHETIC PESTICIDE FOR YOUR PEST .....	238
12.3.1	<i>Avoid banned or restricted pesticides</i> .....	238
12.3.2	<i>If several pesticides are recommended, then choose the least toxic to people</i> .....	238
12.3.3	<i>If several pesticides have low toxicity, then choose the least damaging to natural enemies</i> .....	238
12.4	HOW TO INCLUDE HEALTH AND ENVIRONMENTAL IMPACTS IN FARMER TRAINING.....	239
12.4.1	<i>Effects of pesticides on health</i> .....	240
12.4.2	<i>Effects of pesticides on insects, natural enemies, and livestock</i> .....	242
	1. Pest populations "spring back" after natural enemies are killed.....	242
	2. Pests develop resistance to pesticides .....	242
	3. Negative impacts on animals within and outside the crop system .....	243
12.4.3	<i>Direct effects of pesticides on tea quality</i> .....	243
<b>CHAPTER THIRTEEN PROCESSING AND MARKETING OF TEA.....</b>		<b>244</b>
13.1	PROCESSING BY SMALL FARMERS .....	245
13.1.1	<i>Processing for green tea</i> .....	245
	1. Storage between plucking and processing.....	246
	2. Fermentation stopping .....	246
	3. Rolling (sometimes called "squeezing") .....	250
	4. High temperature drying .....	251
	5. Low temperature drying (and scenting if desired) .....	251
	6. Classification .....	253
	7. Final roasting .....	253
	8. Packaging and labeling .....	253
13.1.2	<i>Processing for black tea</i> .....	254
13.1.3	<i>Processing for half-fermented teas (Oolong or Poochong)</i> .....	255
13.1.4	<i>Storing of processed tea</i> .....	255
13.2	HOW CUSTOMERS JUDGE TEA QUALITY .....	256
13.2.1	<i>The nature of the processed tea</i> .....	257
13.2.2	<i>How the fresh tea was produced and processed</i> .....	259
13.2.3	<i>The way the tea is packaged</i> .....	260

13.3	MARKETING .....	262
13.3.1	<i>Identify possible customers</i> .....	262
	Customers within Viet Nam.....	262
	Customers in other countries.....	263
13.3.2	<i>Study what the customers want (and teach customers about quality)</i> .....	264
13.3.3	<i>Sort your production to match your customers</i> .....	264
13.3.4	<i>Improve your quality to match what your customers want</i> .....	265
 <b>CHAPTER FOURTEEN CONVERSION TO ORGANIC TEA PRODUCTION.....</b>		<b>266</b>
14.1	WHAT IS ORGANIC PRODUCTION? .....	266
14.2	MAIN DIFFERENCES BETWEEN IPM PRODUCTION AND ORGANIC PRODUCTION .....	267
14.2.1	<i>Organic pest management (insects, diseases, and weeds)</i> .....	267
14.2.2	<i>Sustainable soil and nutrient management</i> .....	268
14.2.3	<i>Managing the whole farm, not just the tea crop</i> .....	268
14.3	THE PERIOD OF CONVERSION BETWEEN CONVENTIONAL AND ORGANIC PRODUCTION .....	269
14.4	SHOULD I CONVERT? ADVANTAGES AND DISADVANTAGES.....	269
	<i>Some disadvantages of converting to organic production:</i> .....	270
	<i>Some advantages of converting to organic production:</i> .....	270
 <b>INDEX OF KEY WORDS AND TERMS .....</b>		<b>271</b>