

Water Relations of Plants

PAUL J. KRAMER

*Department of Botany
Duke University
Durham, North Carolina*



1983



ACADEMIC PRESS

A Subsidiary of Harcourt Brace Jovanovich, Publishers

New York London

Paris San Diego San Francisco São Paulo Sydney Tokyo Toronto

Contents

Preface

ix

1 Water: Its Functions and Properties

Introduction	1
Uses of Water in Plants	5
Properties of Water	7
Properties of Aqueous Solutions	15
Summary	21
Supplementary Reading	22

2 Cell Water Relations

Introduction	25
Cell Structure	25
Distribution of Water in Cells	30
Cell Membranes	32
Movement of Water and Solutes in Plants	38
Cell Water Terminology	46
Components of the Water Potential Equation	50
Summary	55
Supplementary Reading	56

3 Soil and Water

Introduction	57
Important Characteristics of Soil	58
How Water Occurs in Soil	67
Movement of Water in Soil	73

Summary	82
Supplementary Reading	83
4 Measurement and Control of Soil Water	
Introduction	84
Field Measurements of Soil Water	85
Laboratory Measurements of Soil Water	96
Experimental Control of Soil Water Content	99
Irrigation	106
Summary	118
Supplementary Reading	119
5 Root Growth and Functions	
Introduction	120
Functions of Roots	121
Root Growth	122
The Absorbing Zone of Roots	130
Summary	144
Supplementary Reading	145
6 Development of Root Systems	
Introduction	146
Root Systems	147
Internal Factors Affecting the Development of Root Systems	157
Environmental Factors Affecting Root Growth	164
Summary	185
Supplementary Reading	186
7 Water Movement in the Soil–Plant–Atmosphere Continuum	
Introduction	187
The Soil–Plant–Atmosphere Continuum Concept	189
Driving Forces and Resistances	196

Water Movement through Plants	200
Varying Resistances in Roots	207
Summary	212
Supplementary Reading	213
8 The Absorption of Water and Root and Stem Pressures	
Introduction	215
Absorption Mechanisms	217
Root and Stem Pressures	226
Summary	233
Supplementary Reading	234
9 Factors Affecting the Absorption of Water	
Introduction	235
Efficiency of Root Systems as Absorbing Surfaces	236
Environmental Factors Affecting Water Absorption	244
Summary	260
Supplementary Reading	261
10 The Conducting System and the Ascent of Sap	
Introduction	262
The Conducting System	263
The Ascent of Sap	281
Conduction in Leaves	284
Summary	288
Supplementary Reading	289
11 Transpiration	
Introduction	291
The Process of Transpiration	294
Plant Factors Affecting Transpiration	305
Interaction of Factors Affecting Transpiration	330

Measurement of Transpiration	331
Evaporation from Stands of Plants	337
Summary	339
Supplementary Reading	340
12 Water Deficits and Plant Growth	
Introduction	342
Cause and Development of Water Deficits	344
Effects of Water Deficits	352
Measurement of Plant Water Stress	374
Summary	388
Supplementary Reading	389
13 Drought Tolerance and Water Use Efficiency	
Introduction	390
Drought	394
Water Use Efficiency	405
Summary	414
Supplementary Reading	415
<i>Bibliography</i>	417
<i>Index</i>	475