

CONTENTS

Contributors

xi

Preface

xv

1. Alone NO Longer: Interactions of Nitric Oxide with Reactive Oxygen Species and Hydrogen Sulfide 1

John T. Hancock and Matthew Whiteman

- 1. Introduction 2
- 2. Generation and Accumulation of NO 3
- 3. Interactions between Reactive Mediators 6
- 4. NO Effects on Proteins 7
- 5. Conclusions 11
- References 11

2. S-Nitrosylation of Nuclear Proteins: New Pathways in Regulation of Gene Expression 15

Izabella Kovacs, Alexandra Ageeva, Eva-Esther König and Christian Lindermayr

- 1. Introduction 16
- 2. Regulation of Gene Expression via Modification of Signaling Pathways 17
- 3. Regulation of Gene Expression via Modification of Transcription Factors 24
- 4. Regulation of Gene Expression via Modification of Chromatin Structure 26
- 5. Conclusion 32
- References 32

3. Auxin and Nitric Oxide: A Counterbalanced Partnership Ensures the Redox Cue Control Required for Determining Root Growth Pattern 41

Natalia Correa-Aragunde, Noelia Foresi and Lorenzo Lamattina

- 1. Introduction 42
- 2. Indole Acetic Acid Induces Oxidative Stress and NO Production 44
- 3. The Counterbalance between NO and ROS Operates Downstream Auxin and Is Critic for Determining Root Architecture 45
- 4. Redox Regulation of Auxin Perception and Signaling 48
- 5. Concluding Remarks and Perspectives 50
- References 50

4. Control of Nitrogen Assimilation in Plants through S-nitrosothiols	55
Lucas Frungillo, Steven H. Spoel and Ione Salgado	
1. Introduction	56
2. Nitrate Uptake and Transport	57
3. Nitrate Assimilation	60
4. Links between Nitrate Assimilation and Nitric Oxide Formation	62
5. Redox Signaling by NO through Protein Modification	65
6. The Role of NO in Nitrate Assimilation Pathways	67
7. Conclusions and Future Remarks	71
Acknowledgements	72
References	72
5. Functional Implications of S-Nitrosothiols under Nitrooxidative Stress Induced by Abiotic Conditions	79
Francisco J. Corpas, Mounira Chaki, Juan C. Begara-Morales, Raquel Valderrama, Beatriz Sánchez-Calvo and Juan B. Barroso	
1. Introduction	80
2. Biochemistry of SNOs	81
3. Role of GSNO as Cellular Signal	86
4. Function of SNOs under Adverse Environmental Conditions	87
5. Conclusions and Perspectives	90
Acknowledgement	91
References	91
6. Costs and Benefits of Nitric Oxide Generation in Plants Exposed to Cadmium	97
Magdalena Arasimowicz-Jelonek, Jolanta Floryszak-Wieczorek and Karolina Izbiańska	
1. Introduction	98
2. NO Costs in Cadmium Stress: From Sensing to Amplifying Cd-Induced Pathology	99
3. Benefits of NO Generation: From NO Priming to Cd Tolerance	104
4. Is There Any Universality of NO Response During HM Stress?	110
5. Conclusions	114
References	115

7. Role of NO-dependent Posttranslational Modifications in Switching Metabolic Pathways 123

María C. Romero-Puertas and Luisa M. Sandalio

1. Introduction	124
2. NO in Plants: Production and Turnover	125
3. NO-Dependent PTM Regulation in Plants	128
4. Metabolic Pathways Affected by NO-dependent PTMs	130
5. Conclusions and Future Research	136
Acknowledgements	137
References	138

8. The Functional Role of Nitric Oxide in Plant Mitochondrial Metabolism 145

Alok Kumar Gupta, Aprajita Kumari, Sonal Mishra, Aakanksha Wany and Kapuganti J. Gupta

1. Introduction	146
2. Nitric Oxide Generation in Mitochondria	147
3. Scavenging of Nitric Oxide by Mitochondria	149
4. Participation of Mitochondrial Generated Nitric Oxide in Cell Death	149
5. AOX in Mitochondria and Relation to NO	150
6. Nitrosylation and Nitration of Mitochondrial Proteins	150
7. Genes Encoding Mitochondrial Proteins Are Regulated by NO	155
8. Effect of NO on TCA Cycle via Aconitase	159
9. Increasing Energy Yield in Mitochondria Mediated by Nitrite Reduction to Nitric Oxide	159
10. Conclusion	160
References	160

9. Nitric Oxide and Reactive Oxygen Species in PCD Signaling 165

Vittoria Locato, Annalisa Paradiso, Wilma Sabetta, Laura De Gara and Maria Concetta de Pinto

1. Introduction	166
2. PCD Induction by NO and/or H ₂ O ₂	169
3. NO and ROS Signaling during Senescence	171
4. NO and ROS Interplay in Self-Incompatibility	173
5. NO and ROS Crosstalk during Hypersensitive Response	175
6. NO and ROS Involvement in PCD Induced by Abiotic Stress	178
7. Conclusions	184
References	184

10. Nitric Oxide: Jack-of-All-Trades of the Nitrogen-Fixing Symbiosis? 193

Imène Hichri, Eliane Meilhoc, Alexandre Boscari, Claude Bruand,
Pierre Frendo and Renaud Brouquisse

1. Introduction	194
2. NO in Plant and Bacteria	197
3. NO Roles in Nitrogen-Fixing Symbiosis	202
4. Conclusions and Future Directions	211
Acknowledgements	213
References	213

11. Nitric Oxide Signaling during the Hypersensitive Disease-Resistance Response 219

Elodie Vandelle, Tengfang Ling, Zahra Imanifard, Ruitao Liu,
Massimo Delledonne and Diana Bellin

1. Introduction	220
2. Origins of the NO Burst: Still Searching for an Answer	221
3. NO Signal Transduction during the HR	226
4. The Role of NO in the HR Cell Death	229
5. NO and Immunity in Plants	232
6. Conclusions	234
Acknowledgement	235
References	235

12. Nitric Oxide-Mediated Chemical Signaling during Systemic Acquired Resistance 245

Pradeep Kachroo, Gah-Hyun Lim and Aardra Kachroo

1. Salicylic Acid Metabolism in Relation to SAR	246
2. Free Radicals and Their Role in SAR	249
3. Relationship among Free Radicals and Other SAR Signals and Lipids	251
4. Fatty Acid Flux and SAR	254
Acknowledgements	255
References	255

13. The Role of Nitric Oxide in Development and Pathogenesis of Biotrophic Phytopathogens – Downy and Powdery Mildews 263

Michaela Sedlářová, Lucie Kubienová, Zuzana Drábková Trojanová,
Lenka Luhová, Aleš Lebeda and Marek Petřivalský

1. Nitric Oxide in Plant Responses to Pathogen Attack	264
2. Sources of NO in Phytopathogens	266

3. NO in the Pathogenesis of Fungal and Hemibiotrophic Phytopathogens	268
4. NO in the Pathogenesis of Downy Mildews	270
5. NO in the Pathogenesis of Powdery Mildews	274
6. Conclusions	277
Conflict of Interest	277
Acknowledgements	278
References	278
14. NO and Ca^{2+}: Critical Components of Cytosolic Signaling Systems Involved in Stomatal Immune Responses	285
Yi Ma and Gerald A. Berkowitz	
1. Introduction	286
2. NO and Ca^{2+} Involve in Plant Innate Immunity	287
3. NO and Ca^{2+} Signaling in Stomatal Innate Immunity	292
4. Concluding Perspectives	310
References	312
<i>Subject Index</i>	325
<i>Author Index</i>	341