CHAPTER 20

INNOVATIVE BIOLOGICAL APPROACHES TO 
BOTRYTIS SUPPRESSION

Henrik U. Stotz¹, Yigal Elad², Ann L.T. Powell³ and John M. 
Labavitch⁴

¹Department of Horticulture, Oregon State Univ., Corvallis, OR 97331 USA; ²Department of Plant 
Pathology, The Volcani Center, Bet-Dagan, 50250, Israel; and ³Department of Vegetable Crops and 
⁴Pomology Department, University of California, Davis, CA 95616

Abstract. Research into the mechanisms used by plants to protect themselves against pathogens has 
expanded considerably in the past few decades, fuelled, in part, by addition of genomic tools to 
investigators’ resources. As a consequence, information about the details of many defence mechanisms 
and the genes that are responsible for their constitutive or induced expression is now available for 
utilization in crop improvement. This chapter briefly addresses many aspects of plant defences against 
Botrytis infection, including considerations of how the pathogen is detected, signalling pathways that 
activate and coordinate defence responses, and the expression of factors that make mechanistically 
different contributions to defence. Almost all of these topics are addressed more fully in earlier chapters 
of this book. The focus here is on use of more recent biochemical and molecular information to enhance 
crop plant defence against Botrytis. We discuss the potential for 1) introducing the Botrytis defence 
systems of wild species by cross-breeding into domesticated, genetically compatible crop species, 2) 
using genetic engineering to introduce into crops genes enabling the synthesis of antifungal metabolites or 
coding peptides and proteins shown to have anti-Botrytis activity, 3) employing powerful techniques 
for “gene discovery” to identify sequences encoding “downstream” factors involved in defence signalling, 
thus offering the possibility of directly linking beneficial plant responses to the plant’s perception of the 
pathogen while eliminating responses that might facilitate infection, and 4) specific possibilities for 
enhancing the ability of biocontrol microorganisms to limit damage due to Botrytis infection of crop 
plants. Broader questions that might serve as guiding principles when specific approaches to enhancing 
crop plant pathogen defences are under consideration are also discussed.

1. Introduction

Improvement of plant-based approaches for suppressing Botrytis development should consider a number of biological and economic questions. Is the goal to 
eliminate the development of the disease or attain an economically relevant level of 
reduction? Should suppression be based on molecular or conventional manipulations 
of the plant’s recognition of, or response to, the pathogen? Do we know enough 
about how Botrytis establishes itself on hosts to devise strategies for countering
specific “attack” mechanisms? Genetic improvements in a crop plant’s defences take time; how sustainable should we expect enhanced defences to be? Are there developmental constraints that naturally limit the effectiveness of biologically based defences?

This chapter will attempt to keep these questions in mind as the authors discuss work in progress, primarily with tomato, that is aimed at reducing crop problems with Botrytis infections. The value of information gained from work with Botrytis-challenged Arabidopsis as a model system and from studies of necrotrophic pathogens similar to Botrytis will be reviewed. The authors will speculate about so far untested approaches for a plant biology-based reduction in crop losses to Botrytis and will examine the possible utility of transformations of both plant hosts and microbial control agents.

2. Potential use of natural genetic resources for Botrytis resistance breeding

Domestication and, during the past century, modern plant breeding have progressively depleted the genetic variation of crop species (Tanksley and McCouch, 1997). Limited genetic diversity is a severe threat to sustainable agriculture because it increases the vulnerability of crops to pathogen and insect epidemics. Tomato is a good example of a genetically depleted species. Fortunately, tomato is compatible with its wild relatives, all of which are diploid (Rick and Chetelat, 1995; Peralta and Spooner, 2001). Wild tomato species have been a significant asset for resistance breeding. Over half of the 42 resistance traits identified in tomato’s wild relatives have been introduced into cultivated tomato (Rick and Chetelat, 1995). Resistance to B. cinerea is not among those, even though it could be accessed from Solanum lycopersicoides (Rick, 1987; Rick and Chetelat, 1995). Wild tomato species have been a significant asset for resistance breeding. Over half of the 42 resistance traits identified in tomato’s wild relatives have been introduced into cultivated tomato (Rick and Chetelat, 1995). Resistance to B. cinerea is not among those, even though it could be accessed from Solanum lycopersicoides (Rick, 1987; Rick and Chetelat, 1995). Stem inoculations provided the first experimental evidence for partial resistance to B. cinerea in F1 hybrids of crosses between tomato cultivars and S. lycopersicoides accessions (Chetelat et al., 1997). Statistically significant differences in resistance to B. cinerea between S. lycopersicoides and tomato were recently recorded after spray inoculation of intact seedlings (Guimarães et al., 2004). Because individual chromosome fragments from S. lycopersicoides have been bred into cultivated tomato (Chetelat and Meglic, 2000; Chetelat et al., 2000), it is now feasible to map resistance genes from S. lycopersicoides in the cultivated tomato background. In addition, resistance to B. cinerea may be imported from other wild tomato relatives.

Differences in foliar susceptibility to B. cinerea among cultivated and wild tomato accessions were first documented by Urbasch (1986). Several accessions of L. hirsutum as well as an accession of Lycopersicon esculentum var. columbiaum displayed strong resistance to B. cinerea in the laboratory and in the field. More recently, wound inoculation of tomato stems and leaves suggested elevated resistance to B. cinerea in accessions of L. peruvianum, L. hirsutum, and L. pimpinellifolium (Egashira et al., 2000). Even though the susceptibilities of stems and leaves were not correlated, all three species performed better than the commercial tomato cultivars tested in this study. However, statistical analysis