Title Combining physical, chemical and biological methods for synergistic control of postharvest diseases: A case study of Black Root Rot of carrot

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Citation Postharvest Biology and Technology, Volume 54, Issue 1, October 2009, Pages 48-52

Keywords Biological control; Carrot; Postharvest disease; Steam; *Thielaviopsis basicola*

Abstract

Combining different control methods can improve control efficacy, increase the spectrum of controlled pathogens and reduce the possibility of resistance development. To be successful, however, the different methods need to be compatible: the first treatment should not have any deleterious effect on the succeeding one; preferably, it should contribute to its efficacy. In the last few years, carrot growers in Israel have begun to brush carrots before storage to remove the outer peel of the root. In the present study we show that this practice enhances the appearance of Black Root Rot during storage, a postharvest disease caused by the fungus *Thielaviopsis basicola.* The chemical fungicide iprodione is usually applied before storage to reduce the development of postharvest diseases. We evaluated the efficacy of combining physical, low-residue chemical and biological control agents as an alternative to the conventional chemical control approach. A technology for the precise application of steam and combined application with stabilized hydrogen peroxide (Tsunami® 100) or a yeast commercial product (Shemer™) were tested. Used alone, both the steam and Tsunami were highly effective at reducing disease decay but were phytotoxic to the roots. Application of combined treatments of sublethal steam followed by a sublethal dosage of Tsunami or Shemer improved efficacy and disease control by 80 and 86%, respectively. These combinations showed a synergistic effect as compared to each of the treatments alone. The same pattern, effecting up to 54% disease control, was observed with the non-compatible combination of applying Tsunami first, washing it off with water and then applying Shemer. Thus disease-control agents can potentially be used for a short period, then washed off, if needed, and efficiently followed by application of a biological control agent. The biological pathway and mode of action are still under investigation but to the best of our knowledge, this is the first study to mathematically demonstrate synergistic effects of sublethal treatments applied sequentially to control postharvest disease as a potential method to reduce the use of chemicals in fruit and vegetables.