From Forest Nursery Notes Winter 2013

158. © Biochar amendment increases resistance to stem lesions caused by *Phytophthora* spp. in tree seedlings. Zwart, D. C. and Kim, S. H. HortScience 47(12):1736-1740. 2012.

Biochar Amendment Increases Resistance to Stem Lesions Caused by *Phytophthora* spp. in Tree Seedlings

Drew C. Zwart and Soo-Hyung Kim[1]
Center for Urban Horticulture, School of Environmental and Forest Sciences, College of the Environment, University of Washington, 3501 NE 41st Street, Box 354115, Seattle, WA 98195

Additional index words. red oak, *Quercus rubra*, red maple, *Acer rubrum*, *Phytophthora cinnamomi*, *Phytophthora cactorum*, phosphorous acid

***Abstract*. Soil amendment with biochar is thought to confer multiple benefits to plants including induction of systemic resistance to plant pathogens. Pathogens in the genus *Phytophthora* cause damaging diseases of woody species throughout the world. The objective of this study was to test 1) whether biochar amendment induces resistance to canker causing *Phytophthora* pathogens; and 2) how this resistance is related to the amount of biochar amendment in two common landscape tree species: *Quercus rubra* (L.) and *Acer rubrum* (L.). Seedlings of *Q. rubra* and *A. rubrum* were planted in peatmoss-based potting mix uniformly amended with 0%, 5%, 10%, or 20% biochar by volume. Plants in each treatment group were stem wound-inoculated with an isolate of *Phytophthora cinnamomi* Rands (host: *Q. rubra*) or *P. cactorum* (Leb. and Cohn) Schröeter (host: *A. rubrum*) using standard agar-plug inoculation procedures. Amendment of potting media with 5% biochar reduced horizontal expansion of lesions in both hosts, whereas the same treatment significantly reduced vertical expansion of lesions in *A. rubrum* ($P < 0.05$). In addition, 5% biochar resulted in a higher midday stem water potential in *Q. rubra* ($P = 0.066$) and significantly greater stem biomass in *A. rubrum* compared with inoculated control plants (0% biochar, $P < 0.05$). Our results suggest that biochar amendment has the potential to alleviate disease progression and physiological stress caused by *Phytophthora* canker pathogens and there is likely an optimal level of biochar incorporation into the root media beyond which the effects may be less pronounced.**

Plant diseases caused by organisms in the genus *Phytophthora* negatively impact nursery stock, field crops, tree crops, and forest systems (Erwin and Ribeiro, 1996; Hansen et al., 2008). *Phytophthora* diseases are also widespread and damaging to woody plants that are commonly found in managed landscapes. In trees, *Phytophthora* pathogens can cause fine root disease, root collar or crown rots, and trunk or stem lesions that are often referred to as "bleeding cankers" (Erwin and Ribeiro, 1996). Physiologically, stem canker-causing *Phytophthora* species (e.g., *P. cinnamomi* and *P. cactorum*) are known to kill phloem, leading to plant death through girdling, and also to colonize and block xylem, leading to altered plant water relations (Brown and Brasier, 2007).

Chemical and non-chemical management options are increasingly being sought to preserve valuable infected specimen trees and protect non-infected hosts. Chemical products containing phosphorous acids or derivatives have often been found most effective and are widely recommended for use against *Phytophthora* bleeding cankers (Garbelotto et al., 2009; Weiland et al., 2009). Systemic induced resistance (SIR) is the mechanism underlying *Phytophthora* disease reduction or prevention after treatment with phosphorous acids (Daniel and Guest, 2006; Daniel et al., 2005; Jackson et al., 2000). As a systemic treatment, this material has also been effective in reducing plant damage caused by several fungal pathogens (Agostini et al., 2003; Elliott and Edmonds, 2008; Percival and Noviss, 2010).

Recently, Elad et al. (2010) showed that incorporation of biochar into potting mix of pepper (*Capsicum annuum* cv. Maccabi) and tomato (*Lycopersicum esculentum* cv. 1402) reduced the disease severity caused by two foliar pathogens and damage from a broad mite pest (Elad et al., 2010). In addition, Harel et al. (2012) showed that incorporation of biochar reduced the damage caused by three foliar pathogens of strawberry (*Fragaria* ×*ananassa* cv. Yael). Results in both studies were attributed to biochar-induced systemic resistance resulting from the reduction in disease caused by pathogens exhibiting both necrotrophic and biotrophic strategies and reduction of damage caused by an arthropod pest. These effects may have been caused by direct interactions between the plant and the biochar or may be the result of biochar-related alterations in the soil microbial community (Elad et al., 2011; Kolton et al., 2011; Warnock et al., 2007). If SIR was the cause of the observed decrease in disease severity, similar results may be possible in defense against *Phytophthora* pathogens. The potential for biochar incorporation as a disease management option has only recently been suggested and research to date is limited (Elad et al., 2011; Lehmann et al., 2011).

The objective of the present study was to determine if biochar amendment of a soilless potting media can reduce the development and impact of stem lesions caused by *Phytophthora* spp. on common nursery and landscape hosts and to determine if an optimal rate of biochar amendment exists beyond which benefits are reduced. By testing an aboveground disease and providing all plants with ample nutrients and moisture, any reduction in disease severity resulting from biochar incorporation can reasonably be attributed to an increased systemic resistance in the plant rather than a direct effect of biochar on the pathogen. Separate experiments on two host–pathogen systems were conducted to test the hypothesis of induced resistance and to determine the potential effectiveness for this soil amendment treatment on two combinations of plant host and *Phytophthora* pathogen.

Materials and Methods

Treatments. Treatments consisted of varying levels of biochar amendment by volume to potting mix (5%, 10%, 20%, or 0% control) in inoculated plants in both experiments, a non-inoculated control (no biochar amendment) in the maple experiment and a chemically treated and inoculated treatment (no biochar amendment) in the maple experiment. In the non-amended treatments, inoculated plants growing in 0% biochar amended potting mix are referred to as 0%+, whereas non-inoculated plants growing in 0% biochar are referred to as 0%–. The chemically treated seedlings were planted in potting mix without biochar and each pot was drenched with 1 pint (473 mL) Agrifos® (mono- and dipotassium salts of phosphorous acid; Liquid Fertiliser Pty. Ltd., Queensland, Australia) 6 d before inoculation according to labeled rates for ornamental applications (0.3549 L per 378.54 L of water).

The biochar used in this experiment was produced from pine parent material (*Pinus taeda, P. palustris, P. echinata, P. elliotti*), which was pyrolyzed for 1 h between temperatures of 550 and 600 °C in a pyro-torrefaction style kiln. The biochar was ground to create particle sizes between four and six mesh. The biochar contained (% dry weight): 1.0% mobile carbon (C), 63.1% resident C, 0.1% mobile nitrogen (N), 0.3% resident N, 17% mobile hydrogen–oxygen (H-O), 6.8% resident H-O, 8.6% soluble ash, 3.7% non-soluble ash (analyzed July 2011 by Control Laboratories Inc., Soil Control Laboratory, Watsonville, CA). The biochar was obtained from New Earth Renewable Energy, a commercial producer that is no longer in operation.

Received for publication 27 June 2012. Accepted for publication 13 Oct. 2012.
This work was funded in part by The Bartlett Tree Expert Co.
We thank Ashura Takanohara for his assistance with this work.
The funders had no role in study design, data collection and analysis, decision to publish, or manuscript preparation.
[1]To whom reprint requests should be addressed; e-mail soohkim@uw.edu.