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Biochar Affects Macronutrient Leaching from a Soilless Substrate

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***Abstract*. Byproducts of pyrolysis, known collectively as biochar, are becoming more common and readily available as ventures into alternative energy generation are explored. Little is known about how these materials affect greenhouse container substrates. The objective of this research was to determine the effect of one form of biochar on the nutrient retention and release in a typical commercial greenhouse container substrate. Glass columns filled with 85:15 sphagnum peatmoss:perlite (v:v) and amended with 0%, 1%, 5%, or 10% biochar were drenched with nutrient solution and leached to determine the impact of biochar on nutrient retention and leaching. Nitrate release curves were exponential and peaked lower, at later leaching events, and had higher residual nitrate release over time with increasing biochar amendment rate. This suggests that biochar might be effective in moderating extreme fluctuations of nitrate levels in container substrates over time. Peak phosphate concentration decreased with increasing biochar amendment rate, whereas time of peak release, girth of the peak curve, and final residual phosphate release all increased with increasing biochar amendment. Additional phosphate levels in leachates from biochar-amended substrates, in addition to the higher phosphate concentrations present in later leaching events, suggest this form of biochar as a modest source of phosphate for ornamental plant production. Although there was not sufficient potassium (K) from biochar to adequately replace all fertilizer K in plant production, increasing levels of this form of biochar will add a substantial quantity of K to the substrate and should be accounted for in fertility programs.**

Modern pyrolysis systems are used to extract liquid and gas petroleum products from biomass for fuel or other chemical products. Biochar is the charred organic matter that remains after pyrolysis of biomass or manure. Biochar is essentially the same as charcoal with the primary distinction being that biochar is intended for some form of soil or agricultural application (Lehmann and Joseph, 2009). Return of biochar to soil systems, where it is believed to be stable for hundreds or thousands of years, is touted as a promising solution to reducing atmospheric carbon (Glaser et al., 2002).

The influence of biochar in mineral soil systems has been studied and reviewed extensively (Lehmann et al., 2011; Spokas et al., 2011). Some of the most commonly cited beneficial impacts of biochar have been improved crop growth in highly weathered or sandy soils (Lehmann et al., 2003; Novak et al., 2009), increased soil pH (Novak et al., 2009), shifts to beneficial microbial populations (Lehmann et al., 2011), increased mycorrhizal associations (Warnock et al., 2007), and improved nutrient retention (Clough and Condron, 2010). Benefits of biochar are not consistently realized in temperate soils. A meta-analysis on 100 biochar studies concluded that variability in biochar source and application parameters resulted in ≈20% negative results, 30% nonsignificant difference in results, and 50% short-term positive results (Spokas et al., 2011). However, the authors of the meta-analysis caution that there was a greater number of increased yield results reported for studies that occurred in weathered or degraded soils that had prior limited fertility and productivity.

The influence of biochars on soilless substrates used in greenhouse and nursery container substrates has been studied less, and only a few citations tangentially related to greenhouse and nursery production in soilless substrates are available. Kadota and Niimi (2004) reported 10% or 30% additions of biochar combined with either pyroligneous acid (wood vinegar) or barnyard manure to a 2:1:1:1:1 peatmoss:soil:vermiculite:perlite:sand (v/v) substrate had either no effect or minor changes (positive and negative) in growth parameters of several bedding plant species. Graber et al. (2010) reported that biochar improved growth and productivity of pepper (*Capsicum annuum* L.) and tomato (*Lycopersicum esculentum* Mill.) plants in a blend of coconut fiber and tuff and attributed improvements to either stimulated shifts in microbial populations toward beneficial plant growth-promoting rhizobacteria or fungi or low doses of phytotoxic biochar chemicals, which may have stimulated plant growth at low doses. Ruamrungsri et al. (2011) reported that gloriosa lily (*Gloriosa rothschildiana* L.) in a 1:1:1 sand:rice husk charcoal:coconut fiber substrate did not respond to varying levels of applied calcium (Ca) fertilizers as a result of high Ca levels in rice husk charcoal. Santiago and Santiago (1989) briefly summarized their work using wood-based charcoal chips for hydroponic culture in humid tropical regions of Asia but provided few details other than plants grew well when fertilized with resin-coated fertilizers. Dumroese et al. (2011) evaluated pelletized biochar (pellets were 43% biochar, 43% wood flour, 7% polyacetic acid, and 7% starch) in combination with sphagnum peatmoss for production of forest seedlings. They found that amendment with 25% biochar pellets improved hydraulic conductivity and water retention at high matric potentials and beneficially increased substrate pH, although concern was noted about lower cation exchange capacity and higher carbon: nitrogen ratio. Beck et al. (2011) showed that amendment of an unspecified greenroof media with 7% biochar increased water retention and decreased total nitrogen and phosphorus, nitrate, phosphate, and organic carbon in runoff.

The body of biochar research in soilless substrates is far less complete than that for mineral soils; however, the collection of papers thus far seems to indicate similar potential benefits in soilless substrates including additions of some nutrients, reduction in leaching of nitrates and phosphates, beneficial shifts in microbial populations, and improved physical properties. Despite this, these articles have limited applicability to production methods typical of greenhouse production in sphagnum peatmoss substrates. The objective of this research was to determine the effect biochar additions have on nutrient dynamics in a sphagnum peatmoss-based soilless substrate typical of those used in greenhouse production of ornamental crops.

Materials and Methods

A standard commercial soilless substrate composed of 85:15 sphagnum peatmoss: perlite (v:v) (BM-6; Berger Peat Moss, Saint-Modeste, Quebec, Canada) was selected as the base substrate for the study. The base substrate contained no incorporated macronutrient fertilizers. Biochar used in this study was obtained from a local bioenergy pyrolysis unit [Synterra Energy (formerly Red Lion Bio-Energy), Toledo, OH] with particle size distribution and chemical properties in Tables 1 and 2. Particle size distribution was determined by passing ≈100 cm^3 oven-dried (72 °C) biochar through 19.0-, 12.5-, 6.30-,

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