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Pine Bark Substrates Amended with Parboiled Rice Hulls: Physical Properties and Growth of Container-grown Spirea during Long-term Nursery Production

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Abstract. **The decline in the availability of pine (*Pinus taeda* L.) bark (PB) supplies and increasing prices have caused concerns in the nursery industry. Research was conducted to evaluate the effect of parboiled rice (*Oryza sativa* L.) hulls (PBH) as a substrate amendment to PB-based container substrates on the growth of *Spiraea* ×*bumalda* L. 'Anthony Waterer' and to examine the changes in physical properties of the substrates during long-term production cycles under outdoor nursery conditions. Six substrates were formulated by blending PB with 0%, 20%, 40%, 60%, 80%, or 100% PBH (by volume). Substrate composition affected plant growth components evaluated, generally decreasing growth as the amount of PBH increased. However, amending PB with up to 40% PBH did not result in a significant decrease in plant growth or increase the volume or frequency of irrigation for container-grown spirea. Physical properties of substrates amended with PBH improved over time. Based on these results, PB-based substrates amended with up to 40% PBH retained physical properties that were generally within current guidelines for nursery container substrates after one (25 weeks) and two (70 weeks) growing seasons.**

The most common components of soilless container media used by the nursery industry in the United States are bark from loblolly pine (*Pinus taeda* L.) and douglas fir [*Pseudotsuga menziesii* (Mirb.) Franco]. Loblolly PB is widely used by growers on the East Coast, in the Midwest, and in the southern regions of the United States and douglas fir bark is commonly used on the West Coast. Within the last decade, the nursery industry has faced a steady decline in the availability of PB as well as higher costs because of an increase in demand for alternative uses (e.g., heating fuel), a decline in log harvest, and an increase in freight costs (Haynes, 2003; Lu et al., 2006). A greater shortage and inferior quality of PB are expected as a result of the increasing demand for wood-based materials to be used as biofuels (Day, 2009). The industry is interested in alternative, economical, and sustainable container substrates that are able to provide adequate growing conditions for nursery production.

To address this issue, a long list of bark alternatives has been evaluated, including but not limited to pine trees/wood (Boyer et al., 2008; Fain et al., 2008; Jackson, 2008; Jackson et al., 2009; Wright and Browder, 2005; Wright et al., 2006), recycled paper (Craig and Cole, 2000), composted turkey litter (Tyler et al., 1993), cotton gin waste (Cole et al., 2005; Jackson et al., 2005; Owings, 1993), and sewage sludge (Guerrero et al., 2002). Other new materials currently being evaluated as substitutes for PB in nursery production include some fast-growing herbaceous crops such as switchgrass, willow, corn, and bamboo (Boyer et al., 2010).

Another possible alternative is rice (*Oryza sativa* L.) hull. Rice hulls are a relatively underused and sustainable container substrate, which are normally considered a waste byproduct of the rice milling and processing industry (Lovelace and Kuczmarski, 1992). Large quantities of rice hulls are produced annually in the United States, especially in the southern and western states. Numerous studies have been conducted evaluating different forms of rice hulls as alternative substrates in propagation, greenhouse, and nursery production. Rice hulls are available in a variety of forms, including fresh, aged, carbonized, composted, burnt, and parboiled (Buck, 2008). Fresh rice hulls are typically avoided as container substrates because of residual rice and/or weed seed.

Parboiled rice hulls are produced by steaming and drying rice hulls after the milling process. This results in a lightweight and consistent product that is free of viable weed and/or rice seed (Evans and Gachukia, 2004). Another advantage in using PBH as a horticultural substrate amendment is the low decomposition rate during the typical production cycle of nursery crops. Despite being an organic compound, rice hulls consist mainly of lignin, cutin, and insoluble silica, providing a slow breakdown of particles and therefore making PBH an appropriate substrate for long-term crop production (Juliano et al., 1987).

Einert and Guidry (1975) published some of the earliest work on the use of fresh and composted rice hulls as an amendment for the soil-based container production of woody ornamentals. Although statistical analyses were not included, either form of rice hulls appeared to be a suitable media amendment based on mortality and growth data for Pfitzer juniper [*Juniperus* ×*pfitzeriana* (L.) Späth]. Laiche and Nash (1990) evaluated the effect of composted rice hulls on the growth of three woody plants (*Rhododendron indicum* L., *Ilex crenata* Thunb., and *Juniperus horizontalis* Moench.) in containers. Their results demonstrated plant growth in organic components of 100% composted rice hulls or 50% composted rice hulls:50% bark compared favorably with the growth obtained using 100% PB.

Lovelace and Kuczmarski (1992) reported that aged rice hulls compared favorably to 100% PB in cost and performance when used as a component of a blend including PB, rice hulls, and sand (2:2:1 by volume) for a variety of woody ornamentals. Baiyeri (2005) demonstrated that when using composted rice hulls amended with poultry manure (3:1 by volume), sucker plantlets from five banana genotypes generally resulted in more vigorous suckers than when sawdust and poultry manure (3:1 by volume) or rice hulls, sawdust, and poultry manure (1.5:1.5:1 by volume) were used at the nursery stage of production.

Fresh (Einert, 1972; Papafotiou et al., 2001; Sambo et al., 2008), carbonized (Kämpf and Jung, 1991; Tatum and Winter, 1997), parboiled (Evans and Gachukia, 2007), and ground parboiled (Buck and Evans, 2010) rice hulls have been evaluated as substrates on a number of greenhouse crops. Dueitt and Newman (1994) determined that fresh rice hulls hold more water than aged rice hulls in greenhouse media for seedlings of *Tagetes erecta* L. and *Limonium suworowii* (Reg.) Kuntze. Evans and Gachukia (2007) reported that the large particles of PBH provide adequate drainage and aeration in peat-based substrates. More recently, Buck and Evans (2010) revealed that given its physical properties, ground PBH can be used as a suitable replacement for up to 40% peatmoss to grow greenhouse crops.

A preferred container substrate should provide stable plant support, a reservoir for nutrients and water to the root system, and adequate gas exchange (Nelson, 2003). Bunt (1988) stated that the most important physical properties of containerized substrates are dry bulk density (DBD; $g \cdot cm^{-3}$), air-filled pore space (AS; %), water-holding capacity

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