

Performance of Container Landscape Plants in Media with Hemp Hurd Fiber Substituted for Peat

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Abstract. Hemp (*Cannabis sativa*) hurd fiber is a by-product of various hemp industries, including grain, textile, and medicinal. The first use of hurd as a container substrate was in research on greenhouse crops; it has not been tested on landscape plants. We evaluated the performance of three shrubs [forsythia (*Forsythia × intermedia*), northern bayberry (*Morella pensylvanica*, Bobbee™, ‘Bobzam’), and Siberian cypress (*Microbiota decussata*)] and two herbaceous perennials [bee balm (*Monarda didyma*, Sugar Buzz®, ‘Grape Gumball’) and switchgrass (*Panicum virgatum*, Ruby Ribbons™, ‘RR1’), grown in standard nursery medium with hurd in place of peatmoss. The control medium consisted of pine bark, peat, and sand at 4:2:1. Experimental media had 50% or 100% of the peat portion of the control medium replaced with hurd. For all shrub species, plants grown in media containing hurd were of similar size and visually indistinguishable from plants grown in control medium. Plants of switchgrass grown in all three media were visually and physically similar, but shoot weight was slightly greater for plants in control medium. Bee balm plants grown in control medium had a slightly greater shoot weight and total number of inflorescences than plants grown in media containing hurd. These differences may be attributable to nitrogen immobilization or less nutrient retention in the media containing hurd, resulting from the greater porosity of hurd compared with peat. Root area was greater for switchgrass and bee balm grown in hurd replacement media than control medium, possibly because hurd retains less water and nutrients to sustain shoot growth beyond a certain threshold, at which point plants redirect the allocation of photosynthates to the roots. Hemp hurd fiber is a promising alternative substrate for the container production of landscape plants and we expect that many species would perform well in media containing hurd.

Sphagnum peatmoss is an essential component of container media used to produce landscape trees, shrubs, and herbaceous perennials (Horticultural Trade Association 2022). A typical landscape plant potting medium contains ~30% peat, 55% partially composted softwood bark, and 15% sand. The cost of peat is increasing, receiving a steady supply has been problematic, and there are growing concerns over the potential ecological damage caused by peat extraction (Beretta and Ripamonti 2021; Mander et al. 2024). Nursery growers are interested in alternative potting substrates that reduce reliance on peat and produce similar-quality plants. Several peat alternatives, such as biochar, coir, and wood fiber, have been evaluated for woody plants, but

no single product has been widely adopted by the nursery industry to replace peat (Agarwal et al. 2021; Atzori et al. 2021).

Hemp (*Cannabis sativa*) fiber production in the United States is increasing annually (Boyle 2025). Hemp stems produce two different fibrous tissues: bast and hurd (Small 2015). Bast fibers are long and run the length of the stem surrounding the woody core, which consists of short hurd fibers. Only bast

fiber is desired for the textile industry; however, most (~70%) of the hemp stem is hurd fiber (Smart et al. 2023). Although there are some recognized uses for hurd, including animal bedding, hempcrete, and wood paneling, hemp farmers and industry stakeholders are interested in identifying new, larger end markets for their hurd by-product.

Recent studies with petunia (*Petunia × hybrida*), geranium (*Pelargonium × hortorum*), and tomato (*Solanum lycopersicum*) have demonstrated great potential for hurd fiber as an alternative substrate for peat (Caballero Mejia et al. 2025a, 2025b). The hurd product used in those studies had a small particle size of ~2 mm in diameter and was free of contaminants such as seeds, leaf debris, and soil particles. When the peat portion of a peat-vermiculite medium was replaced 50% with either hurd or wood fiber, the resulting media had a similar pH, electrical conductivity (EC), air-filled porosity (AFP), total porosity (TP), and bulk density (BD) (Caballero Mejia et al. 2025a). The objective of our study was to evaluate the use of hurd as a substitute for peat in a standard nursery medium, consisting of four parts softwood bark, two parts peat, and one part sand, for the container production of landscape shrubs and herbaceous perennials.

Materials and Methods

Experimental media. Three experimental media were tested in comparison with the control medium, which consisted of four parts pine bark (Premium Pine Bark Mulch; Nature’s Choice, Inc, Glenville, GA, USA), two parts sphagnum peatmoss (Canadian sphagnum peatmoss 0–20 mm; Lambert, Quebec, Canada), and one part sand. Experimental medium 1 had 50% of the peat portion of the control medium replaced with hurd (pure powdered hurd 2 mm; Hemp Traders, Los Angeles, CA, USA) and experimental medium 2 had 100% of the peat portion of the control medium replaced with hurd. The physical properties of container capacity (CC), AFP, TP, and BD were measured for four replicate samples of each substrate and experimental media according to Elliott (1992). Initial pH, EC, and nutrient content were measured for three replicate samples of each substrate and



Fig. 1. Bee balm (*Monarda didyma*, Sugar Buzz®, ‘Grape Gumball’) inflorescences fully open (A), partially open (B), and in bud (C).

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Substrate or medium	AFP (%)	CC (%)	TP (%)	BD (g·cm ⁻³)	pH	EC (mS·cm ⁻¹)	NO ₃ (mg·kg ⁻¹)	NH ₄ (mg·kg ⁻¹)	P (mg·kg ⁻¹)	K (mg·kg ⁻¹)	Ca (mg·kg ⁻¹)	Mg (mg·kg ⁻¹)
Hurd	23.9 b ¹	63.2 a	87.1 a	0.085 d	5.7 b	0.75 a	31.77 a	13.63 a	33.74 a	210.13 a	20.75 a	18.54 a
Peat	15.7 c	61.8 a	77.6 b	0.095 d	4.1 d	0.25 b	7.03 b	0.60 d	0.00 c	1.89 d	11.10 b	7.81 b
Bark	31.3 a	22.7 c	54.0 d	0.297 c	4.3 d	0.16 cd	1.07 b	1.17 bc	3.99 b	28.82 bc	8.80 bc	3.10 c
Sand	1.8 d	26.6 c	28.5 e	1.557 a	6.0 a	0.04 e	1.40 b	1.00 c	0.13 c	2.59 d	2.58 d	0.68 d
Control medium	23.7 b	45.6 b	69.3 c	0.340 b	4.3 d	0.13 d	2.47 b	1.00 c	0.66 c	10.79 cd	5.89 c	2.50 c
50% Hurd replacement	23.7 b	44.8 b	68.6 c	0.354 b	4.5 c	0.16 cd	4.60 b	1.00 c	1.99 bc	19.98 b-d	6.82 c	2.80 c
100% Hurd replacement	20.7 bc	49.7 b	70.5 c	0.365 b	4.6 c	0.20 bc	7.10 b	1.40 b	4.42 b	36.30 b	7.13 c	3.25 c

Mean separation within columns indicated by different letters, according to Tukey's honestly significant difference test at $P \leq 0.05$ and $n = 4$ for AFP, CC, TP, and BD; and $n = 3$ for saturated media extract results. AFP = air-filled porosity; BD = bulk density; CC = container capacity; EC = electrical conductivity; TP = total porosity.

Table 2. Performance of northern bayberry (*Morella pensylvanica*, BobbeTM, 'Bobzam'), forsythia (*Forsythia × intermedia*), and Siberian cypress (*Microbiota decussata*) grown in bark, peat, and sand medium at 4:2:1 (control), and two experimental media with 50% or 100% of the peat portion of the control medium replaced with hurd.

Plant and medium	2024					2025				
	Ht (cm)	Width (cm)	Size increase (%)	Shoot wt (g)	No. of shoots			Shoot length (cm)		
					Primary	Lateral	Total	Primary	Lateral	Total
Bayberry	72.5 ^j	55.3 a	482.4 a	233.0 a	10.6 a	1.3 a	517.3 a	40.9 a	558.2 a	—
	50% Hurd replacement	72.6 a	419.8 a	225.3 a	11.3 a	1.9 a	526.8 a	54.3 a	581.1 a	—
	100% Hurd replacement	70.2 a	476.9 a	214.9 a	10.5 a	1.1 a	494.6 a	43.2 a	537.8 a	—
Forsythia	111.6 a	—	819.9 a	128.6 a	2.7 a	3.6 a	204.2 a	53.1 a	257.2 a	—
	50% Hurd replacement	104.1 a	787.1 a	106.4 b	2.7 a	2.1 a	201.9 a	33.3 a	235.2 a	—
	100% Hurd replacement	102.9 a	732.5 a	117.2 ab	2.7 a	1.4 a	201.5 a	23.9 a	225.4 a	—
Siberian cypress	35.5 a	29.0 a	31.8 a	50.8 a	—	—	—	—	—	16.3 a
	50% Hurd replacement	33.1 a	29.6 a	42.0 a	—	—	—	—	—	16.7 a
	100% Hurd replacement	33.8 a	26.2 a	34.0 a	—	—	—	—	—	17.9 a

¹ Mean separation within columns, within species, indicated by different letters, according to Tukey's honestly significant difference test at $P \leq 0.05$ and $n = 10$. For Siberian cypress, $n = 5$.

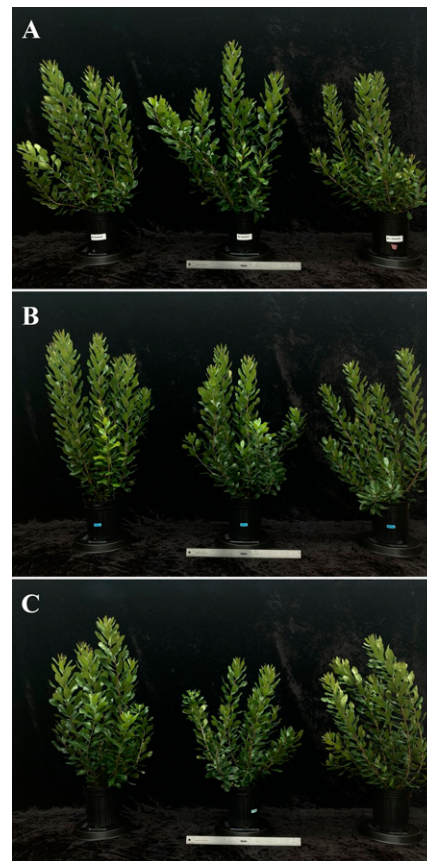


Fig. 2. Northern bayberry (*Morella pensylvanica*, Bobbee™, 'Bobzam') plants grown in bark, peat, and sand medium at 4:2:1 (control) (A), and two experimental media with 50% (B) or 100% (C) of the peat portion of the control medium replaced with hurd.

experimental media by saturated media extract analysis at the University of Connecticut (UConn) Soil Testing Laboratory (Storrs, CT, USA).

Shrub study. The shrubs forsythia (*Forsythia* $\times$ *intermedia*), northern bayberry (*Morella pennsylvanica*, Bobbee™, ‘Bobzam’), and Siberian cypress (*Microbiota decussata*) were studied. In Feb 2024, forsythia was propagated by softwood cuttings collected from containerized stock plants that were forced in a greenhouse, along with Siberian cypress by hardwood cuttings collected from landscape plants on the UConn campus in Storrs, CT, USA. On 18 Apr 2024, rooted cuttings were potted in 1-L containers using control medium and were grown in a greenhouse with a heating set point of 15.5 °C, a ventilation set point of 25 °C, and a 16-h photoperiod with day-length extension provided by 1000-W high-pressure sodium lamps. Northern bayberry plants were micropropagated and then established in 50-plug trays. On 23 May 2024, plants were potted in 2.8-L containers using experimental media. Before transplanting forsythia and Siberian cypress, the existing media was gently removed from the root balls by washing with water. Containers for all species were top-dressed with 13 g 15N–3.9P–9.9K controlled-release fertilizer (Osmocote Plus

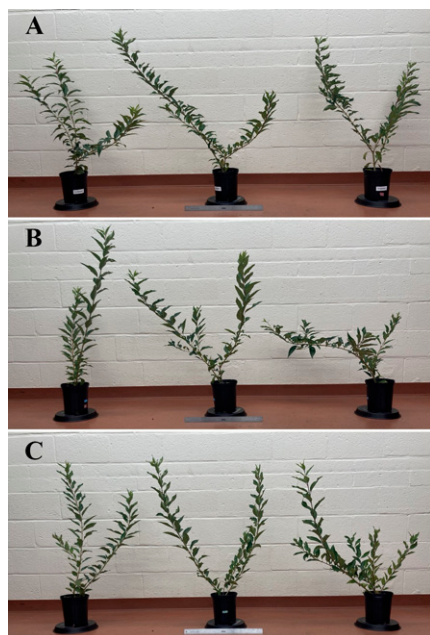


Fig. 3. Forsythia (*Forsythia ×intermedia*) plants grown in bark, peat, and sand medium at 4:2:1 (control) (A), and two experimental media with 50% (B) or 100% (C) of the peat portion of the control medium replaced with hurd.

8- to 9-month formulation; Everris NA, Dublin, OH, USA). The experimental unit was a single container plant. Containers were set outdoors on benches at the UConn Floriculture Greenhouse Facility (Storrs, CT, USA) and were arranged, by species, as a completely randomized design (CRD) with 10 replications.

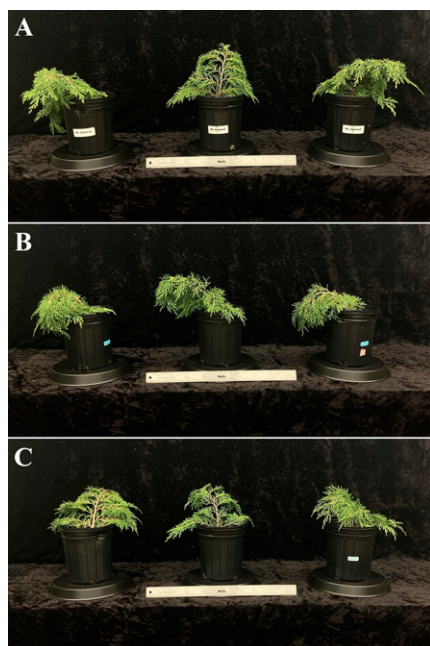


Fig. 4. Siberian cypress (*Microbiota decussata*) plants in Sep 2024, 5 months after potting, grown in bark, peat, and sand medium at 4:2:1 (control) (A), and two experimental media with 50% (B) or 100% (C) of the peat portion of the control medium replaced with hurd.

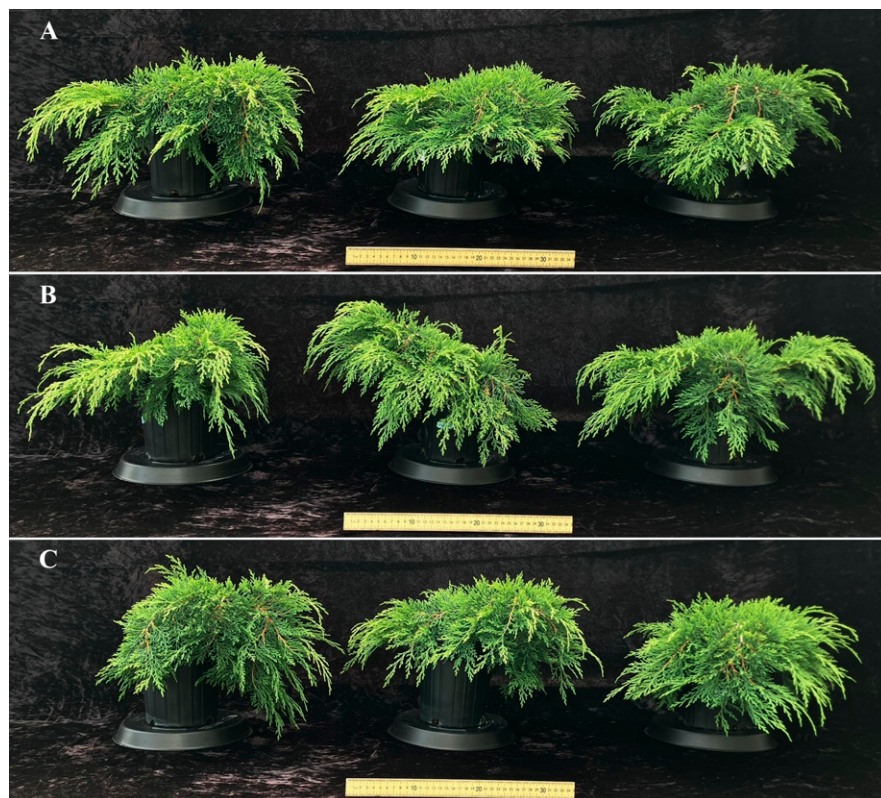


Fig. 5. Siberian cypress (*Microbiota decussata*) plants in May 2025, 13 months after potting, grown in bark, peat, and sand medium at 4:2:1 (control) (A), and two experimental media with 50% (B) or 100% (C) of the peat portion of the control medium replaced with hurd.

Containers were irrigated using trickle emitters as needed. At each irrigation event, containers received ~450 mL water. Pour-through testing, according to Cavins et al. (2004), was conducted every 2 weeks for the same three replicate plants per treatment, selected at random at the start of the experiment. The pH and EC of the leachate were measured with a portable meter (HI 9813-6; Hanna Instruments, Smithfield, RI, USA). Plant height (from stem base to tip) was measured after transplanting and then again at harvest, which began 5 Sep 2024 and lasted 2 d. Data were collected on plant width (measured twice at right angles to each measurement and averaged), shoot fresh weight, and number and length of primary and lateral shoots. Total shoot length was calculated by summing the lengths of primary and lateral shoots. The percent increase in plant size was calculated by subtracting the initial height from the final height, dividing the difference by the initial height, and multiplying the remainder by 100%. For Siberian cypress, only five replicates were harvested destructively in 2024, and the remaining five replicates were overwintered in an unheated pit greenhouse and allowed to grow out in Spring 2025. On 28 May 2025, data were collected on overwintered plants for plant survival, final plant height and width, number and length of primary and lateral shoots, shoot fresh weight, and percent root area, quantified using the particle analysis tool in ImageJ v. 1.54g (National Institutes of Health, Bethesda MD, USA).

Herbaceous perennial study. The herbaceous perennials switchgrass (*Panicum virgatum*, Ruby Ribbons™, 'RR1') and bee balm (*Monarda didyma*, Sugar Buzz®, 'Grape Gumball') were studied. Bee balm was obtained from Prides Corner Farms (Lebanon, CT, USA) as established, 72-cell plugs and two plugs were potted per 2.8-L container using experimental media 10 Mar 2025. On the same date, switchgrass divisions containing five culms were prepared from overwintered container stock plants and potted in the same size containers using experimental media. Plants were top-dressed with 8 g 15N-3.9P-9.9K controlled-release fertilizer (Osmocote Plus 5- to 6-month formulation; Everris NA) and were grown in a greenhouse with a heating set point of 15.5 °C, a ventilation set point of 21 °C, and a 16-h photoperiod. The experimental unit was a single container plant. Plants were arranged by species as a CRD with 10 replications. Irrigation was provided by trickle emitters as needed, with plants receiving ~215 mL water at each irrigation event. Beginning 21 Apr 2025, plants were fertigated weekly with 20N-4.4P-16.6K water-soluble fertilizer (Peters 20-10-20; Graco Fertilizer Co, Cairo, GA, USA) at 200 mg·L⁻¹ N until plant harvest. Pour-through testing was conducted as described. Bee balm plants were harvested 8 May 2025 and switchgrass was harvested 24 Jun 2025. Data were collected on plant height (from the base to where the leaf blades began to bend for switchgrass) and width (as described for shrubs), number of inflorescences,

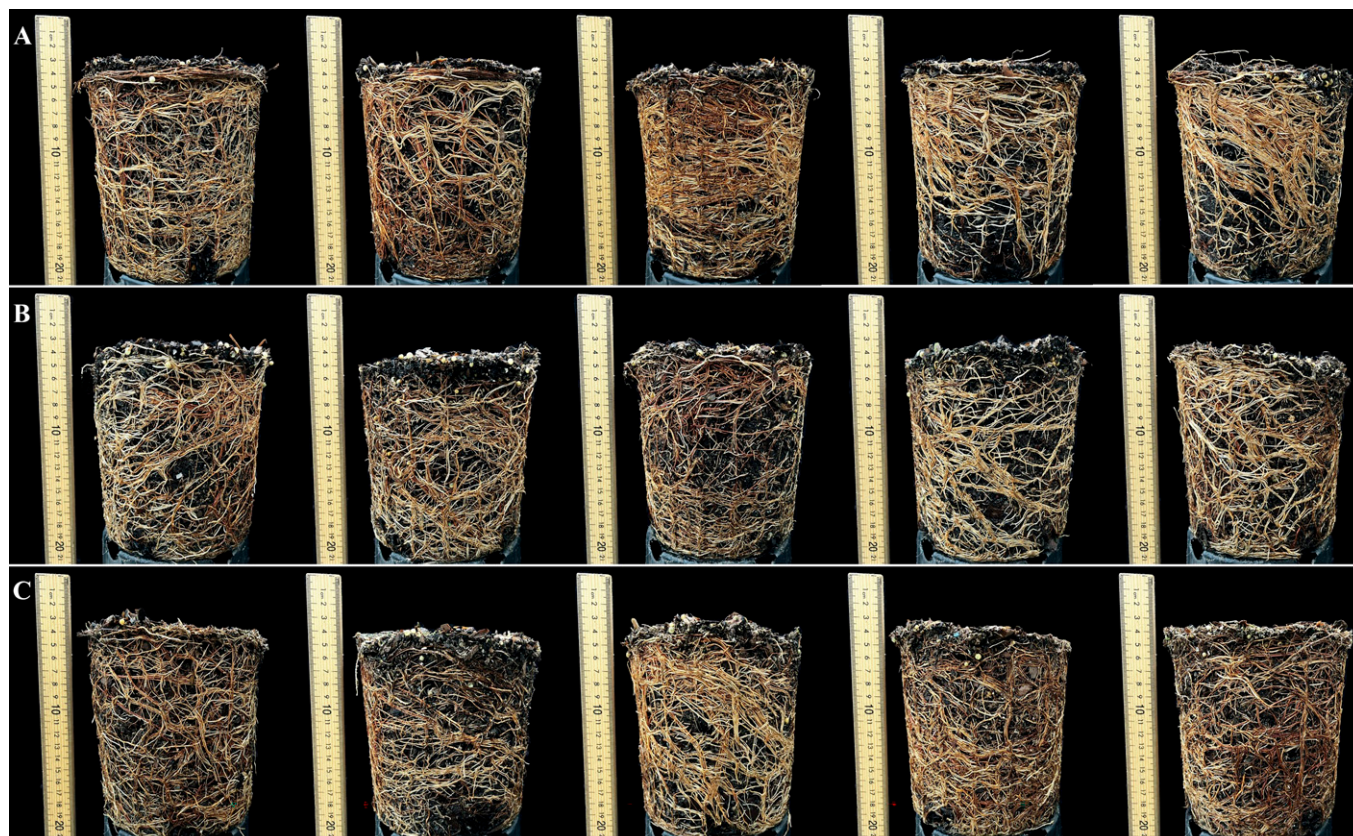


Fig. 6. Roots of Siberian cypress (*Microbiota decussata*) in May 2025, 13 months after potting grown in bark, peat, and sand medium at 4:2:1 (control) (A), and two experimental media with 50% (B) or 100% (C) of the peat portion of the control medium replaced with hurd.

shoot fresh weight, and root area percentage. The number of tillers was counted for switchgrass, and the number of fully open (> 30 open flowers), partially open (1–30 open flowers), and unopened inflorescences (no open flowers) were counted for bee balm (Fig. 1).

Statistical analysis. Data analysis was conducted using RStudio v. 4.4.3 [2025-02-28 (Posit, Boston, MA, USA)] and the packages agricolae v. 1.3.7 and ggplot2 v. 3.5.1. Each species was analyzed separately. Root area percentages for switchgrass were log-transformed.

Data were subjected to analysis of variance and mean separation with Tukey's honestly significant difference test at $P < 0.05$.

Results and Discussion

The experimental hurd replacement media had similar AFP, CC, TP, and BD values as the control medium, and all values were within recommended ranges for nursery production container media (Table 1) (Jackson et al. 2008). The control medium had a slightly lower pH than the experimental hurd media; however, all media pH values were as expected for softwood bark-based media and were suitable for container production of the plant species evaluated. Media EC and nutrient concentrations were within ranges considered acceptable to optimum for container media of landscape plants (Mylavarapu and Yeager 2015).

Plants of bayberry, forsythia, and Siberian cypress grown in 50% and 100% hurd replacement media were similar to the control plants for all measured parameters and were visually indistinguishable from the control plants (Table 2, Figs. 2-6). The only exception was forsythia plants grown in the 50% hurd replacement medium, which had a slightly less shoot fresh weight than control plants for reasons that are unclear beyond random effects (Table 2). Bayberry plants in all media grew vigorously, filled out containers quickly, and were of marketable size and quality by the end of the growing season (Fig. 2). Siberian cypress plants that

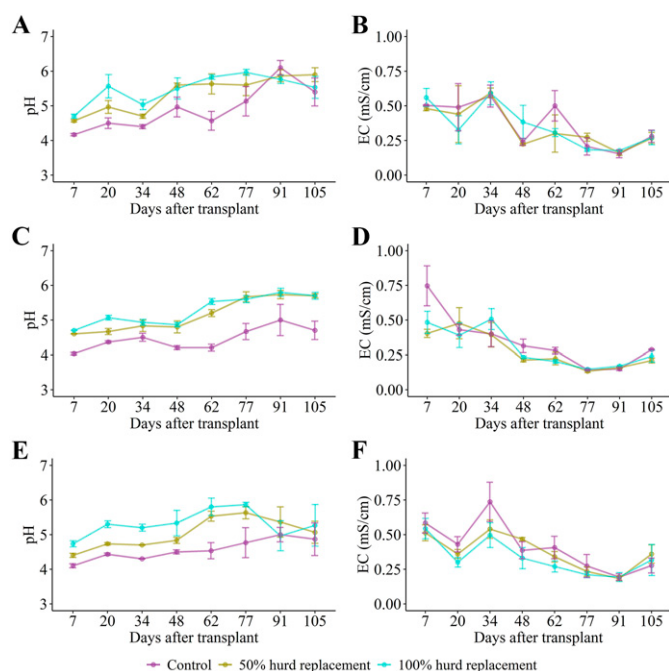


Fig. 7. Pour-through values for pH and electrical conductivity (EC) for northern bayberry (*Morella pensylvanica*, Bobbee™, 'Bobzam') (A and B), forsythia (*Forsythia × intermedia*) (C and D), and Siberian cypress (*Microbiota decussata*) (E and F) grown in bark, peat, and sand medium at 4:2:1 (control), and two experimental media with 50% or 100% of the peat portion of the control medium replaced with hurd.

Table 3. Performance of bee balm (*Monarda didyma*, Sugar Buzz®, ‘Grape Gumball’) and switchgrass (*Panicum virgatum*, Ruby Ribbons™) grown in bark, peat, and sand medium at 4:2:1 (control), and two experimental media with 50% or 100% of the peat portion of the control medium replaced with hurd.

Medium	Ht (cm)	Width (cm)	Shoot wt (g)	No. of inflorescences				No. of tillers	Root area (%)
				Fully open	Partially open	In bud	Total		
Bee balm									
Control	37.3 a ⁱ	33.8 a	146.9 a	9 a	9 a	9 a	26 a	—	41.0 c
50% Hurd replacement	35.0 a	31.3 b	124.0 b	8 a	7 a	6 a	21 b	—	45.3 b
100% Hurd replacement	34.8 a	31.7 ab	120.2 b	8 a	7 a	9 a	24 ab	—	50.7 a
Switchgrass									
Control	75.5 a	89.4 a	149.6 a	—	—	—	14 ab	35 a	24.8 b
50% Hurd replacement	76.0 a	90.9 a	140.3 ab	—	—	—	15 a	36 a	28.5 a
100% Hurd replacement	73.1 a	88.6 a	125.2 b	—	—	—	11 b	30 a	28.9 a

ⁱMean separation within columns, within species, indicated by different letters, according to Tukey’s honestly significant difference test at $P \leq 0.05$ and $n = 10$.

were overwintered and allowed to grow out the following spring developed very well and tripled their shoot weight during the 8 months from Sep 2024 data collection to the end of May 2025 (Table 2, Figs. 4 and 5). After potting in experimental media, study plants were not pruned because we did not want to affect their natural grow-out. If forsythia plants had been pruned in late spring or early summer, they would have achieved a fuller habit, and developed the market size and quality typical of forsythia in #1 containers. During the 2024 growing season, the EC was similar for all

media, and pH was slightly less for the control medium compared with the 50% and 100% hurd replacement media (Fig. 7).

Bee balm plants grown in the control medium had a greater shoot fresh weight than plants grown in hurd-containing media, and had a greater width and number of inflorescences than plants grown in the 50% hurd replacement medium (Table 3). These differences, however, were not evident visually (Fig. 8). At the time of harvest, bee balm plants from all media treatments had similar amounts of fully and partially open inflorescences and

inflorescences in bud (Table 3, Figs. 1 and 8). Switchgrass plants grown in all media had similar height, width, and number of tillers, and were visually indistinguishable (Table 3, Fig. 9). Control switchgrass plants had a greater shoot fresh weight than plants grown in the 100% hurd replacement medium; however, the root area percentage was less for the control plants than the plants grown in hurd replacement media (Table 3, Fig. 10). Similarly, for bee balm, the root area percentage was lowest for control plants (Table 3, Fig. 11). It is possible that hurd retains less water and nutrients to



Fig. 8. Bee balm (*Monarda didyma*, Sugar Buzz®, ‘Grape Gumball’) plants grown in bark, peat, and sand medium at 4:2:1 (control) (A), and two experimental media with 50% (B) or 100% (C) of the peat portion of the control medium replaced with hurd.

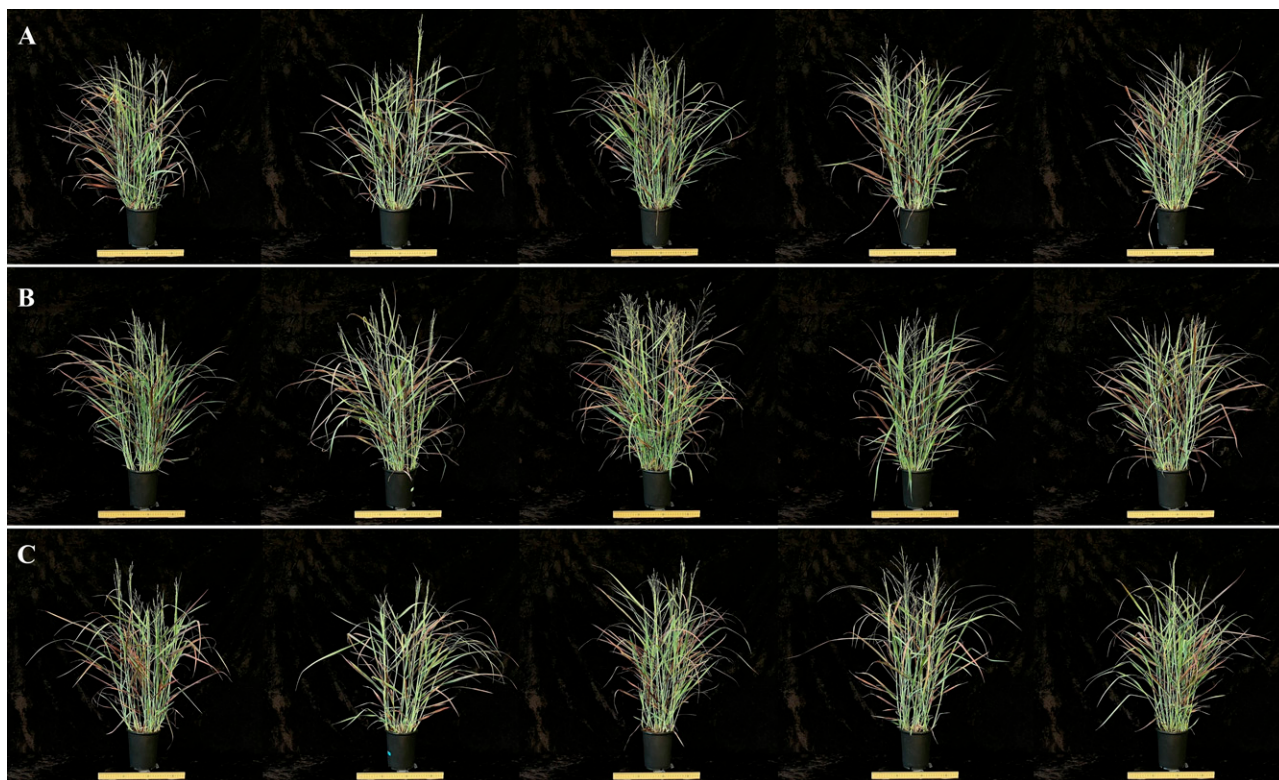


Fig. 9. Switchgrass (*Panicum virgatum*, Ruby Ribbons™, 'RR1') plants grown in bark, peat, and sand medium at 4:2:1 (control) (A), and two experimental media with 50% (B) or 100% (C) of the peat portion of the control medium replaced with hurd.

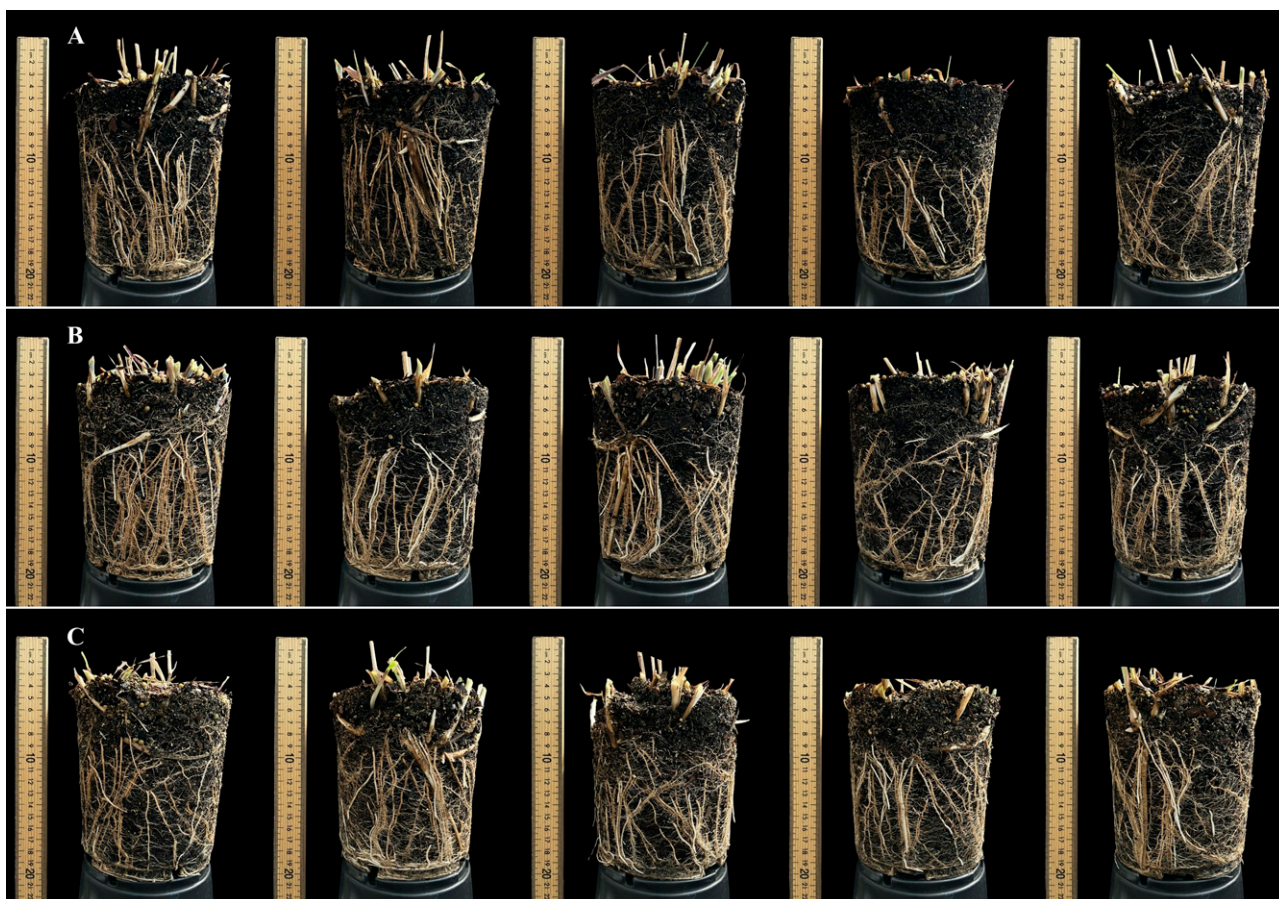


Fig. 10. Roots of switchgrass (*Panicum virgatum*, Ruby Ribbons™, 'RR1') grown in bark, peat, and sand medium at 4:2:1 (control) (A), and two experimental media with 50% (B) or 100% (C) of the peat portion of the control medium replaced with hurd.

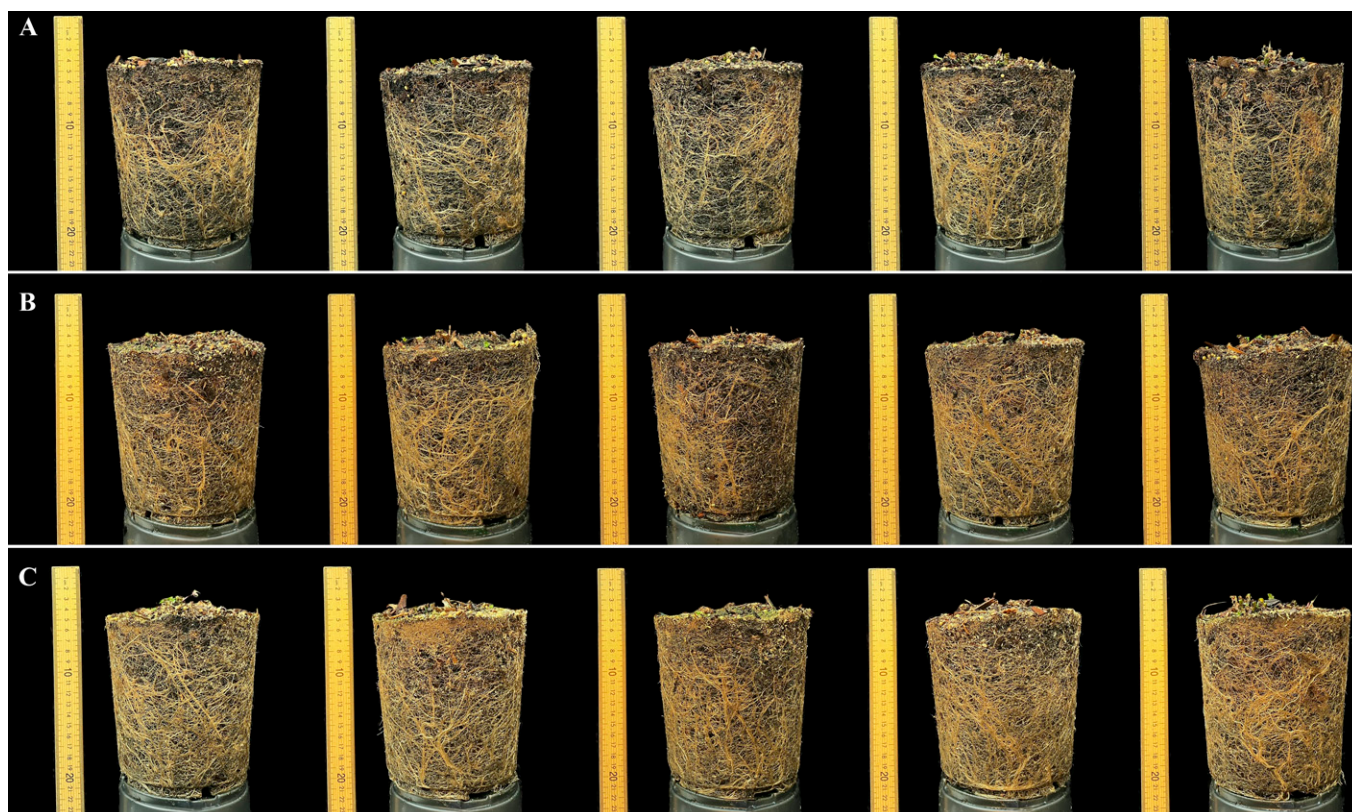


Fig. 11. Roots of bee balm (*Monarda didyma*, Sugar Buzz®, ‘Grape Gumball’) grown in bark, peat, and sand medium at 4:2:1 (control) (A), and two experimental media with 50% (B) or 100% (C) of the peat portion of the control medium replaced with hurd.

sustain shoot growth beyond a certain threshold, at which point plants may have redirected the allocation of photosynthates to the roots. For both herbaceous perennial species, the EC and pH of all three media were similar, except

pH was slightly higher for switchgrass grown in the 100% hurd replacement medium during the first ~65 d of the study (Fig. 12).

Hemp hurd, as a component of container media, may be expected to perform similarly

to wood substrate because both are composed of xylem fiber. Research on a wide range of woody species indicates that wood substrates have great potential as alternatives for the peat or bark portions of container media (Beretta and Ripamonti 2021; Frangi et al. 2008; Jackson et al. 2008; Wright et al. 2006). Experimental growing media containing $\leq 40\%$ wood fiber supported plant growth and quality adequately of ox-eye daisy (*Leucanthemum vulgare*) and sweet William (*Dianthus barbatus*) (Di Lonardo et al. 2021, 2025). In some cases, reduced plant growth in wood fiber-containing media has been observed and attributed to N immobilization or less nutrient retention because wood substrate is more porous than bark and peat, allowing for greater leaching (Caballero Mejia et al. 2025a, 2025b; Frangi et al. 2008; Jackson et al. 2008; Wright et al. 2006). It has been shown for some woody and herbaceous perennial species that growth in wood fiber-containing media can be improved with additional fertilizer (Di Lonardo et al. 2025; Jackson et al. 2008). In a study of three US native grasses, lopsided Indiangrass (*Sorghastrum secundum*), wiregrass (*Aristida beyrichiana*), and sugarcane plumegrass (*Saccharum giganteum*), plants grown in a medium with 27% wood chips performed as well as those in two commercial mixes (LaPierre et al. 2025).

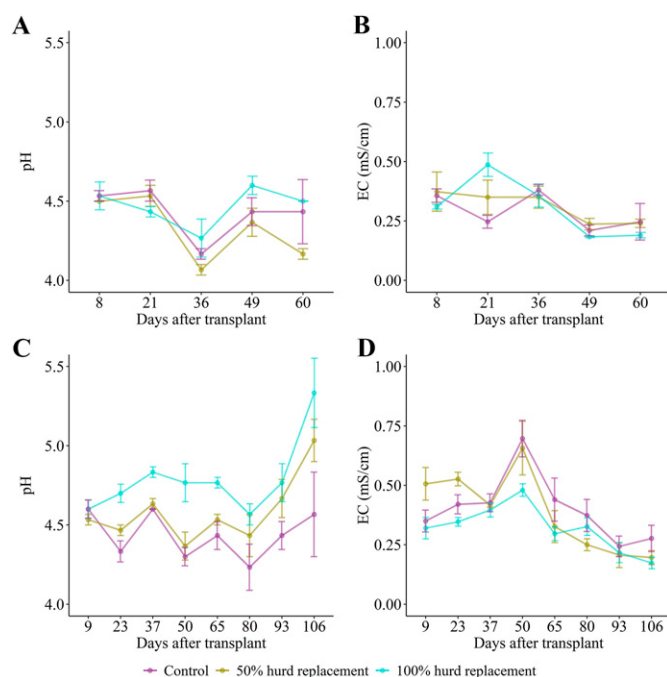


Fig. 12. Pour-through values for pH and electrical conductivity (EC) for bee balm (*Monarda didyma*, Sugar Buzz®, ‘Grape Gumball’) (A and B) and (*Panicum virgatum*, Ruby Ribbons™, ‘RR1’) (C and D) grown in bark, peat, and sand medium at 4:2:1 (control), and two experimental media with 50% or 100% of the peat portion of the control medium replaced with hurd.

Conclusion

Our findings demonstrate that hurd substitution for 50% and 100% of the peatmoss

produced forsythia, northern bayberry, and Siberian cypress plants similar to those grown in standard medium comprised of four parts bark, two parts peat, and one part sand. We expect that many other woody nursery crops will grow well in media containing hurd. The herbaceous perennials bee balm and switchgrass also performed well in media containing hurd. A few growth parameters were reduced slightly for bee balm and switchgrass grown in media with hurd substitution, possibly as a result of greater porosity and less nutrient retention of media containing hurd instead of peat (Caballero Meija et al. 2025a). Nitrogen availability of media containing hurd is likely affected by N immobilization because the C-to-N ratio for hemp fiber is high, similar to wood fiber (Chaowana et al. 2024; Wu et al. 2025). Increasing the fertilizer rate would likely enhance the growth of bee balm and switchgrass in hurd replacement media. We used the manufacturer's recommended low rate of fertilizer; however, in a production setting, a medium to high rate would typically be used for the study species.

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