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Hemp Hurd Fiber as a Substitute for Peat in Container Production of Petunia and Geranium

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Abstract. **Hemp (*Cannabis sativa*) hurd fiber was studied as a potential new substrate to substitute for sphagnum peatmoss in container production of petunia (*Petunia* ×*hybrida* Shock Wave® Coral Crush) and geranium (*Pelargonium* ×*hortorum* Maverick™ Red Hybrid). Media composed of varying proportions of hurd, peat, and vermiculite at 1:0:1, 0.33:0.66:1, 0.66:0.33:1, and 0:1:1 (control) were evaluated. Petunia grown in 0.33:0.66:1 medium had similar shoot weight, flowers, and plant width and were visually indistinguishable from plants grown in control medium. However, as the amount of hurd substituted for peat increased, plant performance declined. Geranium grown in 0.33:0.66:1 medium had greater shoot weight and width than plants in control and 1:0:1 media. Media pH registered above and below recommended ranges for petunia and geranium, respectively, based on pour-thru testing. This may have led to growth reductions due to Fe deficiency for petunia in 1:0:1 medium and Mn toxicity for geranium in control and 0.33:0.66:1 media. Growth of petunia and geranium in peat:vermiculite medium with either hurd or wood fiber in substitution of peat at 50% was also studied. Petunia in the hurd medium were slightly smaller than those in wood fiber and control media, whereas geranium was similar across media. This is the first reported use of hurd as a substrate for bedding plant production. These findings suggest that hurd is a promising new substrate and may be substituted for ~30% of the peat portion of a standard peat:vermiculite medium to produce high-quality plants.**

Growers are interested in sustainable substrates to replace sphagnum peatmoss in container media due to the increasing cost of peat and consumer awareness of the environmental impacts of peat extraction from natural bogs (Mander et al. 2024). Studies on alternative substrates, including coir, biochar, and wood fiber, demonstrate that many offer benefits to plant production; however, no single substrate has been broadly adopted by the horticultural industry to replace peat (Agarwal et al. 2023; Atzori et al. 2021).

Hemp (*Cannabis sativa*) farming for fiber, grain and/or flower has increased since 2018 when the plant was legalized in the United States. The hemp stem consists of long bast fibers and short hurd or shive fibers (Small 2015). Decortication of the hemp stem results in mostly hurd at ∼70% (Smart et al. 2023). Bast are important for the textile industry, whereas hurd has fewer recognized uses. Novel uses for hurd include animal bedding, wood paneling, and hempcrete (Kymäläinen et al. 2001). There have been a few reported uses of hemp fiber for plant growing mats and in hydroponics production, but little research exists on its use as a substrate in potting media (Nerlich et al. 2022; Terrafibre 2025).

This research evaluated the use of hemp hurd as a substitute for peat in a standard bedding plant medium composed of equal parts peat and vermiculite (Boodley and Sheldrake 1982). Growth and performance of petunia (*Petunia* ×*hybrida*) and geranium (*Pelargonium* ×*hortorum*) were studied because they are two of the most widely produced and sold greenhouse crops in the United States (Coleman 2025). An additional objective of this research was to compare the use of hurd and wood fiber in place of peat for growing these crops.

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Materials and Methods

Hurd experiments. There were four experimental media composed of different proportions of the substrates hurd [100% powdered hurd 2 mm; Hemp Traders, Los Angeles, CA, USA (Fig. 1)], sphagnum peatmoss (Canadian sphagnum peatmoss 0–20 mm; Lambert Quebec, Canada), and vermiculite (horticultural grade fine vermiculite; Whittemore Company, Lawrence, MA, USA) as follows: 1:0:1, 0.33:0.66:1, 0.66:0.33:1, and 0:1:1 (control). Four replicate samples of each substrate and experimental media were assessed for physical properties of air-filled porosity (AFP), container capacity (CC), total porosity (TP), and bulk density (BD) according to Elliott (1992). Initial pH, electrical conductivity (EC), and nutrient content for three replicate samples of each substrate and experimental media were determined by saturated media extract (SME) analysis at the University of Connecticut (UConn) Soil Testing Laboratory (Storrs, CT, USA).

Three experiments were conducted. The first two experiments used seeds of petunia (*Petunia* ×*hybrida* Shock Wave® Coral Crush), and the third experiment used seeds of geranium (*Pelargonium* ×*hortorum* Maverick™ Red Hybrid). Petunia seedlings with four expanded leaves were transplanted to 1.5-L containers on 22 Nov 2023 for Expt. 1 and 23 Jan 2024 for Expt. 2, and experiments lasted 42 d. Geranium seedlings with two expanded leaves were transplanted on 19 Mar 2024 and the experiment lasted 70 d. Containers were top-dressed with 3 g of 15N–3.9P–10K controlled-release fertilizer (Osmocote Plus 3- to 4-month formulation; Everris NA, Dublin, OH, USA). The experimental unit was a single container plant and for each

Fig. 1. Substrates: (**A**) hurd (100% powdered hurd 2 mm; Hemp Traders, Los Angeles, CA, USA); (**B**) sphagnum peatmoss (Canadian sphagnum peatmoss 0-20 mm; Lambert Quebec, Canada).

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Table 1. Air-filled porosity (AFP), container capacity (CC), total porosity (TP), and bulk density (BD) and saturated media extract (SME) analysis of pH, electrical conductivity (EC), and nutrient content of substrates, hurd, peat, vermiculite, and wood fiber, and six container media formulations.

Substrate or media	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 ($mg·kg^{-1}$)	Fe ($mg·kg^{-1}$)	Mn ($mg·kg^{-1}$)
Hurd	23.9 b[i]	63.2 bc	87.1 ab	0.085 e	5.7 a	0.75 a	31.77 a	13.63 a	33.74 a	210.13 a	20.75 a	18.54 a	0.31 c	0.22 bc
Peat	15.7 c	61.8 c	77.6 d	0.095 de	4.1 de	0.25 c	7.03 cde	0.60 fg	0.00 e	1.89 e	11.10 c	7.81 de	0.46 c	0.04 c
Vermiculite	20.5 b	70.6 a	91.1 a	0.102 d	5.0 b	0.04 f	1.00 e	1.00 e	0.00 e	0.75 e	0.49 f	2.29 f	2.81 ab	0.02 c
Wood fiber	37.6 a	41.6 d	79.2 d	0.055 f	4.1 e	0.36 b	1.57 e	4.03 b	3.31 d	67.39 b	15.39 b	13.01 c	0.30 c	1.72 a
1 hurd:1 vermiculite	14.7 cd	69.0 a	83.7 bc	0.141 c	5.0 b	0.34 b	14.27 b	2.57 c	13.08 b	39.08 c	12.34 bc	25.05 a	2.70 ab	0.32 b
0.66 hurd:0.33 peat:1 vermiculite	10.9 d	68.3 ab	79.2 d	0.144 c	4.4 c	0.23 cd	12.33 bc	1.43 d	8.68 c	22.83 cd	9.26 cd	17.90 b	3.95 a	0.23 bc
0.33 hurd:0.66 peat:1 vermiculite	11.3 d	68.2 ab	79.5 cd	0.157 ab	4.3 cde	0.21 cde	9.37 bcd	0.80 ef	3.49 d	11.75 de	7.16 de	11.50 cd	3.00 ab	0.14 bc
0.5 hurd:0.5 peat:1 vermiculite	10.7 d	68.7 a	79.4 cd	0.140 c	4.4 cd	0.20 cde	6.40 cde	1.00 e	3.89 d	12.54 de	5.58 e	9.21 cde	2.28 b	0.09 bc
0.5 wood fiber:0.5 peat:1 vermiculite	14.9 cd	61.3 c	76.1 d	0.147 bc	4.1 de	0.16 de	2.43 e	1.00 e	0.26 e	8.21 de	5.75 de	8.37 de	1.99 b	0.16 bc
1 peat:1 vermiculite (control)	11.1 d	66.0 abc	77.1 d	0.162 a	4.2 cde	0.15 e	4.50 de	0.37 g	0.00 e	4.27 de	5.17 e	5.80 ef	1.95 b	0.06 bc

[i] 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 SME results.

Table 2. Shoot weight, number of flowers, plant width, plant height, number of dead plants, and foliar nutrient content of *Petunia ×hybrida* Shock Wave® Coral Crush and *Pelargonium ×hortorum* Maverick™ Red Hybrid grown in four container medium formulations with varying proportions of hurd, peat, and vermiculite from Expts. 1, 2, and 3.

						Foliar nutrient content						
Media formulation hurd:peat:vermiculite	Shoot wt (g)	No. flowers[i]	Plant width (cm)[ii]	Plant ht (cm)	No. dead plants	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)
Expt. 1—Petunia												
1:0:1	211 c[iii]	177 c	43.9 c			5.94 a	0.267 b	4.89 a	1.84 a	1.28 a	79 b	115 b
0.66:0.33:1	278 b	230 b	47.4 bc			5.41 a	0.316 ab	6.17 a	1.63 a	1.42 a	110 ab	306 a
0.33:0.66:1	304 ab	267 ab	50.6 ab			5.58 a	0.389 a	6.27 a	1.52 a	1.47 a	131 ab	317 a
0:1:1 (control)	349 a	285 a	52.5 a			5.76 a	0.380 a	5.98 a	1.34 a	1.41 a	342 a	292 a
Expt. 2—Petunia												
1:0:1	207 b	140 c	42.8 b			6.98 a	0.629 b	7.09 a	1.69 a	1.31 a	79 b	137 b
0.66:0.33:1	222 b	167 bc	46.3 ab			6.54 a	0.561 b	7.18 a	1.26 b	1.26 ab	89 b	286 a
0.33:0.66:1	291 a	204 ab	49.0 a			6.44 a	0.670 ab	7.38 a	1.07 b	1.03 b	124 b	294 a
0:1:1 (control)	322 a	224 a	50.9 a			6.53 a	0.847 a	7.20 a	1.12 b	1.08 b	244 a	278 a
Expt. 3—Geranium												
1:0:1	343 bc	7.5 a	42.9 bc	41.2 ab		2.38 ab	0.213 b	2.12 a	0.84 ab	0.31 a	39 a	40 b
0.66:0.33:1	485 ab	9.9 a	50.2 ab	44.9 ab		2.18 b	0.205 b	1.86 b	0.78 ab	0.32 a	48 a	75 b
0.33:0.66:1	591 a	11.2 a	53.0 a	46.6 a		2.14 b	0.184 b	1.60 c	0.68 b	0.29 a	62 a	122 a
0:1:1 (control)	241 c	9.0 a	34.0 c	39.2 b	4	2.57 a	0.313 a	2.14 a	0.94 a	0.31 a	101 a	125 a

[i] Individual flowers were counted for petunia and inflorescences for geranium.
[ii] Plant width was measured twice at right angles to each measurement and averaged.
[iii] Mean separation within columns, within experiment, indicated by different letters, according to Tukey's honestly significant difference test at $P \leq 0.05$ and n = 10. Foliar nutrient content was n = 5.

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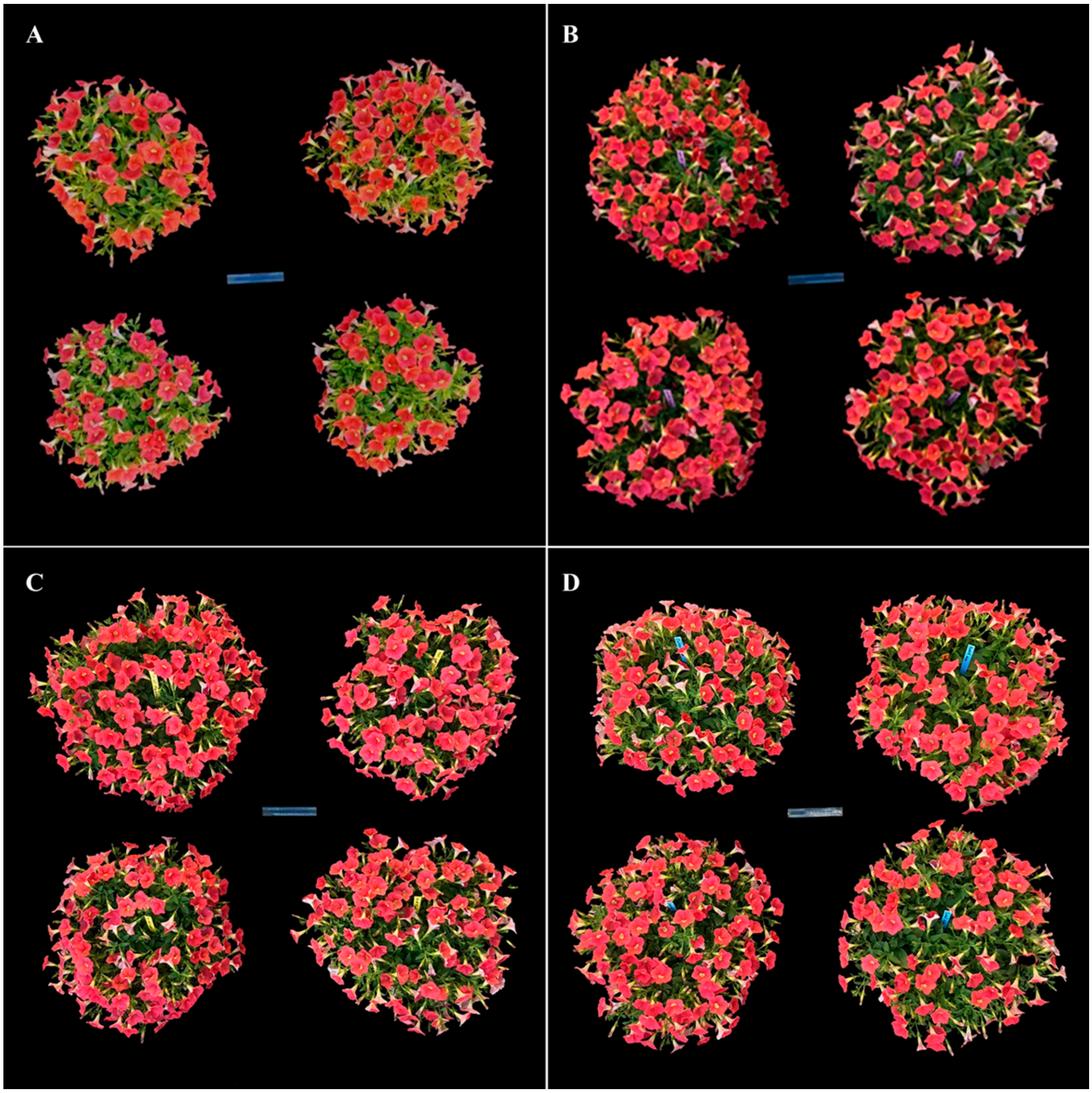

Fig. 2. Finished containers of petunia (*Petunia ×hybrida* Shock Wave® Coral Crush) for Expt. 2 grown in four container media formulations with varying proportions of hurd, peat, and vermiculite as follows: (**A**) 1 hurd:1 vermiculite; (**B**) 0.66 hurd:0.33 peat:1 vermiculite; (**C**) 0.33 hurd:0.66 peat:1 vermiculite; (**D**) 1 peat:1 vermiculite (control).

experiment plants were arranged as a completely random design with 10 replications in a greenhouse with heating set point of 18 °C, ventilation set point of 23 °C and 14-h photoperiod supported by 1000-W high pressure sodium lamps (Phantom HPS 100 W; Hydrofarm, Petaluma, CA, USA).

In Expt. 1 petunia were fertigated as needed with 20N–4.3P–16.6K, acidifying at 215 kg·tonne^{-1}, water-soluble fertilizer (Peters 20–10–20; Graco Fertilizer Co., Cairo, GA, USA) at 250 mg·L^{-1} N for the first 7 d, then with 13N–0.87P–10.8K, basifying at 190 kg·tonne^{-1}, water-soluble fertilizer (Graco Fertilizer Co.) at 250 mg·L^{-1} N for the rest of the experiment. In Expt. 2 petunia were fertigated as needed with 15N–2.2P–12.5K, basifying at 71 kg·tonne^{-1}, water-soluble fertilizer (Jack's 15–5–15; JR Peters Inc., Allentown, PA, USA) at 250 mg·L^{-1} N. In Expt. 3 geranium were fertigated as needed with 13N–0.87P–10.8K, basifying at 190 kg·tonne^{-1}, water-soluble fertilizer (Peters Excel 13–2–13; Graco Fertilizer Co.) at 250 mg·L^{-1} N for the first 28 d, then at 125 mg·L^{-1} N for the rest of the experiment. At each fertigation event, all containers received ∼1 L of fertilizer solution. Irrigation water had pH of 7.1 and EC of 0.21 mS·cm^{-1}.

For all three experiments pour-thru testing, according to Cavins et al. (2004), was conducted every 7 d for the same three replicate plants per treatment, selected at random at the start of experiments, and pH and EC of the leachate were measured with a portable meter (HI 9813-6; Hanna Instruments, Smithfield, RI, USA). Plants were irrigated with water when EC exceeded 3.3 mS·cm^{-1}. At the end of each experiment, data were collected on plant height, plant width, measured twice at right angles to each measurement and averaged, and shoot fresh weight per plant. The number of flowers was counted for petunia and number of inflorescences for geranium. Foliar nutrient content for five replications, selected at random, per experiment, were analyzed by the UConn Soil Testing Laboratory.

Hurd and wood fiber experiments. There were three treatment media, which differed in proportions of the substrates hurd, wood fiber (HydraFiber EZ Blend, HydraFiber Advanced Substrate, Buffalo Grove, IL, USA), peat, and vermiculite as follows: 0.5:0:0.5:1, 0:0.5:0.5:1, and 0:0:1:1 (control). Physical properties and initial pH, EC, and nutrient content of the substrates and experimental media were tested as described for the hurd experiments. Two experiments were conducted. The first with petunia seeds and the second with geranium seeds and using the same genotypes as for hurd experiments. Seedling size at transplanting, container size, controlled-release fertilizer, experimental unit and design, and greenhouse settings were as described for hurd experiments, except hurd and wood fiber experiments had eight replications. Petunia seedlings were transplanted on 21

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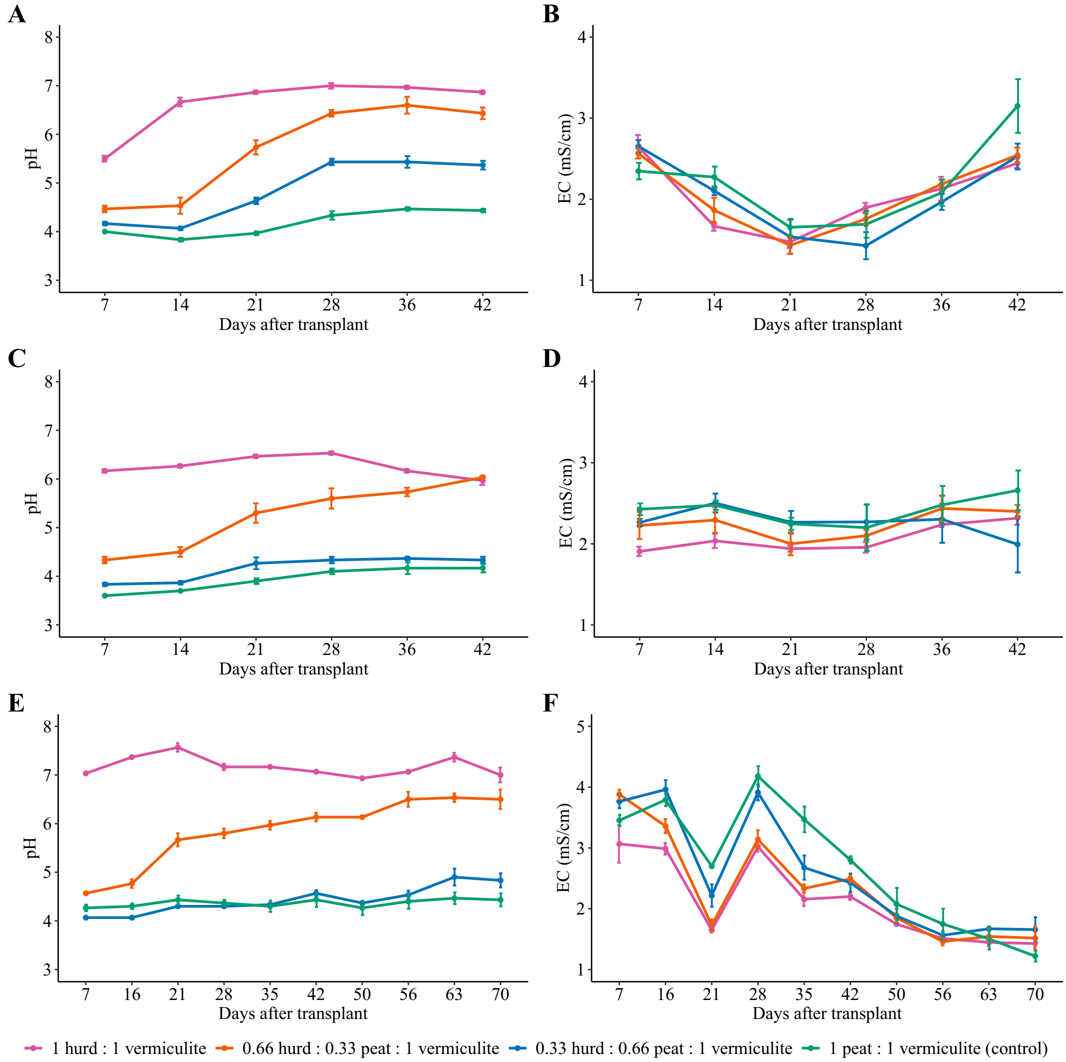

Fig. 3. Pour through values for pH and electrical conductivity (EC) from four container media formulations with varying proportions of hurd, peat, and vermiculite planted with petunia (*Petunia* ×*hybrida* Shock Wave® Coral Crush) for Expts. 1 (**A** and **B**) and 2 (**C** and **D**) and geranium (*Pelargonium* ×*hortorum* Maverick™ Red Hybrid) for Expt. 3 (**E** and **F**). Vertical bars indicate ± standard error.

May 2024 and grown for 42 d and geranium seedlings on 15 May 2024 and grown for 70 d. Petunia were fertigated as needed with 15N–2.2P–12.5K, basifying at 71 kg·tonne^{-1}, water-soluble fertilizer (Jack's 15–5–15; JR Peters Inc.) at 250 mg·L^{-1} N. Geranium were fertigated as needed with 13N–0.87P–10.8K, basifying at 190 kg·tonne^{-1}, water-soluble fertilizer (Peters Excel 13–2–13; ICL Peters) at 250 mg·L^{-1} N for the first 28 d, then at 125 mg·L^{-1} N for the rest of the experiment. Fertigation volume was ~1 L. Pour-thru testing, data collection, and foliar nutrient content were conducted as described for hurd experiments.

Statistical analysis. Data analysis was conducted using RStudio software version 4.4.0 (Posit, Boston, MA, USA) and the packages 'agricolae' version 1.3.7 and 'ggplot2' version 3.5.1. Each experiment was analyzed separately. Data were subjected to analysis of variance and mean separation with Tukey's honestly significant difference test at $P \leq 0.05$.

Results and Discussion

This study is the first to examine use of hemp hurd fiber as a substrate to replace peatmoss for growing bedding plants. Hurd possessed 87% TP, 0.085 g·cm^{-3} BD, pH 5.7, and EC of 0.75 mS·cm^{-1} (Table 1). Compared with peatmoss, hurd had greater AFP, TP, pH, EC, and macronutrient content. The blending of hurd with vermiculite at 1:1, and then with peat and vermiculite, generally reduced TP, pH, EC, and nutrient content. Media composed of hurd, peat, and vermiculite were similar to each other and to the control media (peat:vermiculite) for most of these properties.

Petunia grown in 0.33:0.66:1 (hurd: peat:vermiculite) medium produced similar shoot fresh weight, flowers, and plant width (Table 2) and were visually indistinguishable from plants grown in 0:1:1 (control) medium (Fig. 2). Generally, as the amount of hurd substituted for peat increased to 1:0:1, plant performance declined (Table 2). Although smaller than control plants, petunia grown in 0.66:0.33:1 were still visually appealing plants and were of excellent market quality (Ball Seed 2025; Fig. 2). Similar trends in petunia growth were found for Expt. 2, with slightly more equivalent performance among hurd containing media.

In Expt. 1, the fertilizer was changed to a basifying (190 kg·tonne^{-1}) formulation when, at 7 d after transplanting (DAT), control and 0.33:0.66:0 media were at or below pH 4.0, which is well outside the recommended pH range of 5.4 to 6.2 for petunia [Fig. 3 (Argo and Fisher 2002)]. This change resulted in the gradual increase of pH for all media over the course of Expt. 1; however, only 0.33:0.66:1 and 0.66:0.33:1 media reached and maintained pH levels within the recommended range. Petunia grown in 1:0:1 medium accumulated less foliar P, Fe, and Mn than plants did in the control medium in Expt. 1 (Table 2). Petunia can become Fe deficient when grown at high pH levels, which may be one reason

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Fig. 4. Representative petunia (*Petunia* ×*hybrida* Shock Wave® Coral Crush) exhibiting symptoms of Fe deficiency (**A**), and geranium (*Pelargonium* ×*hortorum* Maverick™ Red Hybrid) exhibiting symptoms of Mn toxicity (**B**).

why plants in 1:0:1 medium did not grow as well as control plants in Expt. 1 (Argo and Fisher 2002). Some petunia plants in 1:0:1 medium displayed slightly chlorotic foliage, which is symptomatic of Fe deficiency (Fig. 4A).

Petunia plants in the control medium were among the best performers in Expt. 1 (Table 2), despite the low pH. Therefore, in Expt. 2 a less basifying (71 kg·tonne^{-1}) fertilizer formulation was used, which prevented the 1:0:1 medium pH from rising to above 6.2 (Fig. 3). In Expt. 2, all hurd containing media had pH within optimal range or below it; however, foliar Fe content was less than the control (Table 2).

Geranium grown in 0.33:0.66:1 and 0.66:0.33:1 media had greater shoot fresh weight and plant width but lower foliar N, P, and K compared with control plants (Table 2; Fig. 5). Control plants may have accumulated greater foliar N, P, and K because they had fewer shoots among which to allocate nutrients. Similar compensatory relationships between available nutrient sources and plant organ sinks have been reported for other crops (Lentz et al. 2023; Tei et al. 2003; Wu et al. 2024). Geranium in 1:0:1 medium was smaller than those in 0.33:0.66:1 medium as far as shoot fresh weight and plant width, but similar in size to plants in the other two media (Table 2; Fig. 5).

Geranium plants were leached with water on two occasions when EC reached $\geq$ 3.3 mS·cm^{-1} on 16 and 28 DAT (Fig. 3). The fertility rate was reduced from 250 to 125 mg·L^{-1} N following the second leaching, and as a result, no further leaching was necessary for the duration of Expt. 3. Media pH for the control and 0.33:0.66:1 media was well below the recommended range of 6.0 to 6.6 for geranium for the duration of Expt. 3. Geranium grown at low pH levels can develop Mn toxicity (Argo and Fisher 2002), which we suspect had occurred for plants from control and 0.33:0.66:1 media because they had greater foliar Mn content compared with the other hurd media (Table 2). Other indications of Mn toxicity for control and 0.33:0.66:1 plants were chlorotic and necrotic foliage (Fig. 4B), which likely contributed to the loss of four control plants (Table 2). Although media moisture content was not quantified, the control medium may have been moister than ideal for geranium because irrigation was applied to all as needed for the driest plants in the study, which were those in 1:0:1 medium.

When petunia was grown in control medium with either hurd or wood fiber in substitution of peat at 50%, plants in hurd medium (0.5:0:0.5:1) produced less shoot weight and flowers than wood fiber (0:0.5:0.5:1) and control media (Table 3). There were no significant differences in foliar nutrient content for petunia in all three media. Petunia grown in wood fiber medium were visually indistinguishable from those grown in control medium (Fig. 6). Geranium grown in the same three media had similar growth and foliar nutrient content (Table 3; Fig. 7). Three geranium plants grown in control medium and one in hurd medium died after developing chlorotic and necrotic leaves (Table 3). Plants accumulated foliar Mn at similar or higher amounts than geranium did in Expt. 3 and therefore may have experienced Mn toxicity due to low media pH (Tables 2 and 3; Fig. 8). For all media, pH increased slightly for petunia and more so for geranium but was below recommended ranges for the duration of experiments (Fig. 8). Over the course of the experiments, media EC increased for petunia and decreased for geranium.

Studies using wood fiber to grow geranium and petunia have shown that plant performance may be reduced when wood fiber is substituted for peat at rates of 40% or more due to decreased water holding capacity and nutrient level (Dickson et al. 2022; Jackson and Bartley 2017; Zawadzińska et al. 2021). The wood fiber used in this research had lower CC and greater AFP than peat and hurd substrates, but its TP and pH was like peat (Table 1). Wood fiber had the lowest BD at 0.055 g·cm^{-3}. Macronutrient content of wood fiber substrate was greater than peat but less than hurd. The immobilization of N by wood fiber is another reported reason for inferior growth of petunia and geranium at 40% or higher peat substitution rates (Harris et al. 2020; Zawadzińska et al. 2021). Thiessen et al. (2024) found that petunia growth in wood fiber was improved with higher fertility, which offset losses from N immobilization. Others also suggest that increased fertilizer is required when wood fiber is incorporated in place of peat at $\geq$40%, but blending wood with peat at 30% would likely require minimal change to fertigation for petunia and geranium (Dickson et al. 2022; Harris et al. 2020). For the interspecific geranium cultivar Calliope Dark Red only plants grown in peat substituted with wood fiber at $\leq$20% had similar growth compared with the no wood fiber control (Zawadzińska et al. 2021).

The results of this research demonstrate that hurd fiber is a promising new substrate alternative for peat in bedding plant production. Hurd substituted for $\sim$30% of the peat portion of a standard peat:vermiculite medium resulted in comparable petunia and better-quality geranium plants than the control medium. At higher rates of hurd substitution, not enough nutrients were provided to plants due to high medium pH and/or TP. Future studies might evaluate

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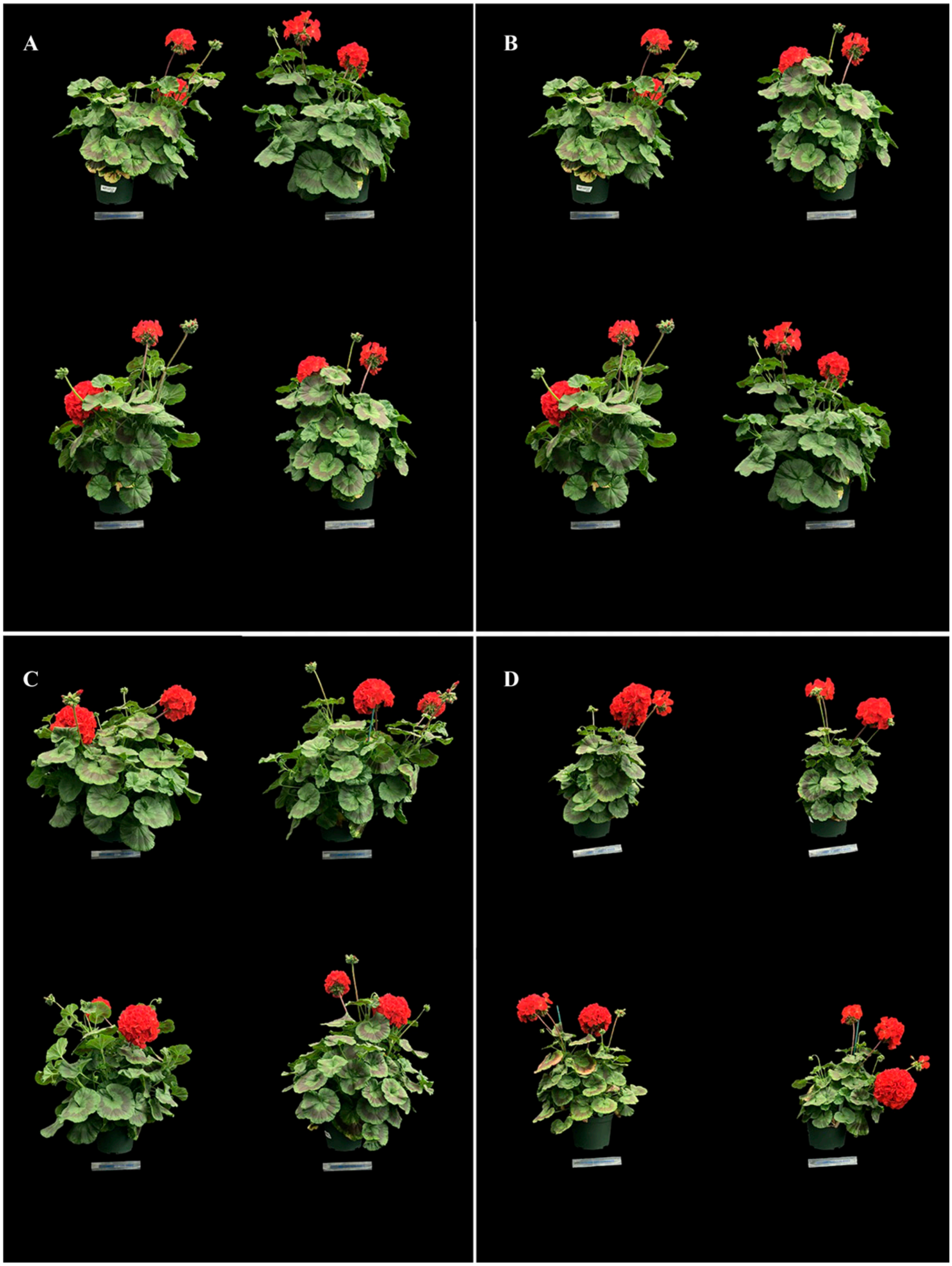

Fig. 5. Finished containers of geranium (*Pelargonium ×hortorum* Maverick™ Red Hybrid) for Expt. 3 grown in four container media formulations with varying proportions of hurd, peat, and vermiculite as follows: (**A**) 1 hurd:1 vermiculite; (**B**) 0.66 hurd:0.33 peat:1 vermiculite; (**C**) 0.33 hurd:0.66 peat:1 vermiculite; (**D**) 1 peat:1 vermiculite (control).

fertility level and formulation to optimize plant performance for media incorporating hurd.

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Table 3. Shoot weight, number of flowers, plant width, plant height, number of dead plants, and foliar nutrient content of *Petunia ×hybrida* Shock Wave® Coral Crush and *Pelargonium ×hortorum* Maverick™ Red Hybrid grown in three container medium formulations with varying proportions of hurd, wood fiber, peat, and vermiculite.

						Foliar nutrient content						
Media formulation hurd:wood fiber: peat:vermiculite	Shoot wt (g)	No. flowers[i]	Plant width (cm)[ii]	Plant ht (cm)	No. dead plants	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)
Petunia												
0.5:0:0.5:1	193 b[iii]	198 b	63.3 a	18.3 a		6.53 a	0.487 a	6.48 a	1.06 a	0.83 a	177 a	188 a
0:0.5:0.5:1	308 a	284 a	66.3 a	19.3 a		6.62 a	0.665 a	6.38 a	1.05 a	0.77 a	137 a	219 a
0:0:1:1 (control)	321 a	286 a	65.5 a	19.0 a		6.98 a	0.642 a	6.73 a	1.07 a	0.71 a	328 a	214 a
Geranium												
0.5:0:0.5:1	257 a	6.7 a	43.2 a	44.4 a	1	3.38 a	0.296 a	2.42 a	0.62 a	0.32 a	67 a	142 a
0:0.5:0.5:1	251 a	7.0 a	43.2 a	41.3 a		3.17 a	0.307 a	2.31 a	0.60 a	0.31 a	93 a	155 a
0:0:1:1 (control)	244 a	6.2 a	42.3 a	43.3 a	3	3.28 a	0.303 a	2.19 a	0.62 a	0.33 a	63 a	139 a

[i] Individual flowers were counted for petunia and inflorescences for geranium.

[ii] Plant width was measured twice at right angles to each measurement and averaged.

[iii] 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 = 8. Foliar nutrient content was n = 4.

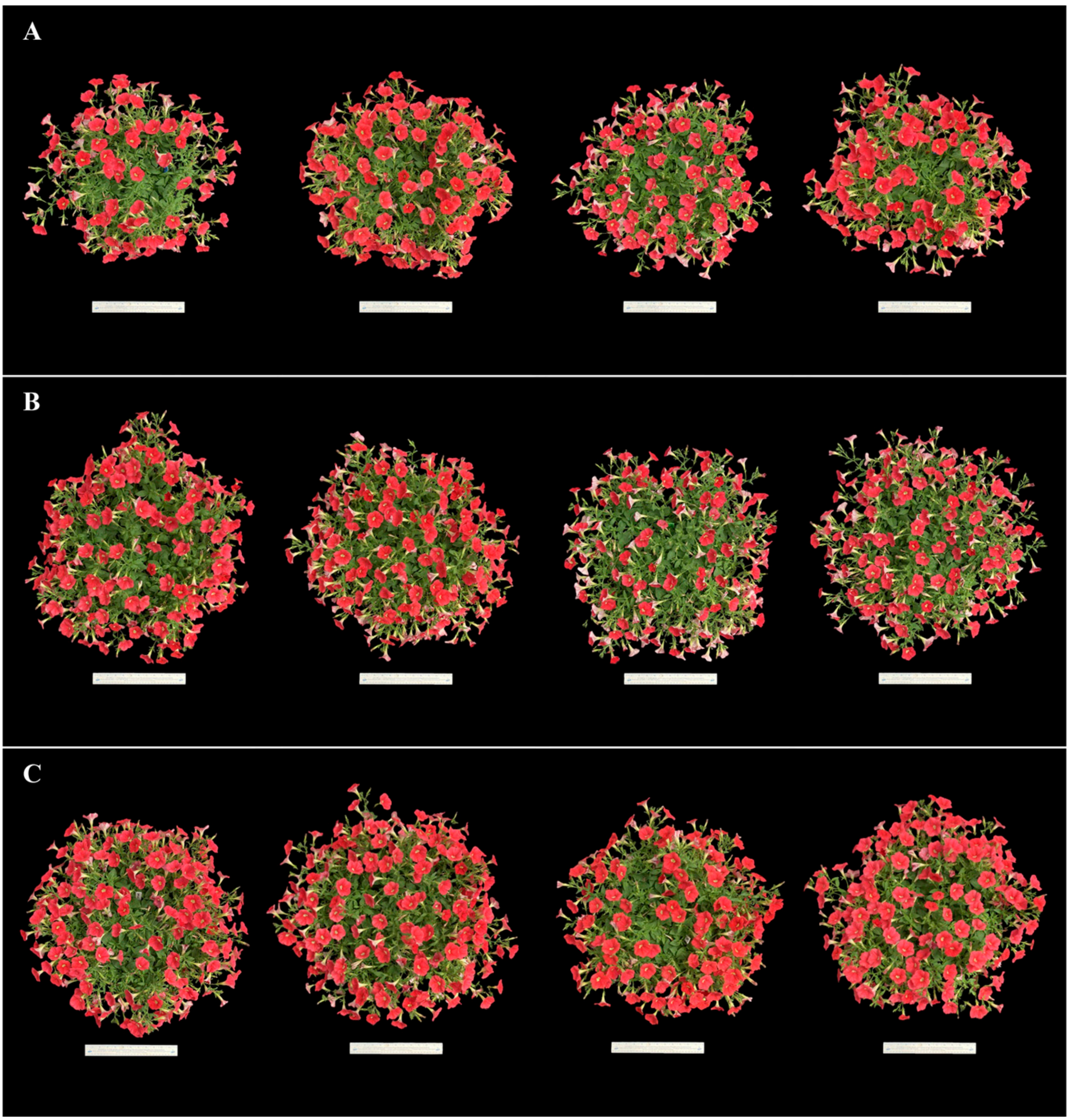

Fig. 6. Finished containers of petunia (*Petunia ×hybrida* Shock Wave® Coral Crush) grown in three container media formulations with varying proportions of hurd or wood fiber, peat and vermiculite as follows: (**A**) 0.5 hurd:0.5 peat:1 vermiculite; (**B**) 0.5 wood fiber:0.5 peat:1 vermiculite; (**C**) 1 peat:1 vermiculite (control).

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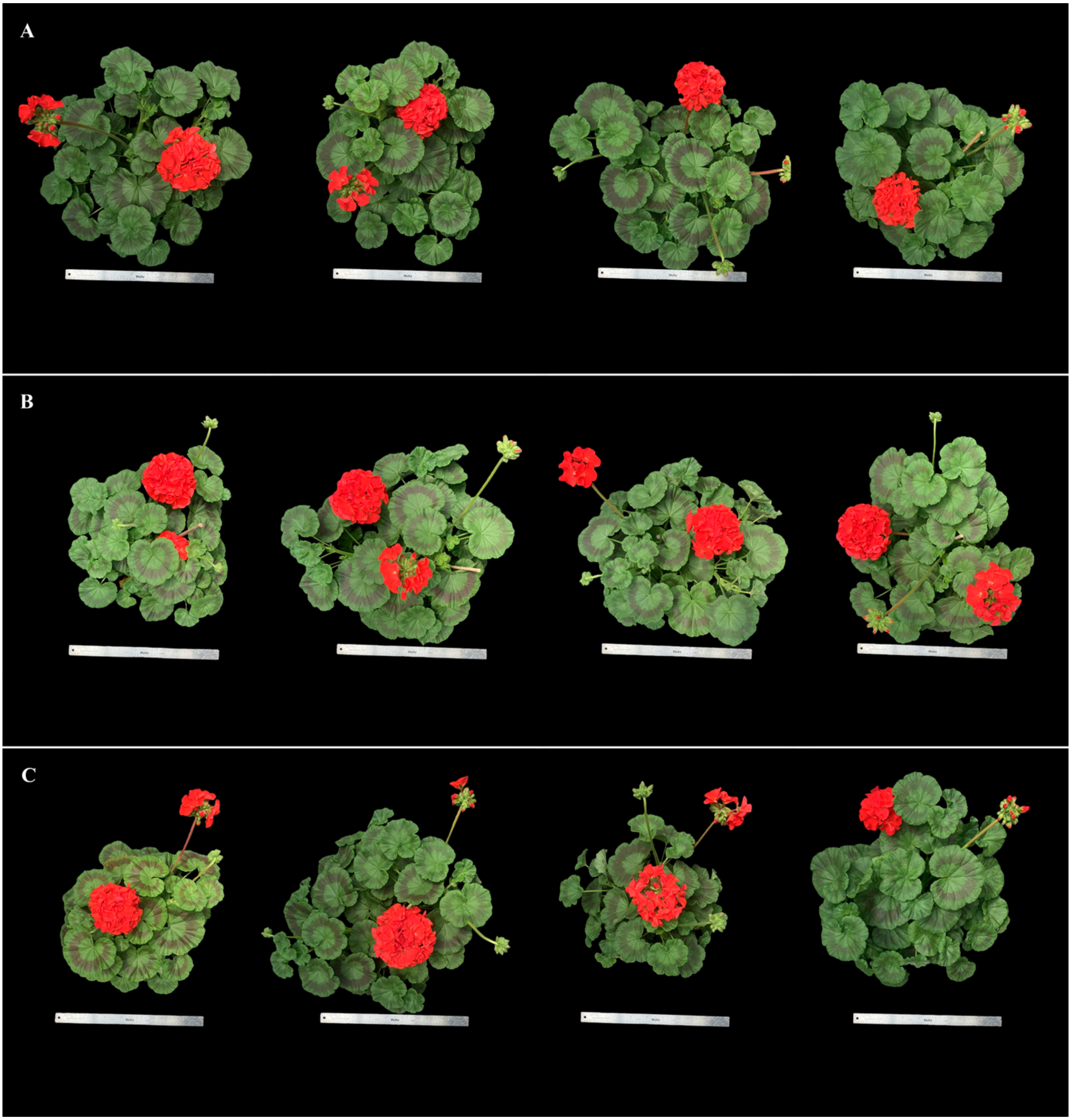

Fig. 7. Finished containers of geranium (*Pelargonium ×hortorum* Maverick™ Red Hybrid) grown in three container media formulations with varying proportions of hurd or wood fiber, peat, and vermiculite as follows: (**A**) 0.5 hurd:0.5 peat:1 vermiculite; (**B**) 0.5 wood fiber:0.5 peat:1 vermiculite; (**C**) 1 peat:1 vermiculite (control).

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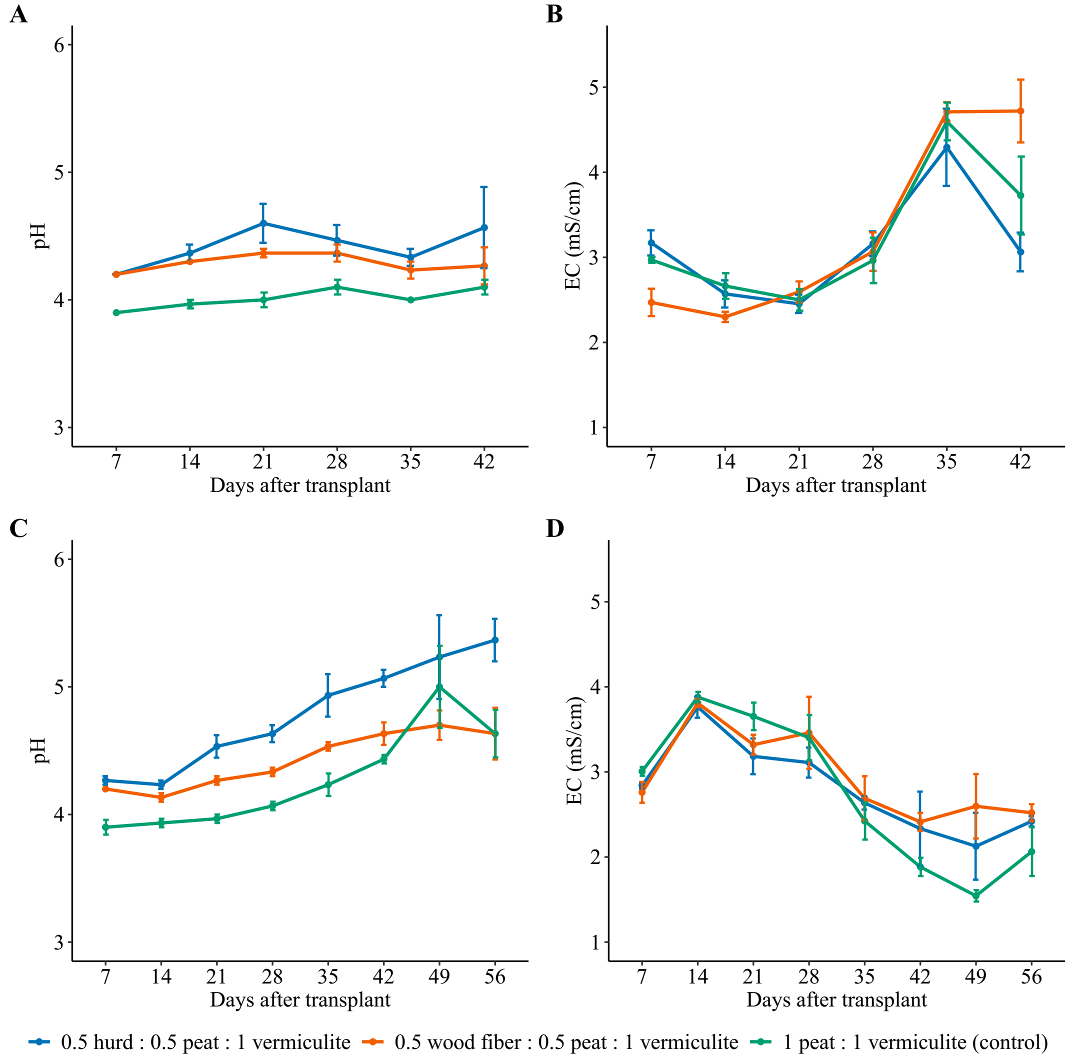

Fig. 8. Pour through values for pH and electrical conductivity (EC) from three container media formulations with varying proportions of hurd or wood fiber, peat, and vermiculite planted with petunia [*Petunia ×hybrida* Shock Wave® Coral Crush (**A** and **B**)] or geranium [*Pelargonium ×hortorum* Maverick™ Red Hybrid (**C** and **D**)]. Vertical bars indicate ± standard error.

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