Using Ground Kenaf Stem Core as a Major Component of Container Media

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Abstract. Results of a series of experiments showed that the ground, noncomposted woody stem core of kenaf (*Hibiscus cannabinus* L.) can be used successfully as a container medium amendment for producing potted tropical foliage and woody nursery crops. The growth of *Brassaia actinophylla* Endl., *Hibiscus rosa-sinensis* L. 'Jane Cowl', and *Pittosporum tobira* (Thunb.) Ait. 'Wheeler's Dwarf' in 70% or 80% kenaf (by volume, the balance being peatmoss or perlite or vermiculite and other nutrients) was similar to or greater than growth in two popular commercial mixes. Undesirable shrinkage of certain kenaf-amended media during plant production was reduced greatly by mixing it with at least 30% peatmoss or by using a coarser kenaf grind. As the portion of peatmoss increased from 0% to 30%, noncapillary porosity and water-holding capacity per container increased. A medium consisting of 50% kenaf, 40% peatmoss, and 10% vermiculite held as much water as a commercial medium. However, plants in most kenaf-amended media required more-frequent irrigation than those in the commercial media.

Peatmoss, composted bark, perlite, and other materials commonly used in nursery media are not produced in most container-plant production areas and must be imported. Freight costs have risen and become a substantial portion of nursery production costs. Hence, many materials have been studied for use as container media. Media amended with composted shredded municipal garbage (Conover and Poole, 1990), yard waste (McConnell et al., 1990), a mixture of composted municipal leaf, sewage sludge, and street sand (Bugbee et al., 1991), and bagasse (Trochoulis et al., 1990) have produced high-quality containerized plants. Several species produced in spent mushroom compost had heavier shoots and roots than those grown in 100% composted bark (Chong et al., 1991).

Kenaf (*Hibiscus cannabinus*) is an annual tropical species grown in several Gulf states, including Louisiana, Mississippi, and Texas, as a fiber crop. When harvested in the fall, the average yield of dry stem is ≈ 17 t·ha⁻¹, of which 60% to 65% is the stem core (mechanically separated from the bast). Potential uses of kenaf include manufacturing paper and pulp, animal bedding, livestock feed (Phillips, 1993), poultry litter, and container mixes (Shi and Pill, 1993).

Since kenaf is grown in several nursery production areas, it may cost less to use ground kenaf as a major ingredient in container media than other materials traditionally being used by the nursery industry. This would make growers more competitive and allow for greater profits.

The objectives of this study were to determine the physical properties of media with noncomposted, ground kenaf as a major component and to evaluate these media for use in producing selected tropical foliage and nursery crops.

Materials and Methods

Growth of Brassaia actinophylla with fine-grind kenaf. Dry kenaf stem core was ground to yield nearly 80% (by weight) of the

particles <2 mm (Table 1). The five media were (percentage volume) 1) 100 kenaf, 2) 80 kenaf : 20 peatmoss, 3) 70 kenaf : 30 peatmoss, 4) 70 kenaf : 20 peatmoss : 10 vermiculite, and 5) 50 kenaf : 40 peatmoss : 10 vermiculite. To each cubic meter of medium, 5 kg of powdered dolomitic limestone, 1 kg of the micronutrient source Micromax (Grace-Sierra Horticultural Products, Milpitas, Calif.), 5.5 kg each of superphosphate (20% P₂O₅) and gypsum, 6.8 kg of 18N-2.6P-10K Osmocote (Grace-Sierra), and 352 ml of Aqua-Gro L (Aquatrols of America, Pensauken, N.J.) were added. Sunshine Mix no. 1 (Fisons Horticulture, Seattle, Wash.) and Metro Mix 250 (Grace-Sierra) with 6.8 kg·m⁻³ of Osmocote were used for comparison. All pots were drenched with a metalaxyl fungicide (Subdue, Ciba Corp., Greensboro, N.C.) at the first irrigation. Particle size distribution was determined using a shaker and sieves as described by Wang (1991), using 100-g samples.

On 27 Mar. 1991, *Brassaia actinophylla* seedlings in cell trays ≈ 7.5 cm tall were transplanted one per 15-cm (1.25-liter) pot and grown in a greenhouse. Maximum photosynthetic photon flux (PPF) was 470 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$. Plants in each medium were checked daily. When one or more pots in a given treatment became light, all pots with this medium were watered and the date was recorded. Water containing 0.84 g·liter⁻¹ Peters 24N-3.4P-13.7K (Grace-Sierra) soluble fertilizer was used alternately with city water. Leachate samples were collected from pots with plants on 10 Apr., 31 May, and 11 July. These samples were measured for pH and electrical conductivity (EC). Plant growth data, including shoot height and fresh and dry weights, stem diameter (1 cm above medium), leaf number, petiole length and blade area of the uppermost mature leaf, and root grade, were collected on 17 July. There were two pots per treatment in each of the 10 replications arranged in a randomized complete block (RCB).

Plantless pots filled with the five kenaf and two commercial media also were fertigated weekly and used for measuring physical properties at the completion of this experiment. Techniques for measuring these parameters are described in Wang and Gregg (1990). There were 12 single-pot replicates arranged in a RCB.

Growth of Hibiscus rosa-sinensis in coarse kenaf. Cuttings of 'Jane Cowl' hibiscus were planted in 15-cm (1.25-liter) pots filled with Sunshine no. 1 medium. Plants were placed on a greenhouse bench receiving a maximum PPF of 850 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ until 5 Mar. 1991, when they were moved into a greenhouse receiving 1700

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Table 1. Particle size distribution of five media prepared with fine kenaf stem core and of two commercial media.^z

Medium ^y (% vol)	Particle size (mm)						
	≥8.0	<8.0 and ≥6.3	<6.3 and ≥4.0	<4.0 and ≥2.0	<2.0 and ≥1.0	<1.0 and ≥0.5	<0.5
		(% by wt)					
100:0:0	0 b	0.6 a	1.4 d	18.6 b	29.0 a	21.7 a	28.7 bc
80:20:0	0 b	0.3 a	4.9 bc	19.0 b	24.1 c	19.7 ab	31.9 b
70:30:0	0 b	0.3 a	6.0 b	22.1 b	24.6 bc	20.0 a	27.0 c
70:20:10	0 b	0.1 a	5.3 bc	21.5 b	27.3 ab	20.7 a	25.1 c
50:40:10	0.7 ab	0.3 a	7.1 b	21.2 b	24.6 bc	19.8 ab	26.3 c
Sunshine no. 1	1.9 a	1.1 a	14.1 a	29.0 a	12.1 e	16.0 c	27.2 c
Metro Mix 250	0.4 ab	0.3 a	2.5 cd	12.7 c	17.5 d	17.9 b	48.8 a

^zMean separation within columns by Duncan's multiple range test, $\alpha = 0.05$.^yKenaf (fine) : peatmoss : vermiculite.

$\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ maximum PPF. Plants received 1.5 g·liter⁻¹ Peters 20N–8.6P–16.6K fertilizer at all irrigations. Plants were pinched on 20 Mar. 1991, and all shoots were clipped to two leaves on 20 May and 7 Aug. to encourage branching. On 6 Nov., plants again were pruned to two leaves per branch and transplanted into 11.4-liter pots with the following media (in percentage): 100 kenaf, 90 kenaf : 10 peatmoss, 80 kenaf : 20 peatmoss, 70 kenaf : 30 peatmoss, and 70 kenaf : 20 peatmoss : 10 perlite. Coarsely ground kenaf (92% by weight ≥ 2 mm) was used. A medium consisting of (in percentage) 70 composted pine bark : 30 peatmoss was used for comparison. Powdered dolomitic limestone was added at 2 and 3 kg·m⁻³ to media containing 20% and 30% peatmoss, respectively. Superphosphate and gypsum (2.5 kg·m⁻³), Micromax (1 kg·m⁻³), and Aqua-Gro G (0.93 kg·m⁻³) were added only to the kenaf and bark media. Osmocote (24N–1.7P–5K, 8.3 kg·m⁻³) was added to all media.

After being transplanted, plants were placed in a greenhouse having a maximum PPF of 1200 $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$. The media were arranged in a RCB with 10 replications. On 18 May 1992, shoot height (from medium surface to plant top), width (average of two perpendicular measurements), and fresh weight (cut at medium surface) were determined.

Growth of Pittosporum tobira 'Wheeler's Dwarf in coarse kenaf. Rooted cuttings of this dwarf pittosporum were planted in 2.6-liter pots on 10 Nov. 1991. Media were identical to those used in the hibiscus test. Plants were placed in an outdoor shadehouse

with 70% of full sunlight. Each medium was irrigated only as needed without additional fertilizer. On 18 June 1992 (221 days after planting), shoot height, average plant width, fresh weight, and visual grade were recorded. Leachate samples also were collected for determining pH and EC at the completion of this test.

Data, excluding the number of irrigations, were subjected to analysis of variance, and Duncan's multiple range test was used to separate means. Values for pH were converted to H⁺ concentration, and percentage data were transformed to arcsin values before analysis.

Results

Growth of Brassia actinophylla. Plants in media with 70% or more kenaf grew taller and had thicker stems, heavier fresh and dry weights, and longer petioles than those produced in Sunshine no. 1 or Metro Mix 250 (Table 2). Media containing 80% or 70% kenaf resulted in plants with greater leaf areas and better root grades than the two commercial media.

Plants grown in media with 70% or more kenaf had to be irrigated by as much as 30% to 55% more frequently than those in the commercial media (Table 2). However, during the last 2 weeks, all plants were watered similarly every 1 or 2 days.

Medium containing 100% kenaf had the highest initial and final pH (Table 3). The pH of all media declined with time and with increasing proportion of peatmoss (from 0% to 30%). Media pH

Table 2. Growth of *Brassia actinophylla* 112 days after planting in 15-cm (1.25-liter) pots containing fine-grind kenaf-amended or commercial media.^z

Medium ^y (% vol)	Shoot ht (cm)	Stem diam ^x (cm)	No. of leaves	Shoot fresh wt (g)	Shoot Dry wt (g)	Uppermost mature leaf		Root grade ^w	No. of irrigations ^v
						Petiole length (cm)	Lamina area (cm ²)		
100:0:0	35.1 a	10.3 a	13.8 ab	129 bc	15.7 bc	19.3 a	468 abc	4.2 a	39
80:20:0	37.7 a	9.4 ab	13.9 a	143 ab	17.6 ab	21.1 a	489 ab	4.9 a	39
70:30:0	37.3 a	9.3 ab	13.7 ab	141 ab	17.7 ab	20.7 a	513 ab	4.3 a	35
70:20:10	38.7 a	9.6 a	13.4 ab	162 a	20.2 a	20.1 a	549 a	4.3 a	39
50:40:10	33.6 ab	8.6 bc	12.4 ab	104 cd	13.8 bcd	18.4 ab	411 bc	3.2 b	29
Sunshine no. 1	28.7 bc	8.1 c	12.7 ab	90 d	12.0 cd	16.3 bc	398 bc	3.3 b	25
Metro Mix 250	26.9 c	7.7 c	12.2 b	77 d	10.3 d	15.5 c	356 c	3.3 b	23

^zMean separation within columns by Duncan's multiple range test, $\alpha = 0.05$.^yKenaf (fine) : peatmoss : vermiculite.^xMeasured 1 cm above medium surface.^w5 = Excellent, 4 = good, 3 = acceptable, 2 = fair, 1 = poor.^vNot analyzed statistically.

decline during the 16 weeks of crop growth was greater in media with high than low initial pH. The final pH of all media amended with kenaf was >5 and was higher than those of the two commercial media. The final pH of Metro Mix 250 (4.5) declined by two units compared to the initial value (6.5). The EC of kenaf media was consistently lower than that of Metro Mix 250 and Sunshine no. 1 (Table 3).

The final volume of 100% fine kenaf medium was only 50% of the initial volume (Table 4). This shrinkage was reduced by increasing the proportion of peatmoss in the media. The 70 kenaf : 30 peatmoss medium had a final volume similar to that of Sunshine no. 1. However, replacing one-third of the peatmoss in the above medium with vermiculite (70:20:10) resulted in a 5% reduction in final volume. Metro Mix 250 had the greatest water-saturated weight.

Bulk densities of media with 70% or less kenaf, because of the larger final volumes and higher noncapillary porosities, were less than other media (Table 4). As the percentage of peatmoss increased in the kenaf-amended media, the amount of water retained increased. The 70 kenaf : 30 peatmoss medium had the lowest percentage water retention, despite holding more water per pot than several other media.

Compared to Sunshine no. 1, the 50 kenaf : 40 peatmoss : 10 vermiculite medium had 6% larger final volume and similar weight, total water, and percent water retention. However, the former (50:40:10) resulted in plant growth similar to that in the medium consisting of 70% kenaf and 30% peatmoss.

Growth of Hibiscus rosa-sinensis. Over 40% of coarse-kenaf

Table 3. Leachate pH and electrical conductivity (EC) from fine-grind kenaf-containing or commercial media three times during the growth of *Brassica actinophylla*.^z

Medium ^y (% vol)	Leachate pH			Leachate EC (dS·m ⁻¹)		
	10 Apr.	31 May	11 July	10 Apr.	31 May	11 July
100:0:0	7.17 a	6.49 a	6.03 a	3.18 d	4.70 c	4.59 b
80:20:0	6.03 c	6.27 a	5.56 b	4.41 c	4.11 d	3.85 c
70:30:0	5.60 e	6.42 a	5.30 c	5.11 b	3.42 e	4.03 bc
70:20:10	5.88 d	6.36 a	5.29 c	4.78 b	3.79 de	4.02 bc
50:40:10	5.45 f	6.41 a	5.26 c	4.94 b	3.70 de	4.45 bc
Sunshine no. 1	6.45 b	5.59 b	4.84 d	4.17 c	5.64 b	4.23 bc
Metro Mix 250	6.48 b	5.50 b	4.52 e	5.85 a	9.49 a	6.28 a

^zMean separation within columns by Duncan's multiple range test, $\alpha = 0.05$.

^yKenaf (fine) : peatmoss : vermiculite.

Table 4. Physical properties of five kenaf-amended and two commercial media after being irrigated weekly for 112 days without plants. The initial volume was 1250 cm³.^z

Medium ^y (% vol)	Medium vol (cm ³)	Saturated medium wt (g/pot)	Medium bulk density ^x (g·cm ⁻³)	Non- capillary porosity (%)	Total water (g/pot)	Water retention (% final vol)
100:0:0	588 e	477 e	0.114 b	17.3 d	410 e	69.7 c
80:20:0	807 d	643 d	0.113 b	19.8 c	552 d	68.4 c
70:30:0	943 b	706 c	0.096 d	24.0 a	616 c	65.4 d
70:20:10	876 c	689 c	0.104 c	22.5 ab	598 c	68.3 c
50:40:10	997 a	810 b	0.107 c	21.0 bc	703 b	70.5 bc
Sunshine no. 1	940 b	788 b	0.113 b	12.8 e	682 b	72.6 b
Metro Mix 250	961 ab	909 a	0.185 a	9.3 f	733 a	76.3 a

^zMean separation within columns by Duncan's multiple range test, $\alpha = 0.05$.

^yKenaf (fine) : peatmoss : vermiculite.

^xBased on the final dry weight and volume.

Table 5. Particle sizes of five media prepared with a coarsely ground kenaf stem core and of two commercial media.^z

Medium ^y (% vol)	Particle size (mm)						
	≥8.0	<8.0 and ≥6.3	<6.3 and ≥4.0	<4.0 and ≥2.0	<2.0 and ≥1.0	<1.0 and ≥0.5	<0.5
		(% by wt)					
100:0:0	0.8 b	9.6 a	54.0 a	27.9 c	5.0 e	1.5 g	1.2 e
90:10:0	0.4 b	7.5 b	42.6 b	36.6 a	6.0 e	3.4 f	3.6 d
80:20:0	1.3 b	5.2 d	37.2 c	32.6 b	8.2 d	7.2 d	8.2 c
70:30:0	0.9 b	5.0 d	31.8 e	32.7 b	9.7 c	9.6 c	10.9 b
70:20:10	1.5 b	6.3 c	33.6 d	37.2 a	9.3 cd	4.9 e	7.2 c
Sunshine no. 1	2.5 a	1.6 e	4.8 f	27.0 c	23.3 b	25.5 a	15.2 a
Metro Mix 250	1.1 b	1.1 e	2.9 g	27.2 c	29.4 a	21.8 b	16.6 a

^zMean separation within columns by Duncan's multiple range test, $\alpha = 0.05$.

^yKenaf (course) : peatmoss : vermiculite.

weight was of particles ≥ 4 mm (Table 5). Media prepared from the coarse kenaf had 92% (100% kenaf) to 80% (70 kenaf : 30 peatmoss) weight ≥ 2 mm (Table 5).

All kenaf media resulted in plants as tall as those in Sunshine #1 or bark mix (Table 6). Plants grown in 70 kenaf : 30 peatmoss were wider than and superior to those grown in Sunshine no. 1 or Metro Mix. All media with 80% kenaf produced plants with similar fresh weights as plants grown in Sunshine no. 1. Overall, plants grown in Metro Mix 250 and the bark : peatmoss medium were narrower and

Table 6. Growth of *Hibiscus rosa-sinensis* 'Jane Cowl' in 25-cm (11.4-liter) pots filled with coarse kenaf-amended or commercial media.^z Plants were harvested 194 days after being transplanted into the 25-cm pots.

Medium ^y (% vol)	Shoot ht (cm)	Shoot width (cm)	Shoot fresh wt (g)	No. of irrigations ^x
100:0:0	78.2 ab	94.0 cd	892.4 bc	74
90:10:0	73.0 bc	91.9 d	937.1 bc	67
80:20:0	75.0 abc	100.8 ab	1041.2 ab	47
70:30:0	74.9 abc	103.9 a	1039.4 ab	40
70:20:10	79.3 a	99.3 abc	1151.1 a	56
Sunshine no. 1	76.8 ab	94.8 bcd	1005.1 ab	28
Metro Mix 250	71.0 c	84.9 e	706.8 d	22
Bark mix ^w	73.8 abc	89.7 de	810.5 cd	26

^zMean separation within columns by Duncan's multiple range test, $\alpha = 0.05$.

^yKenaf (coarse) : peatmoss : perlite.

^xNot analyzed statistically.

^w70 Bark : 30 peat moss.

had lower shoot fresh weights than plants grown in the other media.

Plants in Sunshine no. 1 were irrigated 28 times, whereas those in 70 kenaf : 30 peatmoss required 40 irrigations during the 194-day production period (Table 6). Using perlite (70:20:10) to replace one-third of the peatmoss in the 70:30 medium increased irrigations by 40%.

Root coverage on the medium surface (except the top) of certain kenaf media (Fig. 1A) appeared to be denser than on the two commercial media (Fig. 1B). Root penetration throughout the entire medium volume was greater in the kenaf-amended media than the commercial media (Fig. 1).

Growth of Pittosporum tobira 'Wheeler's Dwarf'. Plants produced in the 70 kenaf : 30 peatmoss medium were taller and wider than those grown in the commercial media (Table 7). All other kenaf-amended media resulted in plants taller than plants in Metro Mix 250. Shoots of plants in kenaf and bark medium were substantially wider and heavier than those in the two commercial media. Greater shoot fresh weights were obtained when plants were grown in media with 80% or 70% kenaf or the bark : peatmoss mix than in the other media. Quality of plants grown in kenaf media was very good to excellent, greater than the quality of plants grown in commercial media.

The final pH of leachate samples from all media amended with kenaf stayed >5.4 , whereas pH of the two commercial media was <4.9 (Table 7). Leachate samples from all kenaf media had similar EC, 1.2 to 1.5 $\text{dS}\cdot\text{m}^{-1}$, whereas Metro Mix 250 had the highest leachate EC (2.72 $\text{dS}\cdot\text{m}^{-1}$).

Discussion

This study showed that ground kenaf stem core (a C : N ratio of 30 to 60) can be used successfully without prior composting to

Fig. 1. Appearance of hibiscus roots 221 days following transplanting on the surface and in (A) a medium consisting of 70% coarsely ground kenaf stem core and 30% peatmoss or (B) a commercial medium (Sunshine no. 1). Media were inverted to show the root coverage at bottom (now top).

Table 7. Growth of *Pittosporum tobira* 'Wheeler's Dwarf' in coarse kenaf-amended or commercial media. Plants were harvested 221 days after planting.^z

Medium ^y (% vol)	Shoot	Shoot	Shoot fresh	Overall plant quality ^w	Medium leachate		No. of irrigations ^v
	ht (cm)	width (cm)	wt (g)		pH	EC ^x (dS·m ⁻¹)	
100:0:0	18.6 ab	34.6 c	102.1 b	4.1 b	6.21 a	1.20 c	87
90:10:0	18.7 ab	35.9 bc	108.7 b	4.2 b	5.48 bc	1.31 c	75
80:20:0	18.8 ab	40.0 a	141.1 a	5.0 a	5.38 c	1.46 bc	72
70:30:0	20.2 a	39.9 a	140.7 a	4.6 ab	5.71 b	1.49 bc	70
70:20:10	18.9 ab	38.4 ab	135.5 a	4.3 b	5.60 bc	1.45 bc	74
Sunshine no. 1	17.3 bc	28.3 d	60.3 c	2.4 c	4.85 d	1.32 c	30
Metro Mix 250	16.0 c	24.4 e	41.4 c	2.1 c	4.69 d	2.72 a	26
Bark mix ^u	19.9 a	40.2 a	135.1 a	4.6 ab	6.00 a	1.77 b	48

^zMean separation within columns by Duncan's multiple range test, $\alpha = 0.05$.

^yKenaf (coarse) : peatmoss : perlite.

^xEC = electrical conductivity.

^w5 = Excellent; 4 = good; 3 = marketable; 2 = undersized; 1 = poor.

^vNot analyzed statistically.

^u70 Bark : 30 peatmoss.

produce tropical foliage and nursery crops. One study (Shi and Pill, 1993) showed that growth of impatiens and tomato seedlings was in proportion to the N concentration in NH_4NO_3 solutions used for soaking kenaf-amended media for 5 days before planting. However, Hawcroft and Newman (1992) reported that incorporating 10% to 30% ground kenaf in peat-based media resulted in poor growth of *Celosia*, *Viola*, and *Impatiens*.

The extent of shrinkage of certain fine kenaf media was unacceptable. By reducing the proportion of fine kenaf to 70% and incorporating 30% peatmoss, the 36% shrinkage over a 112-day period was similar to that of the two commercial mixes (Table 4). This 70 kenaf : 30 peatmoss medium had greater water holding-capacity than media with 80% or more kenaf. Therefore, incorporating peatmoss in kenaf media helped to maintain the integrity of the medium structure and prevent severe compaction. This was demonstrated by the increasing noncapillary porosity as peatmoss in kenaf media was increased from 0% to 30%.

Media shrinkage was minimal when the coarse-grind kenaf was used, even at 100%, as observed in hibiscus, pittosporum, and other tests not reported here. Still, incorporating peatmoss resulted in less shrinkage at the end of the production period.

Since ground kenaf holds less water than peatmoss or vermiculite on a similar volume basis, plants grown in media amended with kenaf must be watered more frequently than plants in commercial media. The greater transpiration by larger plants in some kenaf media could also account for the increased water use. Similarly, water-holding capacity of container media decreased with increasing percentage of ground *Melaleuca quinquenervia* bark (Conover and Poole, 1983a, 1983b). Although more frequent irrigation is not preferred, it would provide a more constant level of nutrients and greater leaching in the case of constant fertigation.

The noncapillary porosity of all media amended with kenaf (Table 4) was within the range for good plant growth (Bugbee and Frink, 1986). Conover and Poole (1983a) found that media amended with ground *Melaleuca quinquenervia* bark, having noncapillary pore space of 14% to 28%, resulted in similar growth of *Aglaonema* and *Nephrolepis*.

Media pH increased as the proportion of kenaf increased from 70% to 100% in the *Brassica actinophylla* test. This pattern cannot be seen readily in the other tests because lime was added at 0, 2, and 3 kg·m⁻³ to media having 90% or more, 80%, and 70% kenaf,

respectively. Leachate pH was acceptable after more than half a year (27 weeks) of *Pittosporum* growth (Table 7). Therefore, media amended with 70% or more kenaf maintained the pH in the optimum range (Poole et al., 1981) for longer than the commercial media.

In conclusion, this series of experiments has demonstrated that ground kenaf stem core can substitute for part of the traditional medium components for producing high-quality greenhouse and nursery crops. It is important that the kenaf grown for container media are not defoliated with chemicals, since defoliant residue may interfere with plant growth. In the future, attention needs to be directed toward the postharvest phase to determine how plants in kenaf media would perform under interior and retail conditions.

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