Bradley, M.R. and I. Segal. 1990. Hydroponic system for the production of greenhouse crops, p. 149-154. In: Proc. Intl. Sem. and British-Israel Wkshp. Greenhouse Technol., Bet Dagan, Israel, 26 Mar.-2 Apr.

Gamliel, A., J. Katan, Y. Chen, and A. Grinstein. 1989. Solarization for the recycling of container media. *Acta Hort.* 255:181-188.

Gielis, A. 1992. The recuperation of agricultural and horticultural plastic films in Flanders. MS diss. Center for Environmental Sanitation, Univ. of Gent, Belgium (in Dutch).

Goethals, N. and J. Viaene. 1994. Collection and management of sector specific waste streams in agriculture and horticulture. OVAM-Bestuur Planning en Onderzoek. Brussels, Belgium (in Dutch).

Gouin, F.R. 1991. Recycling greenhouse polyethylene film. *Veg. Views Nwsl.* 2(2):4-5.

Guillaumin, A. 1992. Recycling nutrient solution in soilless tomato culture on a biodegradable substrate. *Revue Horticole* 331:31-33 (in French).

Gunnlaugsson, B. and S. Adalsteinsson. 1995. Pumice as environment-friendly substrate. A comparison with rock wool. *Acta Hort.* 401:131-136.

Ismail, M.R., M.S. Halini, and K. Jusoh. 1993. Growth and yield of tomatoes as influenced by different substrates, substrate volumes and irrigation frequencies. *Acta Hort.* 342:143-153.

Jeannequin, B. and R. Fabre. 1995. Techniques for the recycling or the reduction of waste nutrient solution in soilless cultivation. *Plasticulture* 107:41-47.

Kasrawi, M.A., N. Khraishi, and Y. Tabaza. 1994. Durability and efficiency of recycled

multilayer plastic covering in the production of greenhouse-grown tomatoes. *HortTechnology* 4(4):394-398.

Mugnozza, G.S. 1995. Sustainable greenhouse production in mediterranean climate: A case study in Italy. *Medit.* 6(4):48-53.

Nationaal Instituut voor de Statistiek. 1995. Agricultural and horticultural statistics on May 15 1994. Nationaal Instituut voor de Statistiek, Brussels, Belgium (in Dutch/French).

Lataster, J.M.J., E.A. Van Os, M.N.A. Ruijs, M.C.A. Vollebregt, and A. van der Wees. 1993. Soilless cultivation systems. Vegetables and cutting flowers under glass. Nederlands Ministerie van Landbouw, Natuurbeheer en Visserij, I.K.C. Akker- en tuinbouw. Naaldwijk, The Netherlands (in Dutch).

Projectgroep Kunststofafval. 1991. Design and implementation plan for plastics waste. Projectgroep Kunststofafval, Leidschendam, The Netherlands (in Dutch).

Roberts, W.J. and W. Swanekamp. 1992. Recycling greenhouse glazing from a 6 ha range. *Amer. Soc. Agr. Eng. Paper No.* 92-4032.

Tognoni, F. and G. Serra. 1994. New technologies for protected cultivations to face environmental constraints and to meet consumer's requirements. *Acta Hort.* 361:31-38.

Van Os, E.A. 1994. Closed growing systems for more efficient and environmental friendly production. *Acta Hort.* 361:194-200.

Vernooij, C.J.M. 1991. Reduction of environmental pollution by recirculation of drain water in substrate cultures. *Acta Hort.* 295:101-106.

Growth of Tomato and Coreopsis in Response to Coir Dust in Soilless Media

Wallace G. Pill and
Karen T. Ridley

ADDITIONAL INDEX WORDS. artificial media, *Cocos nucifera* L., *Coreopsis lanceolata* L., *Lycopersicon esculentum* Mill., potting compost, solution fertilization, slow-release fertilization

SUMMARY. We examined the efficacy of coir dust (CD)—the short fibers and dust from the mesocarp of coconuts (*Cocos nucifera* L.)—as an alternative to sphagnum peat (SP) in 50 SP : 50 vermiculite (% volume) medium. Shoot dry mass of coreopsis (*Coreopsis lanceolata* L.) or 'Red Robin' tomato (*Lycopersicon esculentum* Mill.) after 5 weeks' growth in up to 50 CD : 50 vermiculite (% volume) was similar to that in 50 SP : 50 vermiculite and a commercial peat-lite (Pro-Mix BX). These growth responses depended on preplant controlled-release fertilizer (CRF) [Osmocote 17N-3.9P-10.8K at 11.5 lb/yd³ (4 kg·m⁻³)] and/or a post-transplanting weekly solution fertilization (SF) at 350 ppm (mg·L⁻¹) N from 21N-2.2P-16.6K. Compared to SP, CD had lower bulk density and cation exchange capacity (volume basis) and higher C to N ratio, pH, total porosity, and container capacity. We conclude that CD is an adequate alternative to SP in soilless container media.

Sphagnum peat (SP), a common component of soilless container media, provides high water retention, high cation exchange capacity (CEC), and buffering against pH changes (Handreck, 1993a). The level of peatland exploitation is consid-

Department of Plant and Soil Sciences, Delaware Agricultural Experiment Station, University of Delaware, Newark, DE 19717-1303.

Published as Delaware Agricultural Experiment Station journal series paper no. 1624. Contribution 338 of the Dept. of Plant and Soil Sciences. We acknowledge donation of coir dust by International Trading Group Inc., Fort Washington, Pa. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

ered unsustainable by wetland ecologists (Barber, 1993), but sustainable by the peat industry (Robertson, 1993), which recognizes, however, that alternatives to peat must be developed to meet environmental and legal concerns pertaining to peatland exploitation (Pryce, 1991).

Coir is the thick fibrous mesocarp of coconuts (*Cocos nucifera* L.). The long fibers are used in manufacturing industrial products (Balick and Beck, 1990), while coir dust (CD)—the remaining short fibers and dust—may be useful as a soilless growth medium component. Properties of CD that make it suitable as substrate component include (Cresswell, 1992) high water-holding capacity; excellent drainage; absence of weeds and pathogens; physically resilient; renewable resource with no known ecological drawbacks; slow decomposition; acceptable pH, CEC, and electrical conductivity (EC); easily wettable, and no sticks or other extraneous materials. However, chemical and physical properties vary among CD sources (Evans et al., 1996).

There are few published reports of CD performance as a component of container growth media. Cresswell (1992) reported earlier germination and greater seedling weights of tomato (*Lycopersicon esculentum* Mill.), lettuce (*Lactuca sativa* L.), and broccoli (*Brassica oleracea* L. var. *botrytis* L.) in 1 vermiculite : 1 CD (by volume) than in 1 vermiculite : 1 SP or sedge (by volume). Meerow (1994) grew two tropical ornamental species in 5 noncomposted pine bark : 4 SP or CD : 1 sand (by volume) with preplant incorporated controlled-release fertilizer (CRF). While shoot dry mass of *Pentas lanceolata* after 3 months was similar in both media, that of *Ixora coccinea* after 5 months was lower in CD medium, a response attributed to microbial immobilization of N. In a longer-term (8-month) study, Meerow (1995) reported similar shoot growth of *Anthurium* in CD or SP medium, but greater growth of *Ravenia rivularis* in the CD medium.

Handreck (1993a) grew *Petunia ×hybrida* in CD or SP, composted pine bark, and coarse sand in respective volume ratios of 17:68:15, 34:51:15, 51:34:15, 68:17:15, and 85:0:15. Shoot dry mass 5 weeks after transplanting decreased linearly with increasing CD and remained constant with increasing SP. Increasing rate of

preplant CRF in CD or SP medium increased shoot dry mass. Handreck (1993a, 1993b) concluded that extra N, either as preplant CRF or postplanting solution fertilization (SF), was necessary to compensate for the requirements of microbial activity when CD replaced SP in growth media. Stamps and Evans (1997) observed higher quality and shoot fresh mass of *Dieffenbachia maculata* after 6 months of growth in three soilless mixes top-dressed with CRF when CD was substituted for SP. They attributed these responses in part to the greater container capacity and higher K concentration of CD than SP.

Our objective was to determine the effect of substituting increasing percentage of CD for SP in 1 SP : 1

vermiculite (by volume) medium on the growth of tomato and coreopsis in response to preplant incorporated CRF and weekly SF.

Fig. 1. Shoot dry mass of 'Red Robin' tomato and coreopsis at 5 weeks after planting into media containing coir dust and sphagnum peat at (% volume) 0:50, 10:40, 20:30, 30:20, 40:10, or 50:0 and 50% vermiculite. The media received 0 or 11.5 lb/yd³ (0 or 4 kg·m⁻³) of preplant controlled-release fertilizer (CRF) (Osmocote 17N-3.9P-10.8K) or weekly solution fertilization (SF) of 0 or 350 ppm (mg·L⁻¹) N from 21N-2.2P-16.6K. Pro-Mix BX represents a commercial peat-lite comparison. Vertical bar represents the one-way LSD_{0.05}.

Table 1. Significances for shoot dry mass of 'Red Robin' tomato and coreopsis at 5 weeks after planting into media containing coir dust (CD) and sphagnum peat (SP) at (% volume): 0:50, 10:40, 20:30, 30:20, 40:10, or 50:0 and 50% vermiculite. Pro-Mix BX represents a commercial peat-lite control. The media received 0 or 11.5 lb/yd³ (0 or 4 kg·m⁻³) of preplant controlled-release fertilizer (CRF) (Osmocote 17N-3.9P-10.8K) or weekly solution fertilization (SF) at 0 or 350 ppm (mg·L⁻¹) N from 21N-2.2P-16.6K.

Variable	Significance of shoot dry mass ²	
	Tomato	Coreopsis
All treatments (one-way analysis) ¹	***	***
Within CD: SP only		
CD linear	NS	NS
CD quadratic	***	NS
CRF	***	***
CD linear × CRF	**	***
CD quadratic × CRF	**	NS
SF	***	***
CD linear × SF	**	*
CD quadratic × SF	*	NS
CRF × SF	***	***
CD × CRF × SF	NS	NS

¹All treatments = 7 growth media formulations × 2 CRF × 2 SF.

NS, **, *** Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Materials and methods

Two 12 × 12 × 6 inch (2.3 lb) [30 × 30 × 15 cm (5 kg)] compressed briquettes of CD (International Trading Group, Fort Washington, Pa.) were hydrated at the recommended rate [12.8 gal (35 L) per briquette] to yield 4 ft³ (114 L). Hydrated CD, slightly moistened SP (Premier Brands, Stamford, Conn.), and grade 2 horticultural vermiculite (Therm-O-Rock, New Eagle, Pa.) were mixed in respective percentage volumes of 0:50:50, 10:40:50, 20:20:50, 30:20:50, 40:10:50, or 50:0:50. Thus, the media contained 0%, 10%, 20%, 30%, 40%, or 50% CD and 50% vermiculite, the balance being SP. Triplicate samples of CD, SP, and vermiculite were analyzed for total N by the dry combustion method (Nelson and Sommers, 1996), total C by the Dumas method (Bremner, 1996), and CEC (Ross, 1995). These media were amended with [in lb/yd³ (kg·m⁻³)] 8.6 (3.0) dolomitic limestone, 2.9 (1.0) triple superphosphate, 2.9 (1.0) calcium sulfate, 3.5 (1.2) Micromax trace element mix (The Scotts Co., Marysville, Ohio), and 1.7 (0.6) potassium

nitrate (added as a solution after the dry ingredients had been mixed thoroughly). These preplant amendments were based on recommendations for the Cornell peat-lite mix A (Boodley and Sheldrake, 1982). Into one-half of each prepared media, the CRF (Osmocote 17N-3.9P-10.8K, 3- to 4-month release; Scotts Co.) was added at 11.5 lb/yd³ (4 kg·m⁻³). These media plus Pro-Mix BX as a commercial peat-lite comparison (Premier Brands, New Rochelle, N.Y.) were placed in 5-inch-diameter (13-cm) standard plastic pots and watered to just beyond saturation. The pH and EC of all media [1 medium : 2 distilled water (by volume)] were tested 1 d later on samples collected from middepth.

Seeds of 'Red Robin' tomato and coreopsis (*Coreopsis lanceolata* L.) were sown in Redi-Earth Plug Mix (Scotts Co.). One week after sowing, bare root seedlings were transplanted, one per cell, into 1.2 × 1.6 × 2.2-inch deep (3 × 4 × 5.5-cm) cells (1208 inserts) containing Pro-Mix BX and placed in a greenhouse set at 77/70 °F (25/21 °C) day/night under natural light (February to March). Two weeks later, seedling plugs

were transplanted (one per pot) into the prepared media. Each medium consisted of eight 5-inch-diameter (13-cm) pots. Four of the pots containing each medium received once weekly SF [350 ppm (mg·L⁻¹) N from 21-2.2P-16.6K; Scotts Co.] and irrigation on all other days. The remaining four pots received daily irrigation. The 6 (CD to SP ratio) × 2 (± CRF) × 2 (± SF) factorial and Pro-Mix BX given the 2 (CRF) × 2 (SF) treatments were arranged in randomized block design with four single-pot replications. After growing for 5 weeks (8 weeks after planting) in the 77/70 °F (25/21 °C) day/night greenhouse under natural light (March to May), shoots were cut at the growth medium surface and dried at 149 °F (65 °C) for dry mass determination. At harvest, media samples were obtained from middepth of each pot for pH and EC [1 medium : 2 distilled water (by volume)] determinations.

To determine physical properties, each medium was placed in eight replications of 5-inch-diameter (13-cm) standard plastic pots. Height of the growth medium was 3.5 inches (9 cm). These media were irrigated daily for 2 weeks to permit settling. After 1 d of drying, the media were extracted intact from each pot and returned to the pot that had been lined with thin plastic sheeting. Following the method described by Spomer (1990), percentage solids was calculated as 100% of the bulk medium volume minus the total porosity as determined gravimetrically by the amount of water needed to saturate the medium. The water-saturated media were allowed to drain by piercing the plastic sheeting through the pot drainage holes and permitting 24 h of drainage with the pot surface sealed with thin plastic sheeting containing a single small hole. Water-filled pore space at container capacity was determined gravimetrically, and air-filled pore space at container capacity (air porosity) was calculated as the difference between total porosity and container capacity. All media then were dried at 149 °F (65 °C). Medium

Table 2. Cation exchange capacity (CEC), total N and C concentrations, and C to N ratio of coir dust, sphagnum peat, and grade 2 vermiculite. Mean (SD) of three samples.

Growth medium component	CEC		Total C		Total N		C to N ratio
	(meq/100 g)	(meq·L ⁻¹)	(g/100 g)	(mg·L ⁻¹)	(g/100 g)	(mg·L ⁻¹)	
Coir dust	20.7(0.2)	16.7(1.0)	45.3 (0.8)	36577 (2842)	0.51 (0.03)	412 (56)	88.8 (12.1)
Sphagnum peat	18.0(0.4)	26.9(1.4)	48.7 (0.2)	72684 (5164)	0.89 (0.03)	1330 (141)	54.7 (1.8)
Vermiculite	20.5(1.1)	32.8(0.8)	0.1 (0.0)	176 (8)	0.01 (0.00)	16 (4)	10.9 (3.7)

bulk density was calculated as medium dry mass divided by settled medium bulk volume.

A one-way ANOVA, with means separation by LSD ($P \leq 0.05$), was used to compare shoot dry mass or media physical properties of the CD-SP-vermiculite media to those of other media. Data pertaining only to the CD-SP-vermiculite media were analyzed by ANOVA as a 6 (CD-SP) $\times$ 2 (CRF) $\times$ 2 (SF) factorial with CD rate partitioned into linear and quadratic trends.

Results and discussion

Tomato shoot dry masses in CD media and Pro-Mix BX were similar when provided CRF or SF (Fig. 1). Tomato shoot dry mass in media containing $>20\%$ CD was greater when CRF and SF were combined than when CRF or SF were used separately. When CRF and SF were combined, tomato shoot dry mass was greater in media

containing 20% to 40% CD than in Pro-Mix BX. Tomato shoots in CD-containing media and Pro-Mix BX that had not received CRF or SF had similar and very low dry masses, and had severe general chlorosis, indicative of N deficiency.

Coreopsis shoot dry mass in CD-containing media or Pro-Mix BX was similar when CRF and/or SF was supplied (Fig. 1). As with tomato, coreopsis shoot dry mass generally decreased with increasing percentage CD when CRF and SF were absent. Interaction effects of CD rate with CRF or SF on shoot dry mass were quadratic for tomato and linear for coreopsis (Table 1). In media supplied CRF and/or SF, tomato shoot dry mass was generally greater at intermediate CD rates (20% to 40%) than at other rates, while coreopsis shoot dry mass did not change or increased only slightly with increasing CD rate. Handreck (1993a, 1993b) reported re-

duced shoot dry mass and N content of 'Celebrity Salmon' petunia as CD increased from 17% to 85% in soilless media. These responses could be obviated by supplying increased CRF to satiate microbial N demands. The high C to N ratio of CD (89:1, Table 2), similar to the 80:1 reported by Meerow (1994), may result in greater microbial immobilization of N than would the lower C to N ratio of SP (55:1), although the relative rates of decomposition are unknown. Since tomato and coreopsis shoot dry mass failed to decline with increasing CD in media that received CRF and/or SF (Fig. 1), we conclude that N supply from CRF or RF in our study was sufficient to meet both crop and microbial requirements.

Since tomato and coreopsis shoot dry masses in 50% CD plus 50% vermiculite were at least as large as in 50% SP plus 50% vermiculite (Fig. 1), we can conclude that CD was a suitable alterna-

Table 3. Initial and final growth medium pH and electrical conductivity (EC) [1 growth medium : 2 water by volume] 5 weeks after transplanting coreopsis or 'Red Robin' tomato seedlings into media containing 0% to 50% coir dust (CD) or sphagnum peat (SP) in 50% vermiculite (V) as influenced by preplant incorporation of 0 or 11.5 lb/yd³ (0 or 4 kg·m⁻³) of controlled-release fertilizer (CRF) (Osmocote 17N-3.9P-10.8K) or weekly solution fertilization (SF) of 0 or 350 ppm (mg·L⁻¹) N from 21N-2.2P-16.6K.

Treatment	Initial		Final, coreopsis		Final, tomato	
	pH	EC (dS·m ⁻¹)	pH	EC (dS·m ⁻¹)	pH	EC (dS·m ⁻¹)
CD-SP-V ratio (% volume)						
0:50:50	4.29	1.30	5.57	0.45	5.96	0.37
10:40:50	4.20	1.26	5.68	0.46	6.26	0.32
20:30:50	4.46	1.45	5.72	0.42	6.21	0.30
30:20:50	4.56	1.67	5.86	0.39	6.29	0.30
40:10:50	4.79	1.72	5.86	0.37	6.43	0.30
50:0:50	5.07	1.78	6.01	0.33	6.44	0.28
Pro-Mix BX	5.81	0.93	6.58	0.32	6.87	0.30
One-way LSD _{0.05}	0.22	0.20	0.09	0.05	0.15	0.06
Within CD-SP-V media						
CRF (kg·m ⁻³)						
0	4.78	1.28	6.01	0.34	6.08	0.29
4	4.69	1.67	5.55	0.47	6.45	0.33
SF (mg·L ⁻¹ N)						
0	---	---	5.90	0.39	6.30	0.31
350	---	---	5.66	0.52	6.23	0.32
Significance						
One-way treatment ^y	***	***	***	***	***	NS
Within CD-SP-V media						
CD linear	***	***	***	***	***	**
CD quadratic	**	NS	NS	NS	NS	NS
CRF	*	***	***	***	***	**
CD linear $\times$ CRF	NS	NS	NS	NS	NS	NS
CD quadratic $\times$ CRF	NS	NS	NS	NS	NS	NS
SF	---	---	***	*	NS	NS
CD linear $\times$ SF	---	---	NS	NS	NS	NS
CD quadratic $\times$ SF	---	---	NS	NS	NS	NS
CRF $\times$ SF	---	---	NS	NS	NS	NS
CD $\times$ CRF $\times$ SF	---	---	NS	NS	NS	NS

^zValues are not applicable.

^yTreatment (one-way) for initial pH and EC values = 7 growth media $\times$ 2 CRF; for final values = 7 growth media $\times$ 2 CRF $\times$ 2 SF.

NS, **, *, *** Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

Table 4. Physical properties of coir dust (CD), sphagnum peat (SP), grade 2 vermiculite (V), Pro-Mix BX, and 0% to 50% CD in SP and 50% vermiculite.

Properties	Bulk density (g·cm ⁻³)	Solids (% vol.)	Air-filled pore space at container capacity (% volume)	Water-filled pore space at container capacity (% volume) ^z
CD-SP-V ratio (% volume)				
0:50:50	0.151	19.7	17.6	62.7
10:40:50	0.143	17.1	19.9	63.0
20:30:50	0.135	15.4	19.7	64.9
30:20:50	0.131	14.2	17.7	68.1
40:10:50	0.129	13.6	15.9	70.5
50:0:50	0.128	11.1	14.2	74.7
CD	0.081	4.8	9.0	86.2
SP	0.149	14.3	15.0	70.7
V	0.160	16.9	24.6	58.5
Pro-Mix BX	0.100	14.3	11.9	73.8
Significance				
Growth media	***	**	***	***
LSD _{0.05} (one-way)	0.015	2.7	5.2	6.4
CD linear	**	*	**	**
CD quadratic	***	NS	***	***

^{ns,*,**,*}Nonsignificant or significant at $P \leq 0.05$, 0.01, or 0.001, respectively.

tive to SP in these media. Stamps and Evans (1997) found that shoot mass of *Dieffenbachia maculata* was greater in three soilless mixes when 40% to 50% of their volumes contained CD rather than SP. Meerow (1994, 1995) reported that CD was an acceptable substitute for SP in soilless container media in the production of nursery crops.

On a mass basis, CD and SP had similar CEC and total C, but CD had 43% less N (Table 2). However, the 54% lower bulk density of CD compared to SP (Table 4) resulted in CD volumetrically having 38% lower CEC, 50% lower total C and 69% lower N. Handreck (1993a) reported that CD had a lower CEC (21 to 30 meq·L⁻¹, depending on source) than SP (78); but Cresswell (1992) found that CD had a higher CEC (35.5) than SP (25.2). Evans et al. (1996) reported a considerable CEC range for various sources of CD, but the average 28.4 meq·L⁻¹ (following conversion to volumetric basis) was similar to our 26.9 meq·L⁻¹ (Table 2). Based on our volumetric CEC values for CD and SP (Table 2), the estimated difference in CEC for media containing 50% vermiculite and 50% CD or 50% SP would be sufficiently small (<3 meq·L⁻¹, <0.4 meq/media in a 13-cm-diameter pot) to have a negligible effect on cation retention.

Initial pH increased with increasing percentage CD in the media (Table 3), an expected response given the higher pH of straight CD (5.17 ± 0.01) than of straight peat (4.33 ± 0.13). The higher pH of CD than of SP media has been

noted elsewhere (Cresswell, 1992; Handreck, 1993a; Meerow, 1994). Although substituting CD for SP in soilless media may reduce the limestone requirement, the recommended 8.6 lb/ yd³ (3 kg·m⁻³) limestone incorporation (Boodley and Sheldrake Jr., 1982) generally failed to raise initial media pH to 5.0 to 5.8, the recommended range of maximum nutrient availability in highly organic media (Handreck and Black, 1991). Final media pH was in this range after supporting coreopsis, but was generally >6.0 following tomato growth.

The increase in initial EC with increasing percentage CD in the media (Table 3) would be expected given the higher EC of straight CD [0.70 ± 0.05 mmho·cm⁻¹ (dS·m⁻¹)] than of straight peat [0.08 ± 0.01 mmho·cm⁻¹ (dS·m⁻¹)]. The initial EC of all our media fell within the 0.5 to 1.80 mmho·cm⁻¹ (dS·m⁻¹) range (1 medium : 2 distilled water, vol.) considered satisfactory for most crops (Bunt, 1988). While final EC remained higher in 50% CD (≈0.44) than in 50% SP (≈0.31), the range of values [0.28 to 0.52 mmho·cm⁻¹ (dS·m⁻¹)] would indicate low to insufficient fertility.

Since CD had a lower bulk density than SP, increasing CD lowered media bulk density (Table 4). Thus, substituting CD for SP in media may benefit media handling and transportation. Relative to SP, CD had lower percentage solids and thus greater percentage total porosity, greater container capacity, and lower air porosity. Increasing CD in the media increased container

capacity, so that 50% CD : 50% vermiculite had a higher container capacity (75%) than 50% SP : 50% vermiculite (63%). Stamps and Evans (1997) attributed greater mass of *Dieffenbachia maculata* when CD substituted for SP in three soilless mixes, at least in part, to the greater container capacity of the CD-containing media.

Our results showed that CD adequately substituted for all of the SP in 1 SP : 1 vermiculite (by volume) since shoot dry masses of coreopsis and tomato after five weeks' growth in these media were similar. The 1 CD : 1 vermiculite (by volume) resulted in shoot dry masses similar to those achieved in a commercial peat-lite medium, irrespective of fertilization regime (preplant CRF incorporation and/or weekly SF). CD, compared to SP, had lower values of bulk density and CEC (by volume) and higher values of C to N ratio, pH, total porosity and container capacity.

Literature cited

- Balick, M.J. and H.T. Beck (eds.). 1990. Useful palms of the world. Columbia Univ. Press, New York.
- Barber, K.E. 1993. Peatlands as archives of past biodiversity. Biodiversity Conservation 2:474-489.
- Boodley, J.W. and R. Sheldrake, Jr. 1982. Cornell peat-lite mixes for commercial plant growing. N.Y. State College Agr. Life Sci. Ext. Bul. 43.
- Bremner, J.M. 1996. Nitrogen—Total, p. 1085-1121. In: D.L. Sparks (ed.). Methods

of soil analysis. Part 3. Chemical methods. SSSA Book Ser. 5. Soil Sci. Soc. Amer.—Amer. Soc. Agron., Madison, Wis.

Bunt, A.C. 1988. Media and mixes for container-grown plants. Unwin-Hyman, London.

Cresswell, G.C. 1992. Coir dust—A viable alternative to peat? p. 1–5. In: Proc. Austral. Potting Mix Manufacturers' Conf., Sydney.

Evans, M.R., S. Konduru, and R.H. Stamps. 1996. Source variation in physical and chemical properties of coconut coir dust. HortScience 31:965–967.

Handreck, K.A. 1993a. Properties of coir dust, and its use in the formulation of soilless potting media. Commun. Soil Sci. Plant Anal. 24:349–363.

Handreck, K.A. 1993b. Immobilization of nitrogen in potting media. Acta Hort. 342:121–126.

Handreck, K.A. and N.D. Black. 1984. Growing media for ornamental plants and turf. New S. Wales Univ. Press, Kensington, NSW, Austral.

Meerow, A.W. 1994. Growth of two subtropical ornamentals using coir (coconut mesocarp pith) as a peat substitute. HortScience 29:1484–1486.

Meerow, A.W. 1995. Growth of two tropical foliage plants using coir dust as a container medium component. HortTechnology 5:237–239.

Nelson, D.W. and L.E. Sommers. 1996. Total carbon, organic carbon and organic matter, p. 961–1010. In: D.L. Sparks (ed.). Methods of Soil Analysis. Part 3. Chemical methods. SSSA Book Ser. 5. Soil Sci. Soc. Amer.—Amer. Soc. Agron., Madison, Wis.

Pryce, S. 1991. Alternatives to peat. Prof. Hort. 5:101–106.

Robertson, R.A. 1993. Peat, horticulture and environment. Biodiversity Conservation 2:541–547.

Ross, D.S. 1995. Recommended methods for determining soil cation exchange capacity, p. 62–69. In: J.T. Sims and A. Wolf (eds.). Recommended soil testing procedures for the northeastern United States. 2nd ed. Del. Agr. Expt. Sta. Univ. (Newark) NE Reg. Bul. 493.

Spomer, L.A. 1990. Evaluating 'drainage' in container and other shallow-drained horticultural soils. Commun. Soil Sci. Plant Anal. 21:221–35.

Stamps, R.H. and M.R. Evans. 1997. Growth of *Dieffenbachia maculata* 'Camille' in growing media containing sphagnum peat or coir dust. HortScience 32:844–847.

Fungus Gnat Population Development in Coconut Coir and Sphagnum peat-based Substrates

Michael R. Evans,¹
James N. Smith,² and
Raymond A. Cloyd³

ADDITIONAL INDEX WORDS. root media, *Bradysia coprophila*.

SUMMARY. Coir and peat-based substrates were tested for their effectiveness in inhibiting the development of fungus gnat populations. The first experiment was conducted in July under relatively high temperatures (20 to 35 °C) and a second experiment was conducted in April under relatively low temperatures (20 °C). *Euphorbia pulcherrima* Willd. ex Klotzsch 'Freedom' plants were planted into 18-cm-diameter containers filled with substrates containing 80% sphagnum peat or coir, with the remainder being perlite. Half of the containers of each substrate were inoculated with fungus gnat larvae and sealed with either cheesecloth or thrips screen for Expts. 1 and 2, respectively. After 6 and 8 weeks for Expts. 1 and 2, respectively, fungus gnat adult and larval populations were sampled. Adults and larvae were recovered from coir and peat-based substrates in both experiments. In Expt. 1, significantly more adults and larvae were recovered from coir-based than peat-based substrates. In Expt.

2, significantly more adults and larvae were recovered from the peat-based than coir-based substrates. In a third experiment, the peat- and coir-based substrates used in Expts. 1 and 2 were used as well as the Iowa State greenhouse substrate, which contained 40% Sphagnum peat, 40% perlite, and 20% loam (v/v). *Helianthus annuus* L. 'Pacino' seeds were sown into 18-cm-diameter containers filled with the test substrates. Natural infestation was allowed to occur for 6 weeks, after which time potato disks were used to sample the fungus gnat larvae population. Larvae were recovered from all substrates, and there was no significant difference in the number of larvae collected from the three substrates. Based on the results of these experiments, we concluded that coir does not inhibit the development of fungus gnat larvae populations and, when presented with options, fungus gnats will infest coir-based substrates as readily as peat-based substrates.

Since the earliest reports of their potential damage to containerized plants (Hungerford, 1916), fungus gnats (*Bradysia coprophila*) have been a significant problem for greenhouse crop producers. Although adults are generally considered an unsightly nuisance, they have also been implicated in transmitting diseases such as *Thielaviopsis basicola* to *Viola × wittrockiana* Gams. (pansy) seedlings (Harris, 1995). However, the larvae are of the greatest concern because they can cause direct injury through their feeding on the stems and roots of containerized plants (Hamlen and Wettstein, 1978; Hussey, 1964; Mead, 1978; Parr et al., 1954; Wilkinson and Daugherty, 1970). In addition, plants damaged by fungus gnat larvae feeding have been shown to be more susceptible to infection by *Fusarium roseum* and *Fusarium oxysporum* (Leath and Newton, 1969).

Fungus gnats have a life cycle consisting of an egg stage, four larval stages, a pupal stage, and an adult stage (Cloyd, 1994). The adult deposits its eggs in the substrate surface and the larvae inhabit the upper 3 cm of the substrate surface until pupating and emerging from the substrate as adults. A generation requires 21 to 40 d to complete depending on temperature.

Although chemical controls exist for fungus gnats (Cloyd, 1994; Hamlen

Department of Horticulture, Iowa State University, Ames, IA 50011-1100.

Iowa Agricultural and Home Economics Experiment Station journal paper no. J-17500. Project no. 3345 and supported by Hatch and Iowa state funds. Research conducted at Iowa State Univ., Ames. Use of trade names does not imply endorsement of the products named nor criticism of similar ones not named. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.

¹Assistant professor

²Graduate research assistant.

³Graduate research assistant. Current address: Department of Entomology, Purdue University, West Lafayette, IN 47907.