Efficient Propagation Technique of *Euphorbia* $\times$ *lomi* Thai Hybrids

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Additional index words. soilless culture, growing media, cuttings, rooting substrates, α -naphthalene acetic acid, pot plants

Abstract. A simple and efficient in vivo propagation protocol of two cultivars of *Euphorbia* $\times$ *lomi* Rauh is described. Mother plants of ‘Nguen Muang’ and ‘Porn Ying Yai’ were soilless grown in 1 coconut coir dust:1 perlite (by volume) and 2 sphagnum peat:1 perlite (by volume) to produce cuttings. Plants cultured in peat-based substrate showed thicker stems (36.0 versus 30.5 mm, respectively), higher production of cuttings (10.4 versus 5.6 per plant), higher water absorption (265.7 versus 153.5 mL/plant/d), and higher content of nutrients in the root zone as compared with those cultivated in coir dust mixture. Cuttings harvested from 1-year-old mother plants of both cultivars were treated with 4000 ppm of α -naphthalene acetic acid (NAA) powder and inserted into bottom-heated benches filled with different substrates [perlite, 1 perlite:1 coir dust (by volume), coir dust] for rooting. Cuttings in pure perlite evidenced higher rooting percentage (86.2%) and longer roots (6.2 cm) than those in other media. Application of NAA resulted in higher rooting capacity (78.8 versus 68.3%, respectively) and higher amount of roots per cutting (13.4 versus 10.2) than treatment without auxin. Rooted cuttings grown in 1 peat:1 perlite medium (by volume) produced higher marketable potted plants than in 2 peat:1 perlite medium.

Euphorbia $\times$ *lomi* Rauh, an interspecific hybrid of *Euphorbia milii* Des Moulins (or Crown-of-thorns) and *E. lophogona* Lamarck, both endemic to Madagascar (Graf, 1985), was recently introduced to the Mediterranean countries as a new floral crop according to the increased demand for new low-maintenance ornamental plants. *Euphorbia* $\times$ *lomi* is a succulent shrub characterized by an erect, thick, fleshy, branched spiny stems up to 1 to 1.5 m long with long, lanceolate leaves and brightly colored bracts (Rauh, 1979). These hybrids can be year-round grown in dry, high temperature and high solar radiation areas as potted, bedding, or garden plants (Jankalski, 2000).

Crown-of-thorns and the hybrids are generally propagated by tip cuttings (Smoley, 2000), which is the most economic way to produce these plants, but information on the vegetative propagation is still limited. Mother plants are normally cultivated in soil, so disease problems such as root rot are frequent if drainage is not adequate and there is no possibility to monitor plant uptake with dispersion of water and nutrient excesses. V-cleft grafting could reduce the risk of rot

associated with direct rooted cuttings but limit large-scale propagation (McLaughlin and Garofalo, 2002). Seeds should not be used to propagate these genotypes because of producing extremely variable seedlings. Recently, *Euphorbia milii* species was also introduced and cultured in vitro (Airò et al., 2007), also by using a bioreactor system (Dewir et al., 2005). However, tissue culture is very expensive and often requires a high amount of labor (Saranga and Cameron, 2007).

Therefore, in 2004, a research program was initiated at the Research Unit for Mediterranean Flower Species of Palermo, Italy, to develop a comprehensive vegetative propagation system. The objective of this study involved the following steps: 1) growing mother plants of two *Euphorbia* $\times$ *lomi* Thai hybrids year-round in soilless media; 2) rooting cuttings harvested from 1-year-old mother plants in different media with or without auxin application; and 3) planting rooted cuttings to produce potted plants. Three experiments were conducted on two cultivars: 1) to evaluate the effect of soilless media on plant growth and cuttings production; 2) to determine the influence of substrates and auxin application on rooting; and 3) to study the effect of growing media on growth of rooted cuttings and pot plant production.

Materials and Methods

Expt. 1: Mother plant cultivation. This trial was carried out in a double-span polyethylene (PE) -covered 540 m² greenhouse (28 °C day/14 °C night) at Bagheria, near

Palermo (lat. 38°5′ N, long. –13°30′ E, alt. 23 m above sea level) on the coastal region of northwestern Sicily.

Mother plants of the Thai cultivars Nguen Muang and Porn Ying Yai were grown in polypropylene benches (720 L) filled with two growing media composed of 1 coconut coir dust:1 perlite (by volume) and 2 sphagnum peat:1 perlite (by volume) in an open-loop system with no recirculating solution. The physical properties and the chemical characteristics of the media (Table 1) were analyzed according to the methods described by De Boodt et al. (1974) and Sonneveld et al. (1974), respectively.

A split-plot experimental design with two substrates as the main plot and two cultivars as subplots with three replications and 20 plants per replication was used. Mother stock plants were transplanted in early Nov. 2004 in double rows (row spacing of 0.4 m); the final density was 6.2 plants/m². Water and nutrients were supplied by a drip system controlled by a computer (MCI-Ceo; Spagnol Greenhouse Technology, Vidor, Italy). Irrigation scheduling was performed using electronic low-tension tensiometers (Tensio-technik; Florafit, Codognè, Italy) that control irrigation on the basis of substrate matric potential. Plants were daily fertigated at 2 L/h one to five times during the growing cycle. The duration of each fertigation was adjusted when the drainage exceeded the range of 10% to 20%. The composition (mg·L⁻¹) of the supplied nutrient solution was as follows: 143 N-NO₃, 47 N-NH₄, 50 phosphorus, 200 potassium, 120 calcium, 30 magnesium, 1.2 iron, 0.2 copper, 0.2 zinc, 0.3 manganese, 0.2 boron, and 0.03 molybdenum. The pH and the electrical conductivity (EC) were maintained at 5.9 and 2.1 dS·m⁻¹, respectively.

Plant height increase, plant stem diameter increase, total number (basal and lateral) of shoots per plant, number of cuttings suitable for rooting (with average length of 8 to 12 cm) harvested per plant, and fresh weight of cuttings included in this range were recorded for a 12-month period (Jan. to Dec. 2005). Water absorption was calculated from the difference between the volume of nutrient solution applied and the volume of collected drainage. Nutrients content in the root zone (uptaken by roots and retained by substrate) was determined by photometric test with Spectroquant (Merck KGaA, Darmstadt, Germany) as the difference between the concentration of each element in the given solution and in the collected drainage.

Expt. 2: Rooting. This experiment was conducted in a single-span 200 m² greenhouse covered with polymethyl methacrylate maintained at 28 °C day/14 °C night. Uniform (with average length of 8 to 12 cm, weight of 20 to 25 g, and basal diameter of 1.2 to 1.5 cm), semisoft wood cuttings of ‘Nguen Muang’ and ‘Porn Ying Yai’ from 1-year-old stock plants (Expt. 1) were harvested in early Oct. 2005 and the cut end of the cuttings were immersed in hot water (60 °C) for 30 s to prevent latex production

Received for publication 23 Sept. 2008. Accepted for publication 18 Dec. 2008.

This research was financed by the Italian Ministry of Agriculture and Forestry through the program “Programma di sviluppo per il Mezzogiorno d’Italia: ricerca ed innovazione tecnologica” (Project 205/7303/05 Valorizzazione delle produzioni florovivaistiche del meridione), Work N° 58.

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Table 1. Physical and chemical characteristics of the growing media used in Expt. 1.

	1 coir dust: 1 perlite	2 peat:1 perlite
Bulk density (g·cm ⁻³)	0.11	0.12
Total pore space (% vol.)	95.3	93.1
Air content (% vol.)	48.1	34.5
Waterholding capacity pF 1 (% vol.)	47.2	58.6
Easy available water pF 1–1.7 (% vol.)	13.4	20.1
pH ² (H ₂ O)	6.0	5.3
Electrical conductivity ² (dS·m ⁻¹)	0.6	0.5
Cation exchange capacity (meq/100 g)	36.1	55.2

²Measured on watery extract 1:1.5 (v/v).

and then air-dried for 8 h. Basal end of the cuttings was treated with 0 and 4000 ppm of α -naphthalene acetic acid (NAA) powder formulation (Germon; E. Gerlach GmbH, Lubbecke, Germany). Cuttings were placed under mist into benches (6 m $\times$ 1.2 m) filled with different substrates [perlite, 1 perlite:1 coir dust (by volume), coir dust] for rooting.

Benches were bottom-heated at 22 to 23 °C and covered with a PE film, which was removed from 1100 HR to 1500 HR to reduce the temperature. Mist cycles were regulated (30 s every 120 min, from 1000 HR to 1600 HR). Rooting media were drenched every 15 d with 2 mL·L⁻¹ of propamocarb hydrochloride (65% w/w) (Previcur; Bayer CropScience AG, Milano, Italy) for fungal disease control.

The experiment was set as a split-plot design with rooting substrates, auxin applications, and cultivars set as the main plot, subplots, and subsubplots, respectively. Each replication consisted of 30 cuttings. Data on the survival rate of cuttings, rooting percentage, total number of roots per cutting, and length of all roots were collected after 60 d.

Expt. 3: Plant growth. This trial was carried out in a greenhouse as described in Expt. 1. Rooted cuttings of ‘Nguen Muang’ and ‘Porn Ying Yai’ were transplanted into 14-cm plastic pots filled with two growing media composed of 1 sphagnum peat:1 perlite (by volume) and 2 sphagnum peat:1 perlite (by volume) in early Jan. 2006 with a final density of 10 plants/m². Pots were placed on the raised bench with 0.5% slope from the ground and the leached solution from all containers was collected.

During culture, water, macro-, and micro-elements were supplied through a drip fertigation system four to eight times a day as described in Expt. 1. Irrigation scheduling was based on the same criteria adopted for Expt. 1. Plants were fed with a nutrient solution with the same composition, pH, and EC of that used in Expt. 1.

A split-plot experimental design with two mixtures as the main plot and two cultivars as subplots, with three replications, was used. There were 20 plants per replication and each plant was considered as an experimental unit. Number of survived plantlets was counted 40 d after transplanting. Plant height, plant stem

basal diameter, and the number of total inflorescences (flower stalks), leaves, and shoots per plant were monthly recorded for a 6-month period (Apr. to Sept. 2006).

Statistical analysis. Data from each experiment were subjected to two-way (Expts. 1 and 3) and three-way (Expt. 2) analysis of variance; means were separated according to Duncan’s multiple range test using Statistica software (Version 6.0 for Windows, Statsoft Inc., Tulsa, OK). Cuttings viability, rooting, and plantlet survival percentages were arcsine transformed before the analysis, but means were presented from the nontransformed data were reported.

Results and Discussion

Expt. 1. Mother plants cultivated in 2 sphagnum peat:1 perlite (by volume) showed a similar height increase than those grown in 1 coir dust:1 perlite (by volume) (25.9 and 22.1 cm, respectively) (Table 2). Hybrids cultured in peat blend evidenced a higher increment of basal stem diameter (5.2 cm) than plants on coir dust (3.6 cm). The cultivars tested differed both on plant height

increase and on stem diameter increase with ‘Porn Ying Yai’ recording superior values (30.3 and 5.1 cm for height and diameter increment, respectively) than ‘Nguen Muang’ (17.7 and 3.7 cm) (Table 2). Substrate growing response supports similar outcomes previously described (Dewir et al., 2005), in which *Euphorbia milii* ex vitro plantlets grew better in a medium with peatmoss plus perlite and vermiculite than in a coco peat:rice hulls mix.

An average production of 18.3 shoots/plant was obtained regardless of the growing substrates (Table 2). Average amounts of 31.6 and 5.0 shoots were achieved by ‘Nguen Muang’ and ‘Porn Ying Yai’, respectively. A highly significant ($P \leq 0.001$) interaction substrate $\times$ cultivar was recorded. Differences between substrates on shoot production, during a 12-month period of cultivation, varied from 1.3 to 5.3 shoots/plant only, whereas those measured between cultivars ranged from 5.5 (February) to 23.9 shoots/plant (November) (Fig. 1).

A higher number (10.4) of cuttings suitable for rooting was produced from plants cultured in peat-based substrate compared

Table 2. Effects of substrates and cultivars on *Euphorbia × lomi* plant height and diameter increase, shoot production, cutting production, and fresh weight (Expt. 1).

	Plant ht increase (cm)	Plant stem diam ² increase (cm)	Shoots ^y (no./plant)	Cuttings (no./plant)	Cutting fresh wt (g)
Substrate					
1 coir dust:1 perlite	22.1 a ^x	3.6 b	15.5 a	5.6 b	23.6 a
2 peat:1 perlite	25.9 a	5.2 a	21.0 a	10.4 a	26.8 a
Cultivar					
Nguen Muang	17.7 b	3.7 b	31.6 a	13.1 a	20.5 b
Porn Ying Yai	30.3 a	5.1 a	5.0 b	2.9 b	30.0 a
Significance					
Substrate (S)	NS	*	NS	*	NS
Cultivar (C)	***	*	***	**	*
S $\times$ C	NS	NS	***	*	NS

^xMeasured at the base of the main stem.

^yTotal number.

^zMeans within columns separated using Duncan’s multiple range test ($P \leq 0.05$).

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

Fig. 1. Monthly productive trend of the two *Euphorbia × lomi* hybrids on soilless culture with two organic media (Year 2005; Expt. 1). ¹1 coir dust:1 perlite (by volume); ²2 sphagnum peat:1 perlite (by volume). Vertical bars indicate $\pm$ SE of means.

with that (5.6) from coir-grown hybrids (Table 2). Average harvest of 13.1 and 2.9 cuttings/plant were recorded for 'Nguen Muang' and 'Porn Ying Yai', respectively. A significant ($P \leq 0.05$) interaction substrate $\times$ cultivar was observed. Hybrids in the two growing substrates produced cuttings with similar average fresh weight (23.6 and 26.8 g for plants in coir dust and sphagnum peat, respectively) (Table 2); 'Porn Ying Yai' provided heavier cuttings (30.0 g) than those supplied by 'Nguen Muang' (20.5 g).

A higher water absorption was recorded from plants grown in sphagnum peat mixture (324.3 and 206.2 mL/plant/d, for spring/summer and fall/winter, respectively) than those cultivated in 1 coir dust:1 perlite (by volume) (189.3 and 117.5 mL/plant/d) (Table 3). There was no statistical difference in water absorption between cultivars. Plants in 2 peat:1 perlite (by volume) showed higher macro- and micronutrient content in the root zone compared with that measured in coir dust blend (Table 4). The two hybrids did not differ on this parameter.

Effects of the two organic mixes on plant growth, water and nutrient absorption are certainly related to their physical and chemical characteristics, which were formerly studied by several authors (Evans et al., 1996; Prasad and Maher, 1993; Verdonck et al., 1983; Wever, 1995) who reported that the two growing materials, even presenting some similarities, mostly differ on important chemical and hydrological features; coir dust is characterized by higher porosity and air content and lower total and easily available water capacity than peat (Abad et al., 2005). In our trial, the higher diameter increase and the superior production of cuttings by plants in 2 sphagnum peat:1 perlite (by volume) mixture may be correlated to its higher water content that, together with a sufficient degree of aeration, not too far from that of coir dust blend, could establish better environmental conditions in the root zone, which was also characterized by superior content of macro- and micronutrients (in the roots as well as in the substrate). Nevertheless, with appropriate adjustments of water and mineral regimes, their performances may be equivalent

Table 3. Effects of substrates and cultivars on seasonable water absorption of *Euphorbia x lomi* plants (mL/plant/d; Expt. 1).

	Spring- summer	Fall- winter
Substrate		
1 coir dust:1 perlite	189.3 b ^z	117.5 b
2 peat:1 perlite	324.3 a	206.2 a
Cultivar		
Nguen Muang	250.7 a	157.1 a
Porn Ying Yai	262.9 a	166.6 a
Significance		
Substrate (S)	**	**
Cultivar (C)	NS	NS
S $\times$ C	*	*

^zMeans within columns separated using Duncan's multiple range test ($P \leq 0.05$).

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

Table 4. Effects of substrates and cultivars on nutrients content in the root zone of *Euphorbia x lomi* plants (mg/plant/d; Expt. 1).

	NO ₃ -N	NH ₄ -N	Phosphorus	Potassium	Calcium	Magnesium	Iron
Substrate							
1 coir dust:1 perlite	15.7 b ^z	0.21 b	8.2 b	23.1 b	11.9 b	8.05 b	0.18 b
2 peat:1 perlite	27.3 a	0.39 a	15.4 a	42.0 a	20.7 a	13.5 a	0.43 a
Cultivar							
Nguen Muang	20.3 a	0.27 a	11.4 a	31.2 a	16.1 a	10.4 a	0.28 a
Porn Ying Yai	22.7 a	0.33 a	12.1 a	33.9 a	16.5 a	11.1 a	0.32 a
Significance							
Substrate (S)	*	**	*	**	*	*	**
Cultivar (C)	NS	NS	NS	NS	NS	NS	NS
S $\times$ C	NS	*	NS	*	NS	NS	*

^zMeans within columns separated using Duncan's multiple range test ($P \leq 0.05$).

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

Table 5. Effects of rooting substrates, α -naphthalene acetic acid (NAA) treatments, and cultivars on survival rate and rooting parameters of *Euphorbia x lomi* cuttings (Expt. 2).

	Viability (%)	Rooting (%)	Roots	
			Number (no./cutting)	Length (cm)
Substrate				
Perlite	84.9 a ^z	86.2 a	14.5 a	6.2 a
1 perlite:1 coir dust	81.2 a	76.2 b	13.5 a	4.1 b
Coir dust	83.6 a	58.3 c	10.9 b	3.5 b
NAA (ppm)				
0	82.1 a	68.3 b	10.2 b	5.1 a
4000	84.5 a	78.8 a	13.4 a	4.7 a
Cultivar				
Nguen Muang	91.0 a	79.0 a	14.6 a	5.1 a
Porn Ying Yai	75.5 b	67.0 b	11.1 b	4.7 a
Significance				
Substrate (S)	NS	***	*	***
NAA (N)	NS	*	*	NS
Cultivar (C)	***	*	**	NS
S $\times$ N	NS	NS	NS	NS
S $\times$ C	*	NS	NS	NS
N $\times$ C	NS	NS	NS	NS
S $\times$ N $\times$ C	*	NS	NS	NS

^zMeans within columns separated using Duncan's multiple range test ($P \leq 0.05$).

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

(Meerow, 1994). Actually, no differences recorded on plant height increase, shoot total production, and quality of cuttings seem to indicate that *Euphorbia x lomi* hybrids can be grown in both the substrates, confirming coir dust as one of the main alternatives to peat as an organic component of mixtures for hydroponic culture (Cresswell, 1992; Evans and Stamps, 1996; Stamps and Evans, 1999).

Expt. 2. An average value of 83.3% of viable cuttings was obtained irrespective of the rooting substrates (Table 5). The application of NAA did not affect the survival rates of the cuttings. 'Nguen Muang' showed higher cutting viability (91.0%) than 'Porn Ying Yai' (75.5%). Significant ($P \leq 0.05$) two-way (substrate $\times$ cultivar) and three-way (substrate $\times$ hormone $\times$ cultivar) interactions were observed.

Higher rooting rates were recorded from cuttings inserted in perlite-based media [86.2% and 76.2% for perlite and 1 perlite:1 coir dust (by volume), respectively] than that from coir dust alone (58.3%) (Table 5). Application of NAA resulted in a higher number of rooted cuttings than nontreated cuttings (78.8 versus 68.3). Cuttings of 'Nguen Muang' showed a higher rooting percentage (79.0%) compared with 'Porn Ying Yai' (67.0%).

Cuttings in perlite and 1 perlite:1 coir dust (by volume) produced a higher number of roots (14.5 and 13.5, respectively) than those inserted in pure coir dust (10.9) (Table 5). NAA treatment increased the number of roots (13.4) over control (10.2). 'Nguen Muang' produced a higher number of roots/cutting (14.6) than 'Porn Ying Yai' (11.1).

Cuttings in perlite presented longer roots (6.2 cm) than those in the other media [4.1 and 3.5 cm for 1 perlite:1 coir dust (by volume) and coir alone, respectively] (Table 5). Root length was unaffected by NAA treatment and by cultivars.

The highest rooting percentage and roots production recorded with perlite-based media suggested that coir dust alone is less suitable for *Euphorbia x lomi* propagation, probably because of the establishment of less favorable environmental conditions for the development of root organ. The best crop performances in perlite are in line with other researches according to which rooting response of *Clematis* microshoots and stem cuttings was higher in pure perlite than in peat:perlite (Kreen et al., 2002). Al-Salem and Karam (2001) reported that adventitious root formation of *Arbutus andrachne* stem cuttings was enhanced with increasing perlite percentage in the medium up to 100%. The

Table 6. Effects of peat:perlite volume ratio and cultivars on survival rate and growth parameters² of *Euphorbia ×lomi* pot plants (Expt. 3).

	Plantlet survival (%)	Plant ht (cm)	Plant stem diam (cm)	Flower stalks (no./plant)	Leaves (no./plant)	Shoots (no./plant)
Peat:perlite v/v						
1:1	84.5 a ^y	22.5 a	1.9 a	7.2 a	18.2 a	4.4 b
2:1	64.8 b	23.0 a	2.1 a	10.6 a	22.4 a	6.3 a
Cultivar						
Nguen Muang	71.1 a	19.1 b	1.7 b	11.2 a	16.5 b	5.7 a
Porn Ying Yai	78.2 a	26.5 a	2.3 a	6.6 b	24.0 a	5.0 a
Significance						
Substrate (S)	*	NS	NS	NS	NS	*
Cultivar (C)	NS	**	*	*	**	NS
S × C	NS	*	NS	NS	NS	NS

²Measured after 6 months of cultivation.

^yMeans within columns separated using Duncan's multiple range test ($P \leq 0.05$).

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

significant differences among the three rooting media are probably related to the physical properties of substrates, which are characterized by different levels of porosity and waterholding capacity (Hartmann et al., 1997). The improvement of the formation and growth of roots of *Euphorbia ×lomi* cuttings in pure perlite could be linked to a likely increase of air content and oxygen diffusion rate than in coir-based media as reported by Gislerød (1983) for Poinsettia's cuttings in coir dust and rockwool.

Higher NAA effect on rooting rate and number of roots produced by each cutting than treatment without auxin agrees with previous reports describing the effectiveness of NAA in promoting adventitious root formation (Loach, 1988; Lym, 1992).

Expt. 3. Higher survival rate (84.5%) of potted plants was observed in 1 sphagnum peat:1 perlite (by volume) mixture than 2 sphagnum peat:1 perlite (by volume) medium (64.8%) (Table 6). This outcome is in line with Dewir et al. (2005) who had observed that a mixture with 1 peatmoss:1 perlite:1 vermiculite (by volume) resulted in the best acclimatization rate of *Euphorbia milii* ex-vitro plantlets. Moreover, 1 peat:1 perlite volume ratio was commonly used for the establishment of *E. milii* micropropagated plants (Airò et al., 2007) and *Euphorbia lagascae* cuttings (Ibáñez-Torres, 2004). No differences on plantlet viability were evidenced between hybrids.

Plant height, plant stem basal diameter, number of flower stalks/plant, and the number of leaves/plant were not significantly affected by medium composition (Table 6). No significant differences on growing response between high and reduced peat content in the medium confirm previous outcomes (Lym, 1992) reporting similar growth performances of *Euphorbia esula* cuttings on substrates with different amounts of peat. However, plant height was significantly affected by cultivars (26.5 and 19.1 cm for 'Porn Ying Yai' and 'Nguen Muang', respectively) (Table 6). 'Porn Ying Yai' showed higher plant stem diameter (2.3 versus 1.7 cm), produced lower number of flowers (6.6 ver-

sus 11.2 stalks per plant) but more leaves (24.0 versus 16.5 per plant) than 'Nguen Muang'. Pot plants grown in a 2:1 mixture produced a higher number of shoots (6.3) than those cultured in 1:1 medium (4.4) (Table 6). No differences on shoot production were observed between hybrids.

Conclusion

The definition of a vegetative propagation protocol that allows a fast and low-cost mass production of pot plants of *Euphorbia ×lomi* cultivars could be exploited in commercial contexts aimed to propose new floricultural crops. These hybrids may be seriously considered as a valid alternative to the traditional potted plants, considering the high ornamental potentialities (great size inflorescence, long-lasting flowering, water deficit resistance) and taking into account the renewed general interest on drought-tolerant and easy-maintenance species. Additional studies should be conducted to increase plant growth performances and cutting rooting response by testing different growing media, auxin types, and formulations.

Literature Cited

- Abad, M., F. Fornes, C. Carrión, V. Noguera, P. Noguera, Á. Maquieira, and R. Puchades. 2005. Physical properties of various coconut coir dusts compared to peat. HortScience 40: 2138–2144.
- Airò, M., G.V. Zizzo, and B. Ruffoni. 2007. In vitro propagation of an *Euphorbia milii* hybrid. Acta Hort. 748:241–246.
- Al-Salem, M.M. and N.S. Karam. 2001. Auxin, wounding, and propagation medium affect rooting response of stem cuttings of *Arbutus andrachne*. HortScience 36:976–978.
- Cresswell, G.C. 1992. Report on the use of coir dust as substitute for peat in potting media. NSW Agriculture. Biological and Chemical Research Institute, Australia.
- De Boodt, M.F., O.F. Verdonck, and I.M. Cappaert. 1974. Method for measuring the water release curve of organic substrates. Acta Hort. 37:2054–2062.

- Dewir, Y.H., D. Chakrabarty, E.J. Hahn, and K.Y. Paek. 2005. Reversion of inflorescence development in *Euphorbia milii* and its application to large-scale micropropagation in an air-lift bioreactor. J. Hort. Sci. Biotechnol. 80:581–587.
- 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.
- Evans, M.R. and R.H. Stamps. 1996. Growth of bedding plants in sphagnum peat and coir dust-based substrates. J. Environ. Hort. 14:187–190.
- Gislerød, H.R. 1983. Physical conditions of propagation media and their influence on the rooting of cuttings III. The effect of air content and temperature in different propagation media on the rooting of cuttings. Plant Soil 75:1–14.
- Graf, A.B. 1985. Exotica. Vol. 1^o. Roehrs Company, East Rutherford, NJ.
- Hartmann, H.T., D.E. Kester, F.T. Davies, and R.L. Geneve. 1997. Plant propagation: Principles and practices. 7th Ed. Prentice-Hall, Englewood Cliffs, NJ.
- Ibáñez-Torres, A. 2004. Rooting experiments with *Euphorbia lagascae* cuttings. Ann. Biol. 26:101–104.
- Jankalski, S. 2000. Crown of Thorns' hybrids—Past and present. Cactus Succulent J. 72: 202–204.
- Kreen, S., M. Svensson, and K. Rumpunen. 2002. Rooting of clematis microshoots and stem cuttings in different substrates. Scientia Hort. 96:351–357.
- Loach, K. 1988. Hormone applications and adventitious root formation in cuttings—A critical review. Acta Hort. 227:126–133.
- Lym, R.G. 1992. Propagation of *Euphorbia esula* for leafy spurge biocontrol agents. Weed Sci. 40:326–332.
- McLaughlin, J. and J. Garofalo. 2002. Crown-of-thorns (*Euphorbia milii*). Miami-Dade County/Univ Florida Coop. Ext. Serv. Fact-sheet No. 65:1–5.
- Meerow, A.W. 1994. Growth of two subtropical ornamentals using coir (coconut mesocarp pith) as a peat substitute. HortScience 29:1484–1486.
- Prasad, M. and M.J. Maher. 1993. Physical and chemical properties of fractionated peat. Acta Hort. 342:257–264.
- Rauh, W. 1979. *Euphorbia ×lomi* Rauh (*E. lophogona × milii*). Kakteen andere Sukkulente 30:257–259.
- Saranga, J. and R. Cameron. 2007. Adventitious root formation in *Anacardium occidentale* L. in response to phytohormones and removal of roots. Scientia Hort. 111:164–172.
- Smoley, R. 2000. Giant-flowered *Euphorbia milii* hybrids. Cactus Succulent J. 72:198–201.
- Sonneveld, C., J. Van Den Ende, and P.A. Dijk. 1974. Analysis of growing media by means of a 1:1.5 volume extract. Comm. In Soil Sci. Plant Analysis 5:183–202.
- Stamps, R.H. and M.R. Evans. 1999. Growth of *Dracaena marginata* and *Spathiphyllum 'Petite'* in sphagnum peat and coir dust-based growing media. J. Environ. Hort. 17:49–52.
- Verdonck, O., D. De Vleeschauwer, and R. Penninck. 1983. Cocofibre dust, a new growing medium for plants in the tropics. Acta Hort. 133:215–220.
- Wever, G. 1995. Physical analysis of peat and peat-based growing media. Acta Hort. 401:561–568.