the belief of the presence of a toxin in the olive.

H. helix plants showed the best quality in the milled carob 1:1 and the milled carob 3:1 mixes, the organic matter component of these mixes had the highest proportion of particles in the 1- and 2-mm size categories (Table 4). Following in quality were plants in the peatmoss 3:1, chopped carob 1:1, and chopped carob 3:1. The phase distribution of the mixes did not relate to the quality of the *H. helix* plants growing in them; however, plants in the mixes producing the highest visual quality rating generally had the most leaves, the most leaf area per plant, and were the most compact. *H. helix* plants were not affected by the suspected olive toxin as severely as the *P. cadierii* or *N. exaltata* and, although their quality was low, no defoliation or severe yellowing was observed. Also, their root systems were not as restricted as those of the other species.

Carob pumace can replace sphagnum peat in potting mixes, provided that it is ground to an appropriate particle size. The finely milled carob pumace performed well in all the species tested and outperformed the chopped carob on *H. helix.* This response suggests the choice of milled carob pumace as the replacement in a general potting mix. Olive pumace did not perform well, apparently due to the presence of a toxin. Additional studies should be undertaken to ascertain whether some simple treatment, such as leaching, could be used to remove the toxin and render the olive usable. Other possible uses for the olive pumace, perhaps as a weed-controlling mulch, also should be investigated.

Literature Cited

1. Arent, G.L. 1984. Down to earth differences. Florists' Rev. Vol. 175, 4533:32–38.
2. Baker, K.F. (ed.). 1957. The UC system for producing healthy container grown plants. Calif. Agr. Expt. Sta. Man. 23.
3. Bilderback, T.E., W.C. Tonteno, and D.R. Johnson. 1982. Physical properties of media composed of peanut hulls, pine bark, and peatmoss and their effects on azalea growth. J. Amer. Soc. Hort. Sci. 107:522–525.
4. Black, C.A. (ed.). 1976. Methods of soil chemical analysis. Agron. Ser. 9.
5. Bunt, A.C. 1974. Some physical and chemical characteristics of loamless pot-plant substrates and their relation to plant growth. Acta Hort. 37:1954–1965.
6. Bunt, A.C. and P. Adams. 1966. Some critical comparisons of peat-sand and loam-based composts, with special reference to the interpretation of physical and chemical analysis. Plant & Soil 26:213–221.
7. De Boodt, M. and O. Verdonck. 1972. The physical properties of substrates in horticulture. Acta Hort. 26:37–44.
8. Fonteno, W.C., D.K. Cassel, and R.A. Larson. 1981. Physical properties of three container media and their effect on poinsettia growth. J. Amer. Soc. Hort. Sci. 106:736–741.
9. Gartner, J.B., S.M. Still, and J.E. Klett. 1973. The use of hardwood bark as a growth medium. Intl. Plant Prop. Soc. Proc. 23:222–231.
10. Geraldson, C.M. 1957. Soil soluble salts-determination of and association with plant growth. Proc. Fla. State Hort. Soc. 70:121–126.
11. Henney, B.K. 1979. Production of six foliage crops in spent mushroom-compost potting mixes. Proc. Fla. State Hort. Soc. 92:330–332.
12. Joiner, J.N. (ed.). 1981. Foliage plant production. Prentice-Hall Englewood Cliffs, N.J.
13. Paul, J.L. and C.I. Lee. 1976. Relation between growth of chrysanthemums and aeration of various container media. J. Amer. Soc. Hort. Sci. 101:500–503.
14. Pokorny, F.A. and B.K. Henny. 1984. Construction of milled pine bark and sand potting medium from component particles. I. Bulk density: a tool for predicting component volumes. J. Amer. Soc. Hort. Sci. 109:770–773.
15. Poole, R.T. and C.A. Conover. 1977. Influence of medium container size and water regime on growth of *Pellionia pulchra* N.E. Br. and *Pilea involucrata* (Sims). Urb. Proc. Fla. State Hort. Soc. 92:327–329.
16. Self, R.L., J.I. Wear, R.D. Rouse, and H.P. Orr. 1967. Potting mixtures and fertilization practices for container grown ornamental plants. Auburn Univ. Agr. Expt. Sta. Circ. 157.
17. Simpson, A. 1980. Alternative composts. Nurseryman and Garden Centre. 168, no. 30, p. 26.
18. Simpson, A. 1980. Alternative composts: Part 2: Nurseryman and Garden Centre. 168, no. 35, p. 29.
19. Tadashi, H. and R.T. Poole. 1978. A media and fertilizer study in anthurium. J. Amer. Soc. Hort. Sci. 103:98–100.
20. Warncke, D.D. 1983. Saturated medium extract test procedure for greenhouse growth media. In: Joint symposium for the floriculture, nursery crops and mineral nutrition working groups. Amer. Soc. Hort. Sci. 80th Annu. Mtg. McAllen, Texas. 18 Oct. 1983. ASHS. Alexandria, Va.
21. White, J.W. 1966. Criteria for selection of growing media for greenhouse crops. Florist's Rev. Vol. 155, 4009:28–39, 73–75.

HortScience 23(2):336–337. 1988.

Temperature Affects Seed Germination of Four Florida Palm Species

William J. Carpenter[1]

Ornamental Horticulture Department, IFAS, University of Florida, Gainesville, FL 32611

Additional index words. propagation Everglades Palm, Key Palm, Silver Thatch Palm, Scrub palmetto palm, *Acoelorraphe wrightii, Coccothrinax argentata, Sabal etonia, Thrinax morrisii*

Abstract. **Temperature ranges for seed germination were determined for palm species *Acoelorraphe wrightii* (Griseb. & H. Wendl.) H. Wendle ex. Becc., *Coccothrinax argentata* (Jacq) L. H. Bailey, *Sabal etonia* Swingle ex Nash, and *Thrinax morrisii* H. Wendl. Total germination was highest with fewest days to 50% of final germination at 35°C. Temperatures 5° to 10° above or below 35° frequently caused delayed, irregular, and reduced total germination. Temperatures exceeding 10° from 35° generally were inadequate for germination.**

Many native palms frequently are used in landscapes and, until recently, have been moved from natural to urban locations for this purpose. Increased urbanization has caused several of Florida's native palms to be included in the list of endangered indigenous plants (9). Recent legislation protecting palm habitats has created interest in nursery propagation by seed.

Palm species used in this study, *Acoelorraphe wrightii, Coccothrinax argentata, Sabal etonia*, and *Thrinax morrisii*, are native to central and southern Florida. Limited research has been conducted using these genera. Stratification of *S. etonia* seeds for 30 days at 4°C in moist sand has been reported to increase the rate of germination at 30°, permitting 72% germination by 82 days (7). Research with other palm species indicate aqueous seed soaking for 24 to 72 hr prior to propagation shortens slightly the days required for germination (5, 6). Failure to remove the fleshy pericarp from seed delays and causes irregular germination (8). Maintaining relatively high germination medium temperatures from 25° to 35° promoted germination of *Sabal palmetto* (Walt.) Lodd, *S. minor* (Jacq.) Pers., and *Coccothrinax crinita* Becc. (4, 5). The objective of this work was to determine the temperature requirements for germinating seeds of four native palms of Florida.

Seeds of *C. argentata* and *S. etonia* were

Received for publication 3 Apr. 1987. Florida Agricultural Experiment Station's Journal Series no. 8028. 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.

[1]Professor.

Table 1. Effect of temperature on total seed germination percent and days required to 50% of final germination.

Temp (°C)	Germination	
	Total percent	Days to 50%
	Coccothrinax argentata	
25	16 ± 2.5[z]	47 ± 3.1
30	61 ± 2.7	18 ± 3.8
35	89 ± 3.4	17 ± 4.6
40	19 ± 5.4	39 ± 3.3
	Acoelorraphe wrightii	
25	0	---
30	11 ± 3.4	81 ± 6.9
35	100 ± 0.0	43 ± 2.9
40	93 ± 6.2	38 ± 1.8
	Sabal etonia	
25	93 ± 6.1	31 ± 4.2
30	97 ± 2.2	13 ± 2.9
35	98 ± 1.9	21 ± 4.1
40	28 ± 5.0	72 ± 3.3
	Thrinax morrissi	
25	0	---
30	28 ± 3.5	54 ± 2.9
35	71 ± 2.2	52 ± 3.7
40	36 ± 4.9	74 ± 5.3

[z] ± SE of the means of four replications.

collected from an established planting, and *A. wrightii* and *T. morrisii* were purchased from a local seed wholesaler. The fleshy pericarp was immediately removed from collected seeds. Seeds were soaked in deionized water for 24 hr, surface-dried, and dusted with 3a,4,7,7a-tetrahydro-2-[(trichloromethyl)thio]-1*H*-isoindole-1,3(2*H*)-dione (captan) before planting in a moist Canadian peatmoss medium in 10-cm petri dishes. One hundred seeds of each palm species (four replications of 25 seeds) were placed in incubators at constant 25°, 30°, 35°, and 40°C. Germination counts per petri dish were recorded weekly. The cumulative germination percentage and time required for 50% of final germination were calculated. The experiment was a single factor design using SE to report variability around treatment means.

Acoelorraphe wrightii seed had 100% germination at 35°C and 93% at 40°, with 50% of final germination percentage achieved after 43 and 38 days, respectively (Table 1). Germination during the first 7 weeks was slightly increased at 40°, but, by week 11, the 35° treatment had 100% germination. No visual differences in seedling appearance or vigor were observed between 35° and 40° treatments. No germination occurred at 25° during 23 weeks, although seeds and embryos viewed with a microscope appeared normal. Poor and erratic germination occurred at 30° (11%), with 81 days required for 50% of final germination percentage. Nongerminated seed at 30° appeared normal. At the termination of the study, nongerminated seeds from 25° and 30° treatments were placed in a 35° incubator. Within 4 weeks, 100% of seed formerly at 25° and 92% previously at 30° germinated.

Coccothrinax argentata seed germinated significantly earlier and with highest percentages at constant 35°C (Table 1) relative to other temperatures. Seventy-one percent of seed germinated in 3 weeks, and 50% of final germination percentage was achieved in 17 days (Table 1). Total germination was lower at 30° (61%) than 35° (89%), but time required for 50% of final germination was similar. Total germination percentages at 25° and 40° (16% and 19%, respectively) were significantly below the 35° and 30° treatments, and erratic germination increased the days for 50% of final germination to 47 and 39. At the conclusion of the 23-week study, the nongerminated seeds from 25° and 40° treatments appeared normal and were transferred to a 35° incubator. Within 4 weeks, 82% and 56% germination occurred from seed previously unable to germinate at 25° and 40°.

Sabal etonia final germination percentages were not different among 25°, 30°, and 35°C treatments, but initial germination rate was slower at 25° during the first 9 weeks. Days to achieve 50% of final germination ranged from 13 for 30° to 31 for 25° (Table 1). These results conflict with Schopmeyer's (7) findings that *S. etonia* seeds require stratification for 30 days in moist sand at 4° to satisfy dormancy prior to germination at 30°. A temperature of 40° caused delayed, irregular, and significantly reduced germination of *S. etonia*. At 40°, no seed germinated during the first 5 weeks followed by low irregular germination for the remaining 18 weeks, requiring 72 days to achieve 50% of final germination. *S. etonia* seed remained viable, but irregular germination probably would have continued at 40°.

Thrinax morrisii seed required 5 weeks to begin germination. Maximum germination of 71% occurred at 35°C and required 52 days to achieve 50% of final germination. Germination levels were reduced significantly to 28% and 36% at 30° and 40°, with days to 50% of final germination 54 and 74, respectively (Table 1). No germination was recorded at 25° during the study, although no deterioration of seed or embryo was visible. Seed from 25° treatment was transferred to 35° after the study's conclusion and 41% germinated within 4 weeks.

A subsequent study was conducted to determine more accurately the optimum temperature range for the germination of each palm species. One hundred seeds of each palm, four replications of 25 seeds, were planted as described previously and germinated in incubators at constant 24°, 27°, 30°, 33°, 36°, and 39°C. Germination counts were made during a 15-week period. The optimum range for each palm species included those temperatures permitting total germination within 10% of the maximum found. The temperature ranges for optimal germination found were: *C. argentata*, 33° to 36°; *A. wrightii*, 33° to 39°; *S. etonia*, 24° to 36°; and *T. morrisii*, 33° to 36°.

Previous research on palm seed has shown maximum germination depends on collecting seeds from fruit of proper maturity (2, 4), sowing within several months after harvest (5), and maintaining warm temperatures (2–4). The overall temperature range promoting optimum germination in this study was 24° to 40°C, with most palm species having a rather limited specific range. Palm seed receiving temperatures in the optimum range had a definite and distinct period of high germination and a reduced number of days to 50% of final germination. Seeds germinated 3° to 5° above or below optimum ranges had low germination during the normal high germination period, erratic germination over a long period, and significantly reduced total germination. In this investigation, irregular germination began when total germination declined below 20% and caused a substantial increase in the number of days to 50% of final germination (Table 1).

Loomis (5) and Basu (1) compiled tables summarizing the number of days palm species require for germination. Both reported ≈25% of palm species require 100 to 317 days for germination, with most having low total germination. My results show some palm species have rather limited optimum temperature ranges for seed germination, and temperatures above and below the optimum level contribute to long periods of irregular germination and low total germination percentages.

Literature Cited

1. Basu, S.K. and D.P. Mukhernice. 1972. Studies on the germination of palm seeds. Principes 16:136–137.
2. Broschat, T.K. and H. Donselman. 1986. Factors affecting storage and germination of *Chrysalidocarpus lutescens* seeds. J. Amer. Soc. Hort. Sci. 111:872–876.
3. Brown, K.E. 1976. Ecological studies of the cabbage palm, *Sabal palmetto*: III. Seed germination and seedling establishment. Principes 20:98–115.
4. Caulfield, H.W. 1976. Pointers for successful germination of palm seed. Intl. Plant Prop. Soc. Proc. 26:402–405.
5. Loomis, H.F. 1958. The preparation and germination of palm seeds. Principes 2:98–102.
6. Nagao, M.A. and W.S. Sakai. 1979. Effect of growth regulators on seed germination of *Archontophoenix alexandrae*. HortScience 14:182–183.
7. Schopmeyer, C.S. 1974. Seeds of woody plants in the United States. For. Ser. USDA. Agr. Hdbk. 450. p. 883
8. Sento, T. 1976. Studies on the germination of palm seeds. Memoirs of the College of Agr., Ehime Univ. 21:1–78.
9. Ward, D.B. 1978. Plants, p. 218. In: C.H. Pritchard (ed.). Rare and endangered biota of Florida. Vol. 5. University Presses Florida, Gainesville.