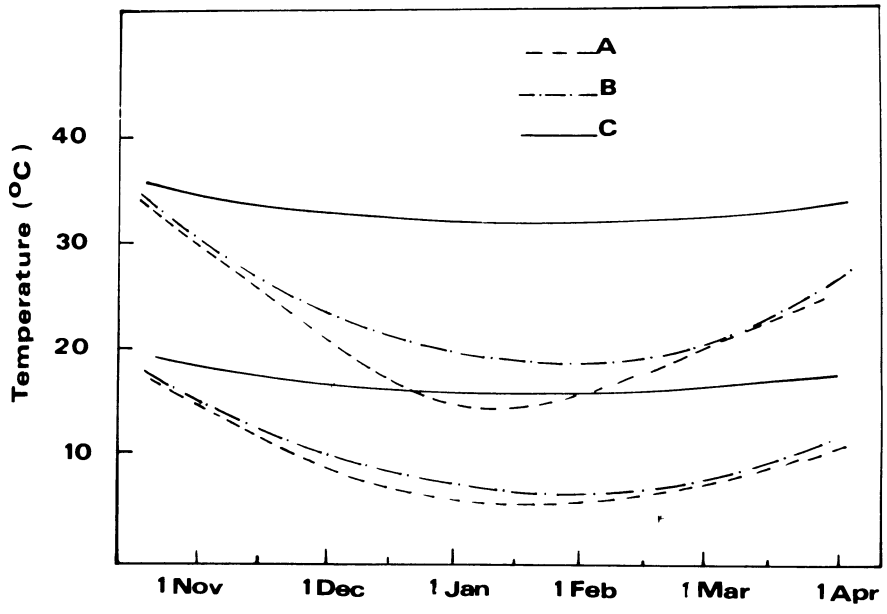

Fig. 3. The average minimum and maximum temperatures (ranges) existing at different dates in the 3 different structures in which *Anigozanthos manglesii* was grown: screenhouse (A); unheated greenhouse (B); heated greenhouse (C).

minal meristems differentiated flowers, and plant resources were directed to flower production.

Literature Cited

1. Dison, B. and S.D. Hopper. 1979. Growing kangaroo paws and related species. J. Soc. Growing Australian Plants 10:199.
2. Hagiladi, A. and J. Ben-Jaacov. 1978. Anigozanthos, 'Kangaroo Paw' (in Hebrew). Hammamot u'Prachim 8:81–83.
3. Hopper, S.D. 1977. The structure and dynamics of a hybrid population of *Anigozanthos Manglesii* Don and *A. humilis* Lindl. (*Haemodoraceae*). Austral. J. Bot. 25:413–422.
4. Hopper, S.D. 1977. The reproduction capacity of *Anigozanthos Manglesii* Don and *A. humilis* Lindl. and their hybrids in a wild population. Austral. J. Bot. 25:423–426.
5. Oliver, K.R. 1971. Kangaroo paw. J. Soc. Growing Australian Plants 6:88.
6. Van der Krogt, M.Th. 1978. *Anigozanthos*. Invloed van de daglengte op de bloemaanleg van *Anigozanthos*. Bloemisterij onderzoek in Nederland over 1979:28–29. Annu. Res. Rpt. Aalsmeer Res. Sta., The Netherlands.
7. Watkins, P.A. 1981. Cultivation of kangaroo paws. Farm Note 89/8., Western Australian Dept. of Agr., Perth Agdex 280/20.

HortScience 18(3):371–372. 1983.

Effect of H_2SO_4 and GA_3 on Seed Germination of *Zamia furfuracea*

B. Dehgan[1] and B. Schutzman[2]

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

Additional index words. *Cycas* spp., *Zamia* spp., dormancy, scarification

Abstract. **Seeds of *Zamia furfuracea* Ait. (cardboard plant) were treated following removal of the sarcotesta (fleshy seed coat) with concentrated H_2SO_4 and 1000 ppm GA_3 in a 4 × 4 factorial combination. The highest total germination of 82.2% in an average time of 74.5 days (germination value = 0.070) was achieved when seeds were exposed to H_2SO_4 for 15 minutes. Average number of days to germination was reduced to 37.7 when 30 minutes of H_2SO_4 treatment was followed by 24-hour GA_3 soak without significantly affecting percent germination (germination value = 0.103). Interactions of H_2SO_4 and GA_3 are explained by the effect of H_2SO_4 on sclerotesta (stony seed coat) thickness and the effect of GA_3 on the accelerated development of an immature embryo.**

Zamia furfuracea Ait., Zamiaceae, is much in demand for subtropical landscapes. It is also one of the most attractive and adaptable of foliage plants for indoor use where there is sufficient light, a fact which is true for other *Zamia* spp. However, slow and erratic seed germination and long production time lead to prohibitive market prices. Smith (9) reported 13% germination of *Z. furfuracea* in 9 weeks and 73% in 25 weeks under laboratory conditions, when both chalazal and micropylar ends of the seeds were cut, while no germination occurred in untreated controls. In greenhouse trials, 72% of the seeds germinated in 28 weeks, when the chalazal end was cut and the outer fleshy coat (sarcotesta) was removed. It is noteworthy that no germination occurred in treated seeds for the first 20 weeks, and untreated seeds had not germinated after 28 weeks. The objective of the present research was to improve the speed and percent germination by rapid scarification of the sclerotesta (stony seed coat) with H_2SO_4 and to accelerate the development of the embryo by the application of GA_3.

Seeds of *Z. furfuracea* were collected from cultivated plants in Miami, Fla. The sarcotesta was removed using a method described by Dehgan & Johnson (3). The seeds were divided subsequently into lots of 90 each in a 4 × 4 factorial experiment with treatments of concentrated (18 M) H_2SO_4 and 1000 ppm GA_3. The H_2SO_4 treatments included a control, 15, 30, and 60 min soak followed by water rinse. The GA_3 treatments were a control, 24, 48, and 72 hr soak prior to planting on the surface of a medium consisting of 1 sand (0.85 mm) : 1 vermiculite. The seeds were planted 15 per container for each of 6 replications per treatment and placed randomly under 30-min-interval intermittent mist. Number of germinated seeds were determined daily, based upon appearance of the coleorhiza, from which the radicle emerges. A Manostat caliper was used to measure the stony seed coat (sclerotesta) thickness at the micropylar end in randomly selected fresh seeds. Germination value (GV), which combines speed and total germination, was calculated using Czabator's (2) method. These were fitted to a full quadratic model with multiple linear regression (1,8). A 3-dimensional plot of the response surface is presented in Fig. 1.

Highest germination (82.2%) occurred with 15 min of H_2SO_4 treatment alone in an average of 74.5 days (GV = 0.070). This time was reduced to 52.7 days when the 15 min H_2SO_4 treatment was followed by 24-hr GA_3 soak without significantly affecting germination (68.9%, GV = 0.073). When seeds were treated with 30-min H_2SO_4 and 24-hr GA_3, however, average days to germination decreased significantly to 37.7 (GV = 0.10).

Received for publication August 20, 1982. Florida Agricultural Experiment Stations Journal No. 4041. We thank John Penkacik for technical assistance and Dewayne Ingram for his suggestions on statistical analysis. DeArmand Hull and the Fairchild Tropical Garden kindly provided the seeds. 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]Associate Professor.
[2]Graduate Student.

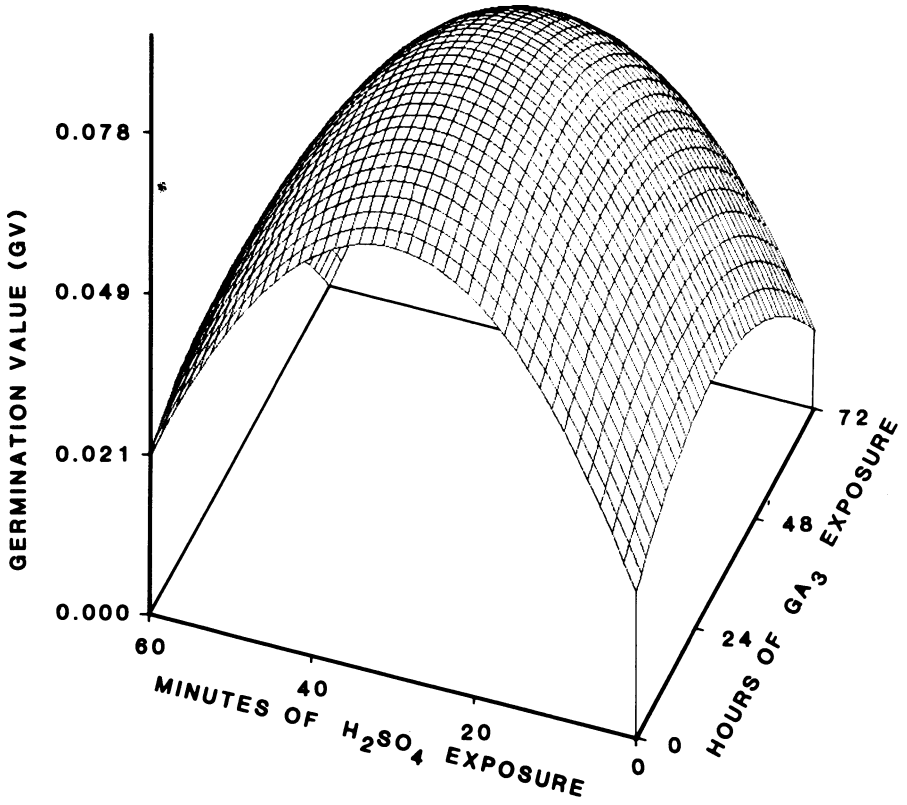

Fig. 1. Three-dimensional plot of response surface model showing effects of H_2SO_4 and GA_3 interactions on germination of *Z. furfuracea* seeds.

Seeds treated with 15- or 30-min H_2SO_4 followed by 48-hr GA_3 soak were not significantly different in speed or total germination from those treated with 24-hr GA_3 soak. Speed of germination was affected significantly by GA_3 without prior H_2SO_4 treatment only at 48 and 72 hr; this was not as effective as combined H_2SO_4 and GA_3 treatments. When seeds were exposed to H_2SO_4, average days to germination were consistently lower with subsequent GA_3 treatment than without it, although percent germination was reduced due to injury (and eventual decay) at the 60-min H_2SO_4 exposures. Least average number of days to germination (30 days) was achieved using 60-min H_2SO_4 and 72-hr GA_3, but percent germination (10%) was smallest of all treatments (GV = 0.004). Untreated control seeds had a 38.8% germination in an average of 96.2 days (GV = 0.015).

These results would suggest a hard seed-coat dormancy concomitant with an immature embryo. Thickness of the seed coat at the micropylar end ranged from 0.3 to 0.8 mm with a mean of 0.55 mm. Possibly a correlation exists between seed-coat thickness and germination response to varying H_2SO_4 exposure times. Increasing H_2SO_4 exposure times may have improved germination of the seeds with thicker micropylar ends, while seeds with thinner micropylar ends, which constitute the majority, were affected detrimentally. The existence of immature embryos was demonstrated in *Z. floridana* by Witte (10), who observed improved germination following storage of seeds at 5°C for one year. Dehgan and Johnson (3), using GA_3, also showed improved germination in *Z. floridana* seeds. In fact, immature embryo in cycads is not unique to *Zamia* spp. Seeds of *Cycas rumphii* Miq. (4) and other *Cycas* spp. (Dehgan and Nance, unpublished data) contained morphologically immature embryos 6 months after abscission. *Encephalartos cycadifolius* (Jacq.) Lehm. was reported by Dyer (5) to have germinated 100% after 7 months of storage. Giddy (6) suggested storing the seeds of cycads for 6 months before planting. However, other taxa, such as *Z. fischeri* Miq. and *Z. loddigesii* Miq., do not show any form of dormancy, and germinate readily if allowed to mature fully, which is indicated by the breakup of the strobilus (personal observation). In taxa where embryo is immature for a period of time after abscission, GA_3 may accelerate embryo development when allowed to penetrate the seed coat (7).

Based on the trend indicated by the response surface (Fig. 1), optimal germination value occurs at the middle ranges of both GA_3 and H_2SO_4 exposures. This agrees with experimental results. We recommend 25–30 min of H_2SO_4 followed by a 24-hr soak in GA_3. A nurseryman interested in either speed or total germination would have to evaluate the tradeoff between the two. Obtaining a greater total increases germination time, and conversely, faster germination is concomitant with lower percentage.

Literature Cited

1. Anonymous. 1982. SAS users guide: statistics. ASA Institute, Cary, N.C.
2. Czabator, F.J. 1962. Germination value: an index combining speed and completeness of pine seed germination. For. Sci. 8:386–396.
3. Dehgan, B. and C.R. Johnson. 1983. Improved seed germination of *Zamia floridana (sensu lato)* with H_2SO_4 and GA_3. Scientia Hort. 9:(In Press).
4. De Silva, B.L.T. and M.S. Tambiah. 1952. A contribution to the life history of *Cycas rumphii* Miq. Ceylon J. Sci. 12:223–249.
5. Dyer, R.A. 1965. The cycads of Southern Africa. Bothalia 8:405–515.
6. Giddy, C. 1974. Cycads of South Africa. Purnell, Cape Town, South Africa.
7. Hartman, H.T. and D.E. Kester. 1975. Plant propagation: principles and practices. Prentice-Hall, Englewood Cliffs, N.J.
8. Myers, R.H. 1976. Response surface methodology. Virginia Polytech. Inst. and State Univ., Blacksburg.
9. Smith, G.S. 1978. Seed scarification to speed germination of ornamental cycads (*Zamia* spp.). HortScience 13:436–438.
10. Witte, W.T. 1977. Storage and germination of zamia seed. Proc. Fla. State Hort. Soc. 90:89–91.