(Homoptera: Pseudococcidae) on bromeliads. *Proc. Fla. State Hort. Soc.* 87:516-518.
12. ———. 1974. The broad mite: New and important pest of greenhouse grown Aphelandra. *J. Econ. Entomol.* 67:791-792.
13. ———, D. E. Short, and R. W. Henley. 1975. Detect and control insects and pests on tropical foliage plants. *Florist* 9(3):72-79.
14. Hermandez-Paz, M. R. 1965. Observations on the biology of the root mealybug, *Rhizoecus americanus* (Hambleton). M.S. Thesis, Dept. of Entomology and Nematology, Univ. of Florida, Gainesville. 80 pp.
15. Hussey, N. W., W. H. Read, and J. J. Hesling. 1969. The pests of protected cultivation—The biology and control of glasshouse and mushroom pests. Am. Elsevier, New York, N.Y. 404 pp.
16. Manglitz, G. R. and E. N. Cary. 1953. Biology and control of *Brevipalpus australis*. *J. Econ. Entomol.* 46:116-119.
17. Morishita, F. S. 1954. Biology and control of *Brevipalpus inornatus* (Banks). *J. Econ. Entomol.* 47:449-456.
18. Poe, S. L. 1971. Treatment for control of a root mealybug on nursery plants. *J. Econ. Entomol.* 65:241-242.
19. Smith, F. F. 1939. Control of cyclamen and broad mites on gerbera. *USDA, Circ.* No. 516. 14 pp.
20. Snetsinger, R. 1966. Biology and control of a root-feeding mealybug on *Saintpaulia*. *J. Econ. Entomol.* 59:1077-1078.

Proc. Fla. State Hort. Soc. 90:89-91. 1977.

STORAGE AND GERMINATION OF ZAMIA SEED

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Abstract. **The Coontie or Zamia, whether** Zamia integrifolia **Ait. or** Z. floridana **A. DC., is a low maintenance dwarf evergreen well suited for many landscape situations in a wide variety of soils and exposures. Better seed propagation methods are needed. In 1976, seed was collected and cleaned, then either germinated or stored one year at 5° C. With fresh seed planted in 30°C. media, germination was about equal for cracked and uncracked seed (60 to 65%), but only 43% for shelled seed. Depth of planting had little effect. After storage, cracked seed germinated better than uncracked (77% vs. 38%) and mild bottom heat increased germination of uncracked seed (49% vs. 27%) but not cracked seed. Heavier seed (2 gm.) germinated better than lighter seed (1.6 gm.)**

Consider the coontie. Besides being a desirable low native evergreen for landscaping, it is of interest in taxonomy, history, toxicology, plant geography and anthropology. Studies on seed germination and culture of coontie could broaden its availability and use in Florida gardens and help to conserve wild populations from depredation by collectors.

Taxonomically, coontie is a modern cycad, one of the more primitive gymnosperms. Cycads may be thought of as living fossils from the Mesozoic era and are considered more nearly allied to ferns than any seed plant (6). About 30 *Zamia* species occur in Mexico, Latin, and South America and in the Caribbean. Plant geographers speculate on how populations of the Florida species originated since the peninsula was submerged during the Mesozoic. Anthropologists favor the introduction of seeds or plants into Florida more recently by aborigines from the Caribbean for use as food plants (9).

A recent revision of *Cycadaceae* is reflected in Hortus III(2). *Zamia* is now treated as being in *Zamiaceae* along with seven other genera, leaving *Cycas* and *Stangeria* in monogeneric families. The two species referred to in this paper as coontie or zamia, *Z. floridana* and *Z. integrifolia*, are difficult to distinguish on the basis of vegetative characters. Supposedly the former has a short or underground tuber-like trunk and pinnae up to 15 x 2 cm. with revolute margins while the latter has a trunk to 50 cm. tall and angled leaf stalks.

Historically, zamia was a food plant for early settlers and Seminole Indians. The raw tuberous roots are rich in starch, but poisonous. By pounding the roots to a pulp, screening out fibers, repeatedly rinsing to leach out the toxic, but water soluble, glycosides, and drying the remainder, a starchy edible residue was produced. Known as Florida Arrowroot by the settlers, it was made into "sofkee" stew by the Seminoles (3). About the turn of the century, production actually became a commercial enterprise (7).

Horticulturally, no native plant is better for foundation plantings of rambling contemporary homes (10). Zamia can also be used as a facing plant in front of shrub borders or plantings, and as a tall ground cover in areas where pedestrian traffic is not desired. As an accent plant in a container or for a patio planting, it attracts attention with its fountain of leathery dark green leaves, reminiscent of a sturdy fern or dwarf palm. Plants are dioecious and the felty brown cones may be an interesting feature, especially in pistillate plants when cones split open to reveal bright orange red fruit. Zamia tolerates a wide range of soils providing they are well drained, and though normally indigenous to shady sites it does almost as well in full sun.

Many Zamia plants used to be collected from the wild and transplanted. Bush (3) stated young plants growing in sand were easily taken up and moved, but Watkins and Sheehan (10) wrote that Zamia is most difficult to transplant because of the far reaching tap root. Depletion of natural stands doubtless led to protection under Florida's Plant Protection Law, which includes all Zamia species in the restricted plant list (1). Restricted plants may be dug up with the owner's permission but they cannot be sold. Nurserymen who propagate restricted plants from seed or by vegetative propagation are permitted to sell commercially grown plants. Currently, Zamia plants are sparsely available in the trade. Vegetative propagation by division of old clumps or by root cuttings is possible (4) just as in *Cycas* but this method is slow and unsuited to production of large numbers of plants.

Seed propagation may be more promising. Formerly germination was reported to be slow and mortality high (10) but Smith (8) recently demonstrated that cutting through the distal end of the seed coat resulted in 84% germination in three months. However, the cutting method is tedious and care must be taken not in injure the embryo. No information is available on how long seed may be stored without losing viability, or the effect of temperature on germination. In general, seed of many

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tropical species is viable for only a short time, and warmer temperatures can affect both germination percentage as well as germination rate (5).

The purposes of these experiments were to develop a simpler method of scarification and to investigate whether depth and position of planting affected Zamia seed germination, whether adequate germination could be obtained after a year's storage, and whether bottom heat or fungicidal seed treatment would be beneficial.

Methods and Materials

Fruit was collected from dehiscing cones of plantings in Gainesville during January, 1976 and kept in a greenhouse for a month to allow the pulpy flesh to partially air dry. Pulp was removed manually by cutting or scraping. Seeds were further washed, scrubbed and air dried at room temperature until March 12. One group of seeds was used for Experiment 1, and the remainder were stored at 5° C. in an open container for one year.

Experiment 1. Seeds were either left intact, the shell cracked, or the shell removed. The first method investigated for cracking the seed coat was to apply pressure on the sides of the seed with a common pliers, at the same time inserting a sharp knife point below the pointed distal end of the seed. With a little practice, it was found that pressure alone would suffice and with reasonable care the endosperm was not crushed.

For each treatment (see *Table 1*), seventy seeds were placed in peat-perlite-sand media, 2:1:1 v/v respectively, using perforated-bottom plastic trays 23 x 30 x 10 cm deep. Planted trays were moistened and placed on a capillary mat in a Parks seed germinator under constant fluorescent lighting. Environmental conditions were warm (30° C) and constantly moist. Data on germination were taken April 22 (6 wks), June 2 (21 wks), and August 12 (22 wks).

Table 1. Percentage germination of fresh Zamia seed after 6, 12, and 22 weeks under warm moist conditions.

Treatment			Percent Germination		
Seed Coat	Orientation of seed tip	Planting depth	6 wks	12 wks	22 wks
cracked	down	2.5 cm	17%	61%	63%
cracked	up	2.5 cm	19%	53%	53%
cracked	side	2.5 cm	31%	51%	56%
cracked	side	1.25 cm	40%	67%	67%
shelled	side	1.25 cm	40%	43%	43%
whole	side	1.25 cm	6%	63%	66%
whole	side	surface	4%	59%	64%
cracked	side	surface	—	—	70%
cracked	side	1.25 cm	—	—	70%
cracked	side	2.5 cm	—	—	50%

Experiment 2. A 2 x 2 x 2 factorial arrangement of treatments with three replications was designed to test the effects of scarification, bottom heat, and fungicide on year-old Zamia seed. Seed was removed from cold storage in May, submerged in water and floating seed discarded. Replications were blocked by seed size. A tray filled with peat-vermiculite media with forty seeds planted 2.5 cm deep was the experimental unit. Fungicide treatment was accomplished by placing a designated seed lot in a small bag with an excess of Arasan fungicide and shaking for 15 seconds to coat the seed. Planted trays were placed on a transite bench under intermittent mist of 6 sec/6 minutes for twelve hours daily. Bottom heat was provided by lead-covered heating cable. Each heated tray rested on two feet of cable (two strands spaced 15 cm apart). Data on percent germination and number of leaves produced were recorded August 15, ANOVA performed, and LSD calculated to separate means in the interactions which occurred.

Results and Discussion

Experiment 1. Table 1 shows germination percentages for each treatment after 6, 12, and 22 wks. Germination rate was greatly speeded by cracking or shelling. After 6 wks, cracked or shelled seed averaged about 30% germination compared to 5% for uncracked seed. Little germination occurred after 12 weeks in any treatment under the conditions of this experiment. Poorest total germination resulted from shelling. Most shelled seed which did not germinate was found to be decomposed. Perhaps minor injuries to the endosperm increased the probability of deterioration. Depth of planting appeared to have minimal effect on total germination, though emergence seemed faster on shallow planted seed. Seed planted on their side emerged faster than seed planted tip up or tip down. Better seedlings were produced by shallow planted seed on their side, because germination was hypogeal and deeper planted seed, or seed planted tip down, had excessively elongated leaf stalks. When seedlings are transplanted, the crown is set at about the soil surface.

Experiment 2. Germination percentages of the experimental units ranged from 10% to 90%. ANOVA on

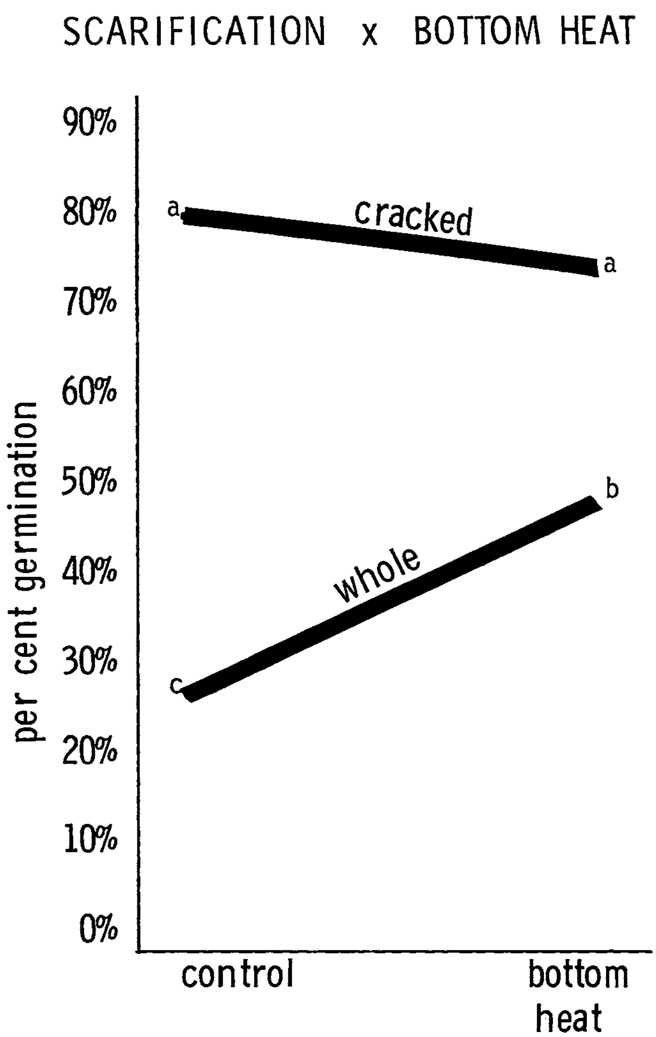

Fig. 1. Effect of scarification and bottom heat on per cent germination of year-old cold stored Zamia seeds. Points indicated by different letters indicates significance at the 5% level.

germination showed very highly significant differences between cracked and uncracked seed (77.5% *vs.* 31%), but this was examined as part of an interaction which occurred with bottom heat (*Fig. 2*). Germination of uncracked seed was significantly increased by bottom heat, but not enough to compare favorably with cracked seed. Use of a fungicide resulted in a significant reduction of germination (54% *vs.* 62%). Arasan may have been slightly phytotoxic to emerging Zamia embryos.

A significant difference between blocks indicated that seed size had an effect on germination. Seed in block #1 passed through a 1.2 cm screen, weighed 1.6 gm/seed, and attained 46% germination while seed in blocks #2 and #3 was larger, weighed 2.0 gm/seed, and attained 64% germination. The number of expanded leaves produced by each experimental unit was analyzed as an index of the rate of germination. Obviously, seedlings emerging early had the greatest number of leaves, assuming a constant rate of leaf production after emergence. Results (*Fig. 2*) followed the same pattern as germination percentages. Heavy seed produced about 1/3 more leaves than light seed, but this was due to greater total germination rather than seedling vigor, and the average number of leaves per seedling was about the same for each block. Under ambient temperature, cracked seed averaged 1.93 leaves per seedling compared with 1.08 leaves per seedling for uncracked seed, an increase of 78%. Fifty-one seedlings from cracked seed had three or more leaves while only one seedling from uncracked seed reached this stage of development in the entire experiment.

Though no direct statistical comparison can be made, one may infer that seed stored for a year germinated as well or better than fresh seed. For one similar set of conditions (cracked, 2.5 cm deep, on side, no fungicide, bottom heat), stored seed achieved 76% germination and fresh seed 56%.

In summary, these experiments confirmed that scarification is an important method for increasing both rate and percentage of germination of Zamia seed. Fungicidal seed treatment was not beneficial. Bottom heat improved germination of whole seed but not scarified seed. Depth of planting was relatively unimportant in these experiments but conditions were moist. Seeds planted on the surface or covered thinly as previously advised (3) may have led to poor stands due to periods of dessication, hence the reputation of Zamia as a hard to germinate seed. Whole seed in these experiments germinated fairly well compared to those of Smith (8), which were planted on the surface in a warm greenhouse and not under mist. The discrepancy may also have a statistical explanation as our experimental units had many more seeds, or it may be due simply to differences in seed lots.

Stored seed germinated as well or better than unstored seed and further work should be done to determine whether Zamia seed can be stored longer than one year without loss of viability. Cracking the seed coat with a pliers turned out to be a simple scarification method and fifteen to twenty seeds per minute could be handled with practice. Traditional methods of scarification with acid or abrasives would tend to injure the embryo which lies adjacent to the distal tip of the seed.

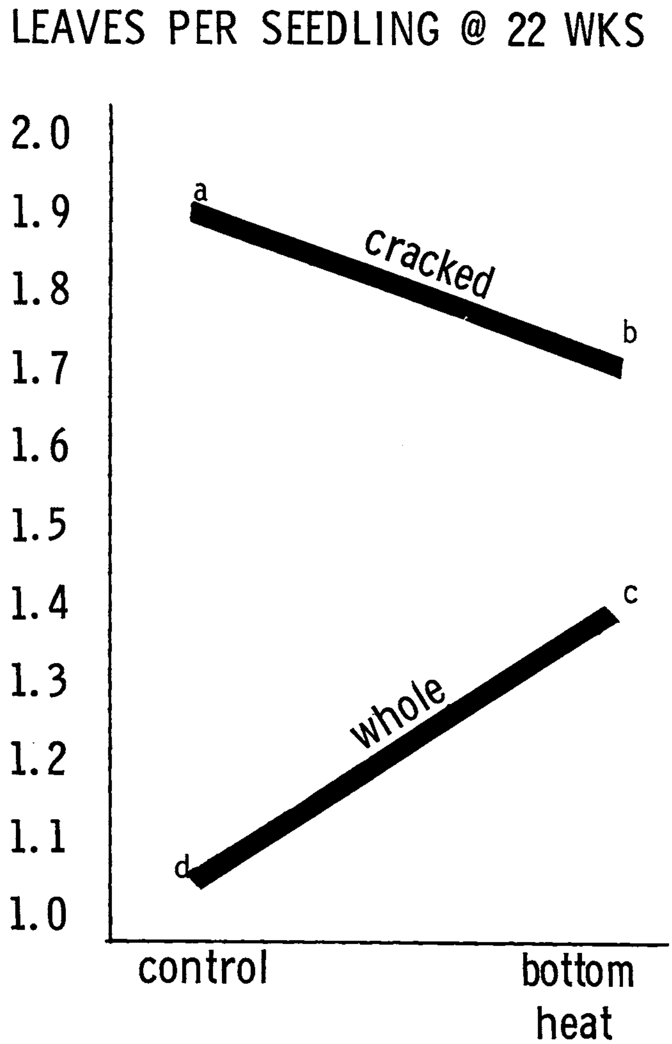

Fig. 2. Effect of scarification and bottom heat on number of leaves per seedling after 22 weeks germination of year-old cold stored Zamia seed. Points indicated by different letters indicates significance at the 5% level.

Literature Cited

1. Anonymous. . Florida Statutes, Chapter 65-426, Senate Bill No. 233 amending Section 865.06.
2. Bailey, L. H. and E. Z. Bailey. 1976. *Hortus III. A Concise Dictionary of Plants Cultivated in the United States and Canada.* Revised and expanded by the staff of the Liberty Hyde Bailey Hortorium.
3. Bush, C. S. and J. F. Morton. 1969. Native trees and plants for Florida landscaping. Bul. 193, Fla. Dept. of Agric.
4. Coulter, J. M. and M. A. Chrysler. 1904. Regeneration in Zamia. *Bot. Gaz.* 38:452-459.
5. Hartmann, H. T. and D. E. Kester. 1968. *Plant Propagation, Principles and Practices.* 2nd Ed. Prentice Hall, Inc.
6. Hewett, D. E. 1964. Some factors affecting the distribution of Zamia in Florida. *M.S. thesis, Univ. of Fla.*
7. Neal, C. M. 1965. *In Gardens of Hawaii.* Spec. Pub. 50 of Bishop Museum Press.
8. Smith, G. S. 1974. Seed treatments to speed germination of *Zamia integrifolia* Ait. *Proc. Fla. State Hort. Soc.* 87:560-562.
9. Smith, H. G. 1951. The ethnological and archaeological significance of *Zamia. Amer. Anthropologist* 53:238-242.
10. Watkins, J. V. and T. J. Sheehan. 1975. *Florida Landscape Plants, Native and Exotic.* Fla. Univ. Press.