palm from North Borneo. There was an interval of five weeks between the date of collection and the date of receipt. Before sowing, some of the embryos were examined. They had already begun to shrink. The actual time of germination with the addition of bottom heat was six months. At one month intervals, some of the embryos were again checked. By the fourth month, they appeared to be well proportioned and filled the cavity again.

Although viable, seeds of most palms will not germinate during the winter months in sub-tropical areas unless they are placed in a glasshouse or other means of applying warmth are used. They will, however, remain viable until spring if the germinating medium is kept slightly moist. Too much moisture will cause seeds to rot.

It is hoped that the information given here will be of some use to anyone attempting to grow palms from seed. The importance of the short period of viability should be impressed on the collector and shipper by those persons who seek foreign sources of seed.

The Preparation and Germination Of Palm Seeds*

H. F. Loomis

Among the several thousands of palm species only the coconut, date and African oil palm have great commercial importance. Several other species are of minor value, while the majority of palms are planted as ornamentals or for their botanical interest. Little has been written on the preparation and germination of palm seeds in general; most references relate to those few species cultivated for their commercial products. While much can be learned from these papers it is the vast group of non-commercial palms that holds most of our interest.

Naturally, the ideal palm seed for planting is that from fully ripe fruits, planted within several days of harvesting under conditions that will induce rapid germination. However, these conditions are not always attainable, for the seeds of many species have to be shipped great distances, and the care they receive before arrival at their destination has much to do with the results obtained after planting.

The three factors most injurious to palm seeds up to the time they are planted are (1) extreme drying out, causing the embryos to shrivel and reducing viability in proportion; (2) the formation of surface molds, many of which seem able to penetrate readily to the embryos and affect their viability; and (3) excessive age. Under the best conditions most palm seeds are short-lived, several months at most, and seeds obtained from individuals or institutions who make a practice of drawing them from stored bulk collections should be under suspicion. Cutting through the seed coat and examining the embryos to see if they are greatly shrunken or discolored from the white to creamy-white seen in viable seeds may make it possible to avoid the planting and long care of worthless samples.

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The first step in preparing fresh palm seeds for planting or shipping should be the removal of the moist flesh that covers most of them. They should then be thoroughly washed and allowed a day or two of air drying, after which they are ready for planting or mailing. For the latter, airmailing is desirable if any great distance is involved. For this the seed should be placed in tightly closed plastic bags mixed with half to an equal mass of peat-moss or sphagnum moistened enough that the seed cannot dry out further but not sufficiently wet to induce the start of germination. To forestall the development of mold in the bags it may be desirable to dust the seeds lightly with a small amount of one of the powdered fungicides, such as Fermate, Spergon, Zerlate or similar compounds. Seeds packed in this way should then be wrapped with enough insulation to keep out freezing temperatures on any flights expected to reach high altitudes. Planting or starting pre-planting treatment of shipped seeds cannot be done too soon after they are received.

The wide variety of conditions under which palm seeds germinate in nature is evidence that no single artificial method can be devised or recommended for sprouting the seeds of all the palms. Except where germination peculiarities are known for certain species and special treatment can be given, methods that have proved satisfactory for the majority of species usually are followed. There has been but one basic method of germination, namely, to plant the seeds in soil or other medium and keep them moist until they sprout. Many refinements of this fundamental procedure, however, have been added and followed with some consistency by palm growers. Detailing several such methods and the results obtained may guide others in planting seeds and point the way for making improvements.

At the United States Plant Introduction Station, Coconut Grove, Florida, newly received palm seeds are cleaned, if this has not already been done, and planted within 24 hours of arrival. Seed pans or large flats are lightly filled with a heat-sterilized mixture of one part rubbed peat-moss and three parts screened woods sand. This is tamped down smoothly and the seeds scattered evenly over the surface, firmed into the mixture and covered with an additional amount to a depth of a quarter to a half inch. The pans are labelled and a record of planting entered in a germination book. Planted containers are placed in a small greenhouse where the winter temperature is not allowed to fall below 40°F, but no heat is provided to keep it above this level. Summer temperatures on sunny days may go 10 to 12° above the outdoor maximum. Seed containers are watched closely and never allowed to dry out, nor are they allowed to become soggy through overwatering. Germination is recorded as occurring on the first day a leaf-shoot appears above the soil surface. Exact germination data have been kept for all palm introductions for the last 12 years and are summarized in Table 1 which shows the species planted and the number of days until germination was recorded.

It will be noted that the most rapid germination was obtained from seed of *Copernicia vespertilionum* which occurred in 14 days, while the longest period was 316 days for *Syagrus comosa*, although a different introduction of this species required but 99 days. Of equal interest were two plantings of locally harvested, fresh seed of *Coccothrinax fragrans*, one germinating in 45 days, the other requiring an unexplainable 237 days.

TABLE 1

Species name	Germination period in days
Acanthophoenix rubra	71
Areca Cathecu	79
*Astrocaryum mexicanum (Hexopetion mexicanum)**	38
Bentinckia nicobarica	75
Butia capitata	142
Chamaedorea erumpens	222
Chrysalidocarpus lutescens	31
Coccothrinax crinita	37
C. fragrans (2)**	45-237
C. Miraguama	104
C. pseudorigida	48
Cocos nucifera	119
Colpothrinax Wrightii	55
Copernicia Burretiana	37
C. Cowellii	37
C. gigas	73
C. hospita	37
C. Torreana	22
C. vespertilionum	14
Corypha umbraculifera (2)	52-108
Dictyosperma album (D. furfuraceum)	84
D. aureum	75
Drymophloeus Beguinii	26
Elaeis guineensis (3)	64-147
Erythea Pimo (Acoelorraphe Pimo)	193
Euterpe longibracteata	24
Gaussia attenuata	43
Geonoma longipetiolata	74
Hyophorbe indica	75
Jubaea chilensis (J. spectabilis)	113
Licuala amplifrons	70
L. grandis	122
Livistona cochinchinensis (L. Hoogendorpii)	31
Mauritia flexuosa	56
Maximiliana elegans	147
Metroxylon amicarum	94
Orbignya Cohune (Attalea Cohune)	67
O. phalerata	71
Phoenix reclinata	42
P. Roebelenii	39
Pritchardia Lowreyana	45
Pseudophoenix vinifera	23
Ptychoraphis augusta (2)	29-68
Raphia pedunculata	81
Rhopalostylis sapida	73
Rhyticocos amara	62
Syagrus campicola	293
S. comosa (2)	99-316
Thrinax Ekmanii	99
Veitchia Joannis	82
Wallichia caryotoides	89
Zombia antillarum	48

*Names in parentheses are synonyms under which seed was received. **Figures in parentheses indicate two or three separate plantings.

A different method of palm seed germination is that of Edwin Johnston, Vero Beach Tropical Garden, Vero Beach, Florida who began importing commercial quantities of many palm seeds from all over the world some years ago. He has consented to the inclusion of a resumé of his method here but did not have his notes available for exact germination data.

Johnston's principal departure from accepted procedures has been to plant the seed in flats of coarse moist sand placed one above the other in a small unlighted and unventilated building with an iron roof where daily temperatures were estimated as going to at least 120° F. in the summer. Exceptionally good and rapid germination of most viable seeds was obtained here. With certain

hard seeds he found that filing or scarifying had little effect but that placing the seeds in a controlled temperature water bath, maintained at 150 to 160°F, for two or three weeks hastened germination when the seeds were removed and planted in the germination house. By above practices he has sprouted up to 95 percent of such notoriously difficult seeds as *Acrocomia* and *Astrocaryum* species.

Since germination of the seeds Johnston planted occurred in the dark the seedlings had to be removed from the trays as soon as they came above the sand surface and planted in the light to allow their normal development.

Johnston has experimented with controlled heat cables either below the seeds or above the sand in which they were planted. He considers that the best results were obtained with the cables above the sand but these results were not as good as with seeds planted in his germination house. Comparing a divided shipment of doum palm seeds *(Hyphaene thebaica)* planted under heat cables and in the iron-roofed germination house, sprouting was obtained in approximately two weeks in the house but required two to three months in the cable-heated bed.

Possibly a considerable part of the success of the Johnston method may be attributed to the great daily temperature fluctuation the seeds are exposed to during the hours of sunlight and darkness. So far as is known no one has attempted to germinate palm seeds by a similar method or one with a continuously maintained temperature as high as the daily maximums reached in his germination house.

Nat J. De Leon, of Miami, Florida has been germinating palm seeds on a considerable scale for several years and in *The Palm Society Bulletin No. 5*, May 1956, reported results of using a controlled temperature cable set at 83°F. beneath four kinds of palm seeds. In slightly less than two and a half months excellent germination was obtained with two species, good germination with one and none from 10 seeds of *Corozo oleifera*, generally considered difficult to sprout. With samples of the same seed, planted at the same time at the Fairchild Tropical Garden without bottom heat, no germination was evident on the surface of the pots in the same period of time and examination of the seeds showed only one species that had broken the seed surface.

Mr. De Leon has continued his germination studies but starts by soaking all seeds in water for several days before planting them in pots containing a mixture of equal parts of peat-moss, sand, and vermiculite with the pots plunged in a bed of peat-moss above the heating cable. Germination data obtained with this method for a number of species are shown in Table 2.

While there is little duplication of species involved in the data shown in Tables 1 and 2, several related species may be compared. No material advantage appears evident for either one of the methods from which these data were drawn.

In PRINCIPES 2: 5, 1958, E. D. Kitzke has described in detail a method of germinating seeds of a number of species of *Copernicia* in water, soaking them for as much as nine months in water alone or for lesser periods after the seeds were scarified near the embryos or were treated with dilute sulphuric acid for 15 minutes. Some fresh *Copernicia* seeds germinated after only two days of soaking in water alone, that is, their em-

TABLE 2

Species name	Germination period in days	Species name	Germination period in days
Areca concinna	43	*Geonoma longipetiolata*	119
A. latiloba	27	*Latania Verschaffeltii*	32
Astrocaryum Standleyanum	148	*Licuala spinosa (L. horrida)*	31
Bactris Ottostapfeana	57	*Loxococcus rupicola*	49
Bentinckia Coddapanna	30	*Mauritia flexuosa*	126
Bismarckia nobilis	39	*Oncosperma fasciculatum*	46
Caryota Cumingii	317	*O. tigillaria*	44
Chamaedorea glaucifolia	89	*Pseudophoenix vinifera*	33
C. Schiedeana	44	*Ptychosperma angustifolium*	43
C. sp. *(C. corallina)*	95	*P. Hosinoi*	39
Chrysalidocarpus lucubensis	150	*P. Ledermannianum*	60
C. madagascariensis	145	*Raphia gracilis*	115
Clinostigma ponapensis	48	*Sabal glaucescens*	59
Copernicia glabrescens	18	*Salacca edulis*	24
Didymosperma caudatum	65	*Salacca Wallichiana*	24
Diplothemium maritimum	73	*Socratea durissima*	55
Erythea Brandegeei	44		

bryos pushed loose the seed coat covering them and began to emerge. In all his experiments as soon as this evidence of germination was seen in any immersed seeds they were removed and planted in individual pots of soil above the surface of which the first leaf sprout usually appeared within 35 days.

Kitzke suggested the application of this method to seeds of other genera of palms and De Leon has reported in PRINCIPES 2: 75 its successful use with six species of as many genera.

A paper by R. Galt, "Methods of Germinating Oil Palm Seeds," in *Journal of the West African Institute for Oil Palm Research*, 1: 76-87, 1953, describes and reviews early commercial methods of germinating seeds and describes several improved methods. These recent methods are based on maintaining a relatively high and uniform temperature (approximately 100°F.) throughout the germination period and rely on actual fire or fire-heated water pipes to do so.

Since so little factual knowledge on palm seed germination has appeared in print the foregoing brief descriptions and reviews may be of aid in helping palm growers decide on a suitable method for sprouting their seeds. The need for carefully controlled experiments on the various phases of palm seed germination is very great and publication of the results will benefit all palm growers, commercial and amateur alike.