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SEED GERMINATION, SEA WATER, AND PLANT SURVIVAL IN THE GREAT FLOOD

GEORGE F. HOWE*

Seeds from the fruits of five different species and families of flowering plants were tested for germination after prolonged periods of soaking in sea water, fresh water, and mixed water baths. Seeds from three out of these five species germinated and grew after 140 days of soaking in each of the solutions mentioned.

The effect of the Genesis Flood upon seed plant life in general is discussed. Several means of plant survival both inside and outside the ark are evaluated. On the basis of present experiments and those of Charles Darwin, it is concluded that seeds from many plants may have resisted the direct contact of flood waters and germinated vigorously after the waters subsided from the surface of the earth. Several unanswered questions and areas for further study are enumerated.

Introduction

The topics of seed dormancy, germination, and growth have challenged the minds of botanists for many years. Several thorough articles and monographs on these topics provide information about the longevity,[1] preservation,[2] and metabolism,[3] of seeds. Some of these references and certainly the paper by Ungar[4] provide information about the effect of salts in the soil water at time of germination. Boyko has investigated the use of salt water as a source for irrigation[5,6].

None of the above studies has dealt specifically with the effect of soaking during storage on the survival of seeds. Since this topic is of interest from the standpoint of experimental plant physiology and also from the vantage of seed germination after the flood recorded in Genesis, the present investigation was undertaken to determine some of the effects of previous soaking upon germination of the seeds. Charles Darwin studied this problem of soaking and floating seeds in order to determine how plants might have traveled across large stretches of ocean water.[7]

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Materials and Methods

Fresh fruits containing seeds of the five following different plants (from five different families) used in these studies were collected in weedy fields surrounding Westmont College, Santa Barbara, California in late June, 1967: *Raphanus sativus* L. (Brassicaceae or mustard family), *Rumex crispus* L. (Polygonaceae or buckwheat family), *Cirsium edule* Nutt. (Asteraceae or sunflower family), *Medicago hispida* Gaertn. (Fabaceae or legume family), and *Malva parviflora* L. (Malvaceae or hollyhock family).

All the specimens collected were dry and apparently ripe fruits from the current growing season (December through March, 1967). Fruit types involved were indehiscent silique *(Raphanus),* achenes *(Rumex* and *Cirsium),* legume *(Medicago),* and shizocarp *(Malva).* Taxonomic verification was conducted by the author, using Jepson[8] for genus and species and Porter[9] for family.

On June 24, 1967, fruits of each species were divided into four groups and treated as follows: (1) control fruits stored dry in paper sacs, (2) fruits soaked in sea water, (3) fruits soaked in sea water mixed with tap water, and (4) fruits soaked in tap water. Soaking baths were changed about every fourth day to prevent stagnation, microbial bloom, or gross changes in saline content.

Sea water for soaking was collected fresh from the Pacific Ocean about every 4 days in a 20 liter bottle, along the beaches of Santa Barbara. The city water of Montecito, California was used to supply the tap water treatment. Approximately 10 liters of fresh sea water were mixed every fourth day with 10 liters of the tap water to provide a "mixed" soaking bath for each species tested.

Fruits were floated in shallow plastic containers holding about 2 liters in the case of *Rumex,* 1 liter for *Malva* and *Medicago,* and about 4 liters for *Raphanus* and *Cirsium.* Floating and soaking of these fruits in the liquids mentioned was performed in a glasshouse. No temperature control was provided during either the soaking or germination phases of this work.

At the beginning of the experiment, fruits of all the species floated for several days, as reported also by Darwin.[10] By the end of the second week, however, nearly all fruits except those of *Cirsium* had sunken to the bottom of the liquids in the shallow storage pans, where they remained submerged throughout the rest of the soaking period. The *Cirsium* fruiting heads floated throughout the entire period of soaking.

Soaking began on June 24 and continued until November 11, 1967, a period of exactly 20 weeks or 140 days which corresponded roughly to the 150 day period in which water prevailed upon the earth during the Great Flood (see Genesis chapters 7 and 8).

At intervals of 4, 8, 12, 16, and 20 weeks after June 24, seed samples of the various plant species were removed from the several treatments and placed under conditions favorable for germination. Seeds selected for a germination study were removed from the fruit and counted before planting. Most germination tests were performed in 4-inch clay pots containing a soil mixture of sand, local clay soil, and peat moss blended in proportion of 1:2:1 respectively.

Ten seeds selected for a particular germination analysis were sown in a pattern as shown in Figure 1, to a depth of ½ inch for *Cirsium* and about ¼ inch for all other species. Soil pots were subsequently watered with tap water during the germination tests.

Since the soil was not sterilized, there remained the possibility of volunteer seed growth within the experimental pots, since the species studied are all common weedy plants of Southern California. The geometry of sowing noted in Figure 1 allowed for easy distinction between the experimental seeds and "volunteer" seedlings of the same or other species. Actually only two of the test species had volunteers in the other treatments: *Malva parviflora* and *Rumex crispus.*

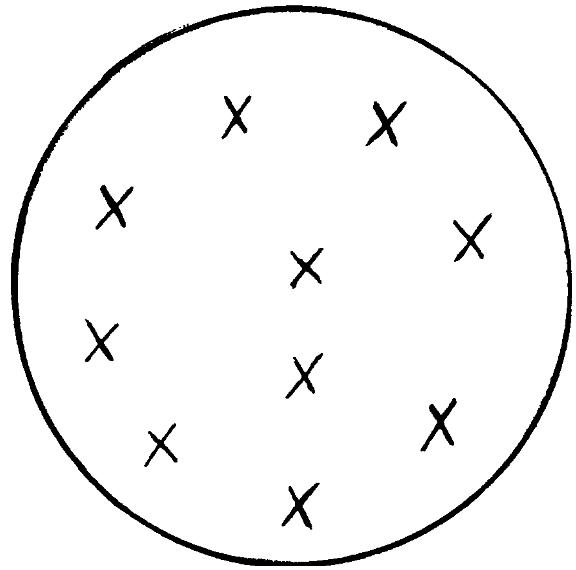

Figure 1. Surface view of a pot as used in germination trials. Each "X" indicates the position in which one seed was planted. This planting pattern enabled one to distinguish clearly between experimental seeds that had been planted and any volunteers present accidentally in the soil.

In the case of the *Rumex* germination studies, most tests were carried out in tap water contained in 50 ml beakers rather than in the soil pots mentioned. The seeds of *Rumex* germinated well this way and were completely visible, so that all possibility of volunteers affecting the *Rumex* count was removed. In the trials of the 16th and 20th weeks, separate observations were made on the germination of *Malva* and *Rumex* seeds in beakers of tap water and in soil-pots. The results of these parallel studies are included in Tables IV and V.

Since the two sets of data concur quite closely, it is evident that the problem of volunteer seedlings was minimal even among those two species which had some volunteer germination from the natural soil. On the basis of the position analysis of planted seeds and on parallel germination trials within beakers or pots, it can be inferred safely that these data represent actual germination of the experimental seeds.

Observations on each germination trial were made for several weeks after planting. Seeds in the soil were scored as "germinated" if the cotyledons emerged and expanded. Although a few of the *Medicago* seedlings later showed signs of "damping off" in one experiment, they were still scored as "germinated." Some of the *Rumex* seedlings, however, that were germinated by soaking in water, grew a root but did not unfurl the cotyledons or cast off the fruit wall

TABLE I—Week 4 (28 days of soaking)

Planting date: July 22 — **Data recorded for: 44 days**

Seeds	**Storage**	**Scarification**	**Soil-pot Results No. Seeds Germinating out of 10**
Raphanus sativus	Control	———	3
" "	Sea water	———	5
" "	Mixed water	———	8
" "	Tap water	———	6
Rumex crispus	Control	———	6
" "	Sea water	———	8
" "	Mixed water	———	9
" "	Tap water	———	Grew in soaking bath.
Cirsium edule	Control	cut	4
" "	Sea water	cut	2
" "	Mixed water	cut	0
" "	Tap water	cut	1
" "	Control	———	0
Medicago hispida	Control	cut	10
" "	Sea water	cut	10
" "	Mixed water	cut	9
" "	Tap water	cut	8
" "	Control	———	0
Malva parviflora	Control	cut	8
" "	Sea water	cut	1
" "	Mixed water	cut	1
" "	Tap water	cut	2
" "	Control	———	0

and such seedlings were not considered as "germinated," despite their root growth.

Early germination trials indicated that controls of *Medicago, Malva,* and *Cirsium* showed little or no germination. It was obvious that some dormancy mechanism prevailed in these three types.

It was discovered that these same three species would germinate readily if the seed coats were first cut tangentially with a razor blade before the germination trials were begun. Cutting was performed on the back of the seed to avoid injury to the radical or the epicotyl. It will be noted accordingly in the tables that seed coats of various lots were routinely scarified by cutting to break the seed-coat dormancy.

Furthermore, control seeds of *Medicago* and *Cirsium* germinated if they were soaked for about 10 minutes in concentrated sulfuric acid prior to planting. No cutting or acid scarification was attempted on seeds of *Rumex* or *Raphanus* because control seeds of these two species germinated readily. The whole fascinating topic of seed-coat dormancy has been reviewed adequately in various plant physiology text books.

Results

Data on the germination of various seed aliquots after 4, 8, 12, 16, and 20 weeks of soaking are presented in Tables I-V. Each table indicates time after soaking period began, the exact starting date for the germination study, and the number of days during which germination data were recorded after planting the seeds or placing them in beakers.

Listed opposite each species is the soaking storage treatment, the scarification procedure (if any), and the number of seeds germinating out of 10. Tables IV and V also provide the results of both soil-pot and beaker germination trials in freshwater, as indicated earlier.

Throughout these tables the phrase "grew in soaking bath" appears opposite those *Rumex* fruits stored in tap water. This indicates that seeds of *Rumex crispus* germinated while they were soaking in the fresh water storage bowl, and continued to grow well until about the 16th week at which time they became heavily covered with algae.

It can be concluded that *Rumex* seeds in fresh water will germinate and grow for long periods of time. After resting upon moist soil, it is conceivable that these seedlings would survive and become established. This germination of *Rumex* seeds even while they are soaking in water may contribute to the growth and survival of the species in swampy or otherwise moist situations.

TABLE II—Week 8 (56 days of soaking)

Planting date: August 19 — Data recorded for: 29 days

Seeds	Storage	Scarification	Soil-pot Results No. Seeds Germinating out of 10
Raphanus sativus	Control	———	8
" "	Sea water	———	1
" "	Mixed water	———	5
" "	Tap water	———	6
Rumex crispus	Control	———	7
" "	Sea water	———	3
" "	Mixed water	———	4
" "	Tap water	———	Grew in soaking bath.
Cirsium edule	Control	cut	10
" "	Sea water	cut	0
" "	Mixed water	cut	0
" "	Tap water	cut	0
Medicago hispida	Control	cut	10
" "	Sea water	cut	8
" "	Mixed water	cut	10
" "	Tap water	cut	6
Malva parviflora	Control	cut	4
" "	Sea water	cut	7
" "	Mixed water	cut	9
" "	Tap water	cut	2

TABLE III—Week 12 (84 days of soaking)

Planting date: September 16 — Data recorded for: 31 days

Seeds	Storage	Scarification	Soil-pot Results No. Seeds Germinating out of 10
Raphanus sativus	Control	———	10
" "	Sea water	———	0
" "	Mixed water	———	3
" "	Tap water	———	2
Rumex crispus	Control	———	9
" "	Sea water	———	3
" "	Mixed water	———	8
" "	Tap water	———	Grew in soaking bath
Cirsium edule	Control	cut	9
" "	Sea water	cut	0
" "	Mixed water	cut	0
" "	Tap water	cut	0
Medicago hispida	Control	cut	8
" "	Sea water	cut	8
" "	Mixed water	cut	7
" "	Tap water	cut	10
Malva parviflora	Control	cut	6
" "	Sea water	cut	4
" "	Mixed water	cut	8
" "	Tap water	cut	4

TABLE IV—Week 16 (112 days of soaking)

Planting date: October 14 — Data Recorded for: 24 days

Seeds	Storage	Scarification	No. of Seeds Germinating out of 10 Soil-pot Results	Beaker Results
Raphanus sativus	Control	———	9	———
" "	Sea water	———	0	———
" "	Mixed water	———	0	———
" "	Tap water	———	5	———
Rumex crispus	Control	———	7	10
" "	Sea water	———	4	10
" "	Mixed water	———	2	6
" "	Tap water	———	Grew in the soaking bath	
Cirsium edule	Control	cut	8	———
" "	Sea water	cut	0	———
" "	Mixed water	cut	0	———
" "	Tap water	cut	0	———
Medicago hispida	Control	cut	8	10
" "	Sea water	cut	10	10
" "	Mixed water	cut	10	10
" "	Tap water	cut	10	10
Malva parviflora	Control	cut	3	4
" "	Sea water	cut	3	9
" "	Mixed water	cut	5	9
" "	Tap water	cut	6	5

TABLE V--Week 20 (140 days of soaking)

Planting date: November 11 — Data recorded for: 22 days

Seeds	Storage	Scarification	No. of Seeds Germinating out of 10 Soil-pot Results	Beaker Results
Raphanus sativus	Control	———	9	———
" "	Sea water	———	0	———
" "	Mixed water	———	0	———
" "	Tap water	———	3	———
Rumex crispus	Control	———	6	2
" "	Sea water	———	7	2
" "	Mixed water	———	2	7
" "	Tap water	———	Grew in the soaking bath	
Cirsium edule	Control	cut	10	———
" "	Sea water	cut	0	———
" "	Mixed water	cut	0	———
" "	Tap water	cut	0	———
Medicago hispida	Control	cut	10	———
" "	Sea water	cut	10	———
" "	Mixed water	cut	10	———
" "	Tap water	cut	10	———
Malva parviflora	Control	cut	5	6
" "	Sea water	cut	7	10
" "	Mixed water	cut	6	9
" "	Tap water	cut	9	4 (fungus present)

After 4 weeks of soaking in sea, tap, or mixed water, seeds of all species tested showed at least some germination (with the one exception of *Cirsium* in the mixed soaking bath).

After 8 weeks it is apparent that *Rumex crispus, Raphanus sativus, Medicago hispida,* and *Malva parviflora* seeds from all soaking treatments germinated. Seeds from *Cirsium edule* taken from the sea, tap, or mixed water storage did not germinate.

After 12 weeks of soaking, germination results were similar to the 8 week data excepting that seeds of *Raphanus sativus* stored in sea water did not germinate.

After 16 weeks of soaking in sea water, tap water, or mixed water treatments, seeds of *Rumex crispus, Medicago hispida,* and *Malva pariviflora* germinated well. It is seen finally in Table V, that after 140 days of soaking in the three storage treatments, seeds of *Rumex crispus, Medicago haspida,* and *Malva parviflora* germinated well in the soil-pot trials (and in the beaker tests where indicated.) Thus seeds from three out of the five weedy species randomly selected germinated and grew after seven weeks of soaking in sea, tap, or mixed water.

These data indicate that there is widespread resistance to salt or fresh water soaking among the seeds of flowering plants. Such resistance may be at least partially attributable to seed-coat dormancy in the case of *Malva parviflora* or *Medicago hispida,* but is also evident in *Rumex crsipus* where no such dormancy exists.

Discussion

Cells of many plants require a high concentration of oxygen to maintain their metabolism.[11] Many land plants die when a region is subjected to prolonged flooding. Dead trees are often visible in the waters of man-made lakes where the roots have died from suffocation before the whole tree or shrub perished. Death in such instances is apparently caused by oxygen deficiency, and can also be noted in "water-logged" soils or overly watered potted plants.

The high oxygen requirement of many land plants presents an apparent problem to the concept of a total flood during the days of Noah. Possible survival mechanisms for various kinds of plants will be examined presently in the light of the Bible narrative.

Much destruction of plant life would have been expected in a global flood. Extinction of many species would be a predictive consequence. Reference to any standard text in Paleobotany will demonstrate that numerous kinds of plants found in fossil beds are not known on earth today.

Whole groups such as the Calamites, Cordaitales, Cycadofilicales, Bennettitales, and the Caytoniales have vanished–to mention just a few. It is of course impossible to know with absolute scientific certainty if some of these plants became extinct before the flood or if they were all destroyed by it.

Evidence does suggest, however, a much richer flora in time past and great extinctions among the fossil plants. Extinction of many species is exactly what one would predict if there had been a great flood. The first suggestion in answer to the problem of plant survival during the world-wide flood is that many plants did not survive!

The record of the flood (Genesis 6-9) contains much detail concerning provisions for animal survival. Although no mention is made of similar activity for preservation of plants, it is entirely probable that Noah and his family stored seeds or other propagules of important crop plants on the ark. If this conjecture is probable, then an interesting suggestion arises about crop plants and centers of ancient civilization.

Edgar Anderson and numerous other workers report that crop plants originated historically at ancient centers of human culture. Thus oranges, tea, and rice came from China; maize from the American Indians; and various cereal grains and fruit crops from the Indo-European area. It is at least possible that valuable plants stored on the ark were preserved by the children of Noah. If certain economic plants were cherished by the different races, one would expect to find important crop plants coming from the several centers of post-flood civilization. Although this idea is admittedly speculative, it does inject an interesting answer to the unsolved problem of crop plant origin.

The ark itself no doubt served to preserve the seeds of some species of plants either on the fur of animals or as various foods provided for them.

Sir Charles Darwin reported that trees floating in the ocean can contain seeds that will germinate:

> I find that when irregularly shaped stones are embedded in the roots of trees, small parcels of earth are frequently enclosed in their interstices and behind them,–so perfectly that not a particle could be washed away during the longest transport: out of one small portion of earth thus completely enclosed by the roots of an oak about 50 years old, three dicotyledonous plants germinated: I am certain of the accuracy of this observation.[12]

This mechanism in itself may have provided for survival of seeds from many plants during the flood.

Darwin stressed the role of icebergs in transporting plant propagules, a phenomenon which also may have contributed to endurance of seeds or other plant parts in the flood:

> As icebergs are known to be sometimes loaded with earth and stones, and have even carried brushwood, bones, and the nest of a land-bird, it can hardly be doubted that they must occasionally, as suggested by Lyell, have transported seeds from one part to another of the arctic and antarctic regions; and during the Glacial period from one part of the now temperate regions to another.[13]

Darwin discovered that seeds contained in dead bodies would readily germinate and grow after the carcases had been floated in salt water:

> Again, I can show that the carcases of birds, when floating on the sea, sometimes escape being immediately devoured: and many kinds of seeds in the crops of floating birds long retain their vitality: peas and vetches, for instance, are killed by even a few days' immersion in sea-water; but some taken out of the crop of a pigeon, which had floated on artificial sea-water for 30 days, to my surprise nearly all germinated.[14]

Carcases of animals strewn upon the surface after the Flood may have contained seeds which eventually germinated.

Finally, the results of this present study indicate that seeds of certain plants will grow after soaking for as long as 140 days in various water baths. It may be argued that the Flood waters were almost as salty as our ocean waters of today, or it may be possible that they had a far lower saline content. In either case, the data of my study demonstrate that three out of five species tested germinated after long soaking periods in sea, mixed, or tap water.

Darwin also experimented with survival of flowering plant seeds after floating the fruits upon a salt-water solution:

> Until I tried, with Mr. Berkeley's aid, a few experiments, it was not even known how far seeds could resist the injurious action of sea-water. To my surprise I found that out of 87 kinds, 64 germinated after an immersion of 28 days, and a few survived an immersion of 137 days.[15]
>
> Altogether, out of the 94 dried plants, 18 floated for above 28 days; and some of the 18 floated for a very much longer period. So that as 64/87 kinds of seeds germinated after an immersion of 28 days; and as 18/94 distinct species with ripe fruit (but not all the same species as in the foregoing experiment) floated, after being dried, for above 28 days, we may conclude, as far as anything can be inferred from these scanty facts, that the seeds of 14/100 kinds of plants of any country might be floated by sea-currents during 28 days, and would retain their power of germination.[16]

Oddly enough, Darwin concluded that legume family members survived the effects of salt water badly and would not germinate after soaking:

> It deserves notice that certain orders were far more injured than others: nine Leguminosae were tried, and with one exception, they resisted the salt-water badly;. . .[17]

This negative result may be explained by the fact that many legume type plants require scarification (cutting or acid treatment) to break their seed-coat dormancy. Perhaps Darwin would have noted better germination of soaked legume members had he understood this scarification requirement. In my experiments, it is evident that the legume *(Medicugo hispida)* germinated quite well with scarification after 140 days of soaking in any of the water solutions.

Since plant species are so often limited to relatively small geographic areas, as for example, many California species of *Ceanothus,* it would seem that mostly plants survived the Flood by resistance of either the seed or plant parts to salt water. Extensive experimentation as regards survival of *Ceanothus* seeds, cuttings, and even parts of the plant with roots attached, would no doubt give us much insight on this survival problem.

From these data and from Darwin's it may be concluded that seeds of many flowering plants could have resisted the direct contact of flood waters and germinated vigorously after the Flood. Thus seed plant survival during the Flood may have occurred by many means–both inside and outside the ark.

Several questions remain as yet unanswered. More studies are needed to find how widespread this resistance to prolonged soaking may be among seeds of flowering plants. It would be of interest to investigate factors which prevent germination and growth of *Raphanus sativus* and *Cirsium edule* seeds after soaking.

The Bible indicated that a dove released by Noah returned with an olive leaf in its mouth. How much soaking in salt or other water solutions would an olive plant be able to resist and still propagate afterwards?

These and other projects might provide data which would be of value in experimental plant physiology and in the understanding of Bible history.

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UNIVERSITIES AND COLLEGES HAVING THE CREATION POINT OF VIEW

WALTER E. LAMMERTS*

Cedarville College was established by the Reformed Presbyterian Church in 1887. Then, as now, it was believed that "education without morality is a menace to the state . . . accordingly the Bible is the textbook of the college." In 1953 the operation of the college was transferred to the trustees of the Baptist Bible Institute of Cleveland; it is now an approved school of the General Association of Regular Baptist Churches.

The scenic 100 acre campus is in the rural community of Cedarville, Ohio, near the large metropolitan areas of Columbus, Cincinnati, and Dayton.

Figure 1. An interior view of the Library.

Present enrollment is about 850 students, and most of the men and women live in student residence halls. For example Maddox Hall very comfortably houses 220 women, usually eight students to a unit consisting of bedroom area, study lounge and rest-room. All students under 25 years of age must live in college-owned or approved residence quarters, unless living at home.

*Walter E. Lammerts, well known rose breeder, holds the Ph.D. in genetics from the University of California at Los Angeles.

Basic costs including tuition, board and room, total about $2,000 for an academic year of three quarters. Scholarships are available to students who have demonstrated academic ability and definite financial need. There are also many opportunities, both on the campus and in the metropolitan areas, for part-time work.

Of particular interest to our society is the doctrinal statement of Cedarville College, paragraph 4 of which reads: "We believe in the literal account of creation and that the Scriptures clearly and distinctly teach that the creation of man lies in the special, immediate, and formative acts of God." Man's subsequent fall into sin and his salvation by faith in Jesus Christ as the Son of God, who physically arose from the dead, and ascended into heaven are also included in the detailed 14-point statement of belief.

Dr. Donald P. Baumann, Ph.D. 1962, Iowa State University, is head of the division of Science and Mathematics. He is professor of bacteriology and chemistry. Assisting him are associate professors Austin D. Elmore, biological science, especially botany; L. Bert Frye, physical sciences and Daniel E. Wetzel, physics and mathematics. Dr. Larry Helmick has recently

Figure 2. Dr. Donald Baumann in one of the laboratories.