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A LONG TERM TEST OF SEED LONGEVITY

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The problem of longevity of seeds has not been solved as yet. Crocker in a review in 1938, comes to the conclusion that loss of viability in seeds is probably due to "gradual dislocation in the chromosome system of embryo cells with duration of storage." "X-ray and heat treatment of seeds have effects similar to aging." There seem to be, however, many other mechanisms which might account for their loss of viability. In some seeds loss of viability may be due to exhaustion of their storage foods due to respiration, whereas others are killed by even moderate drying in air.

In the experimentation that has been carried out in this general field it has become apparent that methods to prolong viability of seeds are:

1) storage at low temperature
2) storage in dry condition
3) storage in the absence of oxygen.

It is most likely that the effectiveness of these treatments has to be explained on the basis that lack of respiration, which is checked by any one of the three conditions mentioned above, and lack of oxidative reactions in general, prevent changes in the seeds and keep them unchanged in their dormant condition. According to Crocker "there seems little doubt that by use of the best storage conditions the recorded life-span of many seeds can be lengthened greatly—perhaps several fold."

If seeds are stored in vacuo after being thoroughly dried, any further aerobic respiration or oxidation is impossible, and therefore it would seem that if checking of the respiration is the governing factor in increasing the longevity of seeds, they could be stored indefinitely. If, on the other hand, the longevity is impaired by chromosome changes induced by various penetrating radiations, then such dry storage in vacuo should have little effect.

Many studies have been conducted to determine the life span of seeds under ordinary conditions of storage or under natural conditions (see e.g. Toole and Brown 1946, Crocker 1938, Crocker 1948, Darlington 1941), but only very few attempts have been made to study longevity of seeds under presumably ideal storage conditions, (see e.g. Sayre 1947). The present experiment is intended as such. At the same time it should shed some light on other problems such as after-ripening, mutative changes in the stored seeds, evolutionary changes of plants under cultivation, etc.

In the case of after-ripening it is found that upon storage certain seeds gradually increase in germinative power. This is clearly seen in data of Benedict (1946) on the effect of relative humidity during storage of guayule seeds. When harvested the different varieties have an average germination of only

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about 30 per cent. When stored at high humidities they lose their germinative power very rapidly, when kept at 30 per cent humidity there is a pronounced after-ripening effect, but in practically a completely dry condition germination remains constant from month to month. The irregular curve for germination of seeds stored at 50 per cent humidity is probably the resultant of two opposing tendencies: loss of germinative power at high humidities and after-ripening at lower humidity.

METHODS EMPLOYED IN THIS EXPERIMENT

For the present experiment seeds were supplied by the Rancho Santa Ana Botanic Garden and taken to the California Institute of Technology in 1947. A sufficient quantity of seeds of each species was obtained to make about 20 separate samples, which could be sealed in individual glass tubes. The seeds were selected by F. W. Went and P. C. Everett, the latter being the Superintendent of the Botanic Garden. Desiccating and sealing, as well as the first two germination tests were carried out at the California Institute of Technology by H. A. Went and P. A. and D. A. Benioff.

For the first germination test a sample usually of 60 seeds was taken for each species and the germination percentage was determined in a darkroom kept at 17 - 18° C. For this the seeds were laid on filter paper moistened with tap water, in petri dishes, and the number germinating was counted daily. All germinated seeds were removed so that each day only the new germinations were counted. When, after the main period of germination, no more seeds germinated during a three-day period, the seeds were discarded. In Table 1 the percentage germination is recorded, and also the time it took for the first 17 per cent and for the last seeds (maximum number) to germinate. The results are shown in the table as Test Number 1. In certain cases special treatments were given to make the seeds germinate. These treatments are noted in footnotes to the table.

After this preliminary germination test the seeds were spread thinly in petri dishes which were placed in racks in vacuum desiccators over powdered phosphoric anhydride (P_2O_5). When the P_2O_5 had liquified, it was changed. The smaller seeds were kept for at least a week in the desiccators, the larger seeds up to a month and longer.

When the seeds were thoroughly dry, the desiccators were opened and the petri dishes were placed in a transfer cabinet in the presence of more P_2O_5. Within this cabinet each species of seeds was transferred from the petri dishes to at least 20 glass tubes in which they were to be sealed. The cabinet was provided with long rubber gloves hermetically sealed to the wall, into which the operator put his hands. Thus no moisture could reach the seeds during the period of transfer.

Again a seed sample of each of the species after drying in the vacuum desiccator was removed and its germination was determined in the same way as before drying. The results are tabulated as Test Number 2. As the table indicates, there were no significant changes in the viability of the seeds due to drying.

The 20 glass tubes containing the same seeds were then attached to a manifold, connected with a vacuum pump. When the pressure had dropped to 0.05 mm. of mercury or less, the tubes were sealed with an oxygen torch. They were then marked with a carborundum pencil and stored at room temperature. Each species received the number under which it appears in the table.

All tubes were inspected with a magnifying glass and those which showed cracks were opened, dried again in vacuo for a week, and resealed in vacuo. In the spring of 1948 these sealed seeds were returned to the Rancho Santa Ana Botanic Garden for storage. Test Number 3 was run in the summer of 1948 by Fred W. Munz, using the same methods as in Tests 1 and 2 except that distilled water instead of tap water was employed.

INSTRUCTIONS FOR FUTURE HANDLING

Because in the sealed tubes the seeds are kept quite completely dry and in the absence of oxygen, it is probably not essential to keep them at low temperatures as well. Therefore it is suggested that these tubes with seeds be kept at room temperature with as small a variation in temperature as possible. The seed storage room at the Rancho Santa Ana Botanic Garden seems suitable for such storage; there the temperature ranges from about 10°C in winter to 20°C in summer, with very little change from day to night.

At stated intervals a set of tubes is to be opened and the germination percentage of the seeds is to be determined under approximately the same conditions as described earlier. Another set of seeds should be planted in soil and be grown to maturity. Herbarium material of these plants should be preserved. As dates for the opening of sets of tubes are suggested: 1948, 1957, 1967, 1987, 2007, 2027, 2047, 2067, 2087, 2107, 2127, 2147, 2167, 2187, 2207, 2227, 2247, 2267, 2287 and 2307. If germination remains unchanged for the first 100 years, longer intervals can be chosen. It is suggested that after each germination test the results be published to make a continuing series with this first report.

CONCLUSIONS FOR THE FIRST THREE TESTS

Although this report describes mainly the way the longevity experiment was set up, and gives the basic data of original viability of the seed, there are a few interesting conclusions which can be drawn from the data already available from the first three tests of germination. The tests before and after drying of the seeds are strictly comparable, having been carried out in the same room and at the same temperature. The germination test at the end of the first year of storage was conducted at a slightly higher temperature (difference 2°C.) but it is believed that this difference is insufficient to account for the observed differences.

In the first place it can be concluded that the rapid drying of the seeds did not influence their viability in any respect, with a few exceptions. Seeds of *Carpenteria, Collomia grandiflora, Gilia achilleaefolia, Phacelia tanacetifolia* and *Tanacetum camphoratum* lost three-fourths of their germinative power, a few others were not so strongly affected, and *Lupinus succulentus* seemed to germinate much better after the drying period. In some the germination was slower, but in others faster, after drying. On the whole there was no important change; for all the species employed the mean for the germination percentage was 37.0% before drying and 34.4% after drying.

After one year of storage the germination percentage for the mean of all species had dropped to 24.4%. It is questionable whether this drop is significant; it shows a trend, but in a certain number of species (12) there was a considerable increase in percentage of germination, whereas in 23 species there was a pronounced decrease. Since this decrease was very marked in the species which had the highest percentage of viable seeds before sealing them in tubes, these have affected the average more than seems consistent with the general trend. With the decreased viability, usually also an increase in the germination time was found.

EXPLANATION OF TABLE 1

In the table showing the results of the three germination tests that have been run, the first number is that given to the seed lots. These numbers appear on the sealed tubes of seeds that are being stored for future tests. The column "Year Coll." refers to the year in which the seeds were grown. "Prop. No." is the propagation number under which these lots of seeds are entered in the records of the Rancho Santa Ana Botanic Garden. For the subsequent divisions there are given in each case three columns: 1, for the test made before the seed was desiccated; 2, for the second test or that made after desiccation; and 3, for the third test. the one made after desiccation and sealing. The first two tests were made at the California Institute of Technology in 1947, the third at the Rancho Santa Ana Botanic Garden in 1948. For the first two tests lots mostly of 50 or 60 seeds were used, but more irregular and frequently much larger numbers were used in test three. The heading "Days required for the first 17%" is in some cases approximate; the figures at first set up for tests 1 and 2 were on the basis of the number of days needed for the first 10 seeds to germinate, but these were changed to what would be 17% on the basis of lots of 60 in order to get a comparison with test 3. The heading "Total days required" refers to the number of days a test was run in which germination was still occurring. In the last group "Percent germinated" the percentages are expressed in the nearest whole number, to save space. It will be noticed that the numbers in column 1 are not continuous. This is because certain ones were omitted because of lack of time for desiccating and sealing so many lots. For tests 1 and 2 unless otherwise indicated by footnotes, the temperatures used were 17°C for days and 16°C for nights. For test 3, the temperature began at 19°C and ended with 20°C, nights and days being about the same at any given time in the test.

The numbers 104 and 105 for which "Schenck" is given instead of a propagation number are for seed that were part of a larger collection made at Twenty-nine Palms on the Mojave Desert by Sara W. Schenck. These seeds were stored in glass jars for some years in the house, then the jars were placed on the trash pile in a paper carton exposed to full desert sun. In the fall of 1946 it occurred to the second author that it would be interesting to ascertain whether any of these seeds were still viable. They were brought in to the Garden and some of them turned over to the first author to be included in the longevity test. Only two are given in the table, but some information is available for others. *Isomeris arborea,* collected in 1935, was tested at Pasadena before desiccation and gave a germination of 63%, the first seeds germinating in 6 days. *Cassia armata,* from 1935 seeds, was also tested at Pasadena before desiccation and showed 97% germination which began on the second day. *Salvia Columbariae,* from 1935 seed, was given propagation no. 5551; when planted in the Garden nursery it gave excellent germination, and in a test made as part of the general test 3, it showed 63% germination, beginning on the fourth day. *Simmondsia chinensis,* from 1935 seed, gave no germination in the Garden nursery, but in a laboratory test all seeds germinated and developed into normal plants when these were put in pots. *Echinocereus Engelmanni* in the laboratory gave germination of 100%. *Washingtonia filifera,* from 1933 seed, was given propagation number 5549; planted in the nursery in 1947 it gave good germination. *Larrea divaricata,* 1935 seed, propagation number 5473, treated with cold water for 24 hours, began to sprout in four days and gave good germination in the nursery. *Franseria dumosa,* 1935 seed, propagation number 5547, planted in the nursery gave fair germination, beginning on the fourth day. *Dalea Emoryi, Encelia Actoni, Salazaria mexicana, Bebbia juncea* var. *aspera,* and *Aster Orcuttii* after 12 years storage still had a few viable seeds, as demonstrated in the laboratory, although those planted in the nursery showed no germination. On the other hand, 1935 seeds of *Yucca brevifolia, Y. schidigera (mohavensis), Nolina Parryi, Cucurbita palmata, Lycium Cooperi, Sphaeralcea ambigua, Lepidium Fremontii, Encelia farinosa, Rhus trilobata* var. *anisophylla, Dalea Fremontii* and *Krameria canescens* gave no germination whatsoever under laboratory conditions. Thus many of the seeds had lost their viability, but some species still retained a remarkable amount, especially when it is realized that on the ground in the trash pile the containers holding the seed were exposed to very high day temperatures for all one summer. Most of the seed were collected in 1935 and the tests run in 1947.

Explanation for Table 2

Table 2 lists alphabetically the species given by number in Table 1. The column "No. under which tested" refers to the number assigned to each species for the whole experiment and employed in Table 1. "Days in desiccator" and "Initial pressure in mm. Hg. in tubes" give data for which there was insufficient space in Table 1. "Source of seed" tells where the strain used originally came from, where such information is available. All materials used are from collections made in California.

Summary

Approximately 100 different kinds of seed of California plants have been sealed in individual glass tubes in vacuo, after rapid drying in vacuo over P_2O_5. The drying itself did not materially affect subsequent germination, which dropped only from 37.0 to 34.4 per cent. The seeds from the first set of tubes opened one year after sealing had dropped in germinative power to only 24.4 per cent.

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Table 1. Germination Tests

Name	Year Coll.	Prop. No.	No. Seeds tested 1	2	3	Number germinated 1	2	3	Days required first 17% 1	2	3	Total days required 1	2	3	Per cent germinated 1	2	3
1. Coreopsis Bigelovii	1946	5247	60	50	94	35	23	62	9	12	17	18	21	31	58	46	66
2. Penstemon heterophyllus var. australis	1946	5307	60	60	388	38	24	150	6	7	8	9	7	16	63	40	39
3. Artemisia pycnocephala	1943	4992	50	60	29	0	0	3	..	..	..	..	..	7	0	0	10
4. Eriogonum arborescens	1943	4997	60	60	111	4	..	14	..	..	..	6	..	22	7	..	13
5. Fallugia paradoxa	1946	5303	60	50	65	3	..	1	..	..	..	5	..	6	5	..	2
6. Baeria maritima	1946	5238	50	60	139	24	56	17	4	2	..	8	6	11	49	93	12
7a. Baeria chrysostoma var. gracilis	1945	..	50	60	166	18	22	3	2	3	..	8	7	18	32	37	2
7b. Baeria chrysostoma var. gracilis	1946	..	50	60	108	2	0	0	..	..	..	10	..	..	3	0	0
8. Boisduvalia densiflora	1942	4787	60	60	276	0	2	0	..	..	..	..	10	..	0	3	0
9. Eriophyllum Nevinii	1946	5334	60	60	168	11	14	11	9	8	..	11	11	13	18	23	7
10. Chaenactis glabriuscula var. tenuifolia	1946	5240	60	60	70	20	12	1	6	19	..	14	21	5	33	20	1
11. Agrostis longiligula	1941	4344	60	60	202	0	3	21	..	..	..	..	8	18	0	5	10
12. Artemisia Suksdorfii[1]	1944	5043	50	60	..	0	0	0	..	..	..	..	..	..	0	0	0
13. Penstemon spectabilis	1946	5308	60	60	208	7	14	66	..	10	8	11	22	18	12	23	32
14. Lasthenia glabrata	1946	5274	60	60	194	21	41	3	3	3	..	5	10	3	36	69	2
15. Haplopappus Parishii	1945	5120	60	60	137	0	1	0	..	..	..	..	9	..	0	2	0
16. Collomia grandiflora	1946	5246	60	60	257	9	2	6	..	..	..	3	7	20	15	3	2
17. Lathyrus Alefeldii[5]	1941	5216	30	60	41	1	0	0	..	..	..	11	..	..	3	0	0
18. Madia elegans ssp. vernalis[2]	1946	5282	60	0	0	0	..	..	..	..	..	..	..	..	0	..	..
19. Eremalche Parryi	1946	5249	60	60	176	5	7	28	..	..	..	8	14	13	8	12	16
21. Sisyrinchium bellum	1946	5176	60	60	170	14	11	1	15	22	..	16	25	8	23	18	1
22. Salvia carduacea [3]	1938	3333	60	60	..	0	0	..	..	..	..	..	..	..	0	0	..
23. Clarkia elegans	1946	5245	60	60	285	60	60	203	1	2	1	3	6	5	100	100	71
24. Lotus scoparius var. brevialatus	1941	4218	60	50	100	4	0	20	..	..	9	7	..	12	7	0	20
25. Pogogyne Douglasii[2]	1942	4872	50	..	..	0	..	..	..	..	..	..	..	..	0	..	..
26. Nemophila maculata	1946	5289	50	60	142	18	16	25	3	8	5	4	17	5	30	27	18
27. Chorizanthe Douglasii	1946	5242	60	50	105	2	0	14	..	..	..	5	..	15	3	0	13
28. Allenrolfea occidentalis	1938	3379	60	60	82	3	3	22	..	..	10	12	12	14	5	5	27
29. Lupinus succulentus[4]	1941	4509	60	60	117	8	19	45	..	4	6	9	10	10	13	32	39
30. Lupinus subvexus[5]	1946	5279	30	60	56	27	0	23	2	..	11	2	..	21	90	0	41
31. Cirsium neomexicanum[2]	1942	4793	60	..	..	0	..	..	..	..	..	..	..	..	0	..	..
32. Cirsium occidentale	1946	5244	60	60	125	46	42	67	5	6	6	12	10	22	77	70	54
33. Eriogonum fasciculatum var. polifolium[7]	1941	4377	..	60	150	0	0	25	..	..	4	..	..	4	0	0	17

Name	Year Coll.	Prop. No.	No. Seeds tested			Number germinated			Days required first 17%			Total days required			Per cent germinated		
			1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
34. Pectis papposa[6]	1946	Went Coll.	50	50	222	0	2	6	..	..	..	..	2	7	0	4	3
35. Eryngium articulatum	1940	3726	60	60	227	0	0	0	..	..	..	..	..	..	0	0	0
36. Monardella lanceolata	1946	5286	60	60	449	57	57	427	2	2	3	4	6	27	95	95	95
37. Monardella undulata[3]	1942	4856	50	60	..	0	0	..	..	..	..	..	..	..	0	0	..
38. Tanacetum camphoratum	1946	5146	60	60	133	14	3	11	7	..	..	10	7	12	23	5	8
39. Oenothera brevipes	1946	5290	60	60	252	6	6	12	..	..	..	12	12	10	10	10	5
40. Malacothrix arachnoidea	1943	4930	60	60	140	15	5	19	7	..	..	11	9	24	25	8	14
41. Psilostrophe Cooperi[2]	1945	5150	60	..	..	0	..	..	..	..	..	..	..	..	0	..	..
42. Suaeda Torreyana	1940	3916	60	60	318	14	4	52	5	..	..	8	9	19	23	7	16
43. Oenothera deltoides var. cognata	1940	5291	60	60	169	31	36	91	3	3	3	7	12	4	52	60	54
44. Mentzelia laevicaulis	1934	2237	60	60	213	0	0	4	..	..	..	..	..	16	0	0	2
45. Mentzelia Lindleyi	1946	5283	50	60	167	2	4	44	..	..	21	4	10	32	4	7	26
46. Baileya pleniradiata	1941	4461	50	60	77	0	0	0	..	..	..	..	..	..	0	0	0
47. Platanus racemosa	1946	5386	60	60	127	27	30	43	5	6	6	8	9	10	45	50	34
48. Linanthus grandiflorus	1946	5277	50	60	160	46	56	2	1	2	..	2	6	3	92	93	1
49. Linanthus montanus	1946	5278	50	60	173	40	48	1	3	2	..	4	10	6	80	80	1
50. Eschscholzia caespitosa (Kern County strain)	1946	5251	50	60	261	22	33	134	5	4	7	10	10	21	44	55	51
51. Eschscholzia caespitosa var. hypecoides	1946	5250	60	60	272	33	46	146	3	6	7	7	14	23	55	77	54
52. Eschscholzia glauca	1942	4808	50	60	220	0	0	1	..	..	..	..	..	9	0	0	1
53. Eschscholzia californica var. crocea	1946	5252	60	60	214	47	43	161	1	4	3	3	10	18	78	72	75
54. Gilia Chamissonis	1946	5255	50	60	330	36	21	93	2	7	6	6	10	9	72	35	28
55. Gilia staminea	1946	5254	50	60	440	46	56	210	1	2	3	3	9	8	92	93	48
56. Gilia tricolor	1946	5257	50	60	259	48	51	145	1	2	2	2	12	20	96	85	56
57. Gilia achilleaefolia	1946	5256	50	60	211	46	8	43	1	..	14	4	7	15	92	13	20
58. Godetia amoena	1946	5259	80	60	363	77	55	283	1	1	6	2	6	20	96	92	78
59. Godetia cylindrica	1946	5264	60	60	393	54	59	233	1	1	6	3	6	35	90	98	59
60. Godetia Dudleyana	1946	5267	50	60	170	45	40	131	1	1	2	5	6	10	90	67	77
61. Godetia Whitneyi	1946	5273	60	60	211	56	60	188	1	2	2	3	9	10	94	100	89
62. Godetia amoena var. Lindleyi	1946	5258	60	60	166	51	57	146	1	2	2	2	5	11	85	95	91
63. Godetia deflexa	1946	5266	60	60	411	60	58	311	1	1	5	1	3	35	100	97	76
64. Godetia biloba	1946	5261	60	60	363	52	54	303	1	2	5	4	4	30	87	90	84
65. Godetia biloba var. Brandegeae	1946	5262	60	60	355	51	55	207	1	3	3	3	11	21	85	92	58
66. Godetia quadrivulnera	1942	4830	60	60	412	0	0	32	..	..	..	..	..	20	0	0	8
67. Godetia viminea var. Congdonii	1946	5270	60	60	192	55	37	118	1	2	7	2	3	27	92	62	61

Name	Year Coll.	Prop. No.	No. Seeds tested 1	2	3	Number germinated 1	2	3	Days required first 17% 1	2	3	Total days required 1	2	3	Per cent germinated 1	2	3
68. Phacelia curvipes	1942	4865	50	60	153	0	0	2	..	..	..	..	..	12	0	0	1
69. Phacelia Parryi	1942	5291	60	60	258	49	28	185	1	2	2	3	4	6	82	47	72
70. Phacelia brachyloba[8]	1942	4862	60	60	444	3	0	0	..	..	..	1	..	..	2	0	0
71. Phacelia ciliata	1946	5292	60	60	154	26	17	94	1	3	3	5	8	4	43	28	61
72. Phacelia tanacetifolia	1946	5296	60	60	168	14	3	0	1	..	..	3	3	..	23	5	0
73. Phacelia viscida	1946	5297	60	60	353	33	28	3	1	3	..	3	4	10	55	46	1
74. Phacelia grandiflora	1941	4199	60	60	197	0	0	0	..	..	..	..	..	..	0	0	0
75. Franseria chenopodiifolia[2]	1941	4208	60	..	..	0	..	..	..	..	..	..	..	..	0	..	..
76. Chorizanthe staticoides	1946	5243	60	60	147	13	12	5	15	18	..	20	22	16	22	20	3
77. Chaenactis Orcuttiana	1946	5241	60	60	132	28	27	4	4	7	..	9	18	13	47	45	3
78. Laya heterotricha	1943	4948	60	60	106	1	0	0	..	..	..	5	..	..	2	0	0
79. Laya platyglossa var. elegans	1942	4842	60	60	103	12	10	4	4	15	..	5	15	17	20	17	4
80. Tidestromia oblongifolia[2]	1940	3915	60	..	..	0	..	..	..	..	..	..	..	..	0	..	..
81. Armeria maritima var. californica[2]	1943	4927	60	..	..	0	..	..	..	..	..	..	..	..	0	..	..
82. Cercidium microphyllum	1940	3653	30	30	14	12	9	3	8	..	10	12	7	10	40	30	21
101. Crossosoma californicum[4]	1947	5438	60	..	129	43	..	39	7	..	10	16	..	18	72	..	30
102. Atriplex hymenelytra	1947	5466	30	..	56	0	..	0	..	..	..	..	..	..	0	..	0
103. Grayia spinosa	1947	5459	30	..	33	0	..	5	..	..	..	..	..	18	0	..	15
104. Chilopsis linearis	1933	Schenck	30	30	38	1	0	0	..	..	..	13	..	..	3	0	0
105. Encelia Actonii	1935	Schenck	60	60	134	8	7	1	..	..	..	8	7	4	13	12	1
106. Geraea canescens	1947	5453	60	60	48	4	0	1	..	..	..	9	..	21	7	0	2
107. Calycanthus occidentalis	1947	5557	30	30	15	1	0	3	..	..	25	13	..	25	3	0	20
108. Adenostoma fasciculatum	1947	5569	60	60	149	0	0	0	..	..	..	..	..	..	0	0	0
109. Achillea borealis ssp. arenicola	1947	5487	60	60	77	59	56	33	3	5	7	9	11	12	98	93	43
110. Salvia spathacea	1945	5196	30	60	32	2	4	1	..	..	..	15	12	10	7	7	3
111. Carpenteria californica	1947	..	60	60	221	60	13	0	2	12	..	6	16	..	100	22	0
112. Godetia Bottae	1947	5497	60	60	265	..	43	68	..	1	8	..	9	27	..	72	26
113. Trichostema lanatum	1947	..	60	60	121	0	0	0	..	..	..	..	..	..	0	0	0

1 Material tested consisting of chaff and a few non-viable seeds.
2 Not desiccated or sealed.
3 Not available for test 3.
4 Many seeds available for test 3 abortive.
5 Seeds for test 2 treated 10 hrs. in conc. H_2SO_4.
6 For test 3 another lot of 213 seeds soaked in water for 18 hrs. gave 11% germination; test 2 reported in the table was for seeds soaked 5 min. in 8% Clorox, test 3 in 5% Clorox (HOCl).
7 For tests 1 and 2, day temperature 3°C, night 9°C.
8 For tests 1 and 2, day and night temperatures 25.5°C.

Table 2. Source of Materials Used in Germination Tests

Name	No. Under which Tested	Days in Desiccator	Initial Pressure mm. Hg. in Tubes	Source of Seed
Achillea borealis ssp. arenicola	109	14	.1	Mouth of Little River, along U. S. Highway 101, north of Eureka, Humboldt Co.
Adenostoma fasciculatum	108	14	.02	2 miles south of Alberhill, Temescal Canyon, Riverside Co.
Agrostis longiligula	11	8	.02	Big Lagoon, south side and west of Redwood Highway, Humboldt Co.
Allenrolfea occidentalis	28	13	.02	Upper San Joaquin Valley, 2 miles east of U. S. Highway 99 on road to Arvin, Kern Co.
Armeria maritima var. californica	81	..	..	Along the coast, about 1 mile north of Cambria, San Luis Obispo Co.
Artemisia pycnocephala	3	15	.02	Along coastal bluffs 4 miles south of Pescadero, San Mateo Co.
Artemisia Suksdorfii	12	15	.02	Redwood Highway at junction of road to Crannell, Humboldt Co.
Atriplex hymenelytra	102	19	.025	Ballarat, Inyo Co.
Baeria chrysostoma var. gracilis	7a	7	.05	Seed raised by F. W. Went from a strain originally designated as Prop. No. 2558, collected at lower end of Aliso Canyon, Rancho Santa Ana, Santa Ana Canyon, San Bernardino Co.
Baeria chrysostoma var. gracilis	7b	7	.05	
Baeria maritima	6	12	.03	Pt. Reyes Peninsula, 1/4 mile from the lighthouse, Marin Co.
Baileya pleniradiata	46	8	.02	Mojave Desert, 2 miles west of Valley Wells, San Bernardino Co.
Boisduvalia densiflora	8	8	.01	.8 mile from Midway on the road to Mariposa, Mariposa Co.
Calycanthus occidentalis	107	19	.02	
Carpenteria californica	111	12	.05	Seed from Prop. No. 2477, from 5 mi. from Augerry on road to Pineridge, Sierra Nevada, Fresno Co. at 4,000 ft.
Cercidium microphyllum	82	33	.1	Colorado Desert, base of Whipple Mts., adjacent to Colorado River, 11 miles above Earp, road to Parker Dam, San Bernardino Co.
Chaenactis glabriuscula var. tenuifolia	10	7	.02	2.1 miles southwest of Lilac School on road to Moosa Canyon, San Diego Co.
Chaenactis Orcuttiana	77	14	.02	Southwest corner of U.S.A., 500 feet north of the Initial Boundary Monument, San Diego Co.
Chilopsis linearis	104	13	.05	Twenty-nine Palms, Mojave Desert, San Bernardino Co.
Chorizanthe Douglasii	27	7	.01	Near King City, Monterey Co.
Chorizanthe staticoides	76	14	.02	.7 mile west of Esperanza, Santa Ana Canyon, Orange Co.
Cirsium neomexicanum	31	..	..	Mojave Desert, Avawatz Mts., Cave Spring, San Bernardino Co.
Cirsium occidentale	32	8	.009	2.5 miles east of Nexada City on the road to Emigrant Gap, Nevada Co.
Clarkia elegans	23	12	.05	Purchased from Theo. Payne.
Collomia grandiflora	16	7	.02	Camp Deer Crossing, Mill Creek between Miramonte and Gen. Grant Park, west slope Sierra Nevada, Fresno Co.
Coreopsis Bigelovii	1	7	.01	Cottonwood Canyon, .1 mile above, San Luis Obispo Co.
Crossosoma californicum	101	19	.02	Junction of upper Pebbly Beach road and road to Renton Mine, Catalina Island, Los Angeles Co.
Encelia Actonii	105	18	.05	Twenty-nine Palms, Mojave Desert, San Bernardino Co.

Name	No. Under which Tested	Days in Desiccator	Initial Pressure mm. Hg. in Tubes	Source of Seed
Eremalche Parryi	19	7	.01	Cottonwood Canyon, .3 mile east of San Luis Obispo County Line, Kern Co.
Eriogonum arborescens	4	7	..	Santa Cruz Island, west side of canyon, ¼ mile back of Prisoners Harbor, Santa Barbara Co.
Eriogonum fasciculatum var. polifolium	33	8	.01	Frazier Park at Pinyon Public Camp, Kern Co.
Eriophyllum Nevinii	9	7	.01	Santa Catalina Island, Los Angeles Co.
Eryngium articulatum	35	12	.03	Head of Sacramento Valley, 6 miles north of Redding, Shasta Co.
Eschscholzia caespitosa (Kern County Strain)	50	12	.01	Tejon Hills, 2 miles northwest of Tejon Ranch Headquarters, Kern Co.
Eschscholzia caespitosa var. hypecoides	51	7	.02	1½ miles from Midway on the road to Wawona, west slope Sierra Nevada, Mariposa Co.
Eschscholzia californica var. crocea	53	7	.025	Sacramento Valley, 1 mile north of Durham, Butte Co.
Eschscholzia glauca	52	12	.01	Between vineyard and road, ¼ mile east of Main Ranch, Santa Cruz Island, Santa Barbara Co.
Fallugia paradoxa	5	7	.01	Eastern Mojave Desert, 6 miles south of Cima, San Bernardino Co.
Franseria chenopodiifolia	75	..	..	Southwest end of Otay Mesa, ½ mile east of the San Diego-Tijuana road, San Diego Co.
Geraea canescens	106	18	.05	Panamint Valley, 11 miles north of Ballarat, Inyo Co.
Gilia achilleaefolia	57	8	.02	Purchased from Theo. Payne.
Gilia Chamissonis	54	12	.02	Coast at Devil's Gate, south of Cape Mendocino, Humboldt Co.
Gilia staminea	55	12	.04	San Joaquin Valley, 3 miles north of Merced River and Highway 99, Merced Co.
Gilia tricolor	56	12	.05	Tejon Ranch, Tejon Canyon, .7 mile below Tejon Canyon School, Kern Co.
Godetia amoena	58	12	.02	North Coast Range, Redwood Hwy., along Russian River, 7.5 mi. north of Cloverdale, Mendocino Co.
Godetia amoena var. Lindleyi	62	7	.025	1 mile inland from Devil's Gate on road to Petrolia, Humboldt Co.
Godetia biloba	64	7	.01	Hell Hollow, .8 mile above Bagby on grade to Bear Valley, west slope Sierra Nevada, Mariposa Co.
Godetia biloba var. Brandegeae	65	7	.02	Sierra Nevada foothills, 1.6 miles northwest of Stanfield Hill, fork of S. Honcut Creek, Yuba Co.
Godetia Bottae	112	..	.05	Santa Lucia Mts., Cachagua Road, .8 mile south of Tularcitos Creek, Monterey Co.
Godetia cylindrica	59	8	.01	Summit of grade from Yokohl Valley to Milo, west slope of Sierra Nevada, Tulare Co.
Godetia deflexa	63	7	.09	Native to Rancho Santa Ana Botanic Garden, Santa Ana Canyon, Orange Co.
Godetia Dudleyana	60	7	.009	3 miles above Miramonte on the road to Gen. Grant Park, west slope Sierra Nevada, Fresno Co.
Godetia quadrivulnera	66	7	.04	¼ mile southwest of Muddy Springs near Roundtop Peak, Rancho Santa Ana, Orange Co.
Godetia viminea var. Congdonii	67	7	.05	3 miles below Pine Grove, on road to Jackson, Amador Co.

Name	No. Under which Tested	Days in Desiccator	Initial Pressure mm. Hg. in Tubes	Source of Seed
Godetia Whitneyi	61	12	.01	Along the coast 4.4 miles north of Westport, Mendocino Co.
Grayia spinosa	103	19	.025	Southern end of Inyo Mts., below Santa Rosa Mine, Inyo Co.
Haplopappus Parishii	15	15	.05	Santa Ana Mts., Indian Canyon along Indian Canyon Truck Trail, Riverside Co.
Lasthenia glabrata	14	8	.02	San Joaquin Valley, 3 miles north of Stockton, San Joaquin Co.
Lathyrus Alefeldii	17	32	.02	2.4 miles west of Dripping Springs Forest Service Camp on road between Aguanga and Temecula, Riverside Co.
Laya heterotricha	78	14	..	Upper Sespe Creek, 3.6 miles south of Summit of Pine Mt. Grade on the Ojai to Cuyama Valley Road, Ventura Co.
Laya platyglossa var. elegans	79	14	.1	.3 mile east of Atwood on south side of Santa Fe Railroad, Orange Co.
Linanthus grandiflorus	48	12	.03	Point Reyes, along roadside at the Radio Corp. Amer. Station, Marin Co.
Linanthus montanus	49	12	.03	2.8 miles above Dunlap on the Sand cut-off to Miramonte, west slope Sierra Nevada, Fresno Co.
Lotus scoparius var. brevialatus	24	13	.02	A mile east of Temecula on road to Aguanga, Riverside Co.
Lupinus succulentus	29	13	..	Rancho Santa Ana Botanic Garden, Santa Ana Canyon, Orange Co.
Lupinus subvexus	30	33	..	N. Fork of Tule River, 1.2 miles above Milo, W. slope Sierra Nevada, Tulare Co.
Madia elegans ssp. vernalis	18	..	..	Sacramento Valley, 1 mile south of Orange Vale, Sacramento Co.
Malacothrix arachnoidea	40	8	.03	Carmel River Valley about 10 miles above Carmel, Monterey Co.
Mentzelia laevicaulis	44	12	.03	Lytle Creek, 1.5 miles below U.S.F.S. Camp at Glenn Ranch, San Gabriel Mts., San Bernardino Co.
Mentzelia Lindleyi	45	12	.02	Purchased from Theo. Payne.
Monardella lanceolata	36	8	.01	Bradshaw's Camp on the Bass Lake, Wawona Road, 3 miles from the Mariposa Co. Line, west slope Sierra Nevada, Madera Co.
Monardella undulata	37	12	.03	Pt Reyes Peninsula, 3 miles by road from the lighthouse, Marin Co.
Nemophila maculata	26	12	..	.5 mile east of Meadow Lakes on Pineridge, Auberry Road, west slope Sierra Nevada, Fresno Co.
Oenothera brevipes	39	8	.02	Mojave Desert, Ord Mt. region, 2.5 miles northeast of Aztec Spring on road to Kane Spring, San Bernardino Co.
Oenothera deltoides var. cognata	43	7	.03	At north side of Merced River on U. S. Hwy. 99, between Merced and Modesto, San Joaquin Valley, Merced Co.
Pectis papposa	34	7	.05	Twenty-nine Palms, San Bernardino Co., Coll. by Went.
Penstemon heterophyllus var. australis	2	7	.02	Near low place on road from Modjeska Peak to Santiago Peak, Santa Ana Mts., Orange Co.
Penstemon spectabilis	13	7	.02	2 miles south of summit of Skyline Drive on road along ridge to Santiago Peak, Orange Co.

Name	No. Under which Tested	Days in Desiccator	Initial Pressure mm. Hg. in Tubes	Source of Seed
Phacelia brachyloba	70	7	.005	1.7 miles above the junction of the U.S.F.S., Main Divide and Trabuco Canyon Truck Trails, Orange Co.
Phacelia ciliata	71	7	..	Mt. Pinos Region, Lockwood Valley, at lower end of Bitter Creek, Ventura Co.
Phacelia curvipes	68	12	.02	Tejon Canyon, 2.8 miles above the Tejon Canyon School, Kern Co.
Phacelia grandiflora	74	7	.05	2.4 miles north of Lilac School on road to Pala, San Diego Co.
Phacelia Parryi	69	7	.04	Purchased from Theo. Payne.
Phacelia tanacetifolia	72	7	.05	Cottonwood Canyon, .3 mile east of San Luis Obispo County Line, Diablo Range, Kern Co.
Phacelia viscida	73	7	.05	Purchased from Theo. Payne.
Platanus racemosa	47	8	.01	Santa Ana Mountains, Irvine Park, Orange Co.
Pogogyne Douglasii	25	..	..	.8 mile from midway on the road to Mariposa, west slope Sierra Nevada, Mariposa Co.
Psilostrophe Cooperi	41	8	..	Mojave Desert, 11 miles north of Valley Wells, road to Kingston, San Bernardino Co.
Salvia carduacea	22	13	.03	6 miles north of Tejon Ranch Headquarters, Tejon Ranch, upper San Joaquin Valley, Kern Co.
Salvia spathacea	110	10	.025	Aliso Canyon, Rancho Santa Ana, San Bernardino Co.
Sisyrinchium bellum	21	7	.01	Rancho Santa Ana, southwest corner of Sect. 16, San Bernardino Co.
Suaeda Torreyana	42	8	.02	.8 mile south of Tecopa, Death Valley region, Inyo Co.
Tanacetum camphoratum	38	8	.03	47th Avenue and Pacheco Street, San Francisco, San Francisco Co.
Tidestromia oblongifolia	80	..	..	Death Valley region, .8 mile southeast of Tecopa, Inyo Co.
Trichostema lanatum	113	12	.1	Seed from plants from Prop. No. 2465, from 3.5 mi. above where Los Angeles Aqueduct crosses road in Bouquet Canyon, Los Angeles Co.