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Delayed Germination

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DELAYED GERMINATION.

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In 1901 there was begun[1] a study of the germination of weed seeds under different conditions. It was observed that a large number of the weed seeds did not germinate freely in the fall.

In 1902 an experiment was performed with both mature and immature seeds. Plantings of these seeds were made in both fall and spring; the spring planting included both seeds which had been frozen and seeds which had not been frozen. It was found that seeds of different species showed great difference in germination. In general the results of 1902 and 1903 indicate that stratification in sand and freezing is favorable to germination; thus, in the Milkweed (*Asclepias syriaca*), there was no germination upon stratification but afterwards 12 per cent; Western Ragweed (*Ambrosia psilostachya*), none before and 18 per cent afterward; Lamb's quarter (*Chenopodium album*) none before and 88 per cent after stratification; Cocklebur (*Xanthium canadense*) none before and 25 per cent afterward.

Subsequently Mr. H. S. Fawcett[2] made a study of 52 different samples of mature weed seeds representing 52 different species. The samples were collected in September, October and November of 1904. The seeds were threshed out and placed in paper envelopes. Fifty seeds of each sample were placed in sand in boxes in a greenhouse and kept under conditions as nearly uniform as possible. The tests were repeated each month from November until May and all boxes of the previous months left. They were kept moist during the winter. In addition a large number of weed samples was placed out of doors to expose them to the freezing and thawing, the seeds being placed in sacks in a wooden box covered with a thin layer of sand; the box was sunk in the ground not more than a foot below the surface and left there all winter. The general effect of the thawing and freezing was to increase the percentage

[1]Pammel, L. H. Proc. Soc. Prom. Agrl. Sci. 24:89.

[2]The Vitality of Weed Seeds under Different Conditions of Treatment and a Study of the Dormant Periods. Proc. Ia. Acad. Sci. 15:25.

of germination and lessen the dormant period, especially true of seeds with hard coats; where the coats were thin the dormant period was still less than with hard coated seeds. For instance the dormant period of common Pig Weed (*Amarantus retroflexus*) was nine and one-third days when kept in packages in a dry room and only six and one-third days after having wintered out of doors. In the case of Wild Rye, the dormant period was lessened from nine to five days. In the common Foxtail (*Setaria glauca*) the average dormant period was lessened from eleven to seven and one-fourth days and the percentage of germination from 34.5 per cent to 38 per cent, while the percentage of germination in the Wild Rye was increased from 22 per cent to 48 per cent and the Pig Weed increased from 40 per cent to 50 per cent. In general, the longest dormant period was found in those seeds which have the hardest and thickest seed coats. The longest dormant period for the Great Ragweed was 152 days; the Barn-yard Grass, 178 days. In this connection it is also interesting to observe that the highest percentage of germination for any planting was the common Mustard (*Brassica arvensis*) which was 100 and for the six plantings, 90.3 per cent.

It has been known for a long time that many seeds refuse to germinate until they have passed a period of rest; Dr. MacDougal[3] calls attention to an interesting condition observed in Arizona in regard to some of the annual plants in which delayed germination occurs. Nobbe and Hanlein,[4] who made a study of the weed seeds of thirty-one different species and continued their experiments for 1,173 days, found a number of these weeds showed germination after a lapse of 1,173 days and among them were *Campanula persicifolia; Chelidonium majus; Mysosurus minimus; Plantago media: Potentilla argentea* and *Thlaspi arvense.*

Winkler[5] observes that the seeds of *Euphorbia Cyparissias* though planted in the spring did not germinate in some cases until forty years later. He states also, that the seeds of *Malva moschata* will not germinate in the season of their production.

Wiesner[6] states in some cases nine years are required for the germination of *Euphorbia exigua.* He notes, also, the well-known fact that in the case of Red Clover *Trifolium pratense,* some seeds will germinate the

[3]The Course of the Vegetation in Southern Arizona. Plant World Nov., 1908. Separate 13.

[4]Ueber die Resistenz von Samen gegen die ausseren Factoren der Keimung. Landw. Versuchs-Stat. 20:63-96. 1877; the original of this paper was not available, the facts are taken from Crocker. Hanlein, Ueber die Keimkraft von Unkrautsamen. Landw. Versuchs-Stat. 25:465-470. 1880.

[5]Bermerkungen uber die Keimpflanzen und die Keimfahigkeit des Samen von *Tithymalus Cyparissias.* Ber Deutsch. Bot. Gesells. 1:452-455. 1883.

first year while others later. The same is true of the Black Locust, *Robinia Pseudo-Acacia* and *Cytisus Laburnum*. In these seeds the differences are due to the unequal ability of taking up water required for germination. Delayed germination was also observed in *Reseda lutea* and *Dianthus armeria*.[6] The seeds of *Sonchus oleraceus* are said not to germinate the following season but to do so at a later period. Wiesner[7] found in the case of *Viscum album*, that the seeds would germinate only sparingly in the fall but readily in the following spring; that these seeds have dormant periods of at least six months and that light is favorable for their germination.

Gifford is authority for the statement in the case of the White Pine that a few seeds will germinate the first year, a large number the second and a few the third. It is well known that cones of the Jack Pine often hang on the tree for twelve or thirteen years—according to Sudworth[8] seven to nine years; also that when a fire passes through, the cones burst open and the seed is ready to germinate. In many cases the seeds of forest trees will germinate better after being subjected to freezing, or in other cases endure freezing but germinate quite as well if not frozen. Many of the seeds of our common Red Cedar will not germinate the first season.

How long some seeds will retain their vitality has never been definitely determined for many species, although we have accurate data for many seeds, particularly the exhaustive work by DeCandolle.[9] It was found by this author that out of 368 seeds kept dry in air for fifteen years, only a small number—17, were capable of germinating. Of these, five species of *Malvaceae*, 9 species of *Leguminosae*, and one *Labiatae*. The experiments of Beal[10] are of interest in this connection.

In 1879, Dr. Beal selected 50 freshly grown seeds of each of 23 different kinds of plants. The seeds were well mixed with moderately moist sand; the mixture was then placed in a pint bottle, which was left uncorked, with the mouth slanting downward so that no water could collect about the seeds. The bottles were then buried three feet below the surface in a sandy knoll and at the end of 5, 10, 15, 20, and

[6]Biol. der Planzen, 45.

[7]Ueber die Ruheperiode undvon einige Keimungsbedigungen der Samen von Viscum album. Ber. Deutsch Bot. Gells. 15:505-515. 1897. See Kienitz. Bot. Centralb. 1:53.

[8]Bull. Div. of Forestry, U. S. Dept. of Agr., 29:35.

[9]Sur la Duree relative de la faculte de germer Ann. Sci. Nat. III, 6:373. 1846. Physiologie vegetale 2:618.

[10]Proc. Soc. Prom. Agrl. Sci. 26:89-1905.

25 years, sets of seed were tested for vitality. The following results were obtained:

Name of Seeds Tested as Known in 1879	5 yr.	10 yr.	15 yr.	20 yr.	25 yr.
Amaranthus retroflexus	+	+	+	+	+
Ambrosia artemisiæfolia	0	0	0	0	0
Braasica nigra	0	+	+	+	+
Bromus secalinus	0	0	0	0	0
Capsella Bursa-pastoris	+	0	+	+	+
Erechthites hieracifolia	0	0	0	0	0
Euphorbia maculata	0	0	0	0	0
Lepidium virginicum	+	+	+	+	+
Lychnis Githago	0	0	0	0	0
Maruta Cotula	+	+	+	0	+
Malva rotundifolia	+	0	0	+	0
Oenothera biennis	+	+	+	+	+
Plantago major	0	0	+	0	0
Polygonium Hydropiper	0	+	+	+	+
Portulaca oleracea	0	+	+	+	+
Quercus rubra	0	0	0	0	0
Rumex crispus	+	?	+	+	+
Setaria glauca	+	+	+	0	+
Stellaria media	+	+	+	+	+
Thuja occidentalis	0	0	0	0	0
Trifolium repens	0	0	0	0	0
Verbascum Thapsus	+	?	+	+	0

It was found that 8 out of 22 failed to germinate. All the acorns which were not placed in bottles were dead in two years.

Prof. L. R. Waldron* records some valuable experiments with buried seed of seven different common weeds.

In fall of 1889, these were planted in a seed-bed out of doors at depths of 1, 2, 3, 4, 5, 7 and 10 inches.

During the same fall Shepherd's Purse produced a few plants at depth of 1 and 2 inches; French weed 25 plants at 1 inch; wild mustard many plants at 1, 2, and 3 inches; wild oats several plants at 1, 2 and 3 inches.

During 1900 the seeds continued to germinate and it was true of them that the small weed seed did not come up through 2 inches of soil; no seeds buried below 3 inches germinated except Kinghead or Great Ragweed and wild oats, which came up through 5 inches of soil.

These data were furnished for the following weeds: Shepherd's Purse, Frenchweed, Green Foxtail, Kinghead, Wild Mustard, Wild Buckwheat, Wild Oats.

*Bull. 62, N. Dak. Exp. Sta., p. 439-445.

Becquerel[11] extended the observations of DeCandolle by removing the integuments sterilizing, and soaking the seeds and keeping them in moist cotton.

Of the 550 species studied by him, belonging to thirty orders of plants, the age of seeds varied from 25 to 135 years. The seeds from the following years germinated: *Acacia bicapsularis* from 1819; *Cytisus biflorus* of 1822; *Trifolium arvense* of 1838; *Ervum lens* of 1841; *Dolichos funarius* of 1868; *Nelumbium codophyllum* of 1850; *N. asperifolium* of 1858; *N. speciosum* of 1888; and *Lavatera pseudo-alba* of 1862.

None of the old seeds of the following orders germinated, *Juncaceae, Liliaceae, Chenopodiaceae, Papaveraceae, Caryophyllaceae,* or *Cucurbitaceae.*

Recently A. J. Ewart[12] has published an exhaustive work on the longevity of seeds. A large number were tested and the records of many are given. It would seem from the work of Ewart that many seeds have a prolonged vitality, some upwards of 50 and 80 years. A few of the results of his studies are given here:

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[11]Ann. d. Sci. Nat. Bot. IX, 5:193-320. 1907. Compt. Rend. del'Acad. des Sci. 142:1549.

[12]Proc. Roy. Soc. of Victoria. 21:1 pt. 1, 1. 1898.

Name of Seed	Years Old	No. of Seeds	Percentage of Germination
Malvaceae—			
Abutilon avicennæ	57	45	6
Var. Behriana			
Hibiscus trionum	57		12
Gossypium herbaceum	10		80
Leguminosae—			
Acacia diffusa	57	32	9
Acacia penninervis	57	15	13.3
Cytisus albus	51	54	78
Melilotus alba	44	250	52
Melilotus alba	77	1000	**18.2**
Nymphaeaceae—			
Nelumbium luteum	55	6	63
Rhamnaceae—			
Ceanothus Americanus	15	20	**0**
Cruciferae—			
Brassica alba	77	115	**0**
Compositae—			
Cichorium intybus	10	100	50
Helianthus annuus	15	20	0
Gramineae—			
Triticum vulgare	10	100	**75**
Zea Mays	7	100	36
Bromus mollis	10	250	0

THE PROLONGED VITALITY OF SEEDS.

The explanation of this must be sought not only in the structure of the seed coat but in the amount of respiration that is carried on at least at times and depends on external conditions and lastly upon certain heritable qualities. One is perhaps not very far wrong in concluding with Kolkwitz[13] that respiration is not essential to continue the vitality of seeds since many seeds will not lose their vitality by prolonged heating. Thus Pouchet[14] states that the vitality of the seeds of *Medicago sativa* was not destroyed when heated with steam heat for four hours; and Haberlandt[15] found that a large number of seeds of sixty-four different species did not lose their vitality after having been heated to 100 degrees C. for forty-eight hours. Among these we may mention some of the seeds of *Gramineae, Leguminoseae, Cucurbitaceae, etc.* Such seeds usu-

[13]Berichte d. Bot. Gesell. 19:285.

[14]Compt rend. 63:939.

[15]Allgem. Land. -u. forstw. Zeit. 1:389.
Utersuchungen auf dem Gebiete des Pflanzenbaues. 2:79.

ally germinate more rapidly than the untreated. The whole subject has been discussed by Detmer.[16]

Schroder[17] has shown that barley containing only two per cent of water germinated well after an interval of twelve weeks. Jost[18] calls attention to the fact that seeds of the grass type which can withstand thorough drying as a rule retain their powers of germination only for a limited number of years. "What the laws of germinating power depend on in the long run is not known, but when we reflect that gradual altering to reduce their solubility, we may conclude that specific protoplasmic bodies undergo as time goes on alterations calculated to render them functionless. At all events it is quite out of the question to suppose that death of the resting seed is brought about by using up reserve substances in respiration.

The writer some years ago made a test of corn kept under different conditions. One sample which germinated 100 per cent early in the spring, in the course of two months, subject to the various changes of the weather, dropped to 66 per cent. In another sample kept in the laboratory, the germination during the early spring was 98 per cent; kernels taken from the same ear two months later dropped to 80 per cent. The loss in vitality here was undoubtedly due to the absorption of moisture and respiratory changes that occurred in the seed, and Ewart[19] suggests that longevity depends not on food materials nor seed coats but upon how long the inert proteid molecules into which the living protoplasm disintegrates when drying, retain the molecular grouping which permits of their re-combination to form the active protoplasmic molecule when the seed is moistened and supplied with oxygen. The same author further demonstrated[20] that "seeds capable of withstanding thorough drying assume a perfectly dormant condition in which they do not respire and are not living although they have a power of restoring life potential in them for a longer or shorter period of years." And Becquerel concludes that only those seeds can preserve their vitality which have thick coats and are impermeable to water and oxygen and do not have a large amount of oxydizable reserve matter. This conclu-

[16]Vergleichende physiologie des Keimungsprocesses der Samen. 102.
See also paper by Edwards and Colin, Ann. d. Sc. Nat. Bot. 1:264. 1834. Sachs Handbuch d. Experimental physiologie d. Pflanzen. 66.

[17]Unters bot. Inst. Tubingen. 2:1.

[18]Lectures on Plant Physiology, Eng. Trans. by Gibson. 342.

[19]Proc. Roy. Soc. of Victoria. 21:184, 1 pt.

[20]Trans Liverpool Biol. Soc. 8:234. 1894.

sion, however, is incorrect, as Ewart states, because the long-lived seeds, and many of them have starchy material, are found in the *Leguminoseae*.

Some years ago one of us[21] made a study of the seeds of leguminous genera found in Gray's Manual. It was found that nearly all of the seeds studied had a cuticle, especially pronounced in the *Mimoseae*, *Caesalpinieae* and most of the *Papilionaceae*. Many of the seeds are known to have an especially long vitality.

It has long been known that some of the seeds of the *Leguminosae*. especially clover, will not germinate the same season that they are planted. The best seeds of the red clover are the purple, these are also the hardest. Hiltner[22] was the first to show that when hard seeds of clover are treated with sulphuric acid they germinate after treatment. Jarzymowski,[23] Ewart and others have shown that such treatment hastens germination. Bergetheil and Day[24] and Miss White[25] have shown that the cuticle is impermeable to water.

It has long been known that certain paired seeds like the cocklebur will not germinate the same season. The cocklebur seeds were first carefully studied by Arthur[26] who found that generally the germination of one seed is delayed although both may germinate the same season. Nobbe and Hanlein's observation on some weed seeds show the same facts.

AN EXPERIMENT WITH SOME IOWA WEED SEEDS.

In 1906 an experiment was started with 130 different kinds of weed seeds. The seeds were mature so far as we could tell. They were placed in paper packages and left in the laboratory. Plantings were made as follows: November, December, January, March and April. A second set of samples of the same weed seeds of 130 species was placed in linen sacks, covered with earth and buried six inches in the soil. They were thus subject to the varying conditions of an Iowa winter. These seeds were carefully removed in April and planted with the other samples for comparison. The tables are too long to produce in this con-

[21]Pammel, L. H. Trans. Acad. Sci., St. Louis, 9.89.

[22]Arch. aus d. biol. Abt. f. Land u. Forst. Wiss. 3:30, 1902.

[23]Inaug. Diss. Halle. 1905.

[24]Ann. of Bot. 21: Jan., 1907.

[25]Proc. Royal Soc. Victoria. 21:203.

[26]Proc. Soc. Prom. Agrl. Sci. 16:70.

[27]Ueber die Resistenz von Samen genen die aussern Factoren der Keimung Landw. Versuchs. Stat. 20:63. Ueber die Keimkraft von Unkrautsamen. Landw. Versuchs Stat. 25:465.

nection. The germination of a few typical illustrations may be brought together in the following table.

PERCENTAGE OF SEEDS GERMINATED BY MONTHS.

Name of Weed	Nov.	Dec.	Jan.	Feb.	Mch.	April	Fr'z'n April
1. Abutilon Theophrasti	9.	37.3	11.3	28.6	27.7	37.3	36.
2. Amaranthus graecizans	9.3	2.6	.66	0	10.	7.3	32.
3. Ambrosia artemisiæfolia	9.2	8.	8.	7.	7.	26.	21.5
4. Arctium Lappa	10.	6.	1.5	1.33	2.	2.6	.42
5. Apocynum cannabinum	54.	12.25	4.	------	2.	46.	54.
6. Brassica arvensis	25.5	39.	34.	33.	19.	52.	44.
7. *Cicuta maculata							
8. Cassia Chamæcrista	16.3	13.6	15.3	3.	2.	8.6	33.
9. Chenopodium album	22.6	20.6	2.6	19.3	15.3	3.	44.6
10. Cirsium lanceolatum	14.	13.3	9.	1.	20.6	16.	34.6
11. Echinòchloa crusgalli	4.6	17.	4.	3.	8.5	13.6	57.
12. Lactuca Canadensis	0	2.6	.50	7.	2.	2.	39.3
13. Melilotus alba	2.5	4.	2.6	6.6	2.5	6.	11.3
14. Plantago major	4.	9.5	.50	1.3	1.5	5.5	32.
15. Polygonum pennsylvanicum	3.	5.5	8.5	0	1.	0	45.
16. Panicum capillare	4.5	8.6	5.	2.6	1.	8.5	28.
17. Rumex crispus	15.3	18.5	1.5	12.	15.4	12.	36.
18. Setaria glauca	5.5	10.	7.5	.66	50.5	32.	35.7
19. Verbena urticæfolia	5.5	5.	1.	.66	4.5	5.3	31.5

The foregoing table further illustrates the differences caused by freezing in the germination of weed seeds; for in the most cases, the germination was greater after the seeds had been subjected to thawing and freezing than when kept in packages in a dry room. Of the November planting, November, 1908, of a total number of 65 species, four species failed to germinate; of 60 species in December, 48; of 63 species in January, 44; of 62 species in March, 27; of 59 species in April, 46; of the seeds exposed to the weather, 64 species, 24 failed to germinate.

The seeds of many of the weeds germinate in a very irregular manner. A few may be given to illustrate this:

*No results.

PERCENTAGES BY MONTHS AND YEARS.

Name of Weed	Nov.				Dec.				Jan.				March				April				April 1st Subjected to Freezing			
	1905	1906	1907	1908	1905	1906	1907	1908	1905	1906	1907	1908	1905	1906	1907	1908	1905	1906	1907	1908	1905	1906	1907	1908
Amaranthus retroflexus	32	6	12	0	38	10	2	2	4	12	0	0	6	26	4	--	12	28	10	0	26	22	62	30
Bidens frondosa	8	4	4	0	2	0	6	0	0	2	0	0	0	0	8	0	0	6	--	0	2	86	68	2
Datura stramonium	0	22	100	--	0	50	70	--	0	32	20	--	0	22	40	--	0	26	46	--	--	28	70	--
Helenium autumnale	--	2	0	--	--	6	0	--	--	6	0	--	--	--	0	--	--	4	--	--	--	4	--	--
Lepidium apetalum	32	14	22	--	32	64	24	--	40	56	2	--	28	94	--	--	54	94	58	--	0	86	32	--
Pastinaca sativa	--	2	30	16	--	10	68	20	--	6	0	8	--	8	52	20	--	72	62	14	--	48	92	98
Setaria viridis	42	14	10	0	66	34	--	0	18	28	2	2	6	50	0	8	82	70	4	0	38	66	6	0
Sonchus oleraceus	52	2	2	--	42	26	6	--	--	2	0	--	--	0	2	--	8	6	2	--	--	38	8	--

The results of these tests seem to indicate the uncertainty with reference to the germination of these various specis of plants. It has been shown by Dr. Beal[28] that certain seeds when buried soon lose their vitality. This was true of *Bromus secalinus* and Duvel[29] has shown this to be true also for some seeds studied by him. The average germination in buried seeds was as follows: Original tests, 63.2 per cent; control in chamber, 57.5 per cent; control in greenhouse, 53.2 per cent; buried 6-8 inches, 20.5 per cent; buried 18-22 inches 26.5 per cent; buried 36-42 inches, 31 per cent. This writer also indicates that there was a considerable loss in the vitality of seeds with hard coats like *Lespedeza* and *Medicago*. For instance, in the case of red clover, seed harvested in the same year was planted in 1902, germinated 2. 4, and 4 per cent for the three different depths of 6-8, 18-22 and 36-42 inches. The hard seed in the clover remained over in the soil. He concludes that the seeds of cultivated plants with but few exceptions lose their vitality when buried in the soil. That seeds of the plants commonly designated as weeds retain their vitality remarkably well when buried in the soil.

Wiesner[30] states that the seeds of *Pontederia crassipes, Mayacca fluviatilis, Heteranthera* will germinate in water if previously dried out in the air, according to F. Muller[31] and according to Bohm[32] *Phascolus multiflorus* will not germinate in the absence of lime salts.

[28]Bull. Mich. Agrl. Col. 5:1884.

[29]The Vitality of Buried Seeds, Bull. B. P. I. U. S. Dept. of Agrl. 83.

[30]Biol. der Pflanz. 45.

[31]Cosmos. 7:183.

[32]Sitzungab. d. Kais. Akad. d. Wis. Wien. 71.
See also Stohman Ann. d. Chem. u. Pharm. 1862. 121:319.

It may be added that Schofield[33] found that the seeds of *Zizania aquatica* soon lose their vitality if exposed to the air and that they germinate only when kept in moist earth or mud. Mr. J. J. Thornber[34] finds that with seeds flooded to a depth of 12 inches for a period of 30 days, there were obtained germinations as follows: Bermuda grass 42 per cent, Johnson grass 45 per cent, *Sesbania macrocarpa* 75 per cent. When extended to 50 days, Bermuda grass germinated 14 per cent, Johnson grass 23 per cent. After submergence of 21 days, radish, rutabaga, sugar beet and tomato seed germinated 100 per cent, cabbage and celery seed 75 per cent, and water melon 33 per cent.

There may be mentioned in connection with studies of germination under induced conditions, the experiments of Italo Giglioli[35] who has shown that latent vitality may occur in seeds when surrounded by gases and liquids. The seeds of alfalfa when in nitrogen dioxide for 776 days germinated 43 per cent, sulphuretted hydrogen 976 days germinated 58 per cent; arseniuretted hydrogen 802 days germinated 87 per cent. The seeds were air dry and placed in bulbs. In regard to liquids the results are surprising, methyl alcohol 841 days, per cent of germination 19 per cent; carbon disulphide 405 days per cent of germination 63.2. Moist seeds kept in oxygen and in nitrogen protoxide do not germinate. Alcoholic solution of iodine 382 days, per cent germination 1.5, alcoholic solution of potassium bromide 757 days 68.4. Giglioli re-examined the seeds of alfalfa which had been kept in the gases and liquids during this time; Hydrogen 16 years, none germinated; wheat and cynara gave the same result. With chlorine and hydrochloric acid gas, seeds of alfalfa 16 years, 3 months and 5 days old, 6.72 per cent germinated. Alcoholic solution of sulphuretted hydrogen, alfalfa 15 years, 9 months, 15 days, 7.03 per cent germinated. These experiments seem to show that seeds may retain their vitality when all respiratory exchange is completely prevented for a long series of years.

To test the vitality of clover seed gathered in the year 1905, the following experiment was conducted;[36] the seeds were treated with hot water, dilute sulfuric acid, concentrated sulfuric acid and, in one case, by scratching.

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[34]The Viability of Seeds. Plant World 11:158.

[35]Latent Vitality of Seeds. Nature 52:544. Action of Gases and liquids on the Vitality of Seeds. 35:328.
Gazette Chimica italiana. 9:19. 1879.
Gior delle staz sper, ital. 8:199. 1874.

[36]This experiment was conducted by J. R. Campbell under our direction.

PERCENTAGE OF GERMINATION AFTER TREATMENT.

	Germination in 24 Hours	Germination in 48 Hours	Germination in 72 Hours	Final
Check—				
Purple, '06	1	3	14	15
Yellow, '06	0	3	11	12
Purple, '09	14	23	30	30
Yellow, '09	3	46	48	48
Hot Water—				
Purple, '06	0	0	0	1
Yellow, '06	0	0	0	0
Purple, '09	0	0	1	1
Yellow, '09	0	1	2	2
Sulphuric acid—				
Purple, '06	0	1	4	6
Yellow, '06	0	2	7	10
Purple, '09	4	37	42	42
Yellow, '09	4	17	18	19
Sulphuric acid, 2 min.—				
Purple, '09	2	5	10	12
Scratched—				
Purple, '06	0	5	11	14
Yellow, '06	1	3	9	9
No. 82—				
Purple, '09	25	33	42	42
Yellow, '09	5	35	36	36
No. 70—				
Purple, '09	21	30	35	35
Yellow, '09	33	35	39	40
No. 71—				
Yellow, '09	29	30	41	41

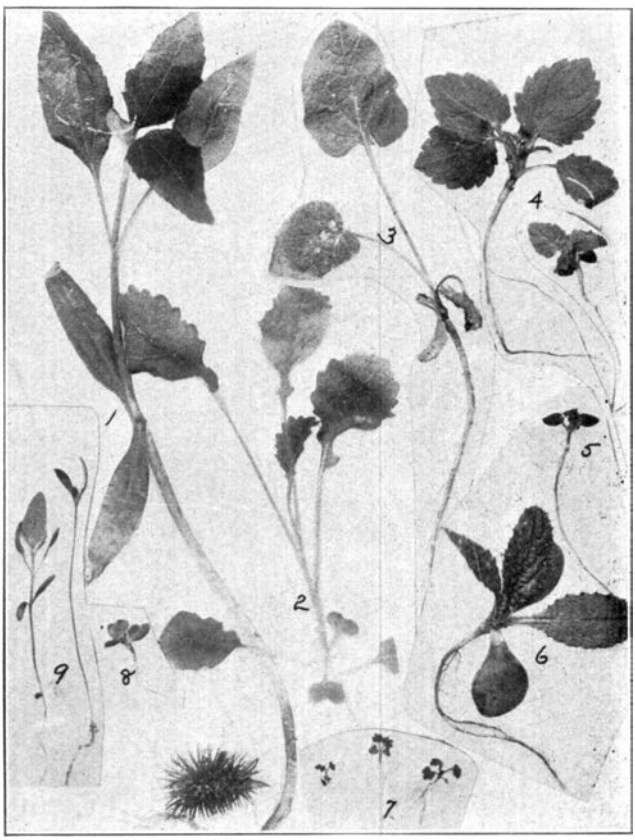
Undoubtedly the hard clover seeds as well as the hard seeds of other plants are for the purpose of tiding the seed over unfavorable conditions. It has been well said by Mr. Ewart, "Macrobiotic seeds are all seeds which show no especial adaptation for dispersal. None are wind or water borne and although some are more or less accidentally distributed by animals, adhesive seeds or fruits are conspicuously absent among them. They are, in fact, distributed in time instead of in space. Falling to the ground beneath or close to the parent plant, a few are immediately germinable but others only after long periods of years or after special actions have been brought to bear upon them."

The case is, however, very different with many seeds that are found in low damp situations like the willow and the cottonwood and the soft

maple. The seeds fall on the damp earth or mud and here the conditions are favorable for immediate germination.

The seeds of the ash and horn-bean begin to germinate the year after they ripen; it is also known that the seeds of many trees and some shrubs which mature early in the season do not retain their vitality for germination a great length of time. The following experiment was conducted with the common soft maple (*Acer saccharinum*).

On June 3d the samaras of the species were beginning to fall from the trees. They were collected and kept under different conditions as follows: A large number of seeds were stored in the cooling room of the college creamery at 45 degrees F.; another sample was left in the laboratory exposed to dry atmosphere; still another sample was left in a pasteboard box between folds of damp cloth; another was placed in damp sand immediately after being picked from the ground.



Some weed seedlings.

1. Xanthium canadense.
2. Brassica nigra.
3. Arctium Lappa.
4. Scrophularia nodosa.
5. Eupatorium.
6. Cirsium lanceolatum.
7. Nepeta cataria.
8. Solidago rigida.
9. Chenopodium album.

Kind of Seed and Treatment	Collected	Planted	Days Dormant	Percent Germination
Soft Maple—				
1. Placed in damp cloth; became slightly mouldy..	6- 3-09	6- 7-09	7th day, 2; 8th, 23; 9th, 7; 10th, 2; 11th, 6; 12th, 2; 13th, 1; 14th, 1; 15th, 2; 16th, 1; 22d, 2.....	75
2. Placed in paste board box in laboratory and kept dry	6- 3-09	6- 7-09	8th, 5; 9th, 12; 11th, 4; 12th, 3; 13th, 2; 14th, 1; 15th, 1; 17th, 1.....	58
3. Picked from the ground.	6- 3-09	*	9th, 1; 10th, 1; 11th, 4; 12th, 8; 13th, 6; 14th, 1;	
4. Kept in laboratory and allowed to dry out. Seeds had become much more shriveled than they were in sample No. 2, but still green	6- 3-09	6-18-09	15th, 1; 16th, 3; 17th, 3; 18th, 4; 21st, 2; 22d, 1; 26th, 5	40
			11th, 10; 13th, 3; 17th, 4; 19th, 1; 20th, 1; 28th, 1; 29th, 1	42
5. Seeds collected from the ground. In fairly good condition. The cotyledons were green	6-18-09	6-18-09	7th, 1; 8th, 2; 9th, 2; 10th, 2; 11th, 17; 13th, 3;	
6. Kept in laboratory. Same condition as No. 2. Seeds had become very much shriveled and dried out	6- 3-09	6-26-09	14th, 2; 15th, 1; 16th, 1; 20th, 1	32
			13th, 1; 15th, 1; 17th, 1..	6
7. Seeds kept in cooling room at the creamery at the following temperature: 45°F. Seeds slightly shriveled but the cotyledons green. Plants are not mouldy	.....	7- 7-09	6th, 1; 7th, 0; 8th, 1; 9th, 6; 10th, 6.....	28

It appears from these tests that the soft maple having a very thin seed coat does not retain its vitality for a great length of time because the loss of water is very rapid. Germination may be delayed by keeping the seeds at a nearly uniform temperature in a refrigerator or cooling room. Of one hundred seeds collected on July 5th from under the trees where they had fallen, none were found which were capable of germination. Many of them, or nearly all of the seeds were decomposed.

*Immediately.