GERMINATION AND DORMANCY CHARACTERISTICS OF SIXTEEN SPECIES OF WEEDY CRUCIFERS

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THESIS

This is to certify that the

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GERMINATION AND DORMANCY CHARACTERISTICS OF SIXTEEN SPECIES OF WEEDY CRUCIFERS

By

Peter Andrew Frank

AN ABSTRACT

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The purpose of this paper is to determine the dormancy and germination characteristics of the seeds of sixteen species of weedy Crucifers and to set up the most satisfactory laboratory procedure for germinating these seeds.

The species of seeds selected for this work included:

1. Arabis glabra (L.) Bernh.
2. Garbarea vulgaris R. Br.
3. Berteroa incana (L.) DC.
4. Brassica arvensis (L.) Ktze.
5. Brassica campestris L.
6. Brassica nigra (L.) Koch.
7. Camelina microcarpa Andrz.
8. Capsella bursa-pastoris (L.) Medic.
9. Erysimum cheiranthoides L.
10. Lepidium apetalum Willd.
11. Lepidium campestre (L.) R. Br.
12. Radicula palustris (L.) Moench.
13. Raphanus raphanistrum L.
14. Sisymbrium altissimum L.
15. Sisymbrium officinale (L.) Scop.
16. Thlaspi arvense L.

Where the seeds were available, germination tests were made on mature, immature, and old seeds of each of the species tested. The germination tests were made in petri dishes on a blotter paper substrate using two replicates of 100 seeds per replicate. Germination was considered to have occurred when the cotyledons and radicle emerged from the seed coat.

The germinating temperatures used in making the tests were: constant temperatures of 20°C., 25°C., 30°C. and alternating temperatures of 20°C. and 30°C. Germination tests using the above temperatures were made both in light and in darkness.

In addition to germinating each of the samples under the above conditions, some samples were given special treatments in an effort to break their dormancy. These treatments were: a prechill treatment for five days at a temperature of 5°C., the use of 0.2 percent solution of potassium nitrate for moistening the substrate, and treatment of the seed coats of two samples were removed to determine what effect this treatment would have on the percent germination.

The mature, immature, and old seed samples were germinated to determine what differences in the germination characteristics, if any, existed in seeds differing in age and stage of maturity.

The data obtained show that practically every sample of freshly harvested seed was in a dormant state and that this dormancy was, in most cases, lost to some extent as the seeds aged. In a few cases, the dormancy was lost entirely.

The temperature condition found most favorable for germination in most samples, was the alternating temperatures of 20°C. and 30°C. Many of the samples showed considerable light sensitivity, some samples germinating better in light, while others germinated better in darkness. The old seed samples showed considerably less sensitivity to temperature than did the freshly harvested seeds. The light sensitivity appeared to be as prominent in the old seeds as in the freshly harvested seeds. In most cases, there were not many differences in the germination characteristics of freshly harvested mature and immature seeds of the same age.

The potassium nitrate treatment was found, in most cases to promote germination and in some samples, the dormancy was completely broken. The sulphuric acid treatment was found difficult to use but did break the dormancy in two samples of seed. The prechill treatment did not prove effective in breaking dormancy but did increase the percent germination in a number of samples, notably those relatively uneffected by the potassium nitrate treatment. The two samples having the seed coats removed, germinated 100 percent.

Some samples did not germinate under any of the conditions used in this work and some other treatment will have to be found to promote germination in these.

Tables showing all of the results obtained in these germination tests and the treatments giving the best results are presented.

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INTRODUCTION

The first requirement in attempting to germinate seeds is a knowledge of the environmental conditions under which the seeds will successfully germinate. That these conditions vary greatly can easily be seen by attempting to germinate a number of different seed samples under identical conditions.

Seed germination is for most purposes defined as "the resumption of growth of an embryo of a seed with the emergence of plumule and radicle from the seed coat." For the majority of seed plants all that is required to induce germination is to expose the seed to what are generally termed "suitable" conditions of moisture, temperature, and oxygen.

In plants of the temperate zone, the seeds generally have a period of dormancy following maturation. Howard (7) observed that more than 75 percent of the species, wild and cultivated, growing around Columbia, Missouri have a distinct period of dormancy. This dormant period, when the seeds will not germinate even though exposed to conditions usually suitable for germination, may be due to several factors. Some of the principal factors inducing dormancy are:

1. immature embryos,
2. impermeable or hard seed coats which restrict the entrance of oxygen and water to the embryo or are too hard mechanically to allow emergence of the embryo, and
3. morphologically mature embryos requiring physiological changes to occur before being capable of germination.

In addition to the primary dormancy of seed there is also a condition known as secondary dormancy. This type of dormancy occurs when germinable seeds are exposed to certain external conditions which throw them into dormancy.

It has been demonstrated by many investigators that by certain treatments, the causes of primary and secondary dormancy may be completely removed allowing the seed to germinate. Included in these treatments are: exposure to optimum light and temperature conditions, scarification, and the application of various chemicals.

Though the underlying causes of germination and dormancy are not fully understood, much work has been accomplished in recent years. As is usually the case, the seeds of cultivated plants have been the first and most widely investigated while the "weedy" species have been largely neglected. There is no doubt that, in the future, as the need arises more investigation will be carried on concerning the germination of such seeds.

With the increased use of herbicides in weed control, there is a definite need for determining the viability not only of treated weed seed but also of the seeds produced by herbicide treated plants. Seed producers may, in the future, object to the practice of considering all seeds in a seed sample viable without making an accurate determination of the viability.

Seed analyses at the present time have very little information on which to base their germinating procedures for weedy seeds. The experiments herein reported have been done with the hope that additional information, with particular reference to sixteen species of weedy Cruciferae, may be added to the meager supply now available.

REVIEW OF LITERATURE

That many seeds require special treatment to promote germination was recognized as long ago as 1860 when Caspary (8) called attention to the light sensitivity of some seeds. Since that time, others have shown that there are a number of other factors capable of influencing the germination of seeds. Among these are temperature, after-ripening, scarification, chemicals applied externally, and substances contained in or produced by the seed.

Everson (5) found that most weed seeds would germinate over a wide range of temperature when after-ripened but only with special treatment if not after-ripened. This after-ripening was found to be hastened by special temperature treatment. In the particular kinds of seeds tested, light was not found to be definitely inhibitive to germination. For six species of Crucifer seeds tested, he found that an alternating temperature of 15°C. or 20°C., maintained for 16 hours and 30°C. for eight hours, was the optimum termperature. All species were germinated in light and in the special case of seeds of Brassica kaber L. prechilling for five days at 2°C. to 10°C. was used to break the dormancy.

Cross (2) also found that an alternating temperature gave the best results. She used an alternating temperature of 8°C. for six hours, 20°C. for ten hours, and 30°C. for eight hours. Germinations at the above temperatures in light on a soil substrate, gave the best results.

Shuck (13) observed that Mustard seeds had a natural tendency to go into a dormant condition. This tendency was most pronounced in in *Brassica arvensis* (L.) Ktze. Freshly harvested Mustard seeds were very sensitive to high temperatures. Prechilling at 6°C. for three to five days was often required before germination would take place. Seed which germinated at 20°C. in light, often reverted to the dormant condition when put in darkness. A 0.2 percent solution of potassium nitrate was very effective in promoting germination at temperatures of 15°C. to 20°C. in light but sometimes had an inhibitory effect at temperatures of 25°C. to 30°C. Not all of the lots of fresh seed gave good germination results at the same temperature. The length of prechilling time also affected the results when the seeds were later exposed to a higher temperature. When seeds were prechilled for too long a period they did not germinate well, but this could be overcome by the use of an alternating temperature. Mustard seeds generally germinated more readily following dry storage but occasionally reverted to the dormant state under such conditions. Reversion of seed to the dormant condition was considered to be due to the slowing down of the metabolic processes caused by unfavorable temperature, light, or moisture conditions.

In germinating seeds of herb and drug plants (6), light and potassium nitrate solution were needed to break the dormancy of *Lepidium sativum* L. and *Barbarea verna* (Mill.) Asch. The former germinated best at a constant temperature of 15°C., while the latter germinated better at an alternating temperature of 20°C. and 30°C.

A considerable number of cultivated species of *Brassica* were germinated by a number of investigators to determine the proper laboratory procedure and in practically every case an alternating temperature of

20°C. and 30°C. gave the best results (12,16). Dormant samples of cultivated Mustard were easily made germinable by treating them with a potassium nitrate solution.

Dormancy in Mustard seeds and the majority of other seeds were considered by Thornton (15) to be due to the impermeability of the seed coats to gases. Carbon dioxide and possibly other inhibiting substances were believed to be prevented from escaping and oxygen prevented from entering. If the seed coats were removed, the toxic substances escaped and the oxygen supply to the embryo was increased and resulted in the germination of the excised embryos. Temperature was considered to be very important in promoting dormancy. For each rise in temperature, the rate of respiration increased with a greater release of carbon dioxide and a greater need for oxygen. When the temperature reached a sufficiently high value, the seeds were thrown into dormancy.

Kidd and West (10) found that dormancy could be induced in Brassica alba (L.) Boiss. by increasing the carbon dioxide pressure. The percent of carbon dioxide required varied with the temperature and the supply of oxygen. At 3°C., two to four percent carbon dioxide was sufficient to induce dormancy. Dormant embryos which were removed from the seed coats were found much more sensitive to germinating conditions but still remained dormant for varying lengths of time.

Kidd and West (11) also found only two methods were successful in germinating seeds of Brassica alba that had been forced into dormancy by carbon dioxide. One method was by redrying the seed and the second method was by removing the seed coats. Green ripe, yellow ripe, and dry ripe seeds were all found to germinate readily when the seed coats were removed. The green ripe seeds were found to be the most difficult to germinate with the seed coats intact since they had the most impermeable seed coats.

An inhibitor was found by Cox, Munger, and Smith (1) to be present in the seed coats of certain varieties of Brassica oleracea L. Freshly harvested seed was after-ripened for five days at 4°C. Following this, the seed coats of one lot were removed, one lot was left with the seed coats intact, and one lot had the seed coat slit to expose the radicle and cotyledons. All lots were germinated at 30°C. in darkness. There was no difference in the germination results of the control lot and the lot with the seed coats slit. The excised embryos germinated immediately with a much higher percent germination than the other two lots. The average rate of growth was greatest for the lot having the seed coats removed. Treating the seed coats with cold concentrated sulphuric acid was found to be effective in promoting germination of these dormant seeds. It was believed that the acid broke up many of the cells containing the inhibiting substance which was subsequently leached away. A water soluble alcohol extract was made from the ground seed coats. The extract inhibited germination, as compared to the controls, for five days. At the end of 12 days, however, germination of the extract treated seed exceeded the germination of the controls.

An extract was made from the seeds of Raphanus sativus L. by Ivanovics and Horvath (9). This extract, called Raphanin, was found to be highly active in preventing the germination of many seeds, including Brassica oleracea and Sinapis alba L. at a dilution of 1 : 1000. The germination of radish seeds was unaffected by this extract.

Evenari, Konis, and Ullmann (4) have shown that the essential oils extracted from the valves of Mustard fruits inhibited germination of Mustard seeds and the seeds of other plants. This inhibitor was found to be effective whether in contact with the seeds or not. Much the same was found to be true of other chemicals extracted from other plants.

Volatile products produced by germinating radish seeds were found to be sufficiently toxic to kill potato plants when both were enclosed in the same chamber (3). Evenari, Konis, and Ullmann (4) suggest that the function of these inhibiting substances is to prevent the premature germination of seeds enclosed in their fruit and to prevent the germination of seeds of other plants nearby.

MATERIALS AND PROCEDURES

The various species of seed tested in this work were collected during the summer of 1951. All of the species were found in the vicinity of East Lansing, Michigan, with the exception of *Raphanus raphanistrum* L. and *Brassica campestris* L. which were supplied by Dr. F. H. Steinmetz, Head of the Department of Botany and Entomology, University of Maine, Orono, Maine. Since samples of both mature and immature seeds were needed, the harvest period was necessarily extended over a period of several weeks with samples being harvested as they reached the desired stage of maturity.

The purpose in collecting samples of both mature and immature seed was to determine, if possible, whether differences existed between the dormancy and germination characteristics of the two types of seed. Samples of old seed, the majority of which had been harvested the preceding year, were germinated and used as a further comparison.

All germination tests were made using petri dishes with blotter paper as a substrate. Moisture was provided by wetting the substrate with distilled water. To provide the desired temperatures, thermostatically controlled germinators were used. Continuous light was provided by installing incandescent lights outside the glass doors of the germinators and the amount of light used was six foot-candles. The seed samples which were to be germinated in darkness were placed in light tight coffee containers lined with moist blotter paper.

The first germination tests of each species were made shortly after harvest. In all, four germination tests were made on the majority of species. The second germination tests were made approximately two months after the first and the third germination tests were made approximately two months following the second. The last germination tests were made when most of the samples had been harvested for a period of thiry weeks.

These series of germination tests were made in an attempt to determine:

1. the degree of dormancy of the freshly harvested seed,
2. the length of time required to lose this dormancy, if lost at all, and
3. the germinating conditions most effective in breaking the dormancy and promoting germination.

The different germination conditions used were:

1. a constant temperature of 20°C. in light and darkness,
2. a constant temperature of 25°C. in light and darkness,
3. a constant temperature of 30°C. in light and darkness, and
4. an alternating temperature of 20°C. for 16 hours and 30°C. for 8 hours, in light and in darkness.

The first germination tests of the freshly harvested seeds were allowed to germinate for a period of 10 days. Later germinations of the freshly harvested seeds and the old seeds were made for a period of one week.

A number of other treatments were used on various species to determine their effectiveness in promoting germination. Among these were:

1. the use of a 0.2 percent solution of potassium nitrate in place of distilled water for moistening the substrate,
2. treating the seed coats with concentrated sulphuric acid,
3. prechilling the seeds for five days at 5°C., and
4. removal and cracking of the seed coats.

All germination tests, except those requiring either removal or cracking of the seed coats, were made using two replicates of 100 seeds each. Germination in all cases was considered to have occurred when the radicle and cotyledons emerged from the seed coat.

EXPERIMENTAL RESULTS

Germination of *Arabis glabra* (L.) Bernh.

Mature and immature seeds of *Arabis glabra* (L.) Bernh. were not available and only one germination test of the mature seed was possible. From the results of this germination test, it was apparent that these seeds were less dormant that were the seeds of the majority of the other species at a comparable age (Table 1). The seeds germinated in light gave the best results indicating that they were light sensitive to a

TABLE 1

THE RESULTS OF GERMINATING MATURE SEED OF *ARABIS GLABRA*

Germinating Conditions	Percent Germination — Age of mature seed in weeks*
	24
20°C. Light	97
20°C. Dark	87
25°C. Light	98
25°C. Dark	89
30°C. Light	31
30°C. Dark	0
20-30°C. Light	99
20-30°C. Dark	98

* Age of seed from date of harvest

certain extent. The high temperature was quite inhibitory resulting in 0 percent germination in darkness and 31 percent germination in light. Light sensitivity appeared to be lost when the seeds were germinated using an alternating temperature. Best results were obtained by the use of alternating temperatures of 20°C. and 30°C. and light.

Germination of *Barbarea vulgaris* R. Br.

The seeds of *Barbarea vulgaris* R. Br., both mature and immature, were quite dormant shortly after harvest. This dormancy was lost to some extent as the seeds aged but satisfactory germination under most conditions was not obtained even at the last germination (Table 2).

TABLE 2

THE RESULTS OF GERMINATING MATURE, IMMATURE, AND OLD SEED OF *BARBAREA VULGARIS* R. Br.

Germinating Conditions	Percent Germination								
	Age of mature seed in weeks*				Age of immature seed in weeks*				Old seed
	1	10	17	29	6	14	22	34	
20°C. Light	2	41	45	47	11	51	32	54	42
20°C. Dark	0	51	68	42	0	5	36	17	36
25°C. Light	1	32	51	70	5	63	68	79	70
25°C. Dark	0	19	51	51	1	11	39	21	69
30°C. Light	3	58	59	84	19	60	75	79	72
30°C. Dark	0	22	54	66	0	5	33	40	78
20-30°C. Light	56	77	90	93	79	84	82	83	77
20-30°C. Dark	1	31	67	75	12	52	73	71	75

* Age of seed from date of harvest

Both the mature and immature seeds were light sensitive. The mature seed gave slightly better germination than the immature seed with the highest percent germination in both samples being obtained using the alternating temperatures of 20°C. and 30°C. in light. The old seed appeared to have lost all or most of the sensitivity to light and the best results were obtained by germinating them at a temperature of 30°C. in darkness. Everson (5) also found that germinating Barbarea vulgaris in light at an alternating temperature gave the best results.

Germination of Berteroa incana (L.) DC.

All samples of freshly harvested seed of Berteroa incana (L.) DC. were quite dormant (Table 3). Much of this dormancy was lost as the seed

TABLE 3

THE RESULTS OF GERMINATING MATURE, IMMATURE AND OLD SEED OF BERTEROA INCANA (L.) DC.

Germinating Conditions	Percent Germination								
	Age of mature seed in weeks*				Age of immature seed in weeks*				Old seed
	2	10	18	29	3	11	19	30	
20°C. Light	12	35	39	54	16	32	33	59	53
20°C. Dark	12	50	76	66	11	38	62	61	58
25°C. Light	11	39	53	80	5	27	34	63	62
25°C. Dark	17	40	84	78	16	30	55	67	65
30°C. Light	4	36	87	88	1	13	26	64	60
30°C. Dark	5	62	85	76	0	14	27	41	47
20-30°C. Light	18	51	66	87	11	23	41	74	60
20-30°C. Dark	21	42	80	82	14	39	48	70	69

* Age of seed from date of harvest

aged. Light sensitivity did not appear to be an important factor in germinating seeds of this species. The mature seed in most cases gave higher results than the immature seed, while the old seed gave the lowest germination. The conditions resulting in the highest germination of the mature seeds were a constant temperature of 30°C. and light, while the immature seed germinated slightly better in darkness as the alternating temperatures. It is interesting to note that in Berteroa incana, as in a number of other species, the seeds germinated better in darkness at the lower temperatures and better in light at the higher temperature.

Germination of Brassica arvensis (L.) Ktze.

Seeds of the species Brassica arvensis(L.) Ktze. show almost complete dormancy when germinated shortly after harvest (Table 4). Light

TABLE 4

THE RESULTS OF GERMINATING MATURE, IMMATURE AND OLD SEED OF BRASSICA ARVENSIS (L.) Ktze.

Germinating Conditions	Percent Germination								
	Age of mature seed in weeks*				Age of immature seed in weeks*				Old seed
	0	8	15	28	4	12	19	31	
20°C. Light	1	2	6	36	13	10	9	31	60
20°C. Dark	1	10	13	31	7	20	3	20	44
25°C. Light	1	2	14	26	9	13	8	28	37
25°C. Dark	1	2	4	12	2	5	5	10	24
30°C. Light	1	2	13	23	3	5	2	17	22
30°C. Dark	1	0	2	10	0	1	0	0	7
20-30°C. Light	2	2	23	56	18	25	10	36	67
20-30°C. Dark	5	7	30	52	9	6	4	14	52

* Age of seed from date of harvest

sensitivity is of considerable importance, being found in the old seeds as well as the more recently harvested seeds. Some of the dormancy was lost as the seeds aged and no great difference in the dormancy of the mature and immature seeds was found. The most favorable conditions for germination in all the samples were the alternating temperatures of 20°C. and 30°C. and light. The above conditions were found to give the best results in germinating a number of other species of Brassica.

Germination of Brassica campestris L.

The seeds of Brassica campestris L., in contrast to many species of Brassica, show a definite inhibition of germination in light (Figure 1). This is especially true of the mature seeds. The freshly harvested immature seeds germinated better in light but as the seed aged the germination results in darkness were definitely better (Table 5). The degree

TABLE 5
THE RESULTS OF GERMINATING MATURE, IMMATURE AND OLD SEED OF BRASSICA CAMPESTRIS L.

Germinating Conditions	Percent Germination					
	Age of mature seed in weeks*			Age of immature seed in weeks*		Old seed
	3	7	21	5	23	
20°C. Light	11	7	27	42	20	2
20°C. Dark	75	65	88	34	58	22
25°C. Light	53	21	62	42	23	14
25°C. Dark	95	81	94	34	43	44
30°C. Light	60	65	90	44	22	35
30°C. Dark	97	97	97	34	47	43
20-30°C. Light	45	67	83	60	64	40
20-30°C. Dark	98	100	100	50	81	57

* Age of seed from date of harvest

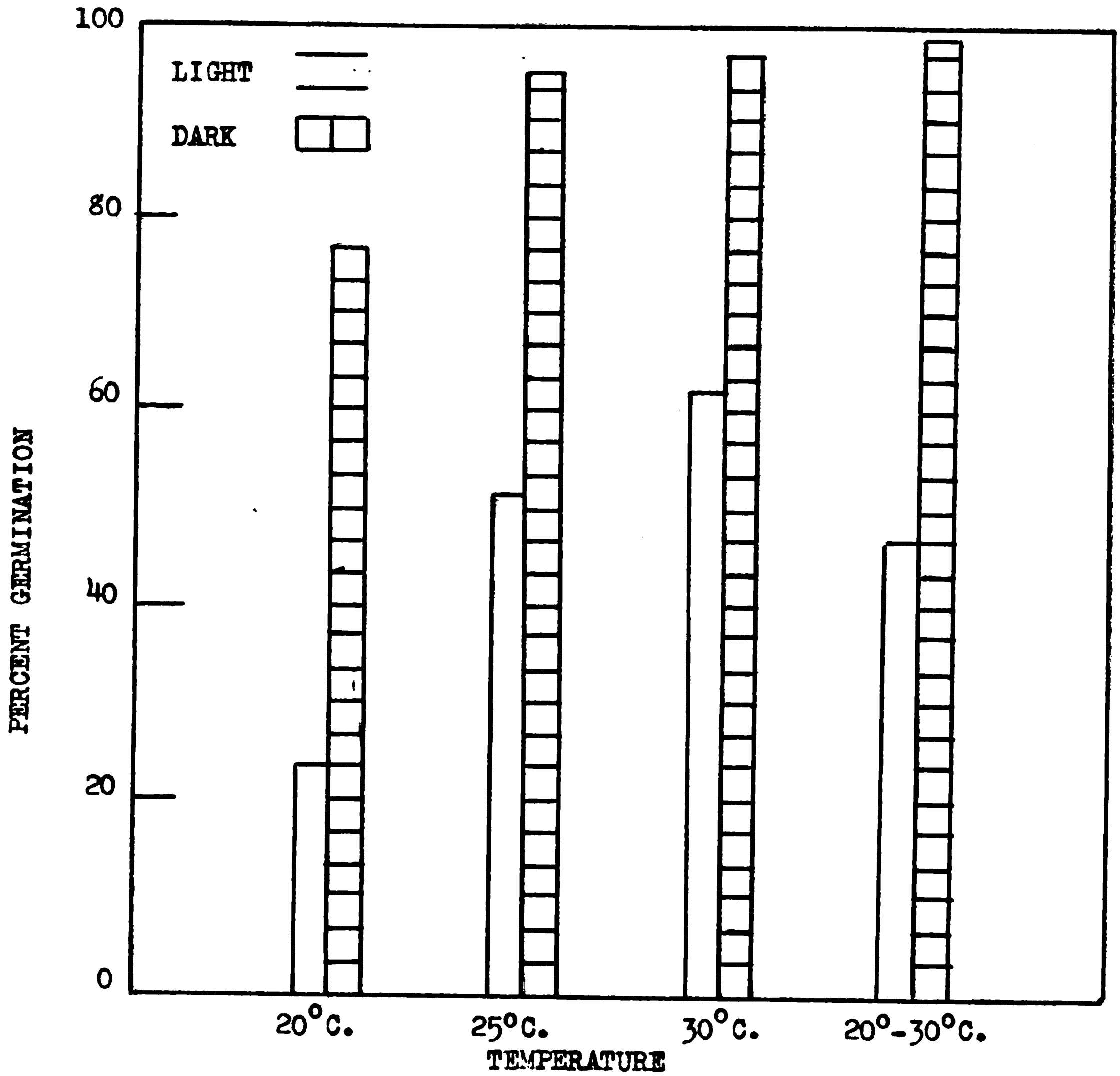

Fig. 1. Germination of mature seeds of Brassica campestris three weeks after harvest showing the inhibiting effect of light.

of dormancy in freshly harvested immature seeds is considerably higher than in the mature seed and is quite dormant, especially at the lower temperatures. Seeds germinated in darkness with the alternating temperatures of 20°C. and 30°C. gave the best results for all of the samples.

Germination of Brassica nigra (L.) Koch.

Seeds of mature and immature Brassica nigra (L.) Koch. are highly dormant when freshly harvested. The immature sample lost but little of its dormancy after aging thirty weeks. No temperature or light treatment used was particularly effective in breaking the dormancy of either the mature or immature seeds (Table 6). Mature seeds lost some of their dormancy on aging. At the low temperature the results were better when the mature seeds were germinated in darkness but as the temperature

TABLE 6

THE RESULTS OF GERMINATING MATURE, IMMATURE AND OLD SEED OF BRASSICA NIGRA (L.) Koch.

Germinating Conditions	Percent Germination								
	Age of mature seed in weeks*				Age of immature seed in weeks*				Old seed
	.5	8	15	28	3	10	18	30	
20°C. Light	0	5	19	18	0	4	3	4	82
20°C. Dark	0	12	32	24	0	1	2	4	73
25°C. Light	0	5	17	31	0	4	0	4	84
25°C. Dark	0	8	16	10	0	0	1	0	71
30°C. Light	0	2	12	37	0	0	0	1	84
30°C. Dark	0	0	5	11	0	0	0	0	58
20-30°C. Light	0	18	47	36	1	11	4	7	84
20-30°C. Dark	0	31	53	36	0	8	3	4	74

* Age of seed from date of harvest

increased the seeds germinated better in light. The old seeds germinated well at all temperatures with the best results being obtained with the use of light.

Germination of *Camelina microcarpa* Andrz.

Seeds of *Camelina microcarpa* Andrz. were both temperature and light sensitive. The seeds of both mature and immature samples were very dormant when freshly harvested and remained in this condition, under all the germinating conditions used, for approximately twenty weeks (Table 7). Best germination was obtained in all three samples when germinated at a constant temperature of 20°C. in darkness and at 20°C. and 30°C. alternating temperatures in darkness. The high constant temperature of 30°C. completely inhibited the germination of the mature and immature seeds and reduced considerably the germination of the old seeds.

TABLE 7
THE RESULTS OF GERMINATING MATURE, IMMATURE AND OLD SEED OF *CAMELINA MICROCARPA* Andrz.

Germinating Conditions	Percent Germination								
	Age of mature seed in weeks*				Age of immature seed in weeks*				Old seed
	2	12	18	30	4	13	20	31	
20°C. Light	0	0	5	42	0	9	5	25	67
20°C. Dark	0	1	12	82	2	8	32	40	96
25°C. Light	0	0	3	36	1	1	0	2	66
25°C. Dark	0	0	1	52	1	0	1	4	91
30°C. Light	0	1	0	0	0	0	0	0	66
30°C. Dark	0	0	0	1	0	0	0	0	64
20-30°C. Light	0	0	4	40	1	1	8	18	83
20-30°C. Dark	0	0	40	83	1	1	34	55	92

* Age of seed from date of harvest

Germination of Capsella bursa-pastoris (L.) Medic.

Seeds of Capsella bursa-pastoris (L.) Medic., like the majority of the other species, were very dormant when freshly harvested and but little of the dormancy was lost as the seeds aged (Table 8). Differences in the germination results of the mature and immature seeds were very slight. Germination was slightly better in darkness, especially at the alternating temperatures of 20°C. and 30°C. The old seeds did not germinate under any of the conditions used and may possibly have lost their viability due to age.

TABLE 8

THE RESULTS OF GERMINATING MATURE, IMMATURE AND OLD SEED OF CAPSELLA BURSA-PASTORIS (L.) Medic.

Germinating Conditions	Percent Germination								
	Age of mature seed in weeks*				Age of immature seed in weeks*				Old seed
	7	15	22	33	3	11	18	31	
20°C. Light	0	0	0	0	1	5	3	4	0
20°C. Dark	2	2	19	2	0	4	11	8	0
25°C. Light	0	2	3	4	0	2	1	6	0
25°C. Dark	0	2	15	1	0	1	8	8	0
30°C. Light	0	2	3	6	0	1	3	5	0
30°C. Dark	0	2	12	2	0	1	6	2	0
20-30°C. Light	0	2	4	4	0	1	6	22	0
20-30°C. Dark	2	22	48	9	0	7	42	35	0

* Age of seed from date of harvest

Germination of Erysimum cheiranthoides L.

Erysimum cheiranthoides L. is a very good example of the effect of an alternating temperature in promoting germination (Table 9, Figure 2).

The mature and immature seeds showed the usual dormancy of freshly harvested seeds (Figure 2, 3). The immature seeds showed slightly less dormancy than the mature seeds at all times. Germination was promoted only by the use of the 20°C. and 30°C. alternating temperatures, with the results being slightly improved by germinating the seeds in light. The old seed germinated poorly at the low temperatures and increased germination resulted with an increase in temperature. The best germination of old seed, however, was obtained when the seeds were germinated in darkness using the 20°C. and 30°C. alternating temperatures. The above results agreed well with those obtained by Steinbauer (14) in his work on germinating this species.

TABLE 9

THE RESULTS OF GERMINATING MATURE, IMMATURE AND OLD SEED OF *ERYSIMUM CHEIRANTHOIDES* L.

Germinating Conditions	Percent Germination								
	Age of mature seed in weeks*				Age of immature seed in weeks*				Old seed
	1	9	16	29	1	10	17	30	
20°C. Light	2	1	1	2	4	8	10	27	13
20°C. Dark	1	0	0	1	1	13	1	8	10
25°C. Light	4	2	1	2	11	17	7	11	53
25°C. Dark	0	1	0	0	0	8	4	8	52
30°C. Light	8	3	2	4	3	16	8	14	78
30°C. Dark	1	1	1	1	0	3	3	3	83
20-30°C. Light	4	14	22	90	65	76	90	94	90
20-30°C. Dark	2	24	20	81	58	87	80	94	96

* Age of seed from date of harvest

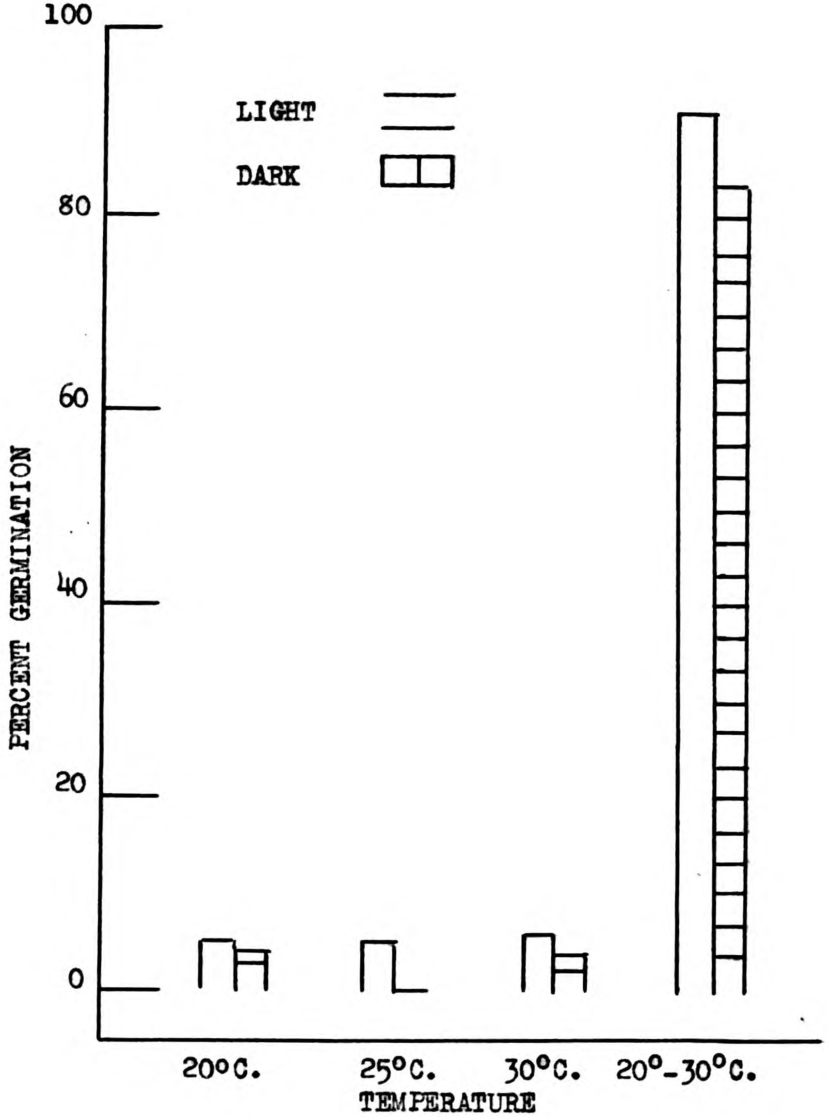

Fig. 2. Germination of mature seeds of <u>Erysimum</u> <u>cheiranthoides</u> 29 weeks after harvest.

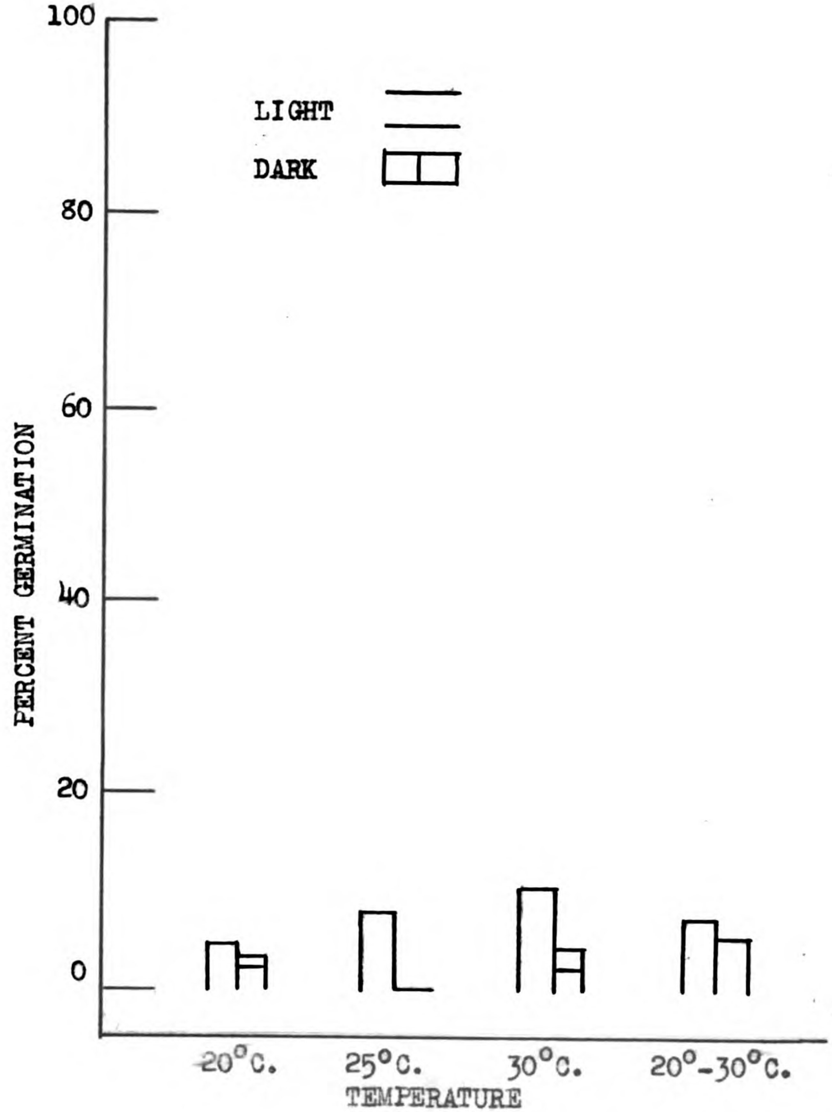

Fig. 3. Germination of mature seeds of <u>Erysimum</u> <u>cheiranthoides</u> one week after harvest.

Germination of Lepidium apetalum Willd.

Both mature and immature samples of Lepidium apetalum Willd. were very dormant when freshly harvested and remained much the same way after aging for 33 and 30 weeks respectively (Table 10). The poor germination obtained under all of the temperature and light treatment indicates that some other means must be found to promote the germination of seeds of this species. Old seeds of Lepidium apetalum were not available for testing with the more recently harvested samples.

TABLE 10

THE RESULTS OF GERMINATING MATURE AND IMMATURE SEED OF LEPIDIUM APETALUM Willd.

Germinating Conditions	Percent Germination						
	Age of mature seed in weeks*				Age of immature seed in weeks*		
	6	14	22	33	4	12	30
20°C. Light	0	0	1	5	1	0	1
20°C. Dark	0	2	7	18	0	0	6
25°C. Light	0	1	1	1	1	1	0
25°C. Dark	0	0	0	1	0	0	0
30°C. Light	0	0	0	0	0	0	0
30°C. Dark	0	0	0	0	0	0	0
20-30°C. Light	0	0	0	0	0	1	0
20-30°C. Dark	0	0	1	4	0	1	2

* age of seed from date of harvest

Germination of Lepidium campestre (L.) R. Br.

From the results shown in Table 11, it can be seen that the mature seeds of Lepidium campestre (L.) R. Br. lost the major part of their initial dormancy at the age of eleven weeks. At the age of 28 weeks nearly

100 percent germination was obtained under all of the germinating conditions with the exception of the constant 30°C. temperature.

The immature seed lost very little of its dormancy with the result that very poor germination was obtained under all of the germinating conditions even at the age of thirty weeks.

The old seeds, in contrast to the freshly harvested seeds, were to a considerable extent, light sensitive under all of the germinating conditions indicating that light sensitivity was acquired as the seeds became more aged. There also appeared to be some change in temperature requirements as the seeds became older. The freshly harvested mature seeds germinated very poorly at the constant temperature of 30°C. while the old seeds gave the best results when germinated at the 30°C. constant temperature and the 20°C. and 30°C. alternating temperatures.

TABLE 11

THE RESULTS OF GERMINATING MATURE, IMMATURE AND OLD SEED OF LEPIDIUM CAMPESTRE (L.) R. Br.

Germinating Conditions	Percent Germination								
	Age of mature seed in weeks*				Age of immature seed in weeks*				Old seed
	1	11	17	28	3	13	19	30	
20°C. Light	0	86	99	96	0	5	7	13	35
20°C. Dark	0	77	98	98	0	2	9	12	27
25°C. Light	0	93	92	98	0	5	8	9	42
25°C. Dark	0	89	94	96	0	3	4	7	22
30°C. Light	0	0	2	11	0	4	5	8	50
30°C. Dark	0	1	2	60	0	1	0	2	3
20-30°C. Light	3	94	98	98	2	3	11	19	50
20-30°C. Dark	0	87	98	97	0	4	8	10	26

* Age of seed from date of harvest

Germination of Radicula palustris (L.) Moench.

The high degree of dormancy and its persistance when seeds of Radicula palustris (L.) Moench. were germinated under the conditions used in this work indicates that seeds of this species must be treated in some other manner to secure successful germination (Table 12). The only germination procedure which resulted in more than one percent was that made on the immature seed which had aged 32 weeks and was germinated using the alternating temperatures in light.

TABLE 12

THE RESULTS OF GERMINATING MATURE AND IMMATURE SEED OF RADICULA PALUSTRIS (L.) Moench.

Germinating Conditions	Percent Germination							
	Age of mature seed in weeks*				Age of immature seed in weeks*			
	3	6	18	32	3	6	18	32
20°C. Light	0	0	0	1	0	1	0	0
20°C. Dark	0	0	0	0	0	0	0	0
25°C. Light	0	0	0	0	0	0	0	1
25°C. Dark	0	0	0	0	0	0	0	0
30°C. Light	0	1	0	1	1	0	0	0
30°C. Dark	0	0	0	0	0	0	0	0
20-30°C. Light	0	0	1	1	1	1	1	9
20-30°C. Dark	0	0	0	0	0	0	0	1

* Age of seed from date of harvest

Germination of Raphanus raphanistrum L.

Immature and old seed of Raphanus raphanistrum L. were not available for these germination tests. The mature seed showed the usual dormancy of freshly harvested seeds, some of which was lost as the seeds aged (Table 13). The germinations in darkness gave the best results with the highest germination being obtained when the seeds were germinated using the alternating temperatures.

TABLE 13

THE RESULTS OF GERMINATING MATURE SEED OF RAPHANUS RAPHANISTRUM L.

Germinating Conditions	Percent Germination		
	Age of mature seed in weeks*		
	10	14	27
20°C. Light	0	1	4
20°C. Dark	4	6	29
25°C. Light	4	4	15
25°C. Dark	2	10	26
30°C. Light	2	1	8
30°C. Dark	1	0	9
20-30°C. Light	1	5	23
20-30°C. Dark	7	13	42

* Age of seed from date of harvest

Germination of Sisymbrium altissimum L.

Seeds of the species Sisymbrium altissimum L. are a good example of the differences found in the germinating characteristics of seeds of different ages and stages of maturity (Table 14).

The freshly harvested seeds showed the usual dormancy and the loss of this dormancy as the seeds aged (Figure 4, 5). The mature seed germinated better in darkness at the lowest temperature and better in light at the higher and alternating temperatures. The immature seed gave better results when germinated in light at all of the temperatures used and appeared to be less dormant than the mature seeds when germinated two weeks after harvest (Figure 5).

The old seed gave almost identical germination results under all the temperature conditions in darkness. The germination tests in light, however, resulted in a considerable increase in germination with an increase in temperature. All samples showed considerable light sensitivity.

The conditions most favorable for germinating the mature seeds after they had aged for thirty weeks were an alternating temperature of 20°C. and 30°C. and light. The immature seeds germinated equally well at 25°C. in light and at the alternating temperatures in light.

TABLE 14

THE RESULTS OF GERMINATING MATURE, IMMATURE AND OLD SEED OF SISYMBRIUM ALTISSIMUM L.

Germinating Conditions	Percent Germination								
	Age of mature seed in weeks*				Age of immature seed in weeks*				Old seed
	2	10	17	30	2	10	17	30	
20°C. Light	7	19	51	56	12	33	20	59	13
20°C. Dark	5	33	67	65	2	14	21	17	91
25°C. Light	5	35	64	64	20	27	43	83	70
25°C. Dark	2	21	55	44	2	12	20	23	92
30°C. Light	1	26	41	66	0	29	16	60	87
30°C. Dark	0	4	3	18	0	2	1	12	92
20-30°C. Light	7	34	50	72	25	51	66	84	63
20-30°C. Dark	2	15	51	41	1	10	13	34	94

* Age of seed from date of harvest

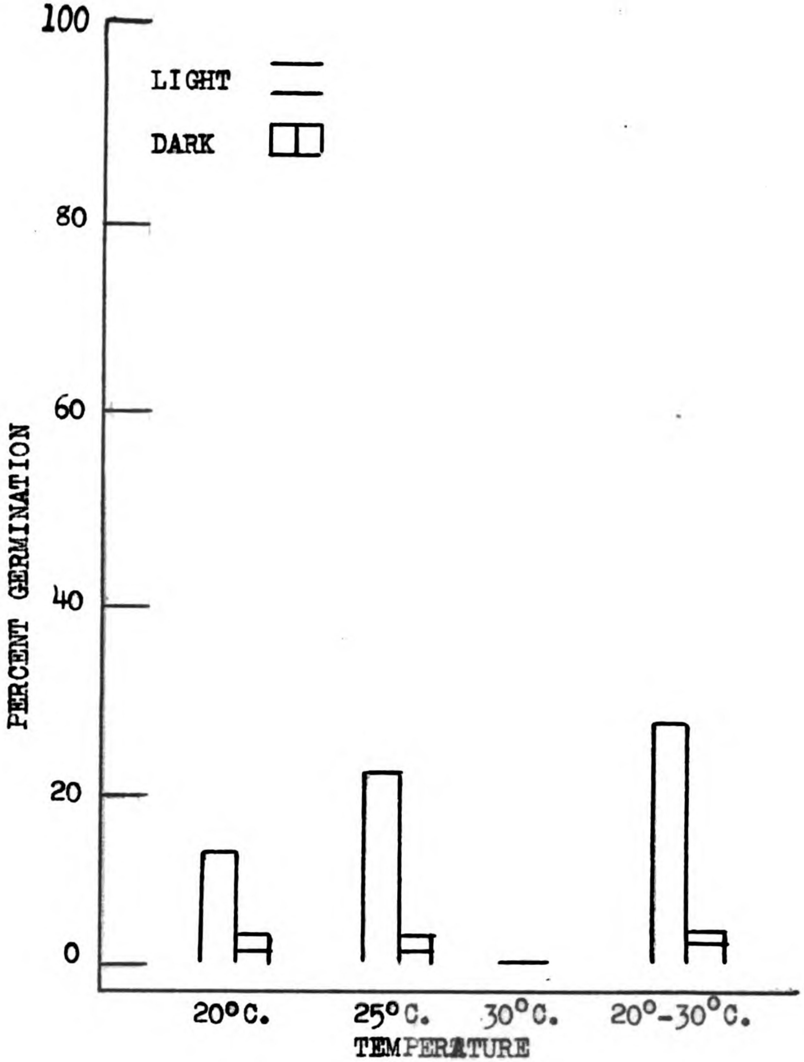

Fig. 4. Germination of immature seed of <u>Sisymbrium altissimum</u> 2 weeks after harvest.

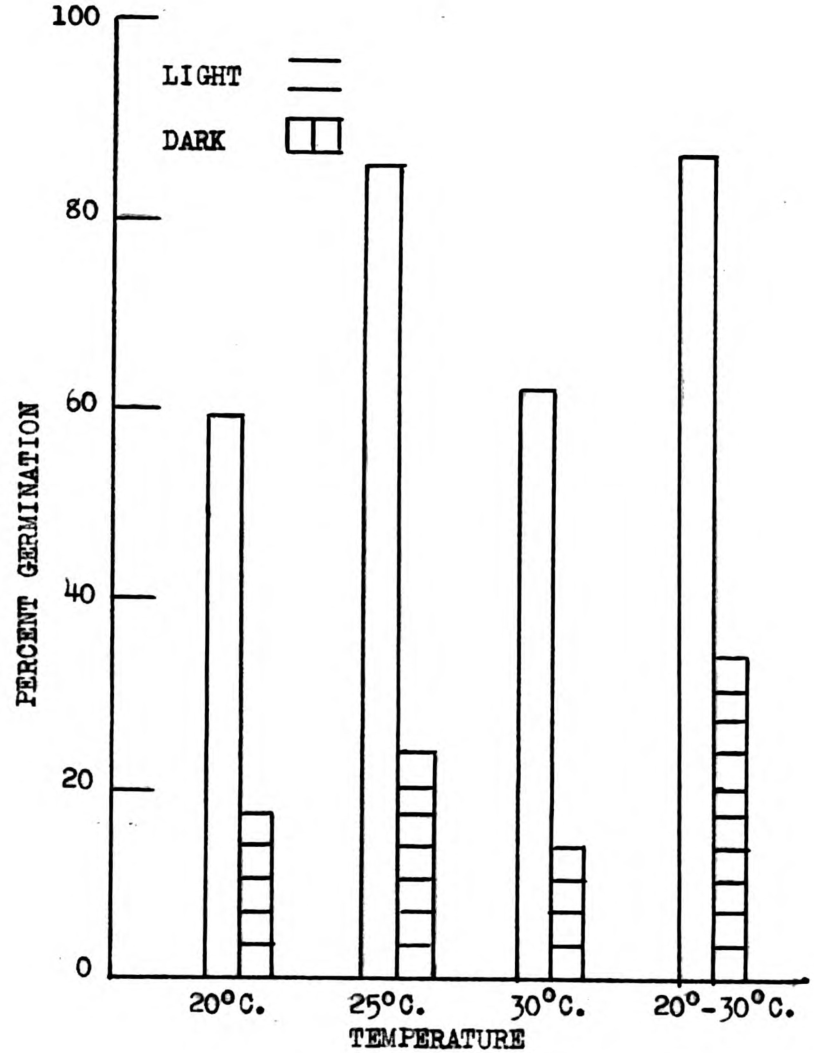

Fig. 5. Germination of immature seed of <u>Sisymbrium altissimum</u> 30 weeks after harvest.

Germination of Sisymbrium officinale (L.) Scop.

Seeds of the species Sisymbrium officinale (L.) Scop. show the dormancy of freshly harvested seeds common to most of the other species. This dormancy is gradually lost to the extent that the percent germination of mature seeds increased from 4 percent when germinated at 30°C. in darkness at the age of one-half week to the high of 62 percent under the same conditions when the seed had aged for 28 weeks (Table 15). Much the same was true for the immature seeds. Both the mature and immature seeds germinated better in darkness at the 20°C. and 25°C. temperatures and better in light at the 30°C. constant temperature. Best results

TABLE 15

THE RESULTS OF GERMINATING MATURE, IMMATURE AND OLD SEED OF SISYMBRIUM OFFICINALE (L.) Scop.

Germinating Conditions	Percent Germination								
	Age of mature seed in weeks*				Age of immature seed in weeks*				Old seed
	.5	8	16	28	2	10	17	30	
20°C. Light	0	1	7	1	1	3	1	4	0
20°C. Dark	1	1	14	21	3	22	16	29	0
25°C. Light	1	9	19	25	4	19	9	36	0
25°C. Dark	12	13	21	41	7	20	11	41	0
30°C. Light	6	32	48	61	6	78	37	60	0
30°C. Dark	4	21	23	62	1	16	10	33	0
20-30°C. Light	2	4	14	48	4	15	4	38	0
20-30°C. Dark	2	7	8	23	5	20	17	42	0

* Age of seed from date of harvest

were obtained by germinating both samples at the constant temperature of 30°C. in light. The old seed completely failed to germinate.

Germination of *Thlaspi arvense* L.

Seed of the species *Thlaspi arvense* L. are, under most germinating conditions, almost completely dormant when freshly harvested (Table 16).

All of the samples were light sensitive to some degree. When germinated at the low temperature of 20°C. and the alternating temperatures of 20°C. and 30°C., the results were better when the seeds were kept in darkness. Seeds germinated at the constant temperature of 25°C. gave better results when kept in light. The old seed germinated poorly under

TABLE 16

THE RESULTS OF GERMINATING MATURE, IMMATURE AND OLD SEED OF *THLASPI ARVENSE* L.

Germinating Conditions	Percent Germination								
	Age of mature seed in weeks*				Age of immature seed in weeks*				Old seed
	2	13	18	29	4	15	22	33	
20°C. Light	1	1	5	2	0	1	2	0	1
20°C. Dark	5	1	25	39	23	1	5	21	28
25°C. Light	3	7	48	50	1	12	19	29	17
25°C. Dark	1	4	17	21	1	1	4	3	12
30°C. Light	0	0	0	0	0	2	23	20	1
30°C. Dark	0	0	0	0	0	0	0	2	0
20-30°C. Light	7	8	32	48	2	15	13	42	12
20-30°C. Dark	18	12	84	92	23	11	59	62	27

* Age of seed from date of harvest

PLATE 1

The Results of Germinating Mature Seeds of Thlaspi arvense L.

32 Weeks after Harvest and Treated with KNO_3,

H_2SO_4, and Having Seed Coats Removed

Fig. 1. Seeds treated with 0.2 percent solution of potassium nitrate and germinated at a temperature of 25°C. in light. Result --- 98 percent germination.

Fig. 2. Seed coats treated with concentrated sulphuric acid and germinated at a temperature of 25°C. in light. Result --- 100 percent germination.

Fig. 3. Control, germinated at a temperature of 25°C. in light. Result --- 29 percent germination.

Fig. 4. Seed coats removed and embryos germinated at a temperature of 30°C. in light for two days. Result --- 80 percent germination.

Fig. 5. Sample above after germinating for four days. Result --- 100 percent germination.

Fig. 6. Control, germinated at a temperature of 30°C. in light. Result --- 13 percent germination.


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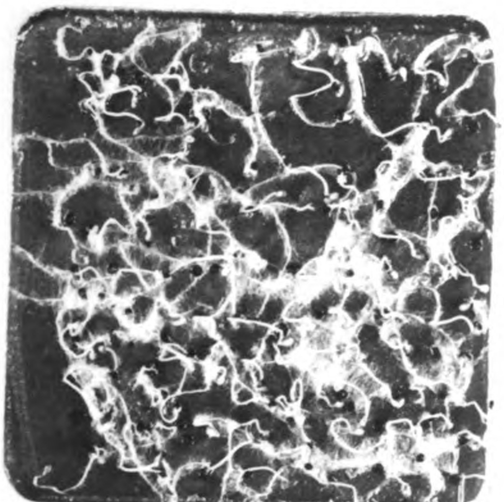
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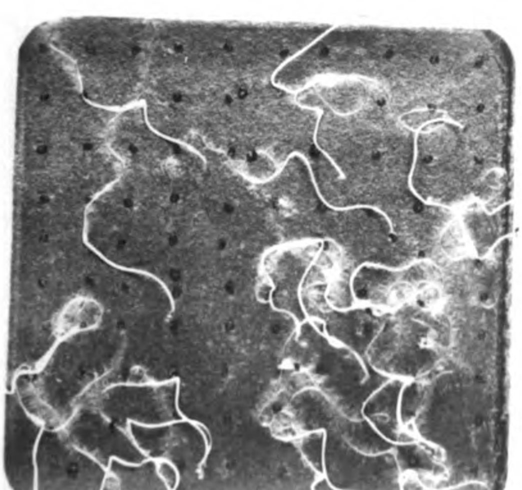
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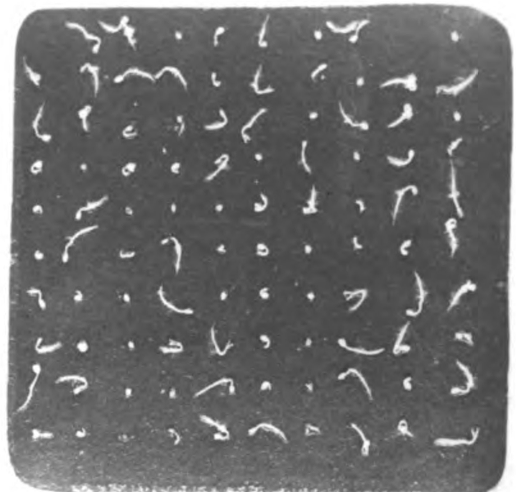
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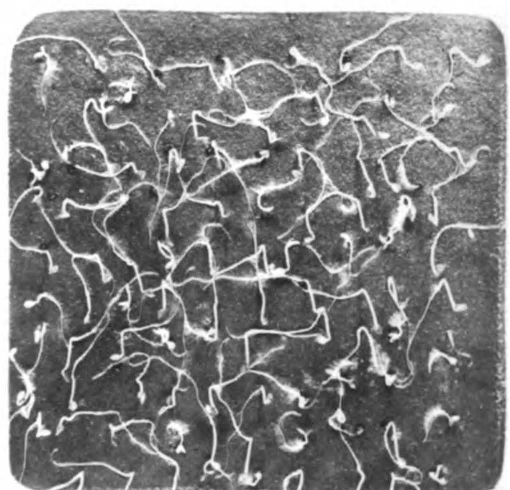
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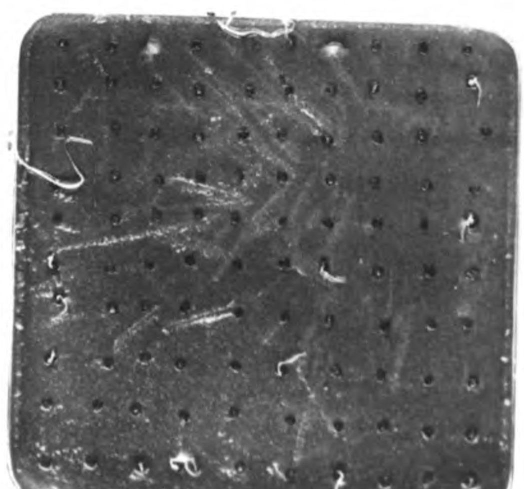
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PLATE 1

PLATE 2

Germination of Mature Seeds of *Thlaspi arvense* L. 32 Weeks After Harvest Showing the Results of Germinating these Seeds at the Constant Temperatures of 20°C. and the Alternating Temperatures of 20°C. and 30°C. in Light and in Darkness.

Fig. 1. Seeds germinated at 20°C. in light, resulting in 0 percent germination.

Fig. 2. Seeds germinated at 20°C. in darkness, resulting in 89 percent germination.

Fig. 3. Seeds germinated at the alternating temperatures of 20°C. and 30°C. in light and resulting in 56 percent germination.

Fig. 4. Seeds germinated at the alternating temperatures of 20°C. and 30°C. in darkness, resulting in 99 percent germination.

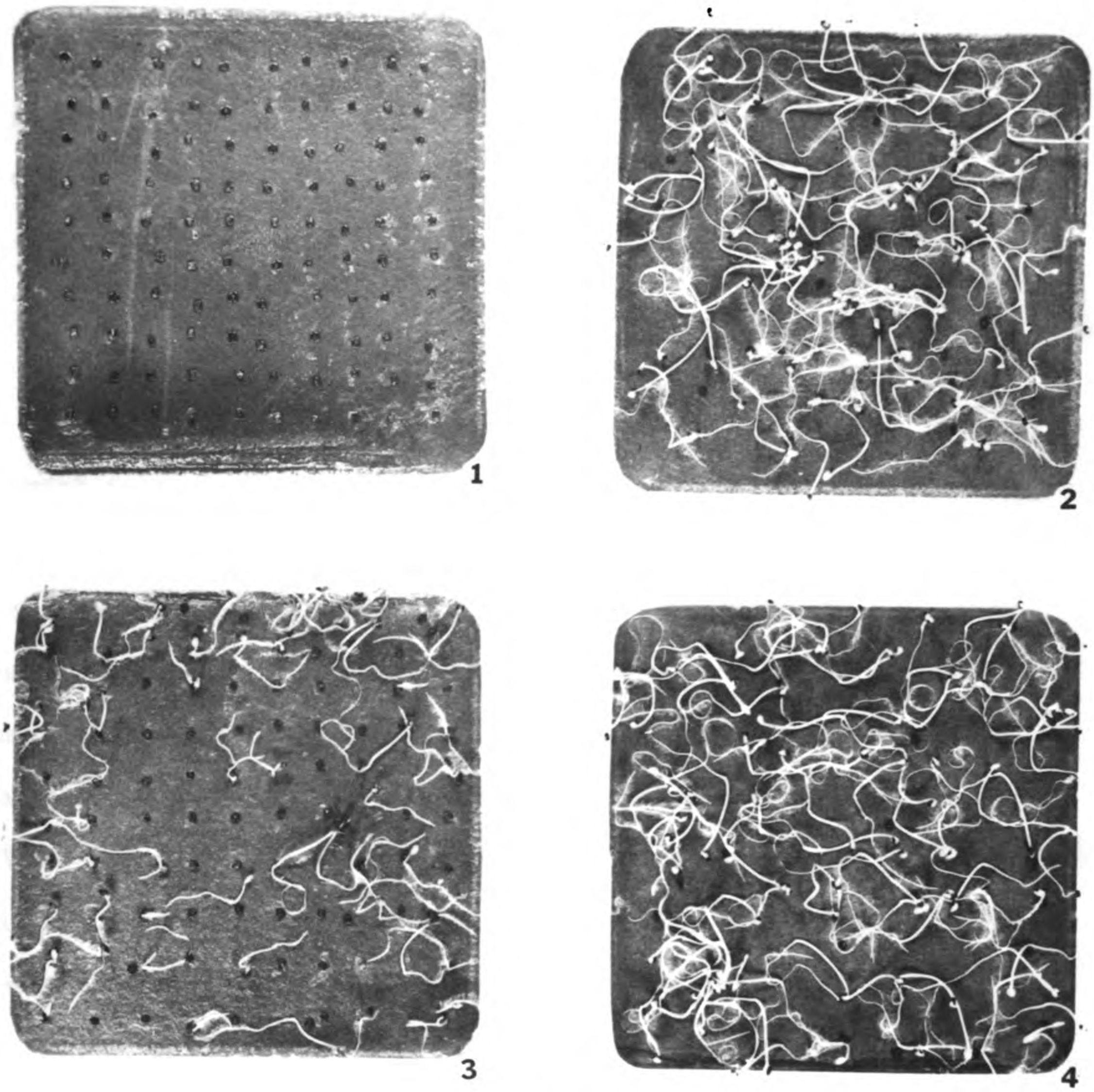

PLATE 2

all of the conditions. The treatment resulting in the highest percent germination for all samples was the alternating temperatures of 20°C. and 30°C. in light.

Germination Results of Some Species After Special Treatment to Break Dormancy

A number of the seed samples were given one or more of the three special treatments to determine the effectiveness of these treatments in breaking dormancy. Table 17 shows the results of these treatments.

Seventeen of the seed samples were treated with the 0.2 percent solution of potassium nitrate and germinated at 25°C. The percent germination on eight of these samples was quite high ranging from 84 percent to 100 percent. Three samples germinated between 53 percent and 63 percent while six samples germinated 39 percent or less. Potassium nitrate was particularly effective in breaking the dormancy of mature seeds of Thlaspi arvense L. which were highly dormant.

Four of the seed samples were treated with concentrated sulphuric acid with good results being obtained on two of the samples. The mature sample of Brassica nigra (L.) Koch. germinated 94 percent and the mature sample of Thlaspi arvense L. germinated 91 percent. Samples of mature Raphanus raphanistrum and immature seeds of Sisymbrium altissimum L. germinated 0 percent and 36 percent respectively. That these last samples germinated poorly, did not mean that the sulphuric acid treatment would not be effective in promoting germination if the optimum immersion time were determined. There was some evidence that the seeds had been injured by the acid which might have accounted for the poor results.

Prechilling the seed samples for five days at a temperature of 5°C. was not effective in completely breaking the dormancy in any seed sample The percent germination was increased to some extent in a number of samples with the best results being obtained on samples relatively unaffected by the potassium nitrate treatment.

Treatments Found Most Favorable for Germinating Some Species of Cruciferae

From the results obtained in germinating the different seed samples a table was made (Table 18) indicating the germinating conditions and treatments found to be most effective in germinating these seeds.

TABLE 17

PERCENT GERMINATION OF SOME SPECIES OF CRUCIFERAE
AFTER CHEMICAL AND PRECHILLING TREATMENTS

Species	KNO_3 Treatment		H_2SO_4 Treatment		Prechill Treatment	
	Seed age in weeks	% Germ.	Seed age in weeks	% Germ.	Seed age in weeks	% Germ.
<u>Barbarea vulgaris</u>						
Mature seed	14	96			15	23
Immature seed	19	84			19	40
Old seed		86				25
<u>Brassica nigra</u>						
Mature seed			13	94		
<u>Camelina microcarpa</u>						
Mature seed	17	22			17	42
Immature seed	18	3			18	60
Old seed		93				74
<u>Capsella bursa-pastoris</u>						
Mature seed	20	28			21	34
Immature seed	16	8			17	57

TABLE 17 (continued)

Species	KNO_3 Treatment		H_2SO_4 Treatment		Prechill Treatment	
	Seed age in weeks	% Germ.	Seed age in weeks	% Germ.	Seed age in weeks	% Germ.
Lepidium apetalum						
Mature seed	19	0			19	11
Lepidium campestre						
Mature seed	3	100			3	21
Immature seed	5	86			5	28
Old seed		63				1
Raphanus raphanistrium						
Mature seed	18	39	18	0		
Sisymbrium altissimum						
Immature seed	34	97	34	36		
Thlaspi arvense						
Mature seed	4	98	19	91	4	68
Immature seed	6	53			6	47
Old seed		61				1

TABLE 18

TREATMENT FOUND MOST FAVORABLE FOR GERMINATING
SOME SPECIES OF CRUCIFERAE

Species	Temperature	Light Conditions	Remarks
<u>Arabis glabra</u>			
Mature seed	20°C. or 25°C.	Light	
<u>Barbarea vulgaris</u>			
Mature seed	20°C. and 30°C.	Light	KNO_3 will break dormancy
Immature seed	20°C. and 30°C.	Light	KNO_3 will break dormancy
Old seed	20°C. and 30°C.	Light	
<u>Berteroa incana</u>			
Mature seed	30°C	Light may be necessary	
Immature seed	20°C. and 30°C.	Dark	
Old seed	20°C. and 30°C.	Dark	
<u>Brassica arvensis</u>			
Mature seed	20°C. and 30°C.	Light	
Immature seed	20°C. and 30°C.	Light	
Old seed	20°C. and 30°C.	Light	
<u>Brassica campestris</u>			
Mature seed	20°C. and 30°C.	Dark	
Immature seed	20°C. and 30°C.	Dark	
Old seed	20°C. and 30°C.	Dark	
<u>Brassica nigra</u>			
Mature seed	20°C. and 30°C.	Dark	H_2SO_4 will break dormancy
Immature seed	20°C. and 30°C.	Light	
Old seed	20°C. to 30°C.	Light	
<u>Camelina microcarpa</u>			
Mature seed	20°C. and 30°C.	Dark	KNO_3 and prechill helpful
Immature seed	20°C. and 30°C.	Dark	Prechill
Old seed	20°C.	Dark	

TABLE 18 (continued)

Species	Temperature	Light Conditions	Remarks
Capsella bursa-pastoris			
Mature seed	20°C. and 30°C.	Dark	KNO_3 and prechill helpful
Immature seed	20°C. and 30°C.	Dark	Prechill
Old seed			No results
Erysimum cheiranthoides			
Mature seed	20°C. and 30°C.	Light	Prechill
Immature seed	20°C. and 30°C.	Light	
Old seed	20°C. and 30°C.	Dark	
Lepidium apetalum			
Mature seed			No results
Immature seed			No results
Old seed			No sample
Lepidium campestre			
Mature seed	20°C. and 30°C.	Light	KNO_3 will break dormancy
Immature seed	20°C. and 30°C.	Light	KNO_3 will break dormancy
Old seed	20°C. and 30°C.	Light	KNO_3 helpful
Radicula palustris			
Mature seed			No results
Immature seed			No results
Old seed			No sample
Raphanus raphanistrum			
Mature seed	20°C. and 30°C.	Dark	KNO_3 helpful
Immature seed			No sample
Old seed			No sample

TABLE 18 (continued)

Species	Temperature	Light Conditions	Remarks
<u>Sisymbrium altissimum</u>			
Mature seed	20°C. and 30°C.	Light	
Immature seed	20°C. and 30°C.	Light	KNO_3
Old seed	20°C. to 30°C.	Dark	
<u>Sisymbrium officinale</u>			
Mature seed	30°C.	Light	
Immature seed	30°C.	Light	
Old seed			No results
<u>Thlaspi arvensi</u>			
Mature seed	20°C. and 30°C.	Dark	KNO_3 will break dormancy
Immature seed	20°C. and 30°C.	Dark	Prechill and KNO_3 helpful
Old seed	20°C. and 30°C.	Dark	KNO_3 helpful

DISCUSSION

From the data, it is seen that a wide variety of results are obtained when seeds of different species of weedy Crucifers are germinated.

The dormancy found in practically all the freshly harvested seeds may be due to either one or both of the following reasons: (1) the impermeability of the seed coats to gases as suggested by Kidd and West (11); (2) the presence of inhibiting substances in the seed coats, as was found to be true of cabbage seeds by Cox, Munger and Smith (1). This dormancy was lost as the seeds aged but in most cases was lost very slowly being present in all or in part even after the seed had aged for thirty or more weeks. The samples of old seed, in most cases, also showed considerable dormancy, some of which may have been due to dry storage (13).

From the results shown in Table 18, it can be seen that the majority of the seed samples germinated better at the alternating temperatures of 20°C. and 30°C. The constant temperature of 30°C. gave the most unsatisfactory results and in a number of cases (Table 1, 11, and 16) actually appeared to induce dormancy in seeds that otherwise germinated well. The samples of Erysimum cheiranthoides (Table 9) were probably the best example of the influence of the proper temperature in promoting germination.

The germination of Lepidium campestre (Table 11) showed very well what immaturity could have on the germination results. The mature seeds germinated almost completely under a number of the germinating conditions when the seeds were eleven weeks old. The highest percent germination of the immature seeds, under any of the treatments, was only 19 percent after aging for a period of thirty weeks. The immature seeds were viable since the germination was 86 percent when treated with a 0.2 percent solution of potassium nitrate at the age of five weeks (Table 17).

In a number of the light sensitive seed samples, it was found that at the low temperature of 20°C. the seeds germinated better in darkness, while at the higher temperature the seeds germinated better in light.

The use of a 0.2 percent solution of potassium nitrate was found to completely break the dormancy of a number of seed samples and was effective in increasing the percent germination in others (Table 17). Shuck (13) found that potassium nitrate was not effective in promoting germination at temperatures of 25°C. to 30°C. and may actually have an inhibitory effect. This was not found to be true in germinating these species of seeds with the possible exception of the mature sample of Lepidium apetalum. There was some evidence that the potassium nitrate treatment cannot be substituted for light in seeds requiring light for germination.

Sulphuric acid treatment of the seed coats was found to promote germination in two of the several samples tested. Seeds having a seed coat of considerable thickness were found to be benefitted by this treatment (Table 17). Thlaspi arvense and Brassica nigra were good examples of this. The exact immersion time in the acid for seeds having thin seed coats was of the utmost importance. The interval of time between the point of beneficial effect and the point of harmful effect to the seeds was so short on the thin coated species, that this treatment was difficult to use.

The prechill treatment helped to promote germination of a number of samples of seed but was not effective in completely breaking the dormancy on any sample (Table 18). The most noticeable results were usually found when used on the seed samples not particularly affected by the potassium nitrate treatment.

The seed coats of two samples of mature seeds, Thlaspi arvense and Brassica arvensis, were removed and the excised seeds germinated under the same conditions as the controls. This treatment proved very effective in promoting germination as both samples of the excised seed germinated 100 percent. Of the controls, that of Thlaspi arvense germinated 13 percent and that of Brassica arvensis germinated 34 percent.

SUMMARY AND CONCLUSIONS

1. The literature pertaining to germination of Cruciferae was reviewed.

2. Seeds of sixteen weedy species of Cruciferae were collected for the purpose of determining the degree of dormancy of the seeds and the most satisfactory procedure for laboratory germination. Mature, immature, and old seed samples were germinated to determine if different treatment was required to germinate seeds at different stages of maturity and age.

3. The temperature treatments used were: constant temperatures of 20°C., 25°C., 30°C., and alternating temperatures of 20°C. and 30°C. Each sample was germinated at the above temperatures in light and in darkness. In addition to the above treatments, some of the samples were given a prechill treatment for five days at 5°C. before being germinated and some samples were chemically treated with either a 0.2 percent solution of potassium nitrate or concentrated sulphuric acid. The seed coats were removed from two samples and the excised embryos germinated Each germination test was made using two replicates of 100 seeds each per replicate.

4. Freshly harvested seeds of all species, with the exception of *Brassica campestris*, were in a highly dormant condition. This dormancy was lost, to a considerable degree, in most species as the seeds became more aged. The percent germination of the mature seed was, with few exceptions, higher than that of the immature seeds.

5. The temperature treatment resulting in the highest percent germination in most of the seed samples, was the alternating temperature of 20°C. and 30°C. The temperature treatment giving the poorest results was the constant temperature of 30°C.

6. Light sensitivity was found to occur in most of the seed samples. Some samples germinated better in light and others germinated better in darkness. The need for light or darkness to promote germination appeared to change, in some samples, with the age of the seeds. Freshly harvested seeds of Sisymbrium altissimum germinated better in light while the old seeds germinated better in darkness.

7. Most of the old seed samples showed considerable dormancy, some of which may have been due to dry storage. The old seed samples, in general, showed much the same light sensitivity shown by the freshly harvested seed samples. The germinating temperature for the old seeds was in some cases less critical than was found in the freshly harvested seeds.

8. Prechilling for five days at 5°C. did not prove to be too effective in breaking dormancy.

9. Treating dormant seeds with a 0.2 percent solution of potassium nitrate proved very effective in breaking the dormancy of most seed samples.

10. Seeds of the species Thlaspi arvense and Brassica arvensis germinated 100 percent when the seed coats were removed and 13 percent and 29 percent respectively with seed coats intact. These results indicated that perhaps the cause for the dormancy was due to the impermeable nature of the seed coats, however, when the seed coats of Brassica arvensis seeds were slit to expose the embryos, the result was only 34 percent germination.

From this, it would seem that some factor other than impermeability of the seed coats was responsible for the dormancy in these seeds.

11. A number of samples failed to germinate to any extent under any of the germinating conditions used, even after aging for about thirty weeks. It is apparent that for these samples some other treatment must be used to promote successful germination.

12. The treatments found most successful in germinating the different seed samples are shown in Table 18.

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