UNIVERSITY OF COLORADO STUDIES

SERIES IN BIOLOGY

No. 18

UNIVERSITY OF COLORADO PRESS
BOULDER, COLORADO
AUGUST, 1965

FURTHER STUDIES ON THE GERMINATION OF SEEDS OF COLORADO ALPINE PLANTS

ERIK K. BONDE*

INTRODUCTION

Bonde (1965) has recently published data on the monthly germination percentages of seeds of plants from the Colorado alpine. These monthly tests were carried out over periods of time ranging up to 33 months with seeds of 19 species collected in 1960 and 1961. The present paper reports daily germination data for 18 of these same species and 41 additional ones, emphasizing the rate of germination of 97 collections of seeds or bulblets of a total of 59 alpine species gathered in 1963 and comparing germination percentages three to four months and eight to nine months after harvest.

MATERIALS AND METHODS

Approximately two-thirds of the seeds and bulblets utilized in these studies were collected in August of 1963 and the remainder in early September. The seeds were gathered in three alpine localities: Summit Lake (SL) in Clear Creek County at an elevation of 12,834 feet, Rollins Pass (RP) in Boulder County at an elevation of 11,671 feet, and James Peak (JP) in the southwest corner of Gilpin County at an elevation of 13,260 feet. All three sites are well above timberline in the Front Range of the Rocky Mountains of central Colorado, and collections from the vicinities of these sites were obtained at altitudes differing only slightly, if at all, from those given. Most of the plant species employed are fairly

*Department of Biology, University of Colorado, Boulder.

common perennial herbs, with the exception of the shrubby *Potentilla fruticosa* and *Dryas octopetala*. The seeds and other plant parts collected with them were allowed to dry in paper bags on a laboratory shelf for a number of weeks, until such time as the seeds could be separated from the debris and placed in screw-top vials. The vials of seeds were then stored in an incubator at 18°C. until tested.

Germination tests were carried out in the dark in incubators at 18°C., except for the short time required for the daily germination counts. The seeds were placed on two layers of filter paper moistened with distilled water in 15-cm. petri dishes. Water was added to the dishes as required during the course of study, with any excess being drained off. Four dishes of 50 seeds each for each species were prepared, giving a total of 200 seeds of each species in each test, except for a few cases in which the seed supply only permitted the use of 25 to 150 seeds. Shrunken seeds or those appearing to be damaged in any way were eliminated. Daily records were kept of the percentage germination of each species in each test for 14 days, and then counts were made on the 21st and 28th days after the beginning of the test, with the exception of four samples (indicated below) which were tested for only 14 days in the first of the two test series. Emergence of the radicle was used as the criterion of germination, and the germinated seeds were removed each time a count was made.

The first tests were all initiated on December 6, 1963. The second series of tests was begun May 12, 1964, for about three-quarters of the seed samples, with the remaining quarter being tested beginning June 3, 1964. The starting date of the second test was June 3 for all the species in the following list after *Polemonium viscosum* and for *Polemonium viscosum* SL, as well. In various figures the data for the second test are grouped together under the heading "May-June."

Germination was tested in the following species:

Achillea lanulosa Nutt.: the achenes were collected on September 4, 1963, at the 12,000-foot marker on the road to Summit Lake.

Allium geyeri Wats.: collected September 4 at the 12,000-foot marker on the road to Summit Lake.

Androsace septentrionalis L.: collected August 21 on Rollins Pass.

Antennaria alpina (L.) Gaertn.: collected August 19 on the east side of Summit Lake and August 21 on Rollins Pass.

Aquilegia coerulea James: collected August 21 on Rollins Pass.

Arenaria fendleri Gray: collected August 19 on the east side of Summit Lake and August 14 one mile east of Rollins Pass.

Arenaria obtusiloba (Rydb.) Fern.: collected August 9 south of the road one mile east of Rollins Pass.

Arenaria rubella (Wahl.) Sm.: collected August 14 south of the road one-quarter of a mile east of Rollins Pass and August 19 on the east side of Summit Lake.

Artemisia arctica Less ssp. *saxicola* (Rydb.) Hulten: collected August 14 one mile east of Rollins Pass and August 19 on the east side of Summit Lake.

Artemisia scopulorum Gray: collected September 4 at the 12,000-foot marker on the road to Summit Lake.

Besseya alpina (Gray) Rydb.: collected August 23 on the summit of James Peak and September 6 one-quarter of a mile east of Rollins Pass.

Caltha leptosepala DC.: collected August 12 and 19 on the east side of Summit Lake.

Campanula uniflora L.: collected August 28 one-quarter of a mile east of Rollins Pass.

Campanula rotundifolia L.: collected August 14 one mile east of Rollins Pass.

Castilleja occidentalis Torr.: collected August 28 one-quarter of a mile east of Rollins Pass and September 4 on the north side of Summit Lake.

Cerastium beeringianum C. & S.: collected on James Peak August 23 and the east side of Summit Lake on August 19.

Chionophila jamesii Benth.: collected September 4 on the north side of Summit Lake.

Cirsium hookerianum Nutt.: collected September 4 at the 12,000-foot marker on the road to Summit Lake.

Claytonia megarhiza (Gray) Parry: collected August 29 on the east side of Summit Lake.

Draba crassifolia R. Grah.: collected August 21 on Rollins Pass.

Draba aurea Vahl: collected August 29 and September 4 east of Summit Lake, and August 28 and September 6 one-quarter of a mile east of Rollins Pass.

Dryas octopetala L.: collected August 14 a mile east of Rollins Pass.

Epilobium alpinum L.: collected September 4 on the north side of Summit Lake.

Erigeron simplex Greene: collected August 19 on the east side of Summit Lake and August 21 on Rollins Pass.

Erigeron pinnatisectus (Gray) Nels.: collected August 19 and August 29 on the east side of Summit Lake.

Erysimum nivale (Greene) Rydb.: collected August 14 one-quarter of a mile east of Rollins Pass.

Gentiana romanzovii Ledeb.: collected September 6 one-quarter of a mile east of Rollins Pass.

Geum rossii (R. Br.) Ser.: collected September 4 on the east side of Summit Lake and September 6 one-quarter of a mile east of Rollins Pass.

Haplopappus pygmaeus (T. & G.) Gray: collected August 14 one mile east of Rollins Pass, August 19 on the east side of Summit Lake, and August 23 on the summit of James Peak.

Heuchera parvifolia Nutt.: collected August 14 one mile east of Rollins Pass and September 4 at the 12,000-foot marker on the road to Summit Lake.

Hymenoxys acaulis (Pursh) Parker: collected August 9 one mile east of Rollins Pass.

Hymenoxys grandiflora (Pursh) Parker: collected August 9 and 14 one mile east of Rollins Pass, August 19 on the north side of Summit Lake, and August 23 on the east side of James Peak a mile below the summit.

Lloydia serotina (L.) Sw.: collected August 28 and September 6 one-quarter of a mile east of Rollins Pass and September 4 on the east side of Summit Lake.

Melandrium furcatum (Raf.) Hulten: collected August 14 one-quarter of a mile east of Rollins Pass, August 23 on the summit of James Peak, and August 29 and September 4 on the north side of Summit Lake.

Mertensia viridis A. Nels.: collected August 29 on the east side of Summit Lake and August 28 and September 6 one-quarter of a mile east of Rollins Pass.

Oxyria digyna (L.) Hill: collected August 14 one-quarter of a mile east of Rollins Pass and September 4 on the north side of Summit Lake.

Pedicularis groenlandica Retz: collected August 29 on the east side of Summit Lake and September 6 at the

edge of King Lake near Rollins Pass.

Penstemon whippleanus Gray: collected September 6 one mile east of Rollins Pass.

Phacelia sericea Hook.: collected August 28 one-quarter of a mile east of Rollins Pass and September 4 at the 12,000-foot marker on the road to Summit Lake.

Polemonium viscosum Nutt.: collected August 28 and September 6 one-quarter of a mile east of Rollins Pass and September 4 on the north side of Summit Lake.

Polygonum bistortoides Pursh: collected August 28 on the west side of Rollins Pass and August 29 on the east side of Summit Lake.

Polygonum viviparum L.: bulblets collected August 14 one-quarter of a mile east of Rollins Pass.

Potentilla diversifolia Lehm.: collected August 21 on Rollins Pass and August 29 on the east side of Summit Lake.

Potentilla fruticosa L.: collected September 4 at the 12,000-foot marker on the road to Summit Lake and September 6 at the tunnel on the east side of Rollins Pass.

Saxifraga bronchialis L.: collected September 6 one-quarter of a mile east of Rollins Pass.

Saxifraga cernua L.: bulblets collected August 29 on the east side of Summit Lake.

Saxifraga flagellaris Willd.: collected August 29 on the east side of Summit Lake.

Saxifraga rhomboidea Greene: collected August 28 one-quarter of a mile east of Rollins Pass.

Sedum integrifolium Raf.: collected September 6 one-quarter of a mile east of Rollins Pass and September 4 on the east side of Summit Lake.

Sedum lanceolatum Torr.: collected September 4 on the east side of Summit Lake and September 6 one-quarter of a mile east of Rollins Pass.

Sedum rhodanthum Gray: collected September 4 on the east side of Summit Lake.

Sibbaldia procumbens L.: collected August 21 on Rollins Pass and August 19 and September 4 on the north side of Summit Lake.

Silene acaulis L.: collected August 19 on the east side of Summit Lake, August 21 on Rollins Pass, and August 23 on the summit of James Peak.

Stellaria weberi Boivin: collected August 28 and September 6 one-quarter of a mile east of Rollins Pass.

Thlaspi alpestre L.: collected August 14 one-quarter of a mile east of Rollins Pass.

Trifolium dasyphyllum T. & G.: collected August 4 and 9 one mile east of Rollins Pass and August 29 on the east side of Summit Lake.

Trifolium nanum Torr.: collected August 14 one-quarter of a mile east of Rollins Pass and August 19 and 29 on the east side of Summit Lake.

Trifolium parryi Gray: collected August 9 on Rollins Pass, August 19 and 29 on the east side of Summit Lake, and August 23 on James Peak.

Veronica wormskjoldii R. & S.: collected September 6 at King Lake near Rollins Pass.

No attempt was made in this present study to examine the possibility of dormancy in any of the species, and no special treatments other than those described were used to increase germination. The species names employed are according to Weber (1961), with the exception of *Artemisia arctica, Melandrium furcatum* (which is there designated as *Lychnis kingii*), *Sedum integrifolium* (there S. *rosea*), and S. *lanceolatum* (there S. *stenopetalum*). Bulblets of *Polygonum viviparum* and *Saxifraga cernua* were collected instead of seeds, and these, along with achenes of members of the Compositae

and Polygonaceae, are here treated as seeds. Ninety collections of 56 species were tested in December and 92 collections of 59 species in May and June. The seed supplies in five cases (*Artemisia arctica* SL, *Caltha leptosepala* SL, *Cerastium beeringianum* RP, *Geum rossii* SL, and *Polygonum bistortoides* RP) were exhausted after the first test, and seven new samples (*Trifolium*) were added for the second test. Voucher specimens of the species studied were collected and deposited in the herbarium of the University of Colorado Museum.

RESULTS

The daily germination data are presented in Tables 1 and 2 (pages 14-27) for tests begun December 6, 1963, and May 12-June 3, 1964, respectively. The percentage germination of 200 seeds is given in each case, unless otherwise noted. The final column lists the standard deviation of the percentage germination of four 50-seed samples where 200 seeds were used. Figures 1 through 5 (pages 28-30) are histograms which show in Figure 1 the percentage of seed samples in various percentage germination categories for December and May-June, in 2 the percentage of seed samples with their first germination on the various days of the tests, in 3 the percentage with their maximum rate of germination on the various days, in 4 the percentage with germination essentially complete on the various days, and in 5 the percentage with their final germination on the various days.

DISCUSSION AND SUMMARY

The 85 seed samples tested in both December and May-June following harvest may be classified into a number of categories on the basis of the total germination during the 28 days of the tests. Asterisks in the lists below indicate tests in which the difference between the means of the two tests is greater than twice the standard error of the difference, for those comparisons in which four 50-seed samples were used.

A. Samples showing no more than a 10% change (of the total number of seeds tested) in germination between December and May-June and germinating 70% or more, with their respective percentages from the two tests given in parentheses:

1. *Androsace septentrionalis* (94.0, 87.0). Bliss (1958) reported 100% germination of seeds of this species from Wyoming in both light and dark 6 to 7 months after collection. Minimum germination time was 5 days in both cases, with a maximum of 8 days in the light and 5 days in the dark. In the present study the minimum time in the dark was 3 days and the maximum 22 to 28 days in the 28-day test begun in May. Pelton (1956) found that seeds of the subspecies *puberulenta* from the subalpine area of south-central Colorado were completely dormant when fresh and showed 39.0% germination after 18 months.

2. *Artemisia arctica* RP (82.0, 74.0).
3. *Artemisia scopulorum* (100, 98.0). Bliss found that this species from Wyoming germinated 100% in the light and 92.0% in the dark, with a minimum of 5 days and a maximum of 12 in the light and 19 in the dark. In the present dark study the minimum time in May was 2 days and the maximum 22 to 28 days.
4. *Besseya alpina* JP (93.5, 88.0).*
5. *Chionophila jamesii* (85.0, 92.0).*
6. *Melandrium furcatum* JP (95.0, 89.0).*
7. *Melandrium furcatum* SL (99.0, 99.0). Bonde (1965) found that SL seeds of this species from the summer of 1961 germinated 94.0% the following December and 30.0% in May.
8. *Oxyria digyna* RP (76.0, 69.0). Sϕrensen (1941) found germination in unspecified amount in seeds from Greenland 9 months after collection, and Bonde reported germination of 62.0% the following May for 1960 SL seeds.
9. *Saxifraga rhomboidea* (89.0, 86.0). Pelton reported that seeds from the subalpine of south-central Colorado were highly dormant when fresh and germinated 21.2% after 18 months.
10. *Sedum lanceolatum* SL (92.5, 90.0).

B. Samples showing no more than 10% variation between December and May-June, with germination between 30% and 70%:

1. *Arenaria fendleri* SL (43.5, 44.5). Bonde found that RP seeds of this species from the summer of 1961 germinated 100% the following May.
2. *Arenaria rubella* RP (62.5, 60.0). Bonde reported that SL seeds of this species from the summer of 1961 germinated 4.0% the following May and that RP seeds germinated 2.0%.
3. *Erigeron simplex* SL (33.5, 41.5).
4. *Erysimum nivale* (41.5, 48.0).
5. *Hymenoxys grandiflora* SL (44.5, 50.0).
6. *Hymenoxys grandiflora* RP (36.0, 37.5). Bliss found that Wyoming seeds of this species germinated 100% in the light and 98.0% in the dark, with a minimum time of 5 days in both and a maximum of 19 in the light and 12 in the dark. In the present study the minimum time in May was 2 days for SL seeds and 3 days for RP and JP seeds, with maxima of 15 to 21, 13, and 15 to 21 days, respectively. Bonde reported that RP seeds from the summer of 1961 germinated 90.0% and 84.0% the following December and May, respectively.
7. *Lloydia serotina* SL (64.5, 60.5).
8. *Melandrium furcatum* RP (68.0, 62.0).
9. *Sedum integrifolium* RP (30.5, 30.5).
10. *Sibbaldia procumbens* SL (24.5, 32.5).
11. *Sibbaldia procumbens* RP (60.0, 64.0). Bliss reported that seeds of this species from Wyoming germinated 44.0% in the light and 43.3% in the dark, with minima of 5 days and maxima of 19 and 22 days, respectively. In the present study the minima in June for SL and RP seeds were 5 and 4 days, respectively, and the maxima 22 to 28 days in both cases. Bonde found that RP seeds from the summer of 1960 germinated 48.0% and 44.0% the following December and June, respectively. Söyrinki (1938) germinated seeds from northern Finland 8 to 9 months after collection and found germination of 47%, 76%, and 100% in three seed samples given dry cold treatment, with 99% germination in a portion of the last sample not cold-treated. The earliest germination he reported was on the sixth day.

C. Samples showing no more than 10% variation between December and May-June, with germination between 0% and 30%:

1. *Allium geyeri* (8.0, 11.0).
2. *Antennaria alpina* RP (12.0, 19.0).
3. *Aquilegia coerulea* (0, 0).
4. *Caltha leptosepala* SL (0, 0).
5. *Campanula uniflora* (0, 0). Sørensen reported no germination in this species from Greenland.
6. *Campanula rotundifolia* (0, 0). Nichols (1934) reported "considerable germination" of seeds of this species from the White Mountains of New Hampshire only after several months of refrigeration after planting, with 14 to 21 days required for germination.
7. *Castilleja occidentalis* RP (0, 0).
8. *Castilleja occidentalis* SL (0, 0.5).
9. *Cerastium beeringianum* JP (9.0, 11.5). Bonde found that RP seeds of this species from the summer of 1961 germinated 10.0% and 0.0% the following December and May, respectively.
10. *Cirsium hookerianum* (3.5, 0).
11. *Claytonia megarhiza* (0.5, 0).
12. *Draba crassifolia* (7.0, 5.3). Bliss reported that this species germinated 11.1% in the light and 0.0% in the dark, with a minimum of 8 days and maximum of 26. In the present dark study the minimum in May was 4 days and the maximum was 12 days. Sørensen reported germination of seeds from Greenland.
13. *Draba aurea* RP (4.5, 1.0).
14. *Dryas octopetala* (12.0, 18.0). Söyrinki tested seeds of this species from Finland 8 to 9 months after collection and found that three cold-treated seed samples germinated 18%, 38%, and 45%, respectively, and that a portion of the last sample which did not receive cold treatment germinated 40%. Germination was observed to begin the third day and end the first week. Sørensen reported germination of seeds from Greenland.
15. *Epilobium alpinum* (1.5, 4.0).
16. *Erigeron simplex* RP (18.0, 13.0).
17. *Haplopappus pygmaeus* JP (0, 4.0).
18. *Haplopappus pygmaeus* SL (1.5, 6.0).
19. *Heuchera parvifolia* SL (4.0, 4.0). Bonde reported germination of 73.0% and 82.0% in seeds of this species from the summer of 1961 in the following December and May, respectively.
20. *Mertensia viridis* SL (3.0, 8.0).
21. *Pedicularis groenlandica* SL (0, 0).
22. *Pedicularis groenlandica* RP (0.5, 0).
23. *Penstemon whippleanus* (6.5, 4.5). Bonde found that RP seeds of this species from the summer of 1961 failed to germinate the following December and May.
24. *Polemonium viscosum* RP (7.0, 6.0).
25. *Polemonium viscosum* SL (1.0, 0). Bliss found 2.8% germination of Wyoming seeds of this species in the light and none in the dark, with a minimum of 5 days and a maximum of 8. In the present study RP seeds had a minimum of 4 days in May and a maximum of 14, while SL seeds failed to germinate.
26. *Potentilla diversifolia* SL (16.5, 19.5). Bliss reported 10.5% and 8.3% germination of Wyoming seeds in the light and dark, respectively, with minima of 12 and 5 days and maxima of 12 and 8 days. In the present study the minima were 3 and 5 days for RP and SL seeds, respectively, and the maxima were 15 to 21 days and 22 to 28 days. Bonde found that RP seeds from the summer of 1961 germinated 63.0% and 78.0% the following December and June, respectively.
27. *Saxifraga bronchialis* (3.0, 3.5).

28. *Saxifraga flagellaris* (0.5, 0).
29. *Sedum integrifolum* SL (20.5, 28.0).
30. *Sedum rhodanthum* (7.0, 5.5).
31. *Silene acaulis* JP (15.0, 10.0). The December test lasted 14 days.
32. *Silene acaulis* RP (27.5, 26.0). The December test lasted 14 days. Bliss found that this species germinated 86.7% and 89.7% in the light and dark, respectively, with minima of 5 days and maxima of 26 days. Söyrinki found that cold-treated seeds from Finland germinated 99% 8 to 9 months after harvest, beginning the second day and ending the eighth week, while seeds without cold treatment germinated 95%, beginning the third day and ending the tenth week. Jones and Richards (1962) reported that seeds from northern Wales germinated poorly, with no effect of light, and Sϕrensen found some germination in seeds from Greenland. In the present study the minima were 1, 2, and 3 days for JP, RP, and SL seeds, respectively, and the maxima were 22 to 28, 22 to 28, and 15 to 21 days. Bonde reported that RP seeds from the summer of 1960 germinated 4.0% and 54.0% the following December and June, respectively, and that 1961 RP seeds germinated 32.0% and 73.0%.
33. *Stellaria weberi* (2.5, 4.5).

D. Samples showing changes between December and May-June of more than 10% of the total number of seeds tested and decreasing in germination:

1. *Antennaria alpina* SL (65.5, 39.0).* Bonde found that RP seeds of this species from the summer of 1961 germinated 22.0% and 16.0% the following December and May, respectively. Sϕrensen reported germination of seeds from Greenland.
2. *Arenaria fendleri* RP (98.5, 83.5).*
3. *Arenaria obtusiloba* (77.5, 47.3).* Bliss found that this species germinated 100% and 85.0% in the light and dark, respectively, with minima of 5 days and maxima of 12 and 15 days. In the present study the minimum in May was 3 days and the maximum 22 to 28 days. Bonde reported that RP seeds from the summer of 1960 germinated 4.0% and 10.0% the following December and May, respectively, and that 1961 SL seeds germinated 94.0% the following May.
4. *Arenaria rubella* SL (47.0, 4.5).*
5. *Besseya alpina* RP (88.0, 27.0).
6. *Erigeron pinnatisectus* SL (91.0, 60.5).* Bliss reported 98.0% and 96.5% germination in this species in the light and dark, respectively, with minima of 5 days and maxima of 15 and 12 days. In the present study the minimum in May for both SL and RP seeds was 2 days and the maxima were 15 to 21 and 22 to 28 days, respectively.
7. *Gentiana romanzovii* (10.5, 0).*
8. *Geum rossii* (43.0, 23.0). Bliss found 100% and 78.0% germination in this species in the light and dark, respectively, with minima of 5 and 8 days and maxima of 29 and 23 days. In the present study the minimum in May was found to be 3 days and the maximum 14 days. Bonde reported 68.0% and 94.0% germination for 1960 RP seeds tested the following December and May, respectively.
9. *Heuchera parvifolia* RP (45.0, 24.5).*
10. *Lloydia serotina* RP (90.0, 76.0).*
11. *Mertensia viridis* RP (25.0, 12.5).*
12. *Polygonum viviparum* (93.0, 69.0).*
13. *Potentilla diversifolia* RP (48.0, 35.0).
14. *Potentilla fruticosa* RP (65.0, 54.0).
15. *Potentilla fruticosa* SL (58.5, 27.5).*
16. *Saxifraga cernua* (95.0, 72.5).* Söyrinki found that bulblets of

this species from Finland germinated 88% 8 to 9 months after collection, beginning at the end of the first week of the test.

17. *Sedum lanceolatum* RP (57.0, 41.5).*
18. *Silene acaulis* SL (23.0, 12.0).* The December test lasted 14 days.
19. *Thlaspi alpestre* (35.0, 13.5).* Bonde reported germination of 22.0% and 30.0% for RP seeds from the summer of 1961 tested in December and June, respectively.
20. *Veronica wormskjoldii* (94.0, 51.5).* Söyrinki reported that seeds of this species from Finland germinated 79% and 85% in two seed samples given cold treatment and 98% in a portion of the first sample not treated with cold, 8 to 9 months after collection. Germination began the seventh day but continued for many months.

E. Samples changing by more than 10% in germination between December and May-June and increasing in germination:

1. *Achillea lanulosa* (1.5, 82.5).*
2. *Cerastium beeringianum* SL (4.0, 18.5).
3. *Draba aurea* SL (20.5, 38.5).
4. *Erigeron pinnatisectus* RP (57.0, 85.5).*
5. *Haplopappus pygmaeus* RP (49.5, 73.0).*
6. *Hymenoxys acaulis* (36.5, 71.5).* Bonde found that RP seeds of this species from the summer of 1960 germinated 92.0% and 94.0% the following December and May, respectively.
7. *Hymenoxys grandiflora* JP (71.0, 83.0).*
8. *Oxyria digyna* SL (68.0, 79.5).* Söyrinki found that seeds of this species from Finland germinated 89% and 94% in two samples given cold treatment. A portion of the latter sample germinated to the same extent without cold treatment. Germination began the second day and continued up to 11 weeks.
9. *Phacelia sericea* SL (12.0, 28.5).*
10. *Phacelia sericea* RP (8.0, 26.5).* It was reported by Bonde that RP seeds of this species from the summer of 1960 germinated 8.0% and 10.0% the following December and May, respectively, and that 1961 RP seeds germinated 31.0% and 26.0%.
11. *Polygonum bistortoides* SL (4.0, 16.0).* Bonde reported germination of 2.0% in SL seeds from the summer of 1960 both the following December and the following June.

F. A comparison of germination of seeds of the same species from the Summit Lake, Rollins Pass, and James Peak sites shows differences of less than 10% among sites in the December tests, in the following cases:

1. *Besseya alpina* (RP 88.0, JP 93.5).
2. *Cerastium beeringianum* (SL 4.0, JP 9.0).
3. *Caltha leptosepala* (RP 0, SL 0).
4. *Oxyria digyna* (RP 76.0, SL 68.0).
5. *Pedicularis groenlandica* (RP 0.5, SL 0).
6. *Phacelia sericea* (SL 12.0, RP 8.0).
7. *Polemonium viscosum* (RP 7.0, SL 1.0).
8. *Polygonum bistortoides* (SL 4.0, RP 2.5).
9. *Potentilla fruticosa* (RP 65.0, SL 58.5).

G. The species with less than 10% difference among the sites in the May-June tests are as follows:

1. *Cerastium beeringianum* (SL 18.5, JP 11.5).
2. *Mertensia viridis* (RP 12.5, SL 8.0).
3. *Pedicularis groenlandica* (RP 0, SL 0).
4. *Phacelia sericea* (SL 28.5, RP 26.5).

5. *Polemonium viscosum* (RP 6.0, SL 0).
6. *Sedum integrifolium* (RP 30.5, SL 28.0).
7. *Trifolium nanum* (RP 31.0, SL 27.5).
8. *Trifolium parryi* (RP 31.0, JP 31.0).

H. Germination differences of more than 10% among seed samples of the same species from the different sites were more common in both tests. The species in which the Summit Lake seeds were higher in germination in December are listed below:

1. *Antennaria alpina* (SL 65.5, RP 12.0).*
2. *Draba aurea* (SL 20.5, RP 4.5).*
3. *Erigeron simplex* (SL 33.5, RP 18.0).*
4. *Erigeron pinnatisectus* (SL 91.0, RP 57.0).*
5. *Geum rossii* (SL 43.0, RP 28.0).
6. *Melandrium furcatum* (SL 99.0, JP 95.0),* (SL 99.0, RP 68.0).*
7. *Sedum lanceolatum* (SL 92.5, RP 57.0).

I. In the May-June tests the following differences of more than 10% appeared, with the Summit Lake seeds higher:

1. *Antennaria alpina* (SL 39.0, RP 19.0).*
2. *Draba aurea* (SL 38.5, RP 1.0).*
3. *Erigeron simplex* (SL 41.5, RP 13.0).*
4. *Melandrium furcatum* (SL 99.0, RP 62.0).*
5. *Oxyria digyna* (SL 79.5, RP 69.0).*
6. *Sedum lanceolatum* (SL 90.0, RP 41.5).*
7. *Trifolium parryi* (SL 41.5, RP 31.0),* (SL 41.5, JP 31.0).*

J. Germination in Rollins Pass seeds exceeded that of seeds from other sources by more than 10% in December in the following cases:

1. *Arenaria fendleri* (RP 98.5, SL 43.5).*
2. *Arenaria rubella* (RP 62.5, SL 47.0).
3. *Artemisia arctica* (RP 82.0, SL 66.0).
4. *Cerastium beeringianum* (RP 17.0, SL 4.0).*
5. *Haplopappus pygmaeus* (RP 49.5, SL 1.5),* (RP 49.5, JP 0).*
6. *Heuchera parvifolia* (RP 45.0, SL 4.0).*
7. *Lloydia serotina* (RP 90.0, SL 64.5).*
8. *Mertensia viridis* (RP 25.0, SL 3.0).*
9. *Potentilla diversifolia* (RP 48.0, SL 16.5).*
10. *Sedum integrifolium* (RP 30.5, SL 20.5).
11. *Sibbaldia procumbens* (RP 60.0, SL 24.5).*
12. *Silene acaulis* (RP 27.5, JP 15.0).* The test lasted 14 days.

K. In May-June the Rollins Pass seeds showed the better germination by more than 10% in the following species:

1. *Arenaria fendleri* (RP 83.5, SL 44.5).*
2. *Arenaria rubella* (RP 60.0, SL 4.5).*
3. *Erigeron pinnatisectus* (RP 85.5, SL 60.5).*
4. *Haplopappus pygmaeus* (RP 73.0, SL 6.0),* (RP 73.0, JP 4.0).*
5. *Heuchera parvifolia* (RP 24.5, SL 4.0).*
6. *Lloydia serotina* (RP 76.0, SL 60.5).*
7. *Potentilla diversifolia* (RP 35.0, SL 19.5).*
8. *Potentilla fruticosa* (RP 54.0, SL 27.5).*
9. *Sibbaldia procumbens* (RP 64.0, SL 32.5).*
10. *Silene acaulis* (RP 26.0, SL 12.0),* (RP 26.0, JP 10.0).*
11. *Trifolium dasyphyllum* (RP 35.5, SL 20.5).*

In similar comparisons, *Hymenoxys grandiflora* from James Peak showed the best germination in December (JP 71.0, SL 44.5, RP 36.0) and in May-June as well (JP 83.0, SL 50.0, RP 37.5). In May-June, in addition, *Besseya alpina* from James Peak showed the better germination (JP 88.0, RP 27.0).

Figure 1 shows that 9.4% of the 85 samples tested in both December and May-June failed completely to germinate in December and that half again as many failed in May-June. Of the percentage-germination categories above 0%, the greatest number of samples germinated in the lowest range of 0.5 to 10.5% in December, but in May-June the samples were fairly uniformly distributed throughout the categories, although there were approximately one-fourth as many in the highest germination category as in December. After 5 or 6 months of additional dry storage there were thus fewer seed samples that failed to germinate, indicating a loss of dormancy with time in some species. On the other hand, about one-quarter as many germinated in the highest percentage category after this period of time, indicating a loss of germinability with time, as well. A comparison of the percentage germination in December and May-June between seeds of 26 species collected from both Summit Lake and Rollins Pass indicates the same general pattern as that for all 85 samples of 56 species in Figure 1, with more seed samples germinating in both the highest and lowest categories in December than in May-June and the intermediate categories being higher in May-June than in December.

Figure 2 compares the first day of germination in December and May-June for all 85 samples of seeds tested twice. In some species germination began a day earlier in May-June than December, and in a few it began after 3 weeks in May-June. In both tests germination began in the largest number of cases the third day after the beginning of the tests. A comparison of germination between seeds from the Summit Lake site and seeds from the Rollins Pass site shows no major differences, although a somewhat larger proportion of the Rollins Pass seed samples initated germination in the first week in the December tests than was the case with the Summit Lake seeds.

Tabulations of the day of maximum germination are presented in Figure 3, with the first day of maximum germination utilized if several days had the same amount of germination. In December the greatest number of seed samples attained their maximum germination on the third day, while in May-June the maximum was found on the fourth day in the greatest number of samples. The maxima for some seeds in May-June came during the fourth week of testing, while in December the latest maxima were found in the third week. In general, then, the day of maximum germination came later in the seeds which had been stored an additional 5 or 6 months. Separate tabulations of the Summit Lake and Rollins Pass seeds reveal no major differences in the pattern of maximum germination between the two.

A comparison of the day of "essential completion" of germination in December and in May-June is made in Figure 4. This day was considered to be the day after which no more than 1% additional germination took place if the final total was less than 5%, or the day when only 5% or less additional germination occurred if the final total was over 5%. The figure shows that in December the greatest number of samples essentially completed their germination on the 8th day and between the 15th and 21st days; in May-June equal numbers of samples essentially completed germination on the 7th and 8th days, indicating a hastening of germination in some cases, after 5-6 months. On the other hand, in some samples completion of germination in May-June was delayed until the fourth week. In general, then, it may be said that aging of the seeds resulted in a delay in the essential completion of germination in some cases and a hastening in others.

The day of the last germination in each of the various seed samples is tabulated in Figure 5. In both tests some samples completed germination as early as the fifth day, but in both the largest number showed their last germination in the fourth weeks of the four-week tests, though usually only one or two seeds germinated in this final period. Rollins Pass seeds taken separately showed the greatest number of samples having the day of final germination in the third week in December, however, but not in May-June. Again there appears a pattern of delay in germination with storage time.

The general features of the total germination of seeds of alpine plants (under the conditions of these tests) which emerge are that most seed samples stored dry following collection undergo no great change in germinability between December and May-June (63.5% of the samples, in 44 of the 56 species), that some samples decrease in germination in this period (23.5% of the samples, in 19 of the 56 species), and that some samples increase in germination (12.9% in 10 of the 56 species). Comparison of germination in seeds of the same species from the Summit Lake and Rollins Pass sites shows that of 28 such species tested in December approximately one-third showed no great differences, slightly less than one-third showed better germination in the Summit Lake seeds, and slightly more than one-third showed better germination in the Rollins Pass seeds. The same held true in the May-June tests. The germination differences in seed samples of the same species from different locations may perhaps be ascribed to environmental differences between the sites during the growing season, to differences in ripeness at the time of seed collection, or to ecotypic differences between the plants from the different sites.

The germination rate of the seeds in general was affected by the 5-6 months of dry storage in that there was a trend toward earlier germination in May-June (in December 85.3% of the seed samples initiated germination in the first week and in May-June 94.3% did so). The day of maximum germination was also advanced (68.8% of the samples attained their maxi-

mum rate in the first week in December, while the figure for May-June was 79.5%). On the other hand, in some certain species the maximum rate was attained later in May-June than in December. The day of essential completion occurred in the first 10 days in 63.7% of the samples in December and 69.9% in May-June, again indicating a hastening of germination after storage. The day of final germination in the 28-day tests was strongly influenced by the age of the seeds in that in December 47.2% of the samples which germinated at all finished germinating in 2 weeks, while in May-June only 28.8% had finished in that time. Thus, although the day of initiation of germination, of attainment of the maximum rate, and of attainment of essential completion were hastened, in general, by 5-6 months of seed storage, the germination period was spread out more, and so the day of completion of germination was delayed in many cases.

The ecological significance of the observed amount and rate of germination and of the changes or lack of changes with time under the unnatural storage and germination conditions employed here is not clear. The data presented presumably give some indication of the potential amount and rate of germination that may be expected under natural conditions for many of the species tested. A thorough study of dormancy, of the effects of various and varying temperatures, of light, and of scarification effects on each species, however, would be required to determine more completely the nature of germination behavior in the natural alpine environment.

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance of Maxine F. Foreman and Larry L. Tieszen during the course of this study and of Dr. William A. Weber in the identification of various species. This study was supported by Grant 10708 from the National Science Foundation.

LITERATURE CITED

BONDE, ERIK K. 1965. Studies on the germination of seeds of Colorado alpine plants. Univ. Colo. Studies, Series in Biol. No. 14. 16 pp.

BLISS, L. C. 1958. Seed germination in arctic and alpine species. Arctic 11:180-188.

JONES, VERNA, and P. W. RICHARDS. *Silene acaulis* (L.) Jacq. 1962. Jour. Ecol. 50:475-487.

PELTON, JOHN. 1956. A study of seed dormancy in eighteen species of high altitude Colorado plants. Butler Univ. Bot. Studies 13:74-84.

NICHOLS, G .E. 1934. The influence of exposure to winter temperatures upon seed germination in various native American plants. Ecol. 15:364-373.

SØRENSEN, THORVALD. 1941. Temperature relations and phenology of the northeast Greenland flowering plants. Medd. om Grønland 125:1-305.

SÖYRINKI, NIILO. 1938-39. Studien über die generative und vegetative Vermehrung der Samenpflanzen in der alpinen Vegetation Petsamo-Lapplands. I, II. Ann. Soc. Zool.-Bot. Fenn. Vanamo 11:1-323 and 14:1-405.

TABLE 1. Germination of 1963 seeds in days after December 6, 1963.
(Percentage germination of 200 seeds, unless otherwise noted)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21	28	S.D.
Achillea lanulosa SL	0.0	0.0	0.5	1.0	1.0	1.0	1.0	1.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	± 1.0
Allium geyeri SL (75 seeds)	0.0	0.0	0.0	0.0	0.0	1.3	2.7	5.3	5.3	5.3	6.7	8.0	8.0	8.0	8.0	8.0	.....
Androsace septentrionalis RP	0.0	12.0	87.5	90.5	90.5	91.0	93.5	93.5	93.5	93.5	93.5	94.0	94.0	94.0	94.0	94.0	9.4
Antennaria alpina SL	0.0	1.0	12.5	28.0	43.0	49.5	50.0	59.0	60.0	60.5	62.0	64.0	64.0	65.5	65.5	65.5	15.2
Antennaria alpina RP	0.0	0.0	0.5	3.0	4.5	4.5	5.0	6.0	8.5	8.5	8.5	8.5	8.5	10.0	10.5	12.0	4.3
Aquilegia coerulea RP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	.....
Arenaria fendleri SL	0.0	24.0	33.0	34.0	36.5	36.5	37.5	38.5	39.0	39.0	41.0	43.0	43.0	43.5	43.5	43.5	9.6
Arenaria fendleri RP	0.0	88.5	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.5	98.5	1.0
Arenaria obtusiloba RP	0.0	18.0	52.5	57.0	63.5	67.5	70.5	71.5	73.0	73.0	73.5	73.5	73.5	73.5	75.0	77.5	12.0
Arenaria rubella SL	0.0	0.0	1.0	3.0	15.5	20.5	29.0	30.5	31.0	39.5	42.0	44.0	45.0	45.0	47.0	47.0	15.8
Arenaria rubella RP	0.0	0.0	1.5	4.0	13.0	18.0	38.5	47.0	50.5	54.5	55.0	56.5	58.5	60.0	62.5	62.5	15.8
Artemisia arctica SL (25 seeds)	0.0	0.0	0.0	2.0	6.0	10.0	28.0	28.0	52.0	52.0	52.0	60.0	60.0	64.0	66.0	66.0	.....
Artemisia arctica RP (100 seeds)	0.0	0.0	0.0	0.0	6.0	18.0	41.0	43.0	54.0	62.0	70.0	73.0	76.0	80.0	82.0	82.0	.....

TABLE 1. Germination of 1963 seeds in days after December 6, 1963.
(Percentage germination of 200 seeds, unless otherwise noted)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21	28	S.D.
Artemisia scopulorum SL	0.0	41.0	84.0	89.0	93.0	97.0	97.0	99.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	± 0.0
Besseya alpina RP (50 seeds)	0.0	0.0	0.0	0.0	0.0	8.0	36.0	58.0	68.0	72.0	80.0	84.0	86.0	86.0	88.0	88.0	.....
Besseya alpina JP	0.0	0.0	0.0	0.0	0.0	13.0	31.5	65.5	72.5	87.0	90.0	92.5	92.5	92.5	93.0	93.5	4.1
Caltha leptosepala SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.....
Caltha leptosepala RP (50 seeds)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.....
Campanula uniflora RP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.....
Campanula rotundifolia RP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.....
Castilleja occidentalis SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.....
Castilleja occidentalis RP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.....
Cerastium beeringianum SL	0.0	0.5	0.5	1.0	2.5	2.5	2.5	3.5	3.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	5.4
Cerastium beeringianum RP	0.0	0.5	4.0	4.5	5.5	6.5	6.5	8.5	10.5	10.5	11.5	12.0	12.0	12.0	13.5	17.0	8.8
Cerastium beeringianum JP	0.0	0.5	1.5	3.0	4.5	5.5	6.5	7.5	7.5	8.0	8.0	8.0	8.0	8.5	9.0	9.0	7.2
Chionophila jamesii SL	0.0	13.0	63.0	75.0	79.0	81.5	84.5	85.0	85.0	85.0	85.0	85.0	85.0	85.0	85.0	85.0	2.6

TABLE 1. Germination of 1963 seeds in days after December 6, 1963.
(Percentage germination of 200 seeds, unless otherwise noted)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21	28	S.D.
Cirsium hookerianum SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	2.0	2.5	2.5	3.0	3.0	3.5	3.5	± 1.0
Claytonia megarhiza SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.5	0.5	1.0
Draba aurea SL	0.0	0.0	0.0	1.5	2.5	4.0	10.0	11.5	13.0	19.0	20.5	20.5	20.5	20.5	20.5	20.5	12.8
Draba aurea RP	0.0	0.0	0.0	0.0	0.0	0.5	2.0	2.0	2.5	3.0	3.0	3.5	3.5	4.5	4.5	4.5	5.3
Draba crassifolia RP	0.0	0.0	2.5	4.5	4.5	6.5	6.5	6.5	6.5	6.5	6.5	7.0	7.0	7.0	7.0	7.0	5.8
Dryas octopetala RP	0.0	0.0	0.0	0.5	2.0	3.0	3.5	9.5	9.5	9.5	10.5	10.5	10.5	11.5	12.0	12.0	5.7
Epilobium alpinum SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.5	1.5	1.5	1.9
Erigeron pinnatisectus SL	0.0	21.0	82.5	87.5	90.5	91.0	91.0	91.0	91.0	91.0	91.0	91.0	91.0	91.0	91.0	91.0	8.9
Erigeron pinnatisectus RP	0.0	2.5	42.0	52.0	54.5	55.5	56.5	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	57.0	11.6
Erigeron simplex SL	0.0	1.5	5.0	8.5	11.0	12.0	16.0	18.0	19.5	25.5	26.0	26.5	26.5	28.0	33.0	33.5	9.8
Erigeron simplex RP	0.0	0.0	4.0	6.5	8.5	9.5	13.0	13.0	13.5	14.5	17.5	17.5	18.0	18.0	18.0	18.0	5.9
Erysimum nivale RP	0.0	0.0	6.5	21.0	32.0	35.0	38.0	40.0	40.5	41.0	41.0	41.0	41.5	41.5	41.5	41.5	10.0
Gentiana romanzovii RP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.5	8.5	9.0	9.0	10.0	10.5	1.9

TABLE 1. Germination of 1963 seeds in days after December 6, 1963.
(Percentage germination of 200 seeds, unless otherwise noted)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21	28	S.D.
Geum rossii SL	0.0	0.0	1.0	5.0	10.5	22.0	28.5	35.0	36.5	39.0	39.0	41.5	41.5	42.0	42.5	43.0	± 16.1
Geum rossii RP (75 seeds)	0.0	0.0	0.0	0.0	0.0	0.0	7.3	16.0	16.0	20.0	22.7	24.7	24.7	25.3	28.0	28.0	-----
Haplopappus pygmaeus SL	0.0	0.0	0.0	0.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	3.0
Haplopappus pygmaeus RP	0.0	0.0	8.5	21.5	31.0	41.5	44.5	47.0	48.0	49.0	49.0	49.0	49.0	49.0	49.5	49.5	7.7
Haplopappus pygmaeus JP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-----
Heuchera parvifolia SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	3.5	4.0	1.6
Heuchera parvifolia RP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	6.5	11.5	28.0	28.5	32.0	45.0	45.0	4.2
Hymenoxys acaulis RP	0.0	0.0	5.5	12.0	23.0	33.5	35.0	35.5	35.5	36.0	36.5	36.5	36.5	36.5	36.5	36.5	11.2
Hymenoxys grandiflora SL	0.0	0.0	6.0	12.0	24.5	32.0	36.0	40.5	41.0	41.0	41.5	41.5	41.5	43.0	44.0	44.5	8.8
Hymenoxys grandiflora RP	0.0	0.0	4.0	8.5	13.0	22.0	26.0	31.5	33.0	35.0	35.5	35.5	35.5	35.5	36.0	36.0	7.3
Hymenoxys grandiflora JP	0.0	0.0	9.5	21.5	28.0	51.5	54.5	62.0	65.0	66.5	67.5	67.5	67.5	69.0	70.0	71.0	7.7
Lloydia serotina SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	6.5	11.0	21.5	31.5	38.0	47.5	62.0	64.5	3.0
Lloydia serotina RP	0.0	0.0	0.0	0.0	0.0	0.0	0.5	6.5	19.0	41.0	57.0	67.0	76.5	85.0	89.5	90.0	1.6

TABLE 1. Germination of 1963 seeds in days after December 6, 1963.
(Percentage germination of 200 seeds, unless otherwise noted)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21	28	S.D.
Melandrium furcatum SL	0.0	0.0	75.5	91.5	97.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	± 2.0
Melandrium furcatum RP	0.0	0.0	20.5	34.0	40.5	48.5	51.0	56.5	58.5	62.0	64.0	65.0	65.5	65.5	66.5	68.0	8.3
Melandrium furcatum JP	0.0	0.0	40.5	68.5	78.5	86.5	90.0	92.0	93.5	94.0	94.0	94.0	94.5	95.0	95.0	95.0	2.6
Mertensia viridis SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.5	2.0	2.5	2.5	3.0	3.0	3.0	3.0	2.0
Mertensia viridis RP	0.0	0.0	1.5	2.0	3.5	4.5	6.5	8.0	9.5	10.5	11.0	14.0	15.5	17.5	24.0	25.0	8.3
Oxyria digyna SL	0.0	0.0	42.5	52.0	57.5	59.0	64.5	65.0	65.5	65.5	67.5	67.5	67.5	67.5	68.0	68.0	3.7
Oxyria digyna RP	0.0	7.5	46.5	55.0	64.5	66.5	70.0	71.5	71.5	72.5	73.0	73.0	75.0	75.0	76.0	76.0	7.1
Pedicularis groenlandica SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.....
Pedicularis groenlandica RP	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0
Penstemon whippleanus RP	0.0	0.0	0.0	0.0	0.0	0.5	0.5	3.0	3.5	3.5	3.5	3.5	5.5	5.5	6.5	6.5	4.1
Phacelia sericea SL	0.0	0.0	0.0	1.5	2.0	4.5	5.0	6.0	7.5	8.5	9.5	12.0	12.0	12.0	12.0	12.0	3.7
Phacelia sericea RP	0.0	0.0	0.0	2.0	3.5	3.5	4.0	5.5	5.5	6.5	6.5	7.5	8.0	8.0	8.0	8.0	2.8
Polemonium viscosum SL	0.0	0.0	0.0	0.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0

TABLE 1. Germination of 1963 seeds in days after December 6, 1963.
(Percentage germination of 200 seeds, unless otherwise noted)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21	28	S.D. ±
Polemonium viscosum RP	0.0	0.0	0.0	0.0	0.0	1.0	2.0	2.0	2.0	4.5	4.5	4.5	6.0	6.5	7.0	7.0	2.6
Polygonum bistortoides SL	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	1.0	1.5	2.0	2.0	2.0	2.0	4.0	4.0	2.8
Polygonum bistortoides RP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.5	1.5	1.5	1.5	2.0	2.0	2.5	2.5	2.5
Polygonum viviparum RP (bulblets)	0.0	0.0	0.0	0.0	5.5	18.5	56.0	68.0	89.5	89.5	89.5	92.0	92.0	92.0	92.0	93.0	5.0
Potentilla diversifolia SL	0.0	0.0	0.0	0.0	0.0	2.5	8.0	8.0	11.0	11.0	11.5	13.5	14.5	14.5	16.0	16.5	11.1
Potentilla diversifolia RP	0.0	0.0	5.5	23.0	38.5	44.5	46.5	47.0	47.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	17.6
Potentilla fruticosa SL	0.0	0.0	0.0	0.0	8.5	18.5	32.5	37.0	42.5	47.0	50.5	51.5	53.5	55.0	58.0	58.5	8.1
Potentilla fruticosa RP	0.0	0.0	0.0	1.0	7.5	16.5	24.0	30.0	36.5	39.0	50.0	53.0	56.0	59.5	63.0	65.0	6.2
Saxifraga bronchialis RP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0	1.4
Saxifraga cernua SL (bulblets)	0.0	0.0	22.0	63.5	80.0	86.5	88.0	90.5	94.5	94.5	94.5	95.0	95.0	95.0	95.0	95.0	3.5
Saxifraga flagellaris SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5	1.0
Saxifraga rhomboidea RP	0.0	0.0	0.0	0.0	14.0	23.5	58.5	64.0	80.0	82.5	84.0	85.5	88.0	88.5	89.0	89.0	8.9
Sedum integrifolium SL	0.0	3.5	10.0	15.5	18.5	19.5	19.5	19.5	20.0	20.0	20.0	20.5	20.5	20.5	20.5	20.5	5.3

TABLE 1. Germination of 1963 seeds in days after December 6, 1963.
(Percentage germination of 200 seeds, unless otherwise noted)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21	28	S.D.
Sedum integrifolium RP	0.0	13.0	23.5	25.5	29.5	30.0	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	± 9.3
Sedum lanceolatum SL	0.0	0.0	3.0	32.5	60.0	69.0	78.5	80.0	83.5	87.5	89.0	90.5	90.5	90.5	92.5	92.5	4.4
Sedum lanceolatum RP	0.0	0.0	0.5	6.0	18.5	27.0	36.5	40.0	45.5	48.5	48.5	49.5	51.0	54.0	56.5	57.0	5.3
Sedum rhodanthum SL	0.0	0.0	0.5	1.0	3.5	4.0	4.5	4.5	4.5	5.0	5.0	6.0	6.0	7.0	7.0	7.0	3.5
Sibbaldia procumbens SL	0.0	0.0	0.0	0.0	0.0	0.5	2.0	4.5	7.0	9.5	13.0	14.0	14.0	17.5	22.0	24.5	4.7
Sibbaldia procumbens RP	0.0	0.0	0.0	0.0	3.0	26.0	43.0	46.5	52.5	55.0	59.0	59.5	59.5	59.5	59.5	60.0	3.7
Silene acaulis SL	0.0	0.0	0.0	1.5	4.5	7.5	12.0	16.5	21.0	22.0	22.0	22.5	22.5	23.0	.....	.....	2.6
Silene acaulis RP	0.0	0.0	1.0	1.5	5.5	11.5	14.5	19.5	22.5	24.0	25.5	25.5	25.5	27.5	.....	.....	1.9
Silene acaulis JP	0.0	0.0	1.0	1.5	2.5	4.5	4.5	9.0	11.5	12.5	14.0	14.0	15.0	15.0	.....	.....	4.7
Stellaria weberi RP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5	2.5	2.5	2.5	.....	.....	1.9
Thlaspi alpestre RP	0.0	0.0	0.0	0.5	4.0	8.5	15.5	20.0	23.0	26.5	29.0	31.0	34.5	35.0	35.5	38.0	10.1
Veronica wormskjoldii RP	0.0	0.0	0.0	0.0	22.5	84.5	90.0	91.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	94.0	1.6

TABLE 2. Germination of 1963 seeds in days after May 12, 1964.
(Percentage germination of 200 seeds, unless otherwise noted)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21	28	S.D.
Achillea lanulosa SL	0.0	11.0	49.5	49.5	65.5	75.0	78.5	78.5	78.5	78.5	79.0	79.0	79.0	79.0	79.5	82.5	± 9.8
Allium geyeri SL (75 seeds)	0.0	0.0	0.0	0.0	0.0	2.7	2.7	5.5	8.2	8.2	11.0	11.0	11.0	11.0	11.0	11.0	.....
Androsace septentrionalis RP	0.0	0.0	53.5	86.5	86.5	86.5	86.5	86.5	86.5	86.5	86.5	86.5	86.5	86.5	86.5	87.0	8.3
Antennaria alpina SL	0.0	0.0	2.5	29.0	29.0	32.5	33.0	36.5	37.5	38.5	38.5	39.0	39.0	39.0	39.0	39.0	7.7
Antennaria alpina RP	0.0	0.0	0.5	2.0	6.5	9.5	12.5	13.0	14.0	15.0	16.0	17.5	17.5	17.5	18.5	19.0	9.3
Aquilegia coerulea RP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.....
Arenaria fendleri SL	2.5	11.0	29.5	32.5	37.5	38.5	39.5	40.0	41.5	43.0	44.0	44.5	44.5	44.5	44.5	44.5	11.0
Arenaria fendleri RP	2.0	58.5	76.5	79.0	80.5	81.0	81.5	82.0	82.5	83.0	83.5	83.5	83.5	83.5	83.5	83.5	5.3
Arenaria obtusiloba RP (150 seeds)	0.0	0.0	5.3	28.6	41.3	42.0	42.0	43.3	44.0	44.6	44.6	44.6	45.3	45.3	46.6	47.3	.....
Arenaria rubella SL	0.0	0.0	0.0	1.0	3.0	3.5	4.0	4.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.4
Arenaria rubella RP	0.0	0.0	0.0	3.0	9.5	23.5	29.0	31.5	40.5	43.0	47.0	57.0	58.0	58.5	59.5	60.0	6.7
Artemisia arctica RP	0.0	3.0	6.5	16.0	32.5	43.5	54.0	62.0	63.0	66.0	67.5	70.0	70.5	70.5	71.0	74.0	9.9
Artemisia scopulorum SL	0.0	14.0	79.5	93.0	96.5	97.0	97.0	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	98.0	2.8

TABLE 2. Germination of 1963 seeds in days after May 12, 1964.
(Percentage germination of 200 seeds, unless otherwise noted)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21	28	S.D.
Besseya alpina RP (100 seeds)	0.0	0.0	0.0	0.0	0.0	2.0	2.0	8.0	20.0	20.0	23.0	24.0	25.0	25.0	27.0	27.0	± -----
Besseya alpina JP	0.0	0.0	0.0	0.0	1.5	17.5	35.0	54.5	62.5	65.5	72.0	77.0	79.5	81.5	86.0	88.0	3.3
Caltha leptosepala SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-----
Campanula uniflora RP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-----
Campanula rotundifolia RP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-----
Castilleja occidentalis SL	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0
Castilleja occidentalis RP (150 seeds)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-----
Cerastium beeringianum SL	0.0	0.0	0.0	8.5	8.5	12.5	12.5	14.0	14.0	14.0	14.5	14.5	14.5	14.5	14.5	18.5	10.8
Cerastium beeringianum JP	0.0	0.0	0.0	0.0	3.5	4.0	4.5	6.5	6.5	8.5	8.5	10.5	10.5	10.5	11.0	11.5	3.8
Chionophila jamesii SL	0.0	0.0	79.0	89.0	90.0	91.0	91.0	91.0	91.0	91.0	91.0	91.0	91.0	91.0	92.0	92.0	2.8
Cirsium hookerianum SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-----
Claytonia megarhiza SL (90 seeds)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-----
Draba aurea SL	0.5	2.0	4.5	10.5	13.0	13.0	14.0	14.5	16.5	18.5	20.0	20.5	21.0	21.5	23.0	38.5	7.2

TABLE 2. Germination of 1963 seeds in days after May 12, 1964.
(Percentage germination of 200 seeds, unless otherwise noted)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21	28	S.D.
Draba aurea RP	0.0	0.0	0.0	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1.0	1.0	1.0	± 1.2
Draba crassifolia RP (150 seeds)	0.0	0.0	0.0	2.6	2.6	2.6	3.3	4.0	4.6	4.6	4.6	5.3	5.3	5.3	5.3	5.3	.....
Dryas octopetala RP	0.0	0.0	0.0	2.5	6.5	7.5	10.5	12.5	15.0	15.5	16.5	17.0	17.0	17.0	17.0	18.0	2.8
Epilobium alpinum SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.3
Erigeron pinnatisectus SL	0.0	40.0	57.5	58.5	59.5	59.5	59.5	59.5	60.0	60.0	60.0	60.0	60.0	60.0	60.5	60.5	11.1
Erigeron pinnatisectus RP	0.0	31.5	78.5	82.5	83.5	84.0	85.0	85.0	85.0	85.0	85.0	85.0	85.0	85.0	85.0	85.5	3.7
Erigeron simplex SL	0.0	5.5	14.5	19.5	19.5	22.0	22.0	22.0	23.0	26.0	26.0	26.0	26.0	27.0	28.0	41.5	6.8
Erigeron simplex RP	0.0	0.0	0.5	3.0	5.0	7.5	7.5	9.5	9.5	10.0	11.0	11.0	11.0	11.0	11.5	13.0	5.3
Erysimum nivale RP	0.0	0.0	6.0	19.0	27.5	33.0	39.0	42.5	45.5	47.5	47.5	48.0	48.0	48.0	48.0	48.0	8.3
Gentiana romanzovii RP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.....
Geum rossii SL	0.0	0.0	0.5	5.0	10.0	12.0	16.0	18.5	21.0	21.5	22.0	22.5	22.5	23.0	23.0	23.0	10.4
Haplopappus pygmaeus SL	0.0	0.0	0.5	4.5	5.0	5.5	5.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	1.5
Haplopappus pygmaeus RP	0.0	0.0	24.5	47.5	58.0	64.5	69.5	71.0	71.0	72.0	72.5	72.5	73.0	73.0	73.0	73.0	10.4

TABLE 2. Germination of 1963 seeds in days after May 12, 1964.
(Percentage germination of 200 seeds, unless otherwise noted)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21	28	S.D.
Haplopappus pygmaeus JP	0.0	0.0	0.5	1.0	1.5	2.5	3.0	3.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	± 4.3
Heuchera parvifolia SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	2.0	2.0	4.0	4.0	1.6
Heuchera parvifolia RP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	4.0	4.5	12.0	15.0	16.0	17.0	23.0	24.5	4.4
Hymenoxys acaulis RP	0.0	2.0	27.5	59.5	69.0	69.5	69.5	70.0	70.0	70.0	70.0	70.0	70.0	70.0	70.0	71.5	8.2
Hymenoxys grandiflora SL	0.0	0.5	7.5	24.5	35.0	41.5	46.0	47.5	49.0	49.0	49.0	49.0	49.0	49.0	50.0	50.0	3.3
Hymenoxys grandiflora RP	0.0	0.0	2.0	12.5	18.5	24.0	31.0	34.5	35.5	36.5	36.5	36.5	37.5	37.5	37.5	37.5	4.1
Hymenoxys grandiflora JP	0.0	0.0	6.5	33.0	46.0	54.0	63.0	73.5	77.0	80.0	80.0	80.0	81.0	81.5	83.0	83.0	6.2
Lloydia serotina SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	4.5	10.0	15.0	30.0	36.0	46.0	57.5	60.5	6.9
Lloydia serotina RP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	15.5	31.0	50.5	63.5	69.0	72.0	76.0	76.0	4.3
Melandrium furcatum SL	0.0	0.5	51.0	98.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	99.0	1.2
Melandrium furcatum RP	0.0	0.5	11.5	35.5	43.5	50.5	52.5	55.0	56.0	56.0	56.0	58.5	59.0	60.0	61.5	62.0	11.2
Melandrium furcatum JP	0.0	0.5	20.0	72.5	79.0	83.0	85.5	86.5	87.0	88.0	88.0	88.0	89.0	89.0	89.0	89.0	5.3
Mertensia viridis SL	0.0	0.0	0.0	0.0	0.5	0.5	3.0	4.0	5.0	6.0	7.0	7.5	7.5	7.5	8.5	8.5	3.4

TABLE 2. Germination of 1963 seeds in days after May 12, 1964.
(Percentage germination of 200 seeds, unless otherwise noted)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21	28	S.D.
Mertensia viridis RP	0.0	0.0	0.5	0.5	2.0	2.5	3.5	7.0	8.0	9.0	9.5	10.0	10.0	10.0	12.0	12.5	± 4.7
Oxyria digyna SL	0.0	0.0	50.5	73.0	75.0	76.0	76.5	77.0	77.0	77.0	77.0	77.0	77.0	77.0	79.5	79.5	7.7
Oxyria digyna RP	0.0	0.0	36.5	54.0	58.5	59.5	61.5	63.0	65.0	65.0	65.0	66.5	66.5	66.5	66.5	69.0	6.2
Pedicularis groenlandica SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-----
Pedicularis groenlandica RP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-----
Penstemon whippleanus RP	0.0	0.0	0.0	0.5	0.5	3.0	3.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.5	2.2
Phacelia sericea SL	0.0	0.0	0.0	14.0	21.0	24.0	26.0	27.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.5	3.0
Phacelia sericea RP	0.0	0.0	0.0	16.0	19.0	21.5	24.0	25.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.5	9.8
Polemonium viscosum RP	0.0	0.0	0.0	1.0	2.0	2.5	2.5	3.5	4.5	5.5	5.5	5.5	5.5	6.0	6.0	6.0	3.7

Germination of 1963 seeds in days after June 3, 1964.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21	28	S.D.
Polemonium viscosum SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-----
Polygonum bistortoides SL	0.0	0.0	0.0	0.5	1.0	10.0	12.0	12.5	13.0	13.0	13.0	13.5	13.5	13.5	14.0	16.0	8.2

TABLE 2. Germination of 1963 seeds in days after June 3, 1964.
(Percentage germination of 200 seeds, unless otherwise noted)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21	28	S.D.
Polygonum viviparum RP (bulblets)	0.0	0.0	0.0	0.0	0.0	3.0	14.0	24.0	51.5	63.0	67.5	68.0	68.5	68.5	68.5	69.0	± 4.4
Potentilla diversifolia SL	0.0	0.0	0.0	0.0	1.0	4.5	9.5	11.5	12.0	14.0	15.5	16.5	16.5	16.5	18.0	19.5	10.0
Potentilla diversifolia RP	0.0	0.0	0.5	24.0	29.0	30.0	31.0	32.0	32.5	33.0	33.0	33.0	33.0	33.5	35.0	35.0	5.3
Potentilla fruticosa SL	0.0	0.0	0.0	1.0	6.5	13.0	15.5	17.0	18.0	22.5	24.0	24.0	24.0	24.5	27.0	27.5	5.7
Potentilla fruticosa RP	0.0	0.0	0.0	9.0	15.5	22.0	30.5	36.5	39.0	41.0	42.0	44.5	44.5	44.5	49.5	54.0	9.7
Saxifraga bronchialis RP (82 seeds)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	-----
Saxifraga cernua SL (bulblets)	0.0	0.0	0.0	23.0	32.5	50.5	57.5	64.5	65.5	69.0	69.0	69.5	72.0	72.0	72.0	72.5	8.2
Saxifraga flagellaris SL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-----
Saxifraga rhomboidea RP	0.0	0.0	0.0	0.0	0.0	15.5	37.0	42.0	47.5	60.0	65.5	79.5	81.5	82.0	84.0	86.0	8.2
Sedum integrifolium SL	0.0	5.0	16.5	22.0	23.5	24.0	25.5	26.0	26.5	26.5	26.5	27.5	27.5	27.5	28.0	28.0	6.3
Sedum integrifolium RP	0.0	13.5	26.5	28.5	29.5	29.5	30.0	30.0	30.5	30.5	30.5	30.5	30.5	30.5	30.5	30.5	4.4
Sedum lanceolatum SL	0.0	0.0	0.5	18.5	26.0	44.0	57.5	60.5	70.0	75.5	80.5	84.5	85.0	85.5	88.5	90.0	7.1
Sedum lanceolatum RP	0.0	0.0	0.5	0.5	2.5	8.0	13.5	17.5	24.5	27.5	32.5	36.0	37.5	38.0	41.0	41.5	7.7

TABLE 2. Germination of 1963 seeds in days after June 3, 1964.
(Percentage germination of 200 seeds, unless otherwise noted)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	21	28	S.D.
Sedum rhodanthum SL	0.0	0.0	0.5	1.0	1.5	3.5	4.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.5	± 5.9
Sibbaldia procumbens SL	0.0	0.0	0.0	0.0	3.0	8.0	13.5	15.0	17.0	20.5	25.0	26.0	29.5	30.0	32.0	32.5	5.9
Sibbaldia procumbens RP	0.0	0.0	0.0	12.5	34.0	52.5	55.0	56.5	57.5	59.5	60.5	61.5	61.5	62.0	63.5	64.0	9.4
Silene acaulis SL	0.0	0.0	1.5	4.0	4.0	7.0	9.0	9.0	9.5	10.0	10.5	10.5	11.0	12.0	12.5	12.5	4.4
Silene acaulis RP	0.0	1.5	15.5	21.0	21.5	21.5	23.5	25.0	25.0	25.5	25.5	25.5	25.5	26.0	27.0	29.0	5.0
Silene acaulis JP	1.0	1.5	4.0	4.0	5.0	5.5	7.5	8.0	8.5	9.0	9.0	9.5	10.0	10.0	13.5	18.5	9.7
Stellaria weberi RP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0	2.5	4.0	4.5	9.0	16.0	6.7
Thlaspi alpestre RP	0.0	0.0	0.0	0.0	0.5	0.5	6.0	8.0	9.5	10.5	11.5	12.0	13.0	13.5	14.0	14.5	2.6
Trifolium dasyphyllum SL	6.5	9.0	9.5	10.5	11.5	11.5	11.5	12.0	13.5	14.5	15.0	15.0	15.5	15.5	18.0	20.5	5.9
Trifolium dasyphyllum RP	2.5	8.5	18.5	20.5	23.0	23.5	24.0	26.5	27.5	28.0	28.5	29.0	30.0	31.0	33.5	35.5	8.2
Trifolium nanum SL	3.0	10.0	13.0	13.5	14.5	15.0	16.5	19.5	20.5	21.0	21.0	21.0	21.5	22.5	25.0	27.5	3.0
Trifolium nanum RP	3.0	8.5	12.0	14.5	16.5	18.0	19.0	19.0	20.0	21.0	21.5	21.5	23.5	23.5	27.0	31.0	10.5
Trifolium parryi SL	0.5	5.0	16.0	20.5	23.5	26.0	27.0	27.5	30.0	31.5	31.5	32.0	35.5	36.5	39.0	41.5	4.1
Trifolium parryi RP	5.0	9.0	13.0	14.0	16.5	17.5	18.5	20.5	20.5	22.0	22.5	23.0	23.0	23.0	27.0	31.0	3.5
Trifolium parryi JP	4.0	7.5	11.5	12.5	15.5	17.0	18.0	19.0	20.5	21.0	21.0	21.5	22.0	24.0	27.5	31.0	5.3
Veronica wormskjoldii RP	0.0	0.0	0.0	0.0	0.0	26.0	46.0	48.0	49.0	49.5	50.5	50.5	51.0	51.5	51.5	51.5	7.2

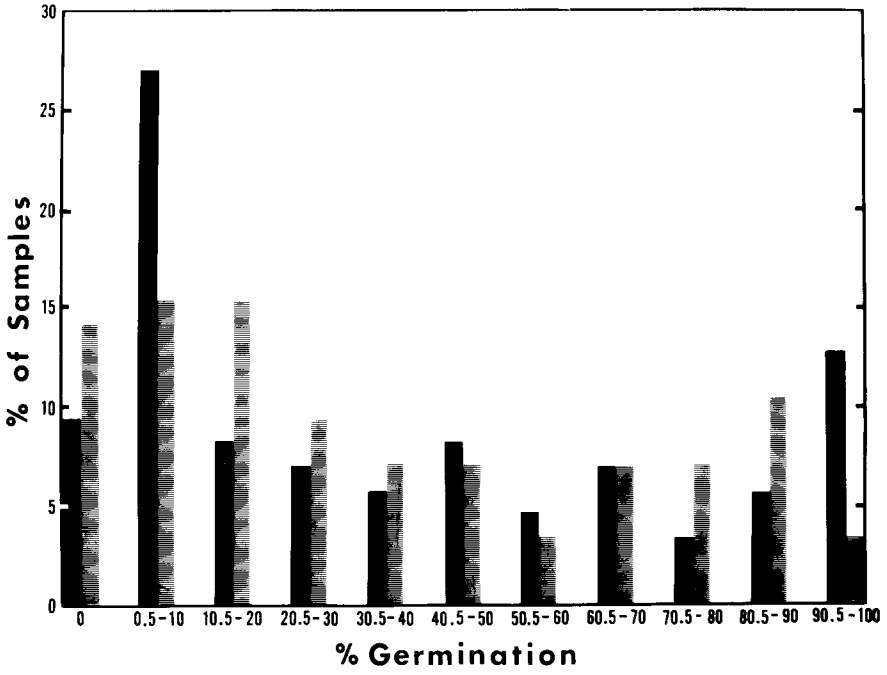

FIGURE 1. Percentages of 85 seed samples from 56 species germinating in the various percentage categories in 28 days. None of the germination percentages lie between the categories on the ordinate. The solid bars represent the data from the December tests and the hatched bars the data from the May-June tests.

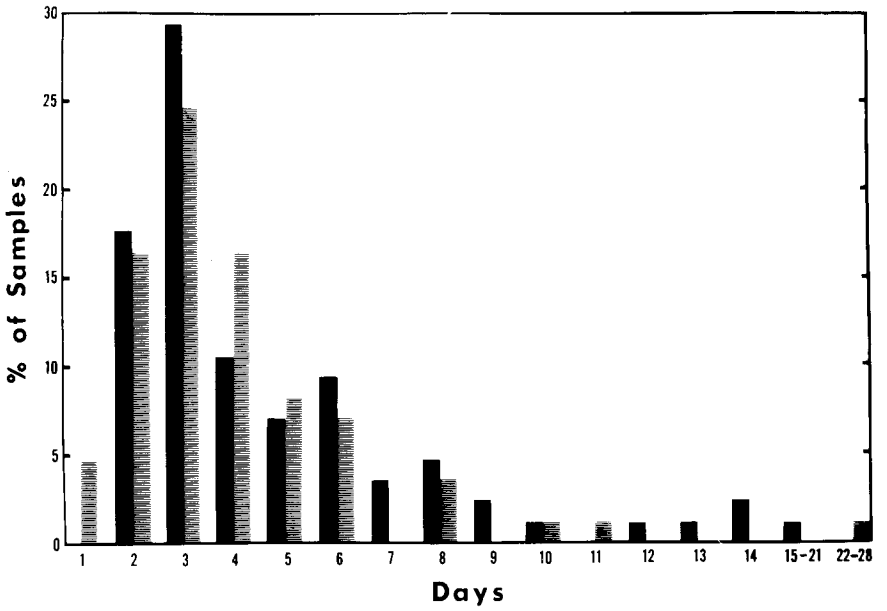

FIGURE 2. Percentages of 85 seed samples from 56 species initiating germination at various numbers of days after beginning of germination tests. The samples failing to germinate in 28 days are shown in Figure 1. The solid bars represent the data from the December tests and the hatched bars the data from the May-June tests.

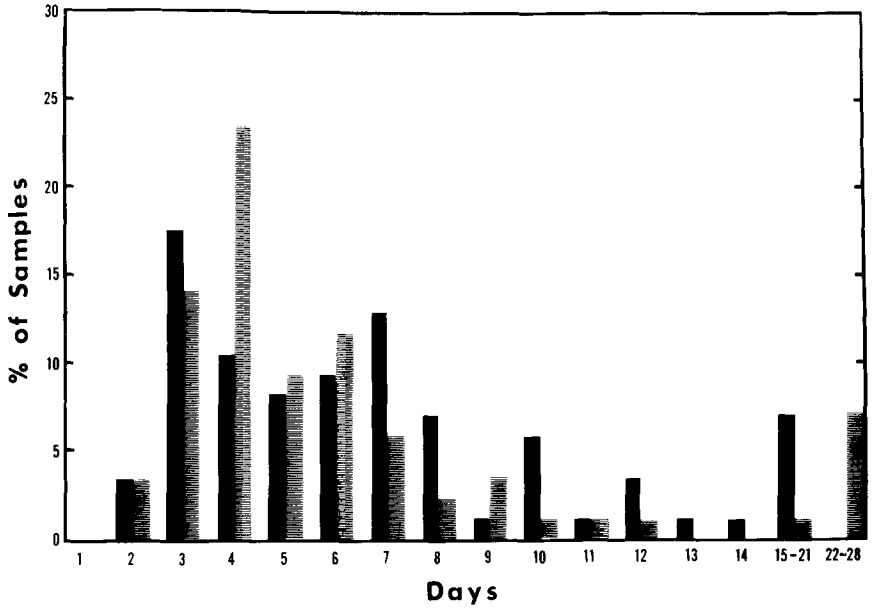

FIGURE 3. Percentages of 85 seed samples from 56 species showing maximum germination at various numbers of days after beginning of germination tests. The first day of maximum germination was used in the calculations if equal amounts of germination occurred on several days. The solid bars represent the data from the December tests and the hatched bars the data from the May-June tests.

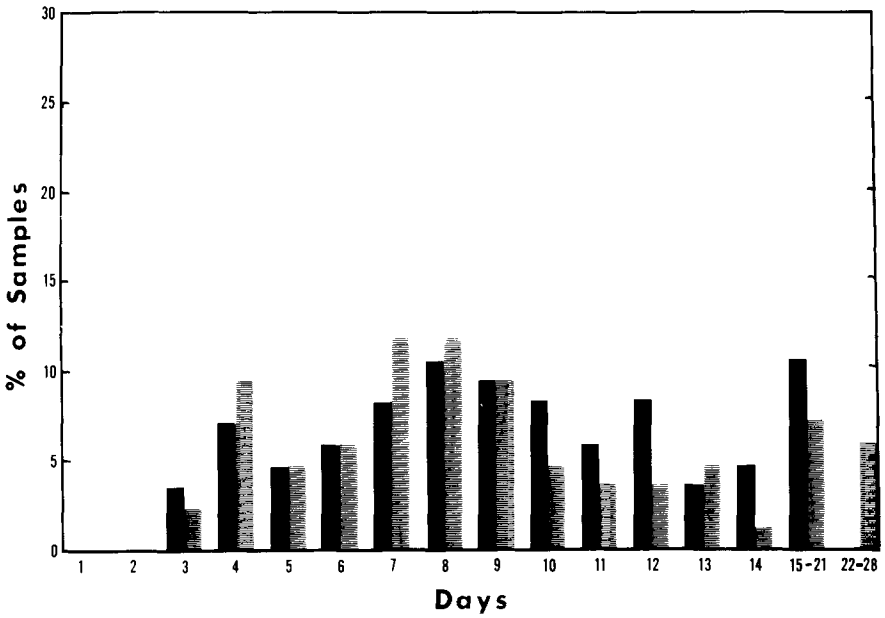

FIGURE 4. Percentages of 85 seed samples from 56 species showing "essential completion" (see text) of germination at various numbers of days after beginning of germination tests. The solid bars represent the data from the December tests and the hatched bars the data from the May-June tests.

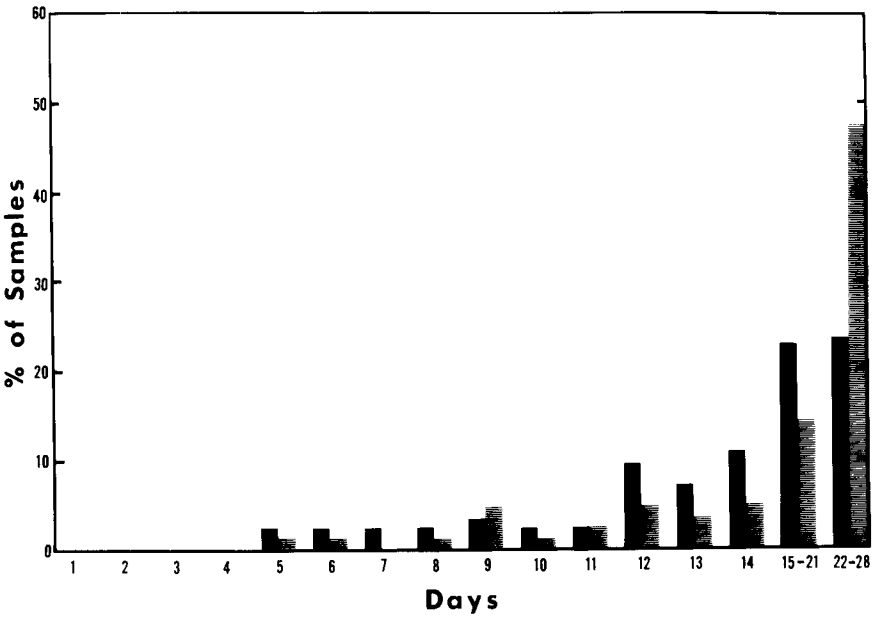

FIGURE 5. Percentages of 85 seed samples from 56 species showing last germination at various numbers of days after beginning of germination tests. The solid bars represent the data from the December tests and the hatched bars the data from the May-June tests.