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repens L., *Erucastrum gallicum* (Willd.) O. E. Schulz, *Sedum Telephium* L., *Rubus acaulis* Michx., *Bidens connata* Muhl. var. *fallax* (Warnst) Sherff, *B. connata* var. *pinnata* Wats., *B. discoidea* (T. & G.) Britton.

These species have been reported as new records for Minnesota including *Poa Chaixii* which is new to America^o: *Ammophila breviligulata* Fernald, *Deschampsia flexuosa* (L.) Trin., *Poa Chaixii* Vill. *Luzula nemorosa* (Poll.) E. Mey., *Iris Pseudacorus* L., *Sagina procumbens* L., *Stellaria aquatica* (L.) Scop., *Potentilla gracilis* Dougl., *Polemonium occidentale* Greene, *Valeriana officinalis* L., *Anthemis tinctoria* L., *Artemisia Stelleriana* Bess., and *Hieracium Pilosella* L. (previously unreported record).

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LONGEVITY OF RED PINE SEED¹

By EUGENE I. ROE

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The length of life of tree seeds, besides being of interest from the botanical point of view, is of great practical importance to those who are engaged in growing stock for forest and ornamental planting. Many of the common species of forest trees being used in the extensive reforestation projects now underway in the United States bear seed at irregular and infrequent intervals. In order, therefore, to have a balanced production of nursery stock of such species, it is necessary to collect and store large amounts of seed during years of abundant crops to provide for the sowings required in the intervening years of scarcity. This is the case with red or Norway pine (*Pinus resinosa* Aiton), the most important of the species now commonly planted on public lands in Minnesota and the other Lake States. Due to the fact that heavy crops of red pine seed are borne on the average from three to five years apart, considerable quantities must be stored during this period to supply a large proportion of the hundreds of pounds which are sown annually in the Federal, State, and private nurseries of this region. Since red pine seed is worth from \$4.50 to \$6.00 per pound, it is, therefore, highly important that it be kept under conditions which will reduce losses in viability to a minimum. An investigation to determine just what storage conditions are best for seed of this species serves as the basis for this paper.

The study in question was begun in the early part of 1930 by C. G. Bates of the Lake States Forest Experiment Station, who had

^o Lakela, Olga. 1933. *Rhodora* 40. 73.

¹ Paper presented before the Biological Section of the Minnesota Academy of Science, Minneapolis, Minn., April 20, 1940.

found from earlier work that the moisture content of seed and the temperature at which it is stored appeared to bear an important relationship to its subsequent germination. Accordingly, both of these factors were used as variables in the present study.

The red pine seed used for the experiment was of the 1928 crop and was bought in February 1930 from a seed dealer in northeastern Wisconsin. During the period from extraction until purchase, it had been stored in a cask in a moderately cool place. Upon arrival in the laboratory the seed was thoroughly mixed and then divided mechanically into samples of approximately 280 seeds each. One set of samples, 80 in all, was dried for 52 days in desiccators over sulphuric acid of such concentration to give a relative humidity of 20 per cent; a similar set was kept for 31 days in desiccators with a relative humidity of 40 per cent. When the samples showed no further change in weight, they were removed from the desiccators, weighed, and put in 1-ounce bottles. The latter were stoppered and then sealed to prevent changes in moisture content by dipping in hot wax. The initial moisture content of 5.9 per cent based on oven-dry weight decreased to 4.7 per cent in the seed dried in a relative humidity of 20 per cent, and increased to 6.5 per cent in that exposed to a humidity of 40 per cent.

Twenty samples of seed from each of the two moisture contents were placed in each of the following storerooms at University Farm in March and April, 1930:

1. Cold room No. 4 of the Division of Plant Pathology and Botany; temperature range, 32 to 39 degrees F.
2. The seed-storage room of the Lake States Forest Experiment Station; temperature range, 41 to 50 degrees F.
3. The apple-storage cellar of the Division of Horticulture. This underground storeroom fluctuates gradually from 32 degrees F. in the winter to about 68 degrees in the summer months.
4. The attic of the Division of Agronomy seedhouse. The temperature here ranges from zero to 100 degrees F.

Although the experiment has now been running for ten years, the results of recent germination tests made on this seed show that much of the original viability of 95 per cent still remains. (Table 1.) Samples stored at the lowest temperature (32 to 39 degrees F.) have shown no loss in germinability, whereas those kept in the storeroom with the highest temperature now show on the average only about one-third of the initial germination, with seed stored under the remaining temperature conditions falling between these extremes. Moisture content has also had considerable effect upon the viability but only in the case of the samples stored at temperatures of 41 to 50 degrees and above, at which temperatures those containing 6.5 per cent moisture show a consistently lower germination than those with a moisture content of 4.7 per cent.

The influence that storage temperature and seed moisture content have on germinability is also shown, but to a much less degree, by the results of the preceding germination tests made on this seed in 1936. At that time all of the samples showed high vitality except those which had been stored in the unheated attic and which had an average germination of about 60 per cent. This was the only temperature condition which showed any appreciable amount of difference between the germination of seed stored at the two moisture contents. The chief value of the comparison of the two years' tests lies in the fact that it indicates that there is a rapid falling off sometime between the sixth and tenth years in the viability of all seed kept at other than the lowest temperatures. This is especially critical in the case of seed with the higher moisture content.

TEMP CONDITION	MOISTURE CONTENT AT BEGINNING OF STORAGE 1930	TOTAL GERMINATION PER CENT	
		1940	1936
32-39° F. COLD ROOM	4.7 %	97.5	95.4
	6.5 "	97.0	94.8
41-50° F. COLD ROOM	4.7 "	93.2	90.8
	6.5 "	57.4	90.6
32-68° F. UNDERGROUND CELLAR	4.7 "	58.9	94.4
	6.5 "	33.7	89.6
0-100° F. UNHEATED ATTIC	4.7 "	46.2	66.8
	6.5 "	26.4	56.8
AVERAGE ALL TEMP. CONDITIONS	4.7 "	76.6	86.9
	6.5 "	53.7	83.1

0 20 40 60 80 100 0 20 40 60 80 100
TOTAL GERMINATION PER CENT

On the basis of these results it can be concluded that if nursery-men and seed dealers store their red pine seed in tightly sealed containers at temperatures of 32 to 40 degrees F. and with moisture contents of not more than 6.5 per cent, they will have no difficulty in retaining the original viability for at least ten years, a period which is doubtless much longer than necessity will require. Temperatures of 40 to 50 degrees F. can also be used with safety if the original moisture content of the seed is reduced to less than 5 per cent.