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THE EFFECT OF LOW TEMPERATURE ON THE GERMINATION AND SURVIVAL OF NATIVE OAKS

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Studies in the distribution of the native trees and shrubs of the prairie region of Iowa and eastern Nebraska have yielded data pertaining to oak species which are difficult to interpret without further research directed at the determination of the response of each plant to single environmental conditions. Studies of the response of the acorns and seedlings of the four species to temperature, soil moisture and light are being made. In this paper are presented data on the response of the acorns and seedlings to low temperature.

Of the four most common oak species of Central Iowa, *Quercus macrocarpa* (bur oak) extends farthest northward followed in order by *Quercus borealis maxima* (northern red oak), *Quercus velutina* (black oak) and *Quercus alba* (white oak). An attempt was made to correlate the northern extent of their range with the temperature which the species can endure during layering and following germination.

Acorns of these four species were layered in moist sphagnum and given various cold storage treatments to determine the effect of temperature on germination and establishment (Table I). They were then placed in the greenhouse at a temperature varying daily from 55 to 90° F.

A unit was made up of four paraffined cardboard containers in each of which were 20 viable acorns of one of the species layered in moist sphagnum.

Except in those experiments where the acorns were exposed to a temperature of 20° F. for one week the order of germination in

Table I — The Length of Time and Temperature Treatments to Which the Sets of Seedlings were exposed

No.	TIME AT EACH LOW TEMPERATURE TREATMENT						
	40° F.	20°	0°	20°	40°	20°	40°
Ck.				None	None		
2	2 wks.						
3	4 "						
6	12 "						
7	2 "	1 wk.			2 wks.		
8	2 "	1 "			2 "	1 wk.	2 wks.
9	6 "			1 wk.	4 "		
11	1 "	1 "	1 wk.	1 "	1 "	1 "	

point of time was the same: first white oak and then in order, bur oak, black oak and red oak. Exposure to 20° F. for one week was sufficient to kill the white oak acorns even when they had been hardened at 40° F. At this treatment, the order of germination of the remaining three species was the same. With a repetition of the treatment which constituted one alternation of freezing and thawing (treatment 9) the black oak reached complete germination almost as rapidly as did the bur oak.

The figures show the percentage of germination (based on 20 acorns) plotted on the time in days following the date of removal of the containers from the cold storage rooms to the greenhouse (Figures 1 and 2). The results of the other treatments are presented but the figures are not included.

Quercus Alba, White Oak

White oak acorns, as is well known, germinate under natural conditions in two to three weeks after falling at temperatures above freezing although occasional freezing does not hinder germination provided there is subsequent warm weather. The seedlings must be protected by duff during the winter because seedlings fully established in soil were killed at a storage temperature of 20° F. for one week although they survived after an exposure of 12 hours.

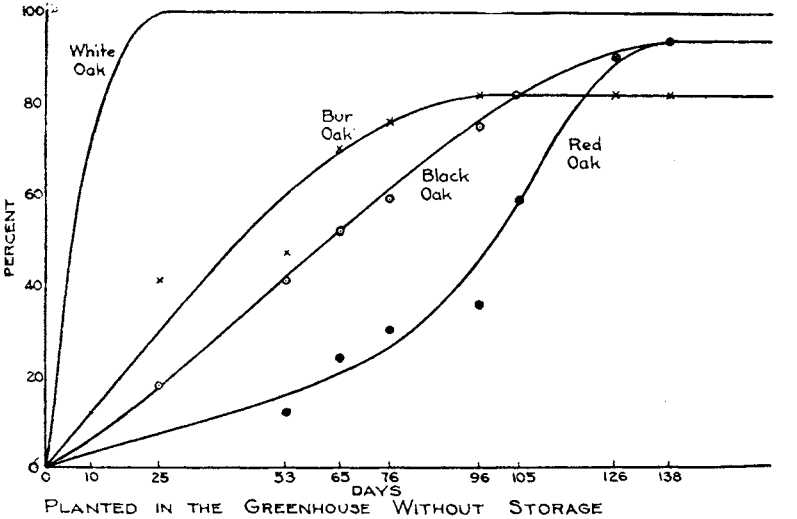
The experiments show however that layering for four weeks at 40° F. reduced the time of 100 per cent germination from 25 days to 10 days and that storage for three months at 40° F. reduced the time of 100 per cent germination to four days. White oak acorns were killed by exposure to a temperature of 20° F. for one week following hardening.

Quercus Macrocarpa, Bur Oak

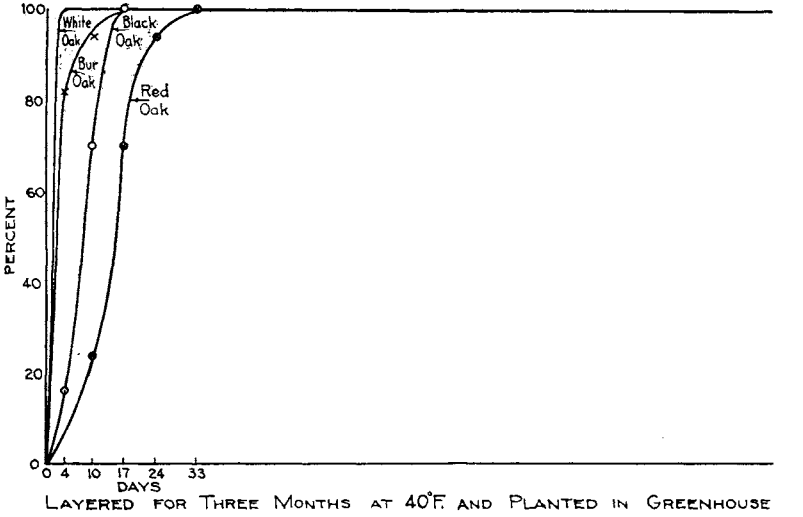
About 30 per cent of the bur oak acorns will germinate in the field within one month without freezing or layering treatment although the percentage of germination varies with the season probably depending on the maturity of the embryos. The experiments show that storage at 40° F. seems necessary for 100 per cent germination of bur oak acorns. (Figure 1). The germination process is hastened in all of the bur oak acorns by storage at 40° F. Storage at 40° F. for only two weeks induced 100 per cent germination in 53 days while storage at 40° F. for four weeks reduced the time of 100 per cent germination to 41 days and at 40° F. for 12 weeks reduced it to 17 days. One or more exposures to temperatures of 20° F. seem to hasten rather than retard 100 per cent

germination, one such exposure added to four weeks storage at 40° F. reducing the time from 41 days to 32 days and two exposures added to six weeks storage at 40° F. reducing the time from 34 days to 18 days.

Although bur oaks in nature are not completely germinated as are the white oaks during the winter, the seedlings when developed in the greenhouse and hardened withstand freezing for 12 hours at 20° F. better than the white oak. Alternate freezing and



PLANTED IN THE GREENHOUSE WITHOUT STORAGE



LAYERED FOR THREE MONTHS AT 40°F. AND PLANTED IN GREENHOUSE

thawing in the early spring is not so harmful to the bur oak as to the white oak because they are not completely developed. Natural storage during the winter under the protection of duff tends to hasten germination in the spring. For these reasons bur oak may reproduce much farther north than white oaks.

Quercus Velutina, Black Oak

Black oak ranks between the bur oak and red oak in germination time but more nearly resembles the bur oak in the rapidity with which the seedlings develop following germination. The slight difference in percentage of germination in favor of the black oak over the bur oak is probably not significant, but the delay in germination without layering, evident in all but the white oak, is significant.

Layering at 40° F. for two weeks reduced total germination time from 138 days to 118 days; layering at 40° F. for four weeks reduced the time to 58 days and layering at 40 °F. for 12 weeks reduced it to 17 days. Layering for at least 12 weeks or alternate freezing and thawing induces changes in black oak acorns which give germination results almost identical with those of bur oak under like conditions.

The reaction of black oak to temperature during the germination period does not seem to account for its absence from northern Minnesota and Michigan where both bur oak and red oak are found in abundance. Low temperatures in the early spring may be the factor which accounts for its absence in the north because freezing experiments showed that six hours at 20° F. killed hardened black oak seedlings.

Quercus Borealis Maxima, Red Oak

Germination in the red oak is much delayed both in initiation and in completion of the process. Red oak acorns planted in the greenhouse require 138 days for almost 100 per cent germination. At the end of this time most of the red oak hypocotyls had only emerged whereas the bur oak and black seedlings were 20 to 35 cm. long. Layering at 40° F. for two weeks gave 100 per cent germination of viable red oak acorns but did not reduce the time below that required for germination when planted. Layering at 40° F. for four weeks reduced the time of 100 per cent germination to 109 days while 12 weeks layering reduced the time to 33 days. Two alternate freezings in addition to six weeks layering reduced the time 20 days below that for six weeks layering without freezing.

Natural layering under duff during the winter would seem to be sufficiently effective to after-ripen the acorns for germination in the late spring. Toward the northern limit of the range of red oak, its slow germination is an important factor in insuring its survival. Hardened seedlings withstood freezing for 12 hours at 20 ° F. without injury and recovered after 24 hours of freezing at this temperature. Because of its slow germination this treatment is probably as severe as any which the seedlings have to endure in late spring even on the northern edge of their range. Protection from the duff through which they grow probably further minimizes the effect of these low temperatures.

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