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**FROST HARDINESS OF WHITE SPRUCE AND
RED PINE SEEDLINGS IN RELATION TO
SOIL MOISTURE**

by
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CORRECTION to Technical Note No. 59

Please correct your copy of Technical Note No. 59 "Frost Hardiness of White Spruce and Red Pine Seedlings in Relation to Soil Moisture", as follows:

Page 3, lists of seed origins, under "White Spruce" -

"Hants County N.B." should read "Hants County N.S."

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Frost Hardiness of White Spruce and Red Pine Seedlings in Relation to Soil Moisture

by

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The problem of frost resistance of crop plants has received consideration from agriculturists and plant physiologists for a long time. Recently, frost damage to trees—particularly in plantations and nurseries—has caused concern to foresters Day and Peace (1946). As indicated in comprehensive discussions by Miller (1938), Curtis and Clark (1950), Bonner and Galston (1952), and others, it is generally considered that frost hardiness and drought resistance are associated. Rosa (1921) found that the frost resistance of cabbage was increased by drought. Siminovitch and Briggs (1953) state that freezing brings about a dehydration of cells very similar to that induced by desiccation.

In view of this it seemed worthwhile to investigate the effect of drought on the frost resistance of certain tree seedlings. An experiment for this purpose was carried out at the Petawawa Forest Experiment Station in 1954 with white spruce (*Picea glauca* (Moench) Voss) and red pine (*Pinus resinosa* Ait.) which were subjected to two conditions of soil moisture. Each species was represented by four strains to provide some indication of the variation within species. The localities in which the seed originated were as follows:

White Spruce

1. Trout Lake, Wisc.
2. Regina Bay, Ont.
3. Hants County, N.B.
4. Grand Lake, N.B.

Red Pine

1. St. Maurice, Que.
2. Dalhousie, N.B.
3. Trois Pistoles, Que.
4. Petawawa, Ont.

The plants were grown from seed and were just under three months old at the time of the test. The seeds were sown in twenty-ounce glass containers and remained there throughout the experiment. Each container was divided into four quadrants which were occupied by four strains of either spruce or pine. The number of seedlings was gradually reduced to ten per quadrant. A sunflower plant was grown in each container. About five weeks before the test, the soil surface was sealed over with paraffin (melting point 120°F.) and further water withheld from those plants being subjected to soil drought. About two weeks later, when the sunflower plants indicated that the soil in the containers was just beyond the permanent wilting point, all sunflower plants were cut off. No water was added to the drought-treated plants after the surface was sealed. The controls were watered regularly throughout the experiment.

Before the frost test all plants were kept in the greenhouse. Shades to reduce the temperature permitted about one-third of total daylight to reach the plants. At the time of the test, all plants had passed the succulent stage,

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and tufts of primary leaves were developing. The watered plants were somewhat larger and darker green than those subjected to drought.

On September 23, all containers were removed from the greenhouse and put out-of-doors to provide an opportunity for natural hardening to occur. Mean minimum night temperature during the hardening period was 45°F. On October 4, the plants were taken to a natural frost hollow described previously by Fraser (1953). The containers were sunk flush with the ground level at eight stations in the frost hollow. These stations ranged from two to 26 feet above the bottom of the pocket and all four major aspects were represented. At each station there were two jars of spruce and two of pine; one of each species contained dry soil, and the other contained moist soil.

On the nights of October 4 and 5, minimum temperature varied from 16°F. to 22°F. On the following night severe frost also occurred but the minima were not quite so low. The maximum temperatures on October 5 varied from 61°F. to 64°F.

On October 6 the plants were removed to a shelter, and on October 18 the survivors were tallied. Analyses of variance by species revealed differences associated with stations, soil drought, and strains for pine, but only with soil drought for spruce.

No pattern could be detected in the variation between stations. Differences could not be related to minimum temperature or to time of exposure to sunshine on the following day. Differences associated with strains, and drought treatment, are presented by species in Figure 1.

Seedlings of all strains of both species were less resistant to frost after they had been subjected to soil drought. Spruce suffered less damage than pine, and in the moist soil, the best pine survival (from Dalhousie, New Brunswick) was about equal to the poorest of spruce (from Regina Bay, Ontario).

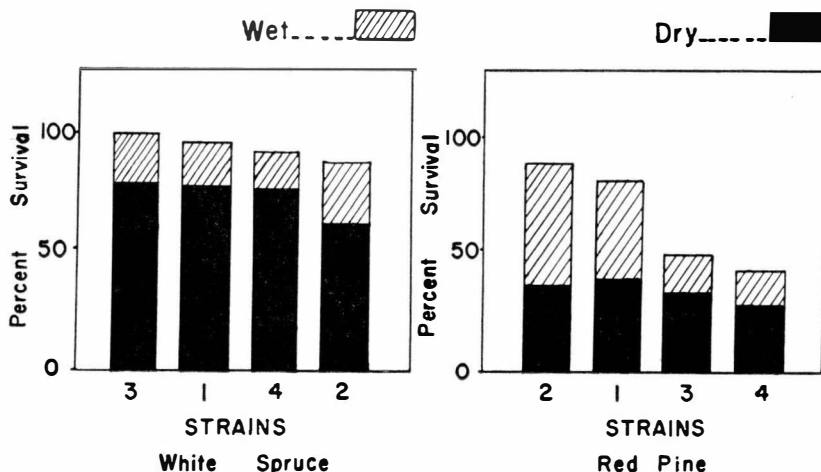
There was little difference between the four strains of spruce. Differences between the strains of pine were quite marked in the moist soil, but strains of pine suffered equally in the dry soil.

It has been observed that plants such as wheat or alfalfa growing in dry soil are more damaged by frosts of short duration than similar plants in moist soil (Hill and Salmon, 1927; Tysdal, 1933). The latter attributes this to the properties of the moist soil which prevent it from becoming as cold as the dry soil. He substantiated this by showing that when soil temperatures were the same there was little difference in damage. On the other hand, the same investigator found that when alfalfa was severely wilted, a high degree of frost resistance was induced. This certainly did not occur in the tree seedlings of our experiment. Perhaps the explanation of the failure of the seedlings in the dry soil to harden lies in the suggestion of Baker (1950) that seedlings go into a drought dormancy. In a dormant condition, the metabolic changes that induce hardening might not occur.

It was not surprising that spruce were more frost resistant than pine, since spruce is a more northerly tree. However, we did not expect to find that red pine was more adversely affected by drought than the spruce; dry sand plains are the normal habitat of red pine. The low frost resistance of the local (Petawawa) strain was also unexpected. The greater variation within red pine compared with white spruce was out of line with the uniform nature of red pine stands compared with spruce stands.

From a practical viewpoint, it would seem advisable to provide an adequate supply of soil water to conifers before the onset of freezing weather.

FIGURE 1 Percent survival of white spruce and red pine seedlings after exposure to 13 degrees of frost.



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