# METHODS OF IMPROVING CONIFER SURVIVALS

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## Introduction

Conifer species hardy enough to withstand the prevailing climatic conditions of the northern Great Plains are recommended for planting in windbreaks to protect farm buildings and livestock. Pine species are also recommended for planting in field windbreaks to reduce wind erosion of soil and to trap snow, a supplemental source of soil moisture.

The climate of the northern Great Plains is characterized by hot summers, sparse precipitation, and strong drying winds that cause high evapo-transpiration from trees and farm crops. Because of these climatic factors, establishment of conifers is not easy. The highest firstyear survivals of conifers planted in the area during the 1916-42 period occurred in the 4 years of highest precipitation (4). Survivals of trees planted in other years were low. The

poorest survivals usually occurred in years of lowest rainfall.

## Precipitation

The monthly, growing season, and annual precipitation at the Northern Great Plains Field Station during 1941-46 and 1955-60 were recorded (table 1). The average monthly amounts varied from 1.56 inches in April to 4.20 inches in June. Precipitation during the growing season was approximately 80 percent of the annual amount. Much of this precipitation fell in amounts of less than 0.5 inch per 24 hours, and such amounts did not help trees or other crops grow. Under the best conditions 0.5 inch of precipitation penetrated the fine sandy loam of the test site to a depth of only 3 to 4 inches. During the 6 months of the growing season (April-September), 28.5, 46.4, 66.5, 46.2, 59.2, and 57.3 percent of the precipitation fell in amounts greater than 0.5 inch per 24 hours.

TABLE 1.--Monthly, growing season, and annual precipitation at the Northern Great Plains Field Station, Mandan, N. Dak., 1941-46 and 1955-60

| Year | Jan.-Mar. | Apr. | May | June | July | Aug. | Sept. | Oct.-Dec. | Apr.-Sept. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|
| | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* | *In.* |
| 1941..... | 1.53 | 1.57 | 1.95 | 5.72 | 1.10 | 2.36 | 4.16 | 1.33 | 16.86 | 19.72 |
| 1942..... | 1.26 | 3.15 | 2.30 | 2.44 | 3.10 | 1.30 | 2.33 | 1.19 | 14.62 | 17.07 |
| 1943..... | 3.39 | .87 | 1.95 | 7.67 | 1.56 | 3.20 | .16 | 2.35 | 15.41 | 21.15 |
| 1944..... | 1.02 | 1.22 | 3.13 | 5.54 | .67 | 3.19 | 1.17 | 3.52 | 14.92 | 19.46 |
| 1945..... | 1.86 | 1.02 | 1.54 | 1.78 | 1.94 | 3.48 | 1.85 | 1.18 | 11.61 | 14.65 |
| 1946..... | 2.03 | 1.28 | 1.81 | 3.14 | 1.25 | 1.28 | 2.36 | 3.62 | 11.12 | 16.77 |
| 1955..... | .69 | 1.52 | 3.15 | 3.06 | 3.88 | 1.70 | 2.93 | 1.40 | 16.24 | 18.33 |
| 1956..... | 1.53 | .08 | 3.45 | 3.61 | 2.65 | 3.13 | .46 | 1.70 | 13.38 | 16.61 |
| 1957..... | .75 | 1.51 | 3.11 | 2.72 | 1.97 | 1.68 | .99 | 2.65 | 11.98 | 15.38 |
| 1958..... | 1.30 | .86 | 1.35 | 4.18 | 1.48 | .90 | .29 | 2.28 | 9.06 | 12.64 |
| 1959..... | .65 | .31 | 1.91 | 2.44 | .20 | 2.20 | 1.93 | 2.33 | 8.99 | 11.97 |
| 1960..... | .54 | .49 | 3.23 | 6.01 | .70 | 3.32 | .22 | .46 | 13.97 | 14.97 |
| Average... | 1.38 | 1.56 | 2.46 | 4.20 | 1.78 | 2.31 | 1.57 | 2.02 | 13.18 | 16.55 |

## Review of Literature

Thomas et al. (9) studied the effect on survival of four water and wax emulsions applied to ponderosa pine to reduce transpiration. These materials gave survivals of 93.6 and 98.4 percent at Pratt, Kans., compared with 92.2 percent in the check. The survivals at Glenwood, Wash., varied from 76 to 100 percent in treated plots and were 86 percent in the check.

Ruth (5) compared freshly dug stock with stock that had been stored in a cold room for 2 months before planting. No significant differences in growth or survival were apparent by the tenth season.

Thames (8) studied the effect on survival of wax coatings applied to loblolly pine foliage. He reported that mortality generally increased with increases in the number of foliage sprayings.

Schubert et al. (6) tested the "sandwich" planting of conifers in which the roots were encased before planting between two pieces of stiff water-absorbent fibrous material stapled together. The method gave poor survivals. The same investigators- also studied survival of trees planted in mechanically dug holes. These consisted of an outer hole 36 inches in diameter, 4 to 6 inches deep, that surrounded an inner hole 9 inches in diameter, about 9 inches deep. Trees planted in the mechanically dug holes had higher survivals than those in the checks.

Sjoblom (7) found the sandwich method produced total mortality, compared with 96 percent mortality in the check.

Derr (3), in clipping the needles of longleaf pine seedlings immediately before planting to test survival, obtained inconclusive results. The treatment did result in a consistent loss in growth and vigor.

Bagley (2) applied chemical fertilizers at planting time. He found the treatment produced only relatively small differences in survival and suggested that other causes were more important in determining whether a seedling survives.

Afanasiev et al. (1) studied the effect that time of planting and length of storage had on survival of eastern redcedar in central and western Oklahoma. They concluded that the best planting period was between December 15 and March 15. Leaving the stock in packages for an extra week had little or no effect on survival.

## Test Results

The low survival of conifers in farm windbreaks discouraged farmers from planting them. Therefore, tests were conducted (194146 and 1955-60) at the Northern Great Plains Field Station, Mandan, N. Dak., to find methods and treatments that would result in better firstyear survivals and thus restore farmer confidence in useful windbreak species.

The first tests consisted of check plantings of stock of the same age and origin as that shipped to farmers and planted by them. Species used in the tests were Rocky Mountain juniper (Juniperus scopulorum), Colorado spruce (Picea pungens), and ponderosa pine (Pinus ponderosa). At the end of the first growing season, the check plantings on the station were compared with farm survivals (table 2). Survivals on farms were reported by the planters on forms mailed to them.

The area of farm plantings included the western half of North Dakota and South Dakota, and the Plains area of eastern Montana and Wyoming. The Mandan station is in south central North Dakota, near the eastern border of the entire area. North Dakota data are included in those for the northern Great Plains and are also shown separately. The climate and growing conditions for the station check plots were similar to those experienced elsewhere in the State.

TABLE 2.--First-year survivals of coniferous stock of the same origin planted from 1941 to 1946

| Species | Years | Mandan, N. Dak. | Western North Dakota | Northern Great Plains |
|---|---|---|---|---|
| | *Number* | *Percent* | *Percent* | *Percent* |
| Rocky Mountain juniper... | 5 | 99.6 | 67.4 | 62.0 |
| Colorado spruce.... | 4 | 98.2 | 56.8 | 43.2 |
| Ponderosa pine..... | 6 | 95.3 | 38.4 | 39.7 |

Station survivals were better than those of western North Dakota and the northern Great Plains. Western North Dakota survivals were approximately equal to or better than those of the entire area. Poorer farm survivals resulted from root exposure during transit, root-drying or heating during storage on the farm, or faulty planting methods. The storage methods used between the date of receipt from the nursery and time of planting influenced survival. Stock stored flat in piles at least 1 foot deep gave lower survivals than stock of the same origin stored standing on its roots. The stock stored in piles had heated and started terminal growth. Ponderosa pine had developed new growth of 4 inches or more when removed from the storage pile for planting. Survival of machine and hand-planted farm trees were compared. The differences were less than 1 percent.

### 1941-46 Tests

Treatments used in 1941-46 were as follows: Undercutting transplant stock in the nursery row at 2-1, removing all needle growth, dipping the roots in a Transplantone starter solution immediately before planting, and dipping treetops immediately before planting in Socony Mobile Oil Co. and Protex wax emulsions diluted with water.

Species used were 2-2 stock of Colorado spruce, ponderosa pine, Rocky Mountain juniper, and eastern redcedar (Juniperus virginiana). The trees were planted 12 inches apart in 36-inch rows. The treatments were

not replicated in a given year. However, some were repeated in 2 or more years.

All survival data in the following tables are based on the number of trees alive at the beginning of the second growing season. The survival of trees that received various treatments in 1941-46 (table 3) was high in all treatments except one in which Colorado spruce was deneedled. Survivals were approximately equal to or exceeded those of the checks. Deneedling appeared harmful to spruce but not to pine. Undercutting in the nursery row the year before planting and dipping the tops in water and wax emulsions or the roots in a hormone starter solution gave beneficial results.

Species used were ponderosa pine, Colorado spruce, Black Hills spruce (Picea glauca var. densata), eastern redcedar, and Rocky Mountain juniper. Trees were spaced 18 by 36 inches in randomized blocks replicated a minimum of three times. Plots in some years were replicated four or five times. Survival data were taken at the beginning of the second growing season, and have been grouped by treatments in the following tables.

The survival of coniferous stock that received the water-wax emulsion and Arquad treatments is summarized (table 4). Rocky Mountain juniper, eastern redcedar, ponderosa pine, and Black Hills spruce had high survivals. Only the use of the Arquad solution treatment in 1959 resulted in a significant

TABLE 3.--Survival 1 year after planting of 2-2 coniferous stock that received at least one of the listed treatments or applications, 1941-46

| Species and year | Trees | Treatment or application | | | | | |
|---|---|---|---|---|---|---|---|
| | | None | Undercutting | Deneedling | Transplantone | Socony wax | Protex |
| Colorado spruce: | *Number* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* |
| 1941 | 15 | 73 | 94 | 46 | -- | 100 | 100 |
| 1944 | 50 | 96 | 100 | -- | -- | -- | -- |
| 1945 | 50 | 100 | -- | -- | 100 | -- | -- |
| Ponderosa pine: | | | | | | | |
| 1941 | 15 | 94 | 100 | 94 | -- | 100 | 100 |
| 1942 | 50 | 74 | 98 | -- | -- | -- | -- |
| 1945 | 50 | 100 | -- | -- | 100 | -- | -- |
| Eastern redcedar: | | | | | | | |
| 1945 | 50 | 100 | -- | -- | 100 | -- | -- |
| 1946 | 50 | 98 | -- | -- | 96 | -- | -- |
| Rocky Mountain juniper: | | | | | | | |
| 1945 | 50 | 98 | -- | -- | 96 | -- | -- |
| 1946 | 50 | 78 | -- | -- | 87 | -- | -- |

1955-60 Tests

Treatments used in 1955-60 were as follows: Dipping the tops in Dowax, Wiltpruf, and Mobilicer A and Mobilicer C wax emulsions diluted with water and in an Arquad solution the day before planting; spraying the tops immediately after planting in Dowax and Wiltpruf wax emulsions diluted with water; fertilizing with 10 to 200 pounds per acre of nitrogen immediately after planting, clipping 50 or 75 percent of the needle growth immediately after planting; enclosing the roots in sandwiches that had been soaked in a liquid fertilizer for 24 hours before planting; and planting stock that had been potted for 1 year in various types and sizes of pots.

TABLE 4.--Survival 1 year after planting of coniferous stock that received one of the listed applications, 1955-60

| Species and year | Trees | Treatment | | | | | | | | L.S.D.,[1] 5 percent |
|---|---|---|---|---|---|---|---|---|---|---|
| | | None | Dowax | | Wiltpruf | | Mobilicer | | Arquad dip | |
| | | | Spray | Dip | Spray | Dip | A dip | C dip | | |
| Rocky Mountain juniper: | *Number* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | |
| 1955..... | 30 | 80 | 87 | 70 | 70 | 70 | -- | -- | -- | (2) |
| 1956..... | 125 | 86 | -- | 94 | -- | 90 | -- | -- | -- | (2) |
| Eastern redcedar: | | | | | | | | | | |
| 1955..... | 30 | 70 | 80 | 93 | 83 | 80 | -- | --- | -- | (2) |
| 1959..... | 60 | 60 | -- | -- | -- | -- | 70 | 62 | 37 | 11 |
| 1960..... | 80 | 67 | -- | -- | -- | 76 | -- | -- | 69 | (2) |
| Ponderosa pine: | | | | | | | | | | |
| 1955..... | 30 | 83 | 83 | 93 | 93 | 80 | -- | -- | -- | (2) |
| 1956..... | 125 | 100 | -- | 98 | -- | 94 | -- | -- | -- | (2) |
| 1958..... | 60 | 90 | -- | -- | -- | -- | 98 | 95 | 88 | (2) |
| 1959..... | 60 | 78 | -- | -- | -- | -- | 88 | 93 | 92 | (2) |
| 1960..... | 80 | 99 | -- | -- | -- | 94 | -- | -- | 80 | (2) |
| Black Hills spruce: | | | | | | | | | | |
| 1958..... | 60 | 98 | -- | -- | -- | -- | 100 | 97 | 95 | (2) |
| 1959..... | 60 | 97 | -- | -- | -- | -- | 90 | 93 | 67 | 24 |
| 1960..... | 80 | 96 | -- | -- | -- | 100 | -- | -- | 94 | (2) |
| Colorado spruce: | | | | | | | | | | |
| 1958..... | 60 | 80 | -- | -- | -- | -- | 92 | 98 | 97 | 12 |
| 1959..... | 60 | 85 | -- | -- | -- | -- | 93 | 77 | 47 | 24 |
| 1960..... | 80 | 100 | -- | -- | -- | 99 | -- | -- | 90 | (2) |

[1] Least significant difference.
[2] No significance.

difference in survival. Arquad is a byproduct of the meatpacking industry. It was difficult to dilute and sometimes left a nondeteriorating, heavy tallow coating on the needles. The coating apparently suffocated the trees and may have been responsible for the low survival in 1959. Trees treated in 1958 and 1960 did not have the heavy tallow and established high survivals. Colorado spruce in treated plots survived better than the check in 1958, and except for its treatment with the Arquad treatment in 1959, its survival was not significantly affected in other years. Arquad-treated spruce trees gave survivals in 1958 and 1960 that compared favorably with other treatments.

This again indicated that difficulty in mixing the solution was responsible for the heavier loss in 1959.

Table 5 shows survival of coniferous stock that received various rates of nitrogen fertilizer immediately after planting. All treatment rates gave good to high survivals in all years except 1959. In that year the survival of all the species was reduced by all of the treatments. Ponderosa pine withstood high fertilizer rates better than the other species. The survival of Black Hills spruce, Colorado spruce, and eastern redcedar generally decreased as fertilizer rates increased. Low precipitation may have been responsible for the

TABLE 5.--Survival 1 year after planting of coniferous stock that received nitrogen fertilizer immediately after planting, 1955-60

| Species and year | Trees | Pounds of nitrogen per acre | | | | | | | | | | | L.S.D., [1] 5 percent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | None | 10 | 20 | 30 | 40 | 80 | 100 | 120 | 150 | 160 | 200 | |
| | *Number* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | |
| Ponderosa pine: | | | | | | | | | | | | | |
| 1957 | 30 | 100 | 100 | -- | 100 | -- | -- | -- | -- | -- | -- | -- | [2] |
| 1958 | 60 | 90 | -- | 90 | -- | 95 | -- | -- | -- | -- | -- | -- | [2] |
| 1959 | 60 | 78 | -- | -- | -- | 72 | 75 | -- | 75 | -- | 60 | -- | 17 |
| 1960 | 80 | 99 | -- | -- | -- | -- | -- | 90 | -- | 92 | -- | 98 | [2] |
| Black Hills spruce: | | | | | | | | | | | | | |
| 1957 | 30 | 97 | 100 | -- | 100 | -- | -- | -- | -- | -- | -- | -- | [2] |
| 1958 | 60 | 98 | -- | 100 | -- | 100 | -- | -- | -- | -- | -- | -- | [2] |
| 1959 | 60 | 97 | -- | -- | -- | 77 | 43 | -- | 48 | -- | 35 | -- | 24 |
| 1960 | 80 | 96 | -- | -- | -- | -- | -- | 100 | -- | 99 | -- | 100 | [2] |
| Colorado spruce: | | | | | | | | | | | | | |
| 1957 | 30 | 93 | 93 | -- | 100 | -- | -- | -- | -- | -- | -- | -- | [2] |
| 1958 | 60 | 80 | -- | 97 | -- | 95 | -- | -- | -- | -- | -- | -- | 12 |
| 1959 | 60 | 85 | -- | -- | -- | 63 | 50 | -- | 42 | -- | 53 | -- | 24 |
| 1960 | 80 | 100 | -- | -- | -- | -- | -- | 96 | -- | 90 | -- | 95 | [2] |
| Eastern redcedar: | | | | | | | | | | | | | |
| 1957 | 30 | 93 | 93 | -- | 83 | -- | -- | -- | -- | -- | -- | -- | [2] |
| 1959 | 60 | 60 | -- | -- | -- | 38 | 48 | -- | 18 | -- | 17 | -- | 11 |
| 1960 | 80 | 67 | -- | -- | -- | -- | -- | 55 | -- | 65 | -- | 74 | [2] |

[1] Least significant difference.
[2] No significance.

low survivals of plots receiving at least 80 pounds of nitrogen in 1959. The growing season rainfall in 1959 was 4.19 inches below normal. High fertilizer rates in seasons of normal rainfall or above had no unfavorable effect or appreciable benefit. This agrees with the conclusions reached by Bagley (2).

Removal of as much as 75 percent of the needle growth had no unfavorable effect on survival, but fertilized sandwiches were detrimental (table 6). They were planted in trenched dry soil in April. April and May precipitation was 0.86 and 1.35 inches, respectively, or about 60 percent of the normal amount. Precipitation at any one time was not sufficient to wet more than the top 2 inches of soil. The sandwiches lost their moisture to the surrounding dry soil shortly after planting and did not regain it until early June when 2.5 inches of rain fell in 48 hours. Similar sandwich survivals were reported by Schubert et al. (6) and Sjoblom (7).

First-year survivals of stock that had been potted the previous year in containers of various kinds and sizes, and in two soil mediums, are summarized in table 7. All treatments except those in which the 5-inch beer cans were used gave high survivals. These cans were small, and the inside tinning process may have created unfavorable reactions. The kind of potting soil used had little, if any, influence.

Pots of aluminum foil were favorable to growth and color of foliage during the 3 years the trees were being tested. Except for the beer cans, the other types of pots had no apparent effect on growth.

TABLE 6.--Survival 1 year after planting of coniferous stock that had 50 or 75 percent of its needle growth removed by clipping or that had its roots enclosed in liquid-fertilized sandwiches, 1955-60

| Species and year | Trees | Treatment--needles clipped | | | | L.S.D.,[1] 5 percent |
|---|---|---|---|---|---|---|
| | | None | 50 | 75 | Sandwich | |
| | *Number* | *Percent* | *Percent* | *Percent* | *Percent* | |
| Ponderosa pine: | | | | | | |
| 1956 | 125 | 100 | 97 | 100 | -- | (2) |
| 1958 | 60 | 90 | -- | -- | 55 | 10 |
| Rocky Mountain juniper: | | | | | | |
| 1956 | 125 | 86 | 95 | -- | -- | (2) |
| Black Hills spruce: | | | | | | |
| 1958 | 60 | 98 | -- | -- | 80 | 5 |
| Colorado spruce: | | | | | | |
| 1958 | 60 | 80 | -- | -- | 5 | 12 |

[1] Least significant difference.
[2] No significance.

TABLE 7.--Survival 1 year after planting of conifers that had been potted the previous year in containers of various kinds, and sizes, and in two different soil mediums, 1955-60

| Species and year | Trees | Beer cans, 5-inch | | Aluminum foil | | | | Building paper, 7-inch | | Wood veneer, 7-inch | | L.S.D.,[3] 5 percent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 5-inch | | 7-inch | | | | | | |
| | | VS[1] | OS[2] | VS | OS | VS | OS | VS | OS | VS | OS | |
| | *Number* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | |
| Eastern redcedar: | | | | | | | | | | | | |
| 1956 | 50 | 92 | 82 | 100 | 100 | 100 | 98 | -- | -- | -- | -- | 10 |
| Ponderosa pine: | | | | | | | | | | | | |
| 1956 | 50 | 56 | -- | -- | -- | 84 | -- | -- | 80 | 92 | -- | 23 |
| Colorado spruce: | | | | | | | | | | | | |
| 1956 | 50 | 58 | -- | -- | -- | 98 | -- | 95 | -- | 95 | 100 | 14 |

[1] Vermiculite and soil.
[2] Organic matter and soil.
[3] Least significant difference.

## Conclusions

The low annual and growing season rainfall of the northern Great Plains is usually accompanied by low humidity and high evaporation. The establishment of conifers is largely governed by the growing season and perhaps more importantly by the April-May rainfall of the first year. The tests reported cover a period of 12 years. April rainfall was below normal in 8 of the years, and May rainfall was below normal in 6 of the years. The

growing season and annual rainfall were above normal in 7 of the years.

The results show that good conifer stands can be established under prevailing climatic conditions. Five coniferous species planted in 82 plots that received no treatment had survivals of 80 to 100 percent in 65 plots and 50 to 79 percent in the other 17 plots. A number of treated plots had survivals of 80 to 100 percent.

The danger of faulty handling may be partly overcome by treatment of stock when it is received from the nursery. The most practical methods are the use of water-wax emulsion solutions and the potting of stock 1 year before permanent planting. Neither method is costly nor time consuming. Pots can be manufactured from building paper. Discarded quart oil cans have made suitable containers and are available at service stations. They require no preparation other than removing one end and all trace of oil. Potted trees should be stored near a running water supply and preferably on the north side of a building.

Care in handling the seedlings from the time of digging in the nursery until planting is completed cannot be overemphasized. If these precautions are taken and the tops are treated to reduce the evapo-transpiration rate, increases in first-year survivals of conifers can be expected.

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