# EFFECT OF ROCK SALT ON THE SURVIVAL AND GROWTH OF JAPANESE BLACK PINE *PINUS THUNBERGII*

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Salt tolerance of many grasses and legumes has been well documented (1,4). Work has been done from the standpoint of both salt spray and salt applied on the soil surface. Some woody plants such as bayberry (*Myrica cerifera* L.), tamarisk (*Tamarix sp.* L.) and Japanese black pine (*Pinus thunbergii* Parl.) are tolerant to salt spray, as well as to salt in the root zone (5).

Japanese black pine was first introduced into the United States along the northeastern coast about 1900 (2). The planting stock came from seed imported from Japan. Japanese black pine was used for coastal plantings in Japan about the middle of the 19th century but was not used elsewhere until much later.

Japanese black pine is now available from many commercial nurseries. The fact that it is tolerant to salt is apparent from the established plantings along the coast (2). However, there is no evidence of work to determine whether variations exist within the species relative to salt tolerance.

The salt tolerance of Japanese black pine makes it useful in two areas. One is as an ornamental plant near the ocean. Japanese black pine has been successfully planted within the back dunes along the mid-Atlantic coast. The second is on highway rights-of-way where salt is applied for snow removal. Salt injury to roadside trees is a severe problem (3,5). Although Japanese black pine could be used on these areas, it is not widely planted.

The objectives of the work being conducted by the Cape May Plant Materials Center are to determine the lethal rate of salt to Japanese black pine and to screen plants grown from seed collected at several locations for exceptional tolerance to salt. This paper deals with the lethal rate of salt applied to 4-year-old Japanese black pine trees compared with that of other pine species.

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## METHODS AND MATERIALS

Four species of pines, each replicated three times, were planted in 1971 to test their tolerance to surface-applied salt. The seedlings were 2 years old at the time of transplanting. Austrian pine (Pinus nijra Arnold), Japanese black pine, pitch pine (P. rigida Mill.) and white pine (P. strobus L.) were used. The plots were allowed to establish for 1 year before salt application. Treatments of 0, 4,485 and 17,935 kilograms (kg) of salt per hectare (ha) were applied in the spring of 1972. Salt was reapplied at the same rate to the 4,485 kg plots again in the spring of 1973. The soil, classified as a sassafras fine sandy loam, was analyzed for sodium ions prior to salt application and again 1 year later. Plant survival and growth rate measurements were recorded during the year of salt application and the following year.

Rainfall was greater than normal for the period April 1972 to March 1973. Precipitation for this period was 135 cm. Normal annual precipitation is 102 cm.

During 1975, the remaining trees were treated with salt again. The original control plots were treated with 8,970 kg/ha of salt in April, June, and August of 1975. These trees received a total of 26,910 kg/ha of salt during the year. Trees treated at the 4,485 kg/ha rate in 1972 were retreated in 1975 with 8,970 kg/ha of salt in April and retreated with the same amount in June. Plant survival and damage were recorded throughout the growing season.

A duplicate of the 1971 planting was made in 1973 and replicated three times. Because of slow establishment, salt was not applied until 1975. During April 1975, salt was applied to the 4 species at rates of 0, 6,725 and 13,450 kg/ha.

The measurements included survival and increase in height and width during the year of salt application and the following year. Soil samples were taken before applying the salt and again in the fall of 1975. Herbicides were not used to control weeds. Irrigation was applied only to dissolve the salt and move it into the root zone.

## RESULTS AND DISCUSSION

### 1971 Planting

The surface-applied salt had spectacular effects on the pine seedlings. The 17,935 kg rate killed all 3-year-old trees except one Japanese black pine. This tree was severely stunted for 2 years, but has recovered. It made normal growth during 1975. No cones have formed on this tree while trees not treated with salt produced mature cones in 1975.

The 4,485 kg rate of salt had little effect on Japanese black pine, as well as, austrian pine (Table 1). However, spring growth was retarded for all species. Japanese black pine, as expected, was the most tolerant to surface applied salt. White pine was the least tolerant to salt applied early in the growing season. Like both austrian and Japanese black pine, pitch pine survival was not affected by the salt. The growth of pitch pine was retarded to a stage between Japanese black pine and white pine.

Prior to salt application, the plots to receive 0, 4,485 and 17,935 kg/ha of salt had Na concentrations of 69, 130, and 237 ppm, respectively. The pH values ranged from 6.1 to 7.2. The higher concentration of Na was in soils of pH values near neutral.

Table 1

Annual growth of four *Pinus* species planted in 1971 and treated with rock salt during 1972 and 1973

| | Salt rate | | | |
|---|---|---|---|---|
| | 0 kg/ha | | 4,485 kg/ha | |
| Species | Height | Width | Height | |
| | (cm) | | (cm) | |
| P. nigra | 38 | 41 | 31 | 38 |
| P. rigida | 41 | 38 | 25 | 28 |
| P. strobus | 36 | 28 | 13 | 15 |
| P. thunbergii | 53 | 66 | 46 | 56 |

Data recorded during 1973•

Table 2

Salt damage to four-year-old *Pinus* spp. during 1975

| Salt Rate | *P. thunbergii* | | *P. nigra* | | *P. rigida* | | *P. strobus* | |
|---|---|---|---|---|---|---|---|---|
| | No.*** Living | Injury | No. Living | Injury | No. Living | Injury | No. Living | Injury |
| 17,940 kg/ha* | 18 | Nd-Sl (C) | 16 | Sl-M (C) | 8 | M-Se | 4 | Se |
| 26,910 kg/ha** | 18 | Sl (C) | 17 | Nd-Se | 11 | M-Se | 6 | Se |

*Applied on April 1 and August 1 in 8,970 kg/ha increments
**Applied on April 1, June 1, and August 1 in 8,970 kg/ha
***Total trees per treatment for each species was 18 in Jan. 1975

Legend: Salt Damage - Nd=None; Sl=Slight; M=Moderate; Se=Severe; C=Mature cones present.

Table 3

Survival and damage to four *Pinus* spp.
by surface-applied salt at three rates.
Trees planted in 1973 and salt applied in April 1975

| Salt Rate | P. thunbergii | | P. nigra | | P. rigida | | P. strobus | |
|---|---|---|---|---|---|---|---|---|
| | No. Living | Damage | No. Living | Damage | No. Living | Damage | No. Living | Damage |
| 0 kg/ha | 45 | Nd | 33 | Nd | 39 | Nd | 43 | Nd |
| 6,725 kg/ha | 33 | Sl | 18 | Sl-Se | 30 | Sl-M | 11 | Sl-M |
| 13,450 kg/ha | 13 | Sl-M | 5 | Sl-M | 3 | Sl-M | 0 | |

Legend: Salt Damage - Nd=None; Si¯Slight; M=Moderate; Se=Severe

Data recorded in October 1975.

There was no indication of Na being retained in the 0-15 centimeter (cm) soil layer 1 year after application. In fact, the Na content in each plot was lower than it had been the previous spring. In plots that had been treated with 4,485 kg/ha of salt, the Na content was 78 ppm while the Na content was 130 ppm prior to salt application. Residual effect of salt appears to be insignificant. Plant damage from surface-applied salt must occur shortly after application; otherwise the salt will be leached below the surface layer of soil where its effectiveness is lost.

Likewise, the Na ions from the 17,935 kg/ha rate had leached below the plow layer 1 year after salt was applied. In fact, the Na concentration immediately before salt application was 237 ppm but had declined to 130 1 year later. In this sandy soil with 102 cm of annual precipitation, salt does not remain in the surface 15 cm-layer for the duration of the growing season.

Salt was reapplied to the 4,485 kg/ha plots again in April 1973. This second treatment slightly reduced the growth rate for Japanese black pine and Austrian pine. However, no plants died as a result of the second application.

After 4 years, the root system had become well established. The three applications of salt at 8,970 kg/ha (Table 2) in 1975 had little effect on the Japanese black pine. No plants were killed. The only apparent damage was premature needle drop. However, one-third of the white pine trees were killed by this high salt rate. Those remaining were severely damaged. By fall, the few remaining white pines that appeared to be alive were nearly barren of any green needles.

## 1973 Planting

New plots were established in the fall of 1973. Soil analyses were made for the 0-15-cm and 15-30-cm layers before salt application. The lower layer had greater concentrations of Na (110 to 330 ppm) than the topsoil (12 to 28 ppm). Soil particle size was nearly identical for the two soil layers and the organic matter content was nearly the same.

Salt was applied to these plots in April 1975 at the rates of 0, 6,725 and 13,450 kg/ha. Damage began to appear within two weeks after the salt was applied. Deformed candles and brown needles were the visible damage symptoms. The number of Japanese black pine still living (Table 3) at the end of the growing season was 45, 33 and 13 for the 0, 6,725 and 13,450 kg/ha plots, respectively. Annual growth for the few living plants was reduced to almost zero in the highest salt plots. New growth was reduced about 50 percent in the 6,725 kg plots.

Austrian pine was not as salt tolerant as Japanese black pine. The number of Austrian pine that survived the 13,450 kg/ha rate was 5 while 13 Japanese black pine survived the same rate. All the white pine were killed from the 13,450 rate. The 6,725 rate killed 75 percent of the white pine and severely reduced the growth rate of those that survived.

## SUMMARY

Under the conditions of this study, Japanese black pine was more salt tolerant than the three other species. Least tolerant was white pine.

These data confirm that Japanese black pine growing in a sandy soil becomes more tolerant to salt as the age of the plant increases. One application of salt (13,450 kg/ha) killed more than one-half of the 2-year-old Japanese black pine and severely restricted the growth of those remaining plants. Conversely, 4-year-old Japanese black pine withstood three applications of salt totalling 26,910 kg/ha.

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