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Nutrient Content in Eastern Redcedar Foliage: Seasonal Variation

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Seasonal variation in foliage nutrient concentration of out-planted eastern redcedar (Juniperus virginiana L.) seedlings from three Great Plains nurseries was examined.

Foliage nitrogen, phosphorus, sulfur, and magnesium concentrations generally increased significantly during the growing season. Calcium, zinc, and iron remained fairly constant. Potassium decreased until July and then increased back to initial levels.

Differences in foliage nutrition concentration between nursery sites and years within the study were also significant.

Background

Foliar nutrient analysis has been used routinely in agronomy for two decades, but in forestry, foliar nutrient analysis is used primarily after nutrient deficiencies appear. At that point, however, growth loss is already significant.

Foliage nutrient analysis in trees is complicated primarily by the extended growth period that is required. Nutrient levels in tree foliage vary with tree age, foliage age, and the crown position of the foliage sampled. In addition, foliage nutrient levels vary between years and within a growing season. Despite these sources of variation, nutrient reference standards have been developed for several commercial forest tree species (see Further Reading Section).

Seasonal nutrient variation has been studied for several tree species but not for eastern redcedar (Juniperus virginiana L.).

The objectives of the research reported here were 1) to provide basic information on the seasonal variation of foliage nutrient concentration in eastern redcedar, 2) to determine if differences in nutrient concentration existed between years in the study, and 3) to determine if differences in nutrient concentration existed between nursery sources over the two-year period of the study.

Plant materials were obtained in each of these years from three nurseries in the northern Great Plains: the U.S. Forest Service Bessey Nursery at Halsey, Nebraska; the Big Sioux Tree Nursery at Watertown, South Dakota; and the Towner Nursery at Towner, North Dakota. Seedlings from the Bessey Nursery and the Big Sioux Nursery were 2-0 stock. Due to a shorter growing season the seedlings from the Towner Nursery in North Dakota were 2-1 stock.

Two hundred and fifty seedlings from each nursery were shipped by common carrier each spring. Upon arrival they were placed in refrigerated storage at 1° C until field planting in Brookings County, South Dakota.

Field planting dates were in late April. Seedlings were machine planted about 18 inches apart in 300-foot rows with 8 feet between rows. The soil was a Lamoure silty clay loam and contained 21 ppm NO_3-N, 9.5 ppm P, 165 ppm K, 30 ppm S, 930 ppm Mg, .46% Ca, 15 ppm Fe, 8.2 ppm Mn, and 165 ppm Zn. The soil pH was 7.9 and the soil contained 3.2% organic matter.[1]

[1] Analysis of soil and plant tissue samples was performed by the Soil Testing Laboratory, Plant Science Department, South Dakota State University, Brookings, SD 57007

Six samples of 12 trees each were used for nutrient analysis. An initial sample was taken upon arrival of the seedlings, a sample was taken one week after planting, and four additional samples were taken at monthly intervals from June until September. Each sample consisted of three replications of four trees. Foliage from the four trees was bulked when analyzed for mineral nutrient concentration.

To avoid dust and soil contamination, seedlings were washed in a detergent solution, rinsed, washed a second time in an ultrasonic cleaner for two minutes, then rinsed with de-ionized water and dried in an oven at 70°C for 72 hours. After drying, all green foliage was removed from the stem and ground in a Wiley mill to pass through a 20-mesh screen.

Nitrogen determination was performed using the Kjeldahl method. Potassium samples were digested in glacial acetic acid and analyzed with a flame photometer. Samples for the remaining seven mineral nutrients were digested in perchloric and nitric acid. Phosphorus and sulfur levels were determined colormetrically. Calcium, magnesium, zinc, iron, and manganese levels were determined using a Perkins-Elmer Model 372 atomic absorption unit.

STATISTICAL ANALYSIS

Foliage nutrient concentration data for sampling date, year, and nursery source were analyzed for significant differences by analysis of variance (ANOVA). Differences in means of foliage nutrient concentration between sampling dates within years and nursery source were determined using the Duncan-Waller multiple range test ($p=.05$). Differences in means between nursery sources were also determined using the Duncan-Waller multiple range test. Differences in means between years were determined by the F-test ($p=.05$) since there were only two years in the study.

RESULTS[2]

Nitrogen

Seasonal variation in total nitrogen (N) concentration in eastern redcedar foliage is shown in Figure 1. The N concentration increased significantly during the growing season in seedlings from the Bessey and Towner nurseries in 1980 and 1981. For the Big Sioux Nursery, N concentration did not change significantly from the beginning of the growing season to the end in either 1980 or 1981.

Phosphorus

The phosphorus (P) concentration generally increased from the beginning of the growing season to the end in both years (Fig 2). The only exception was P concentration in 1980 in seedlings from the Big Sioux Nursery. In this case the P concentration remained unchanged throughout the growing season.

Potassium

Potassium (K) concentration decreased until June or July and then began to increase (Fig 3). At the end of the growing season, K concentration was still significantly below the initial values except for seedlings from the Towner Nursery in 1981 where the final K concentration was actually greater than the initial value.

Sulfur

Total sulfur concentration increased significantly by the end of the growing season over the initial values (Fig 4). This increase was significant in all cases except for seedlings from the Bessey Nursery in 1981.

Magnesium

In 1980 magnesium (Mg) concentrations increased from April until August and then declined in September. Magnesium concentrations were significantly higher at the end of the growing season in 1980 in seedlings from all three nurseries (Fig 5). In 1981 Mg concentration in seedlings from the Big Sioux Nursery followed the same pattern as in 1980, but Mg in seedlings from the Bessey and Towner nurseries was not significantly different at the end of the growing season.

Calcium

The concentration of calcium (Ca) increased from April to a peak in June and

[2] All results reported are significant at $p=.05$ unless otherwise stated.

then declined (Fig 6). In 1980 Ca concentrations were not significantly lower in September than in April for any of the three nurseries, but in 1981 Ca concentrations for all three nurseries were significantly less in September than in April.

Zinc

In 1980 zinc (Zn) concentrations exhibited a pattern similar to calcium. Zn concentration increased from April to a peak in June and then declined (Fig 7). By September Zn levels were the same or slightly higher than in April. In 1981 there was no consistent pattern. Zn in seedlings from the Bessey Nursery was essentially unchanged in September as compared with April, with a peak value in May. Zn in seedlings from the Big Sioux remained unchanged throughout the growing season with no peak, and Zn in seedlings from the Towner Nursery was significantly higher in September than in April.

Iron

Iron concentration was significantly higher in September than in April for all nursery sources and for both years (Fig 8). Seedlings from the Big Sioux Nursery had a peak value in June each year. Seedlings from Towner and Bessey had a peak value in June in 1980 and in August in 1981.

Manganese

Large monthly variations in manganese (Mn) concentrations from one month to the next made it difficult to determine any pattern in Mn concentration (Fig 9). Seedlings from the Towner Nursery increased in Mn concentration in both 1980 and 1981. Seedlings from the Bessey Nursery decreased in Mn concentration in both 1980 and 1981, and seedlings from the Big Sioux Nursery decreased in Mn concentration in 1980 and remained unchanged in 1981.

Nursery Source Variation

To determine if differences in nutrient concentration in eastern redcedar seedlings existed between nursery sources, data from the initial sample taken prior to planting and pooled over two years, were analyzed by ANOVA (Table 1).

Seedlings from the Bessey Nursery in Nebraska had a significantly higher foliage concentration of potassium, zinc, calcium, and manganese. These seedlings also had the lowest concentration of magnesium and iron. Seedlings from the Big Sioux Nursery in South Dakota had the highest concentrations of nitrogen, phosphorus, sulfur, magnesium, and iron. These seedlings also had the lowest concentration of zinc. Seedlings from the Towner Nursery in North Dakota had the lowest concentration of calcium and manganese.

Variation Between Years

Statistical analysis of the data from the initial sample taken prior to planting showed a difference in foliage nutrient concentration between years for most of

Table 1. Nutrient concentration of eastern redcedar foliage averaged over a two-year period to show differences due to nursery source.[1]

Source	% Dry Matter						PPM		
	N	P	K	S	Ca	Mg	Zn	Fe	Mn
Halsey	1.33b	.17b	.60a	.10b	1.11a	.18c	20.5a	331c	173a
Big Sioux	1.63a	.18a	.54b	.13a	.99b	.23a	14.5c	467a	122b
Towner	1.27b	.17b	.57ab	.10b	.95b	.19b	19.2b	405b	106c

[1]Means in each column followed by the same letter are not significantly different at p = .05.

the nutrients (Table 2). However, not all the nutrients were found at their highest concentration in one year. Nitrogen, calcium, and manganese were highest in 1981; and phosphorus, potassium, sulfur, and zinc were highest in 1980. Magnesium and iron were not significantly different either year.

DISCUSSION AND CONCLUSIONS

Very little information exists on foliage nutrient concentration or content in eastern redcedar. Vimmerstedt (1968) in a study with eastern redcedar and eastern white pine examined the levels of potassium, calcium, and magnesium in both species. In the tops of eastern redcedar the level of K was 8.6 meq/100 g or 0.86%, Ca was 30.9 meq/100g or 1.54%, and Mg was 4.0 meq/100g or 0.20%.

Chandler (1937) examined the level of calcium in several tree species including eastern redcedar. Calcium content in September in eastern redcedar foliage was 8.85 meq/100g and nitrogen content was 1.34%.

Fletcher and Ochrymowych (1955) reported a calcium concentration of 1.41% in eastern redcedar foliage in the early part of the growing season which remained fairly constant during the growing season. Magnesium was also fairly constant through the growing season at about 0.20 to 0.22%. Phosphorus increased during the growing season from 0.49% to 0.76%.

Seasonal variations in the nutrient concentration of all nine mineral nutrients were significant. Given these changes in nutrient concentration within a growing season, the best time to analyze eastern redcedar foliage for nutrient content is after growth has stopped and the plant has become dormant.

Differences in foliage nutrient concentration between nursery sources were also significant. However, no one nursery produced eastern redcedar seedlings that were the highest in all nine nutrients. This more than likely reflects differences in nursery fertilization practices and also innate differences in soil nutrient content between nursery sites.

An example of this is the difference between nursery sites in foliage micronutrient content, which is not commonly supplied through fertilizer. Seedlings grown at the Bessey Nursery were lower in iron than the other two nurseries, seedlings grown at the Big Sioux Nursery were lower in zinc, and seedlings grown at the Towner Nursery were lower in manganese.

Significant differences also existed between years of the study. Given this year-to-year variation, any study designed to determine the nutrient content of the production stock at any nursery site should not be confined to one year. Sampling over a 2- or 3-year period would allow for this year-to-year variation.

Table 2. Nutrient concentration of eastern redcedar foliage averaged over the three nursery sources to show differences due to year.[1]

	% Dry Matter						PPM		
Year	N	P	K	S	Ca	Mg	Zn	Fe	Mn
1980	1.33b	.18a	.64a	.12a	.92b	.19a	20.1a	371a	119b
1981	1.48a	.16b	.49b	.10b	1.12a	.21a	16.1b	431a	148a

[1]Means in each column followed by the same letter are not significantly different at p = .05.

Figure 4. Percent sulfur in eastern redcedar foliage from three Great Plains nurseries in 1980 and 1981.

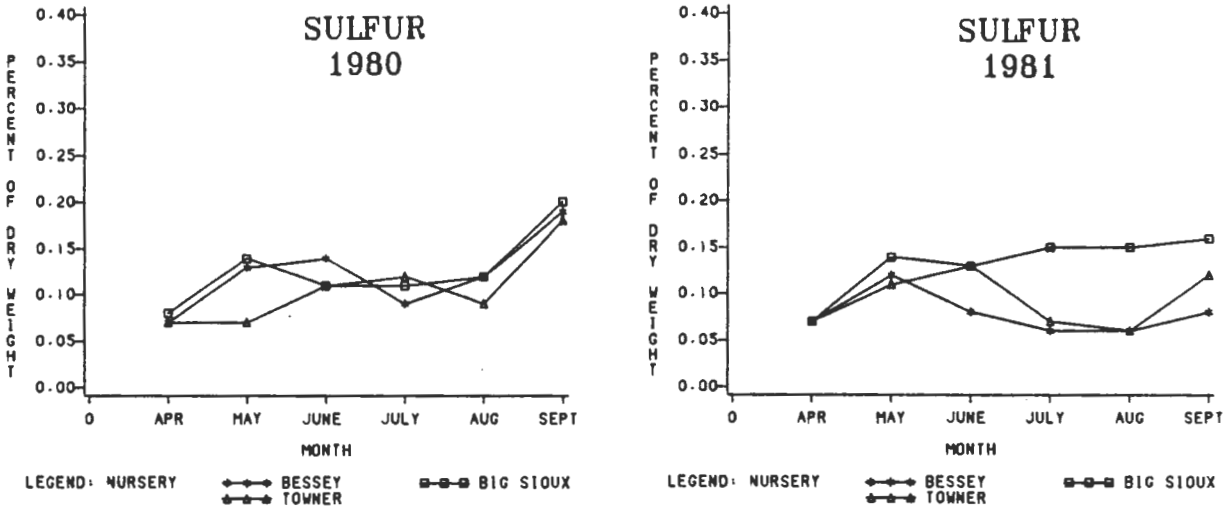


Figure 5. Percent magnesium in eastern redcedar foliage from three Great Plains nurseries in 1980 and 1981.

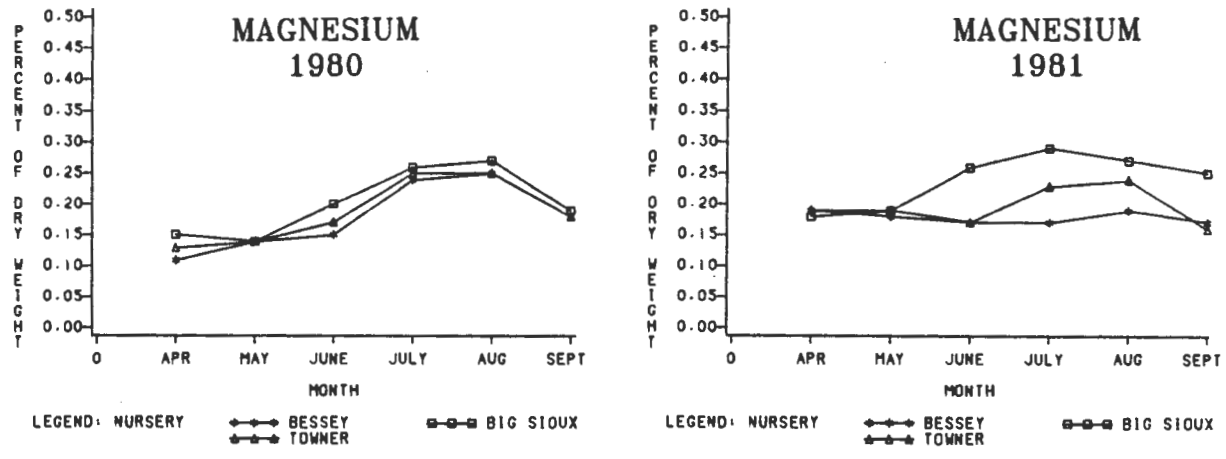


Figure 6. Percent calcium in eastern redcedar foliage from three Great Plains nurseries in 1980 and 1981.

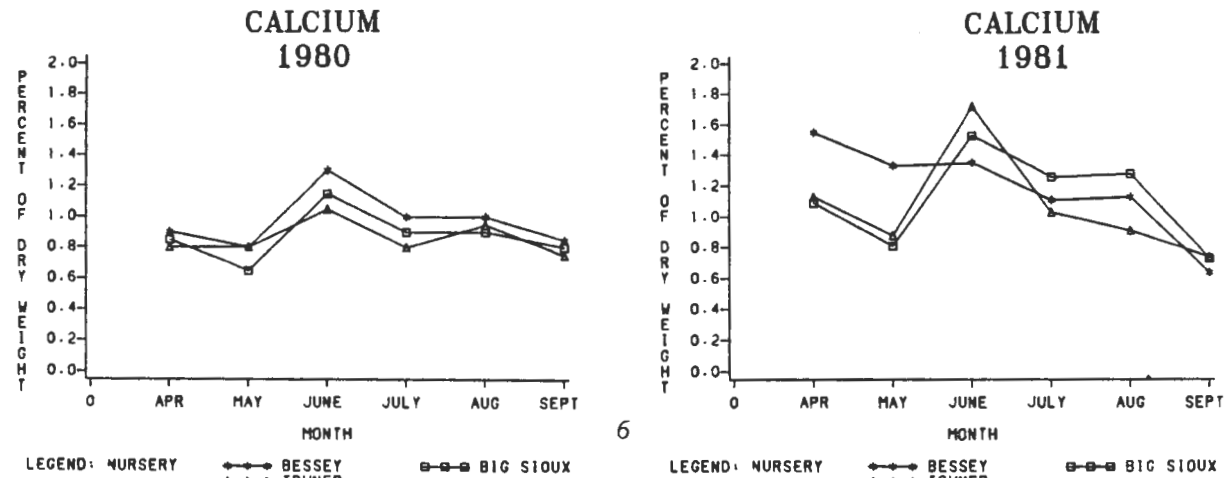


Figure 1. Percent nitrogen in eastern redcedar foliage from three Great Plains nurseries in 1980 and 1981.

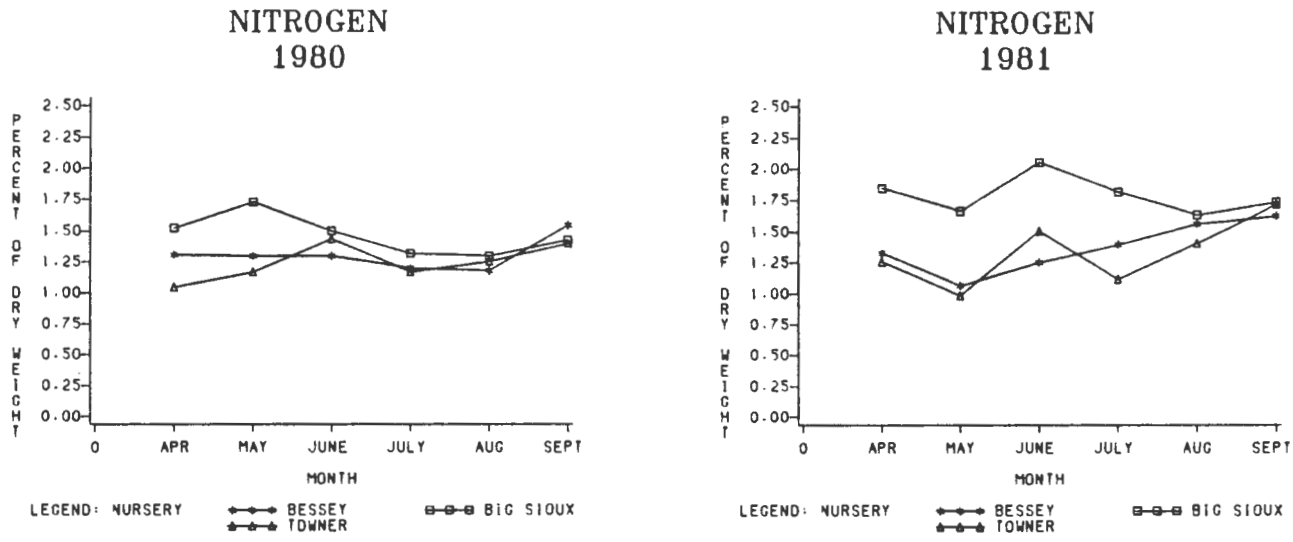


Figure 2. Percent phosphorus in eastern redcedar foliage from three Great Plains nurseries in 1980 and 1981.

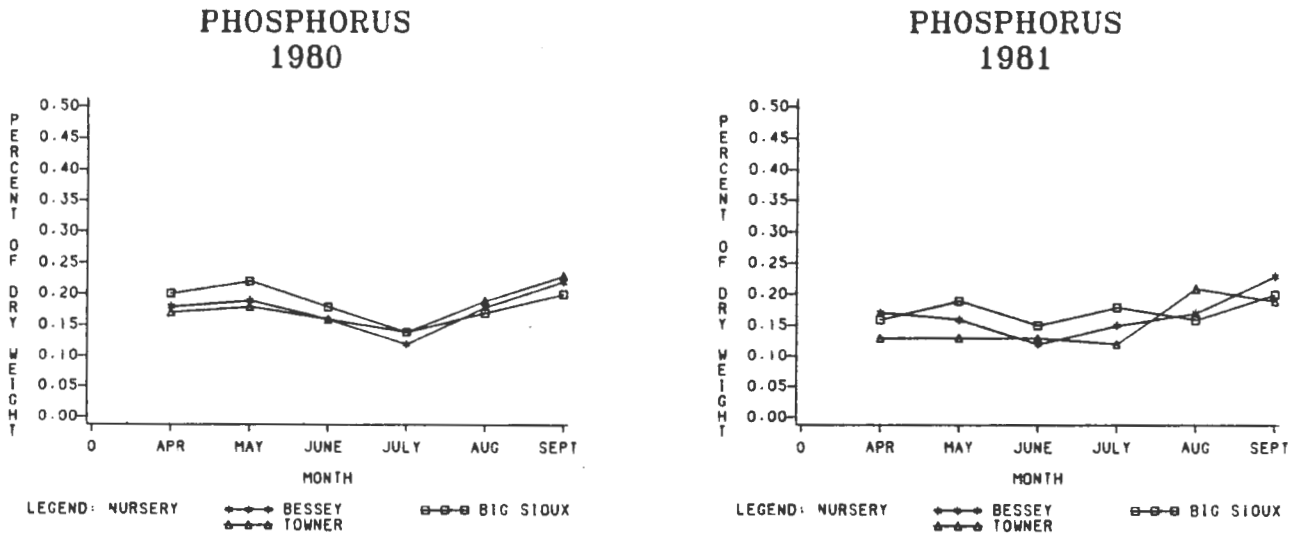


Figure 3. Percent potassium in eastern redcedar foliage from three Great Plains nurseries in 1980 and 1981.

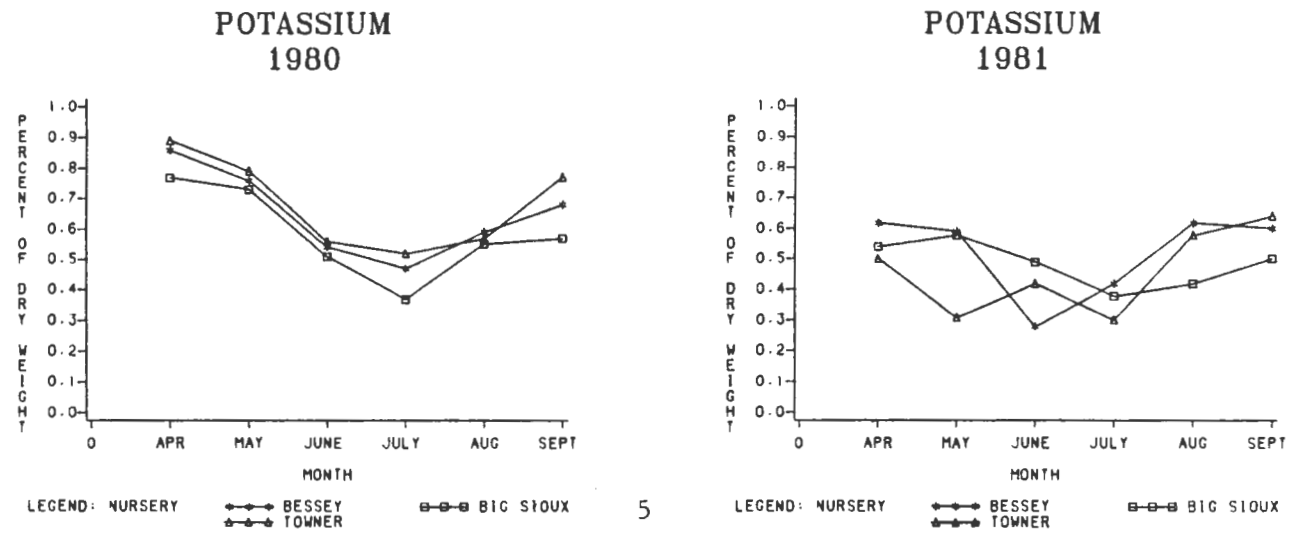


Figure 7. Parts/million of zinc in eastern redcedar foliage from three Great Plains nurseries in 1980 and 1981.

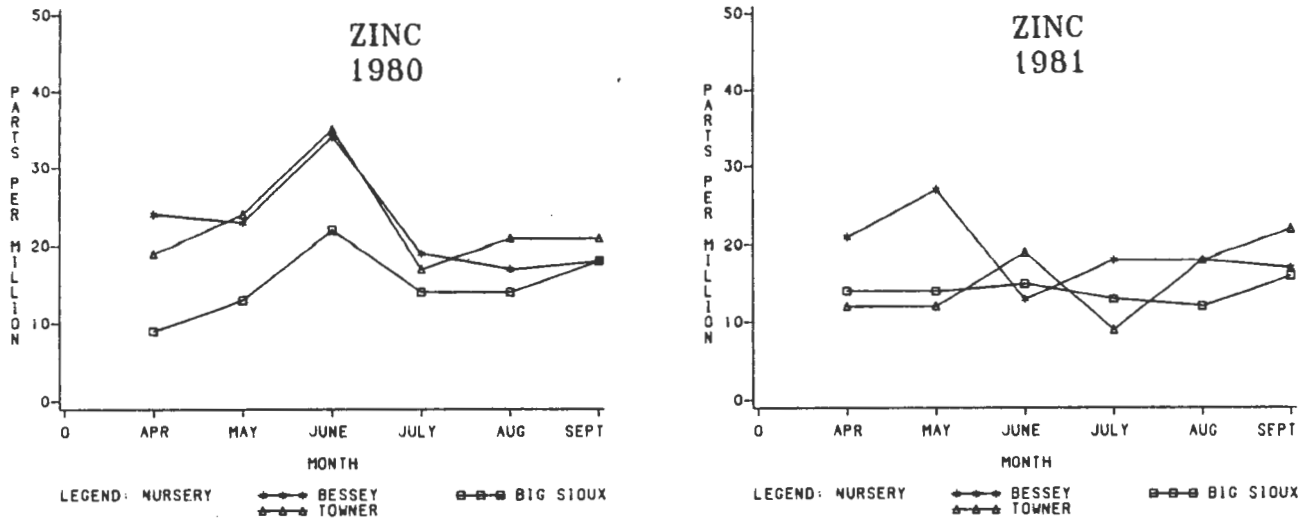


Figure 8. Parts/million of iron in eastern redcedar foliage from three Great Plains nurseries in 1980 and 1981.

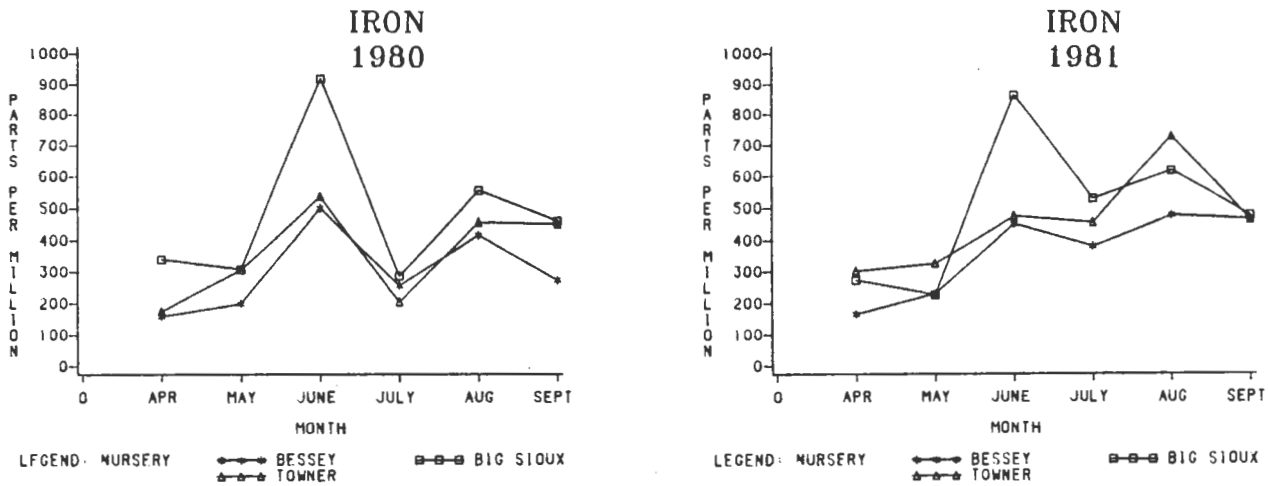
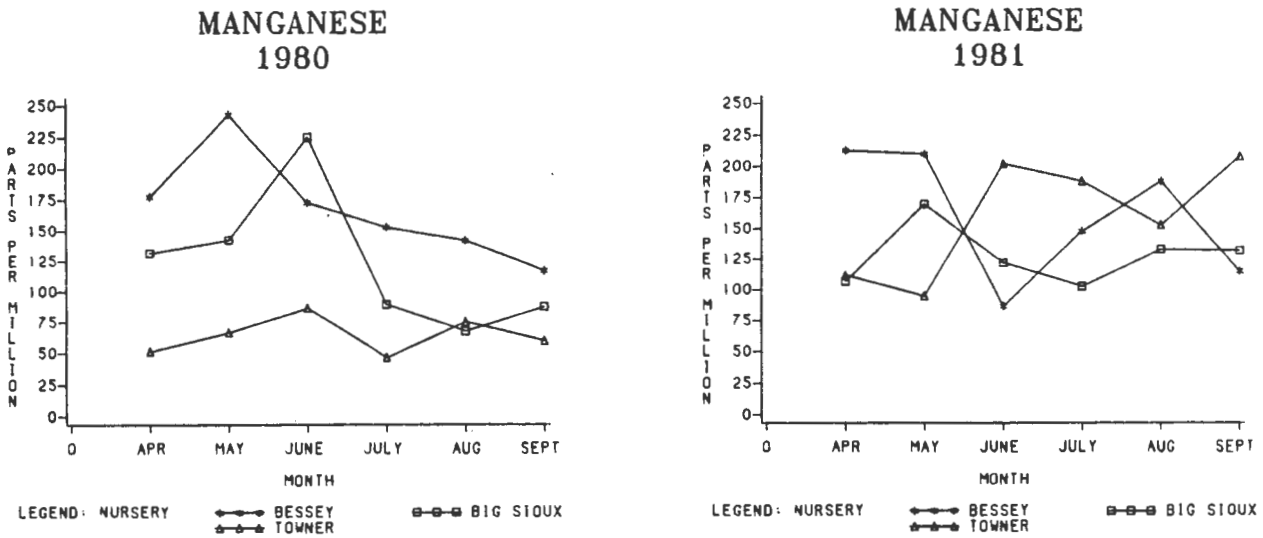


Figure 9. Parts/million of manganese in eastern redcedar foliage from three Great Plains nurseries in 1980 and 1981.



References

1. Chandler, R.F. Jr. 1937. Certain relationships between the calcium and oxlate content of certain forest trees. Jour. Agr. Res. 55: 393-396.

2. Fletcher, Peter W. and Julian Ochrymowych. 1955. Mineral nutrition and growth of eastern redcedar in Missouri. Missouri Ag. Exp. Stn. Bull. 577, 16p.

3. Vimmerstedt, John P. 1968. Root cation exchange capacity and the mineral nutrition of eastern white pine and eastern redcedar. Soil Sci. Soc. Amer. Proc. 32: 289-292.

Suggested Further Reading

I. Reviews of factors which cause nutrient variations.

Leaf, A.L. 1973. Plant analysis as an aid in fertilizing forest. In Soil Testing and Plant Analysis. L.M. Walsh and J.D. Beaton eds. p. 427-454. Soil Sci. Soc. Amer. Spec. Publ. 2. Madison, Wis.

Turner, J., S.F. Dice, D.W. Cole, and S.P. Gessel. 1978. Variation of nutrients in forest tree foliage--A review. Inst. For. Prod. Contrib. 35. 32p. College of For. Res., Univ. of Washington, Seattle, Washington.

Van den Driessche, R. 1974. Prediction of mineral nutrient status of trees by foliar analysis. Bot. Rev. 40:347-394.

II. Foliage nutrient reference standards.

A. Pine

1. Jack pine

Swann, H.S.D. 1970. Relationships between nutrient supply, growth and nutrient concentrations in the foliage of black spruce and jack pine. 27p. Pulp Pap. Res. Inst. Can., Woodlands Rep. 19.

2. Loblolly pine

Fowells, H.A. and R.W. Krause. 1959. The inorganic nutrition of loblolly and Virginia pine with special reference to nitrogen and phosphorus. For. Sci. 5:95-112.

3. Lodgepole pine

Swann, H.S.D. 1972. Foliar nutrient concentrations in lodgepole pine as indicators of tree nutrient status and fertilizer requirement. 19p. Pulp Pap. Res. Inst. Can., Woodlands Pap. 29.

4. Ponderosa pine

Powers, R. F. 1983. Forest fertilization research in California. U.S.D.A., For. Ser. Gen. Tech. Rpt. PNW-163 p 388-396. Portland, Ore.

5. Red pine

Leaf, A.L., J.V. Bergulund and R.E. Leonard. 1970. Annual variation in foliage of fertilized and/or irrigated red pine plantations. Soil Sci. Soc. Amer. Proc. 34:677-682.

6. Scotch pine

Ingestad, T. 1979. Mineral-nutrient requirements of Pinus sylvestris and Picea abies seedlings. Physiol. Plant. 45:373-380.

B. Spruce

1. Black Spruce

Lowry, G.L. and P.M. Avard. 1968. Nutrient content of black spruce and jack pine needles. III. Seasonal variations and recommended sampling procedures. 54p. Pulp Pap. Res. Inst. Can. Woodlands Pap. 10.

2. Red Spruce

Swann, H.S.D. 1971. Relationship between nutrient supply, growth and nutrient concentration in the foliage of white and red spruce. 27p. Pulp Pap. Res. Inst. Can. Woodlands Pap. 29.

3. White Spruce

Armson, K.A. 1968. The effects of fertilization and seedbed density on the growth and nutrient content of white spruce and red pine seedlings. 10p. Univ. of Toronto, Fac. For. Tech. Rept.

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