Response of Different European Black Pine Provenances to Nitrogen Fertilization

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Basic research in plant nutrition makes fertilizer application important in present-day forestry. This is particularly true with nitrogen. Many consider it as a key mineral element. Plant growth is frequently discussed in connection with nutrient levels in the foliage. It may be economic and efficient to restore depleted soil productivity by means of artificial fertilization.

The present study was designed to solve two questions: Would nitrogen fertilization cause changes in the growth, foliar anatomy and chemical composition in European black pine (Pinus nigra ARNOLD); and would all seed origins respond similarly to nitrogen fertilization.

Material *and* Methods

Twenty-seven seedlots, each including seed from ten average trees located within a mile radius, were received from several European researchers. The seeds were stored dry at 35° F. until sowing in the following spring (1959). They were sown in a 4-replicated. randomized complete block design in the nursery at East Lansing, Michigan. Each plot consisted of one 4-foot row and was spaced 6 inches apart. A fifth set of plots was broadcast sown to provide stock for permanent outplanting. The trees received conventional nursery care characteristic in central Michigan.

The 2-0 seedlings were planted on an 8 X 8 foot spacing in Compartment 26-D, Kellogg Forest, Augusta, Michigan, on March 23, 1961. A randomized complete block design with 10 replicates and 4 tree-plots was used.

The plantation site had not ben used since 1948. It was furrowed before planting to break a heavy sod of blue grass. The soil is Oshtemo loamy sand to sandy loam. The site is rolling with eastern and southern aspects. On May 4, 1964, Mr. W. LEMMIEN, resident forester, applied a directed spray of simazine and aminotriazole to 2-foot strips containing the trees at the rate of four pounds simazine plus two gallons of aminotriazole per acre treated.

The northernmost two trees in each plot were fertilized with 45-0-0 urea pellets at the two ounces per tree rate on April 10 and 28, 1964. It was applied to the surface of a 16-inch diameter circle around each tree. The other two trees in the plot remained unfertilized. The plantation is now considered as a split plot design with fertilizer as the main factor and provenances as the subfactor.

In most cases, growth and survival have been satisfactory. Only trees from Corsica and southern France had appreciable winter kill and mortality. Total height was measured periodically; mortality was counted annually.

I collected 70 foliage samples in mid-November, 1964. In most cases a sample was from all ten replicates; for eight seed origins there were separate samples from the first five or second five replicates. The foliage samples were oven-dried immediately after collection at 60° C. for 48 hours. They were then ground in a Wiley mill and made to pass a 20-mesh screen. Ten elements were analyzed spectrographically. Nitrogen was determined by the microKjelchal method and potassium by the flame photometry. All analyses were made at the Plant Nutrition Laboratory, Department of Horticulture, Michigan State University.[2])

For the chemical study the degrees of freedom were 1, 26, and 26 for fertilizer, provenance and error respectively. It could show the significance of main effects but not of fertilizer X provenance interaction. To do that, data from the four bulked samples (fertilized or unfertilized, replicates 1 to 5 or 6 to 10 respectively) from each of the eight selected provenances were subjected to special analyses of variance with degrees of freedom of 1, 1, 1, 7, 7, and 14 for block, fertilizer, error 4 (block×fertilizer), provenance, fertilizer X provenance, and error B (block X provenance plus fertilizer X prov. X block) respectively. The error term derived from these special analyses was used to estimate significance of the provenance differences and provenance X fertilizer interaction for the entire 27 provenances. Most statistical analyses were done with an electronic computer, CDC 3600.

Results *and* Discussion

Total height at the end of the 1963 growing season for fertilized and unfertilized trees averaged 43.8 cm. and 40.2 cm. respectively. The differences were statistically significant. However, they are possibly due to stratification at the time of planting rather than to fertilization.

Height increment during 1964 and 1965 was 0.4 cm. and 0.9 cm. in favor of the fertilized trees. Neither difference was statistically significant. Nitrogen was applied twice — in early and late April of 1964. Presumably it began to reach the root zone by early or mid-May. Height growth was nearly complete by late June. Therefore, there was little expectation of a growth increase during the year of application. There was more reason to expect a growth increase in 1965. Its absence in that year may mean that the fertility level of the soil was already high for black pine.

There was no significant interaction between seed source and fertilization; the possible increase in height growth due to high nitrogen was the same for all seed origins. These results differ from those obtained by GESSEL and WALKER (1956). Their nitrogen fertilization trials on 15- to 20-year-old natural Douglas-fir (Pseudotsuga *menziesii* [MIRB.] FRANCO) stands growing on poor sites in western Washington showed that taller trees responded more than smaller trees in annual height growth.

The effect of genetic control on growth rate is greater than that of nitrogen fertilization. The range in height

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2) The coefficients of variability due to instrumental error for the spectrographically determined elements were calculated by Dr. A. L. KENWORTHY as: P —2.6%, Ca —5.3%, Mg —4.9%, Na —21.2%, Mn —5.3%, Fe —8.4%, Cu —14.3%, B —7.4%, Zn —40.0%, Al —8.6%.

growth between extreme seedlots (Corsica vs. Crimea) was 24 cm. much greater than the possible nitrogen effect.

There was no growth rate-foliar nitrogen relation (rank correlation coefficient = 0.32).

The nitrogen fertilizer did not cause a significant increase in *needle length*. On the average, needles from unfertilized trees were 9.22 cm. long; those from fertilized were 9.49 cm. long. WALKER and YOUNGBERG (1962) applied ammonium nitrate to a 9-year old plantation of slash pine (*Pinus elliottii* ENGELM.) at the 200 pounds per acre rate in the lower coastal plain of Georgia. They observed no increase in needle length either.

Application of fertilizer may result in large changes in *foliar chemical composition*. Significantly increased was the uptake of N and Mn, significantly suppressed was the absorption of K, P, Mg, B, Zn, and Al. However, nitrogen fertilization did not significantly alter the foliar content of Ca, Fe, Na, and Cu in black pine (*Table 1*). My results agreed best with those of SMITH (1962) and his co-workers (1951, 1954) working on citrus trees. Discrepancies between the citrus and pine were noticed in some respects. Application of nitrogen fertilizer suppressed the uptake of manganese ions in citrus trees; the reverse was true with black pine. Nitrogen fertilization stimulated the absorption of magnesium ions in citrus trees, reduced it in black pine.

Table 1. — Effect of nitrogen fertilization on different sources of *Pinus nigra* ARNOLD.

Element	Foliar content of trees		F value due to		
	With Fert.	Without Fert.	Fertilization	Seed origin	Interaction
Nitrogen, %	1.45	1.39	29.68**	7.80**	0.15
Potassium, %	.580	.642	94.81**	2.95**	.34
Phosphorus, %	.160	.165	6.19**	2.74**	.33
Sodium, ppm.	64.5	75.7	3.44	2.42**	.47
Calcium, %	.329	.327	.10	3.17**	.28
Magnesium, %	.106	.115	4.67*	2.99**	.38
Manganese, ppm.	338.2	266.8	57.83**	2.37*	.70
Iron, ppm.	53.2	53.0	.01	2.77*	.83
Copper, ppm.	9.58	10.54	2.73	2.46*	3.48**
Boron, ppm.	16.22	19.62	48.55**	4.89**	.58
Zinc, ppm.	29.4	37.0	56.48**	3.63**	.91
Aluminium, ppm.	289.0	353.6	30.32**	3.51**	.29

* Significant at the 5 percent level
** Significant at the 1 percent level

The pattern of phosphorus and potassium uptake was different between Douglas-fir and black pine. According to HEILMAN and GESSEL (1963), nitrogen fertilization had a greater antagonistic effect on phosphorus uptake than on potassium uptake. However, the reverse was true with black pine.

There was only one case showing a significant fertilization $\times$ genotype interaction. That concerned foliar copper content. Nitrogen fertilization suppressed the uptake of copper ions. This trend was intensified in the following seedlots: MSFG 405 from Turkey, 417 and 424 from Greece. Copper content of unfertilized trees in those seedlots was 17.5, 22.1, and 13.8 ppm. respectively; that of fertilized trees in the same seedlots was 10.3, 12.9, and 7.7 ppm.. The amount of suppression was 41, 42, and 44 percent respectively.

In most cases, the genetic differences in foliar mineral content between the most extreme seedlots were two to eight times greater than the changes due to nitrogen fertilization. However, the reverse was true for only two elements: the differences due to fertilization and extreme seedlots were 71 and 55 ppm. respectively for Mn; 65 and 43 ppm. respectively for Al.

In order to find *a simple correlation between mineral composition and growth rate*, the three Corsican seedlots were excluded from the analysis because they had little chance to express their growth potential due to heavy winter injury. The remaining 24 seedlots were separated into slow and fast growing groups. An analysis of variance was applied to test the difference in the 12 mineral elements between those two groups. There were no indications of significant differences in the 12 mineral elements between the slow and fast growing seedlots.

In Scotch pine, STEINBECK (1965) found a strong relationship between growth rate and nitrogen and magnesium. He considered these two as key mineral elements. The same author also found several interesting geographic trends in foliar nutrient level but their relation to growth character was not clear. For example, he observed the nitrogen level of winter-green Spanish trees was low, of the fastest-growing French-Belgium trees was medium and of the slow growing winter-yellow Scandinavian trees was high.

Summary

Black pine (*Pinus nigra* ARNOLD) seed from 27 native stands, each representing 10 average trees, was sown in the Michigan State University nursery in spring 1959. The test plantation at the Kellogg Forest, Augusta, Michigan was established with 2—0 stock in 1961 following a randomized complete block design with 10 replications. In spring 1964, two ounces of the 45-percent urea pellets were applied to the northernmost two trees per plot and the southernmost two trees were left unfertilized. The plantation follows a split plot design with fertilizer treatment as the main factor, and provenance as the subfactor. I collected 70 foliage samples in mid-November 1964 to determine the response of black pine provenances to nitrogen fertilization. Significantly affected was foliar chemical composition. The uptake of N and Mn was significantly enhanced; the absorption of K, P, Mg, B, Zn, and Al was significantly suppressed. The amount of increase or decrease in foliar chemical composition was nearly the same in every provenance. The change in foliar mineral composition due to fertilization was relatively small compared with the genetic differences.

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