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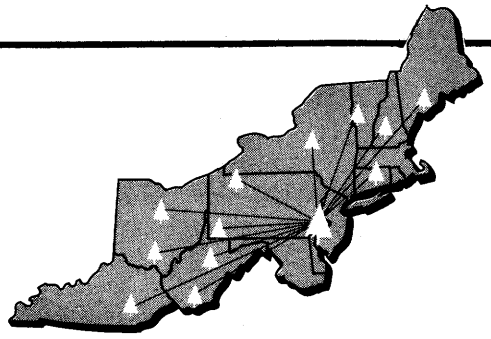

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RESPONSE OF PAPER BIRCH SEEDLINGS TO NITROGEN, PHOSPHORUS, AND POTASSIUM

Abstract.—The effects of N, P, and K on the growth of paper birch seedlings were tested in sand culture tests. Each element was tested singly at different supplies while holding constant the supply of all other elements. Seedling growth increased with increasing amounts of nitrogen. Three to 4 percent in the foliage indicated an adequate supply. Seedlings were relatively unaffected by different levels of phosphorus and potassium.

The nutrient requirements of paper birch (*Betula papyrifera* Marsh) have not been thoroughly investigated. Estimates have been made of the amount of various elements present in different portions of trees growing under natural conditions, but little work has been done in sand or solution culture studies where each element can be controlled. Such studies are needed to determine nutrient requirements of trees and to lay a foundation for forest fertilization studies.

In the study reported here, seedling growth improved with increasing amounts of nitrogen, but was relatively unaffected by different levels of phosphorus and potassium. Three to 4 percent nitrogen in the foliage seemed to be adequate for seedling growth.

Methods

The study was conducted in a growth room. Paper birch seeds were germinated, and the seedlings were grown in glazed containers (8 inches in diameter, 12 inches deep) filled with quartz sand and perlite. A combination of incandescent and fluorescent lamps provided about 3,000 foot candles at seedling height. Day length was 16 hours. Day and night temperatures were kept as close as possible to 85 and 65 degrees F, respectively.

The basic nutrient solution contained the required elements at the following concentrations:

	p.p.m.		*p.p.m.*
Nitrogen	140	Iron	3.000
Phosphorus	100	Manganese	.500
Potassium	175	Boron	.500
Calcium	120	Copper	.060
Magnesium	48	Zinc	.060
Sulfur	64	Molybdenum	.009

When nitrogen, phosphorus, or potassium was the tested element, the respective concentrations were:

Nitrogen *p.p.m.*	Phosphorus *p.p.m.*	Potassium *p.p.m.*
3.5	1	3
35	5	30
70	50	100
140	100	300
280	200	600
560	400	900

The growing periods were 81 days for the nitrogen test, 91 days for the phosphorus test, and 69 days for the potassium test. During these periods, the seedlings were irrigated with solution about twice weekly. Fresh nutrient solutions, having pH values averaging 4.7, were prepared weekly.

Response was measured by seedling height and dry weight of foliage. In addition, the amount of each tested element in the foliage was determined. Nitrogen determinations were made by the semimicro-Kjeldahl method (*8*). Phosphorus determinations were made colorimetrically, using the vanadate-molybdate-yellow method (*1*). Potassium content was measured by atomic absorption spectrophotometry (*9*). Element content was expressed as percent dry weight and as milligrams per seedling.

Response to Nitrogen

As supplies of nitrogen increased, so did the average height of seedlings, and the average dry weight of foliage per seedling (table 1). However, treatment differences in average height were statistically significant only at 3.5 p.p.m. The dry weight relationships among treatments were similar to those of average height, but the weight data were not analyzed statistically. Optimum growth occurred when the nitrogen concentration was between 70 p.p.m and 140 p.p.m.

Nitrogen content also increased as the nitrogen supply increased (table 1). Treatment effects were statistically significant although the difference between any two treatments had to be relatively large to be significant.

Response to Phosphorus

When the supply of phosphorus was increased to a concentration of 200 p.p.m., average height increased. But at 400 p.p.m., height decreased slightly (table 2). Average dry weight of foliage followed the same trend, except that it was unaccountably high at the lowest concentration.

The phosphorus content of the foliage increased with increasing supplies of this element up to 200 p.p.m. (table 2). A de-

Table 1.—*Average height of seedlings, average dry weight of foliage per seedling, and foliar nitrogen content by treatment*

Nitrogen concentration	Seedlings	Average height	Average dry weight	Nitrogen content	
p.p.m.	*No.*	*mm.*	*mg.*	*Pct.*	*mg. per seedling*
3.5	33	42	63	[a]2.6 a	1.7 a
35	41	251	572	2.8 a	17.9 ab
70	47	370	1,253	3.3 ab	42.7 ab
140	31	341	1,201	3.8 bc	47.1 ab
280	29	373	1,421	4.6 c	69.8 bc
560	11	385	1,741	5.8 d	111.2 c

[a]In any column, treatment means having any letter in common are not significantly different from each other at the 5-percent level.

Table 2.—*Average height of seedlings, average dry weight of foliage per seedling, and foliar phosphorus content per seedling*

Phosphorus concentration	Seedlings	Average height	Average dry weight	Phosphorus content	
p.p.m.	*No.*	*mm.*	*mg.*	*Pct.*	*mg. per seedling*
1	2	244	2,131	1.0	20.0
5	11	302	1,002	.4	3.5
50	8	338	1,666	.7	12.9
100	3	347	2,929	.7	21.8
200	1	492	4,956	1.3	64.4
400	6	372	2,357	1.1	28.4

Table 3.—*Average height of seedlings, average dry weight of foliage per seedling, and foliar potassium content by treatment*

Potassium concentration	Seedlings	Average height	Average dry weight	Potassium content	
p.p.m.	*No.*	*mm.*	*mg.*	*Pct.*	*mg. per seedling*
3	20	206	434	[a]1.6 a	6.8 a
30	16	188	581	4.6 b	27.0 abc
100	30	245	448	5.6 bc	24.8 ab
300	11	155	517	7.8 bcd	40.1 abcd
600	6	101	438	11.0 d	48.3 bcd
900	0	0	0	0	0

[a]In any column, treatment means having any letter in common are not significantly different from each other at the 5-percent level.

crease in content occurred at the 400 p.p.m. level, which coincided with the decreases in height and weight.

Because seedlings were few in number and some treatment replications were not represented, no statistical analyses were made.

Response to Potassium

Neither average height nor dry weight of foliage per seedling appeared to be greatly affected by the amount of potassium supplied up to 600 p.p.m. (table 3). However, mortality occurred at a concentration of 900 p.p.m. There seemed to be a slight trend toward decreasing height and dry weight with an increasing supply, but a statistical analysis of the height data showed that differences due to treatment were not significant. The dry weight data were not analyzed, but the rather small differences by treatment suggested that dry weight response did not vary significantly.

The amount of potassium in the foliage increased rapidly with an increase in the potassium concentration (table 3). An analysis of these data showed that the effects of treatment were statistically significant although a relatively large change in potassium supply was needed to make a significant change in the potassium content.

Discussion

The results of this study indicated that a 3 to 4 percent nitrogen content in the foliage was adequate for satisfactory seedling growth. This amount of foliar nitrogen was slightly greater than that reported for seedling and sapling paper birch trees growing under natural conditions (*10*) but was within the range

reported for other hardwood species (*2, 3, 4, 5*) and for many cultivated fruit trees (*7*).

Seedling response did not vary greatly among the different phosphorus levels. However, too few seedlings were harvested to make meaningful comparisons.

Average height and average dry weight did not vary greatly among the different potassium treatments. The foliar content in all but the lowest level of supply exceeded the amounts reported for other forest-grown tree species. However, they were within the range reported for cultivated fruit trees.

Although these results parallel those reported by Ingestad (*6*), they are only tentative. Further testing is required to more accurately define optimum levels of supply and to determine symptoms of deficiency and toxicity.

References

1. Chapman, Homer D., and Parker F. Pratt.
1961. METHODS OF ANALYSIS FOR SOILS, PLANTS AND WATERS. Univ. of Calif. Div. Agr. Sci.: 169-170.
2. Finn, Raymond F.
1953. MINERAL CONTENT OF LEAVES CLUE TO WHITE OAK SITE QUALITY. USDA Forest Serv. Cent. States. Forest Exp. Sta. Tech. Pap. 135. 12 p., illus.
3. Hacskaylo, John, R. F. Finn, and J. P. Vimmerstedt.
1969. DEFICIENCY SYMPTOMS OF SOME FOREST TREES. Ohio Agr. Res. and Develop. Cent. Res. Bull. 1015, 68 p., illus.
4. Hoyle, M. C.
1965. VARIATION IN FOLIAGE COMPOSITION AND DIAMETER GROWTH OF YELLOW BIRCH WITH SEASON, SOIL, AND TREE SIZE. Soil Sci. Soc. Amer. Proc. 29:475-480.
5. Ike, Albert F.
1968. SYMPTOMS OF NUTRIENT DEFICIENCY IN YELLOW POPLAR SEEDLINGS. USDA Forest Serv. Res. Note SE-94. 4 p.
6. Ingestad, Torston.
1962. MACRO-ELEMENT NUTRITION OF PINE, SPRUCE, AND BIRCH SEEDLINGS IN NUTRIENT SOLUTIONS. Medd. Statens Skogsforsknings Inst. 51 (7) 150 p., illus.
7. Kenworthy, A. L. and Lloyd Martin.
1966. MINERAL CONTENTS OF FRUIT PLANTS. *In* Temperate to Tropical Fruit Nutrition. 888 p., illus. Somerset Press, Inc., Somerville, N. J.
8. Mader, D. L., and M. C. Hoyle.
1964. AN INEXPENSIVE PORTABLE UNIT FOR PERCHLORIC ACID DIGESTIONS AND SEMIMICRO-KJELDAHL DETERMINATIONS. Soil. Sci. 98: 295-299, illus.
9. Perkin-Elmer Corp.
1968. ANALYTICAL METHODS FOR ATOMIC ABSORPTION SPECTROPHOTOMETRY. Perkin-Elmer Corp., Norwalk, Conn.
10. Young, Harold E., and Paul M. Carpenter.
1967. WEIGHT, NUTRIENT ELEMENT AND PRODUCTIVITY STUDIES OF SEEDLINGS AND SAPLINGS OF EIGHT TREE SPECIES IN NATURAL ECOSYSTEMS. Maine Agr. Exp. Sta. Tech. Bull. 28, 39 p., illus.

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