SOUTHERN FOREST EXPERIMENT STATION

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GROWTH RESPONSE OF EASTERN COTTONWOOD TO NUTRIENTS IN SAND CULTURE

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SOUTHERN FOREST EXPERIMENT STATION

In a greenhouse test, seedlings grew best when nutrient solutions contained 100 p.p.m. N, 75 p.p.m. P, and 100 p.p.m. K. The foliage from the largest seedlings contained 3.5 to 4.5 percent N, 0.5 to 0.7 percent P, and 3.0 to 4.0 percent K.

The prospect of rapid returns from growing eastern cottonwood *(Populus deltoides* Bartr.) makes plantation fertilization a distinct possibility on appropriate sites. A prerequisite for the economical use of fertilizers is a basic understanding of the nutrient requirements of cottonwood. Information contributing to such an understanding is presented in this note.

METHODS

Seedlings were grown from locally collected seed in sixty-three 5-gallon glazed stone crocks of sized quartz sand in a greenhouse at the Southern Hardwoods Laboratory. The sand in each crock was leached with distilled water until the specific electrical conductance of the leachate fell below 5×10^{-5} mhos per cm.—about 30 p.p.m. total soluble salts *(5)*.

A randomized block design with three replications of 21 crocks each was used to test seven levels each of nitrogen (N), phosphorus (P), and potassium (K). Nutrient solution levels were:

N—0, 10, 25, 50, 100, 200, and 300 p.p.m.

P—0, 5, 10, 25, 50, 75, and 100 p.p.m.

K—0, 25, 50, 100, 200, 300, and 400 p.p.m.

Where one element was varied, the other two elements were supplied at constant rates (100 p.p.m. for N and K, 50 p.p.m. for P). All solutions also contained the following nutrients in p.p.m. concentrations of: calcium, 86; magnesium, 104; chelated iron, 5; boron, 0.5; manganese, 0.5; zinc, 0.05; copper, 0.20; and molybdenum, 0.01. When mixed, the solutions were adjusted to a pH of 5.5 to 6.5 with NaOH.

The sand-culture apparatus was a modified version of the one described by Gauch and

[1] The research was done at the Southern Hardwoods Laboratory, which is maintained at Stoneville, Miss., by the Southern Forest Experiment Station in cooperation with the Mississippi Agricultural Experiment Station and the Southern Hardwood Forest Research Group.

Wadleigh *(1)*. Automatic 90-second irrigations with the nutrient solutions were delivered at 15-minute intervals from a reservoir crock. Each crock unit contained 19 liters of nutrient solution.

The seedlings were grown from fresh seeds sown on the surface of the sand in May 1965, when only distilled water was circulating in the culture apparatus. Six days after sowing, the distilled water was siphoned out, and nutrient solutions at 1/3 the intended final strength were substituted. After 2 weeks, full-strength solutions were put in all crocks. Thereafter, the solutions were replaced with fresh ones every 3 weeks.

As the seedlings grew they were thinned by hand, eventually to one seedling per crock except in those treatments where seedling height growth was much less than the average. In such treatments, enough seedlings were left to assure sufficient plant material for nutrient analyses. Final thinning was done in late June.

It was necessary to periodically add distilled water to reservoir crocks to replace water lost by evaporation and transpiration, and to prevent concentration of the nutrient solutions. Near the end of the study, 1 to 2 gallons were added per crock every 3 days for the largest seedlings.

The seedlings were harvested in late July, approximately 9 weeks after germination. Measurements were made of: (a) seedling height; (b) foliage, stem, and root fresh weight; and (c) foliage, stem, and root dry weight. Dry weights were obtained by drying the tissues to a constant weight at 68° C. Foliage samples were then ground in a Wiley mill and stored for later analyses of N, P, and K.

Foliage analysis for total N was by the Kjeldahl method. P analyses were made on ash extracts by the chlorostannous-reduced molybdophosphoric blue method. K analyses were done on ash extracts by flame photometry.

RESULTS

Based on total seedling dry weight, the best growth occurred at nutrient solution levels of 100 p.p.m. N, 75 p.p.m. P, and 100 p.p.m. K (table 1). Other expressions of seedling growth showed trends similar to total seedling dry weight.

In the P and K series, there was little difference among high levels (table 1). Comparison of treatment means by Duncan's new multiple range test showed no significant increases (0.05 level) in total seedling dry weight for additions of more than 5 p.p.m. P and 25 p.p.m. K.

Table 1.—*Mean seedling growth and foliage contents of N, P, and K*

Nutrient treatment (p.p.m.)	Total height	Total plant dry weight	Foliage nutrients		
			N	P	K
	Cm.	*Grams*	*Percent by weight*		
0 N	7	<0.1	1.58	0.78	1.97
10 N	61	5.3	2.09	.60	2.90
25 N	135	44.9	2.35	.65	2.90
50 N	168	70.4	2.94	.64	3.25
100 N	167	80.8	4.24	.69	3.00
200 N	158	76.8	4.44	.83	3.33
300 N	127	37.3	5.23	.83	3.10
0 P [1]	2	.1	5.81	.40	1.98
5 P	149	55.8	4.38	.30	3.90
10 P	151	53.6	4.20	.53	3.63
25 P	155	60.1	4.07	.50	3.00
50 P	149	63.8	4.30	.52	2.97
75 P	155	67.5	4.26	.70	3.20
100 P	154	56.5	4.00	.71	3.47
0 K	19	1.9	4.24	.72	.57
25 K	126	62.4	3.64	.75	1.20
50 K	156	62.8	3.86	.70	1.95
100 K	179	79.2	4.01	.77	3.35
200 K	161	68.8	3.84	.67	3.77
300 K [1]	152	63.4	3.87	.66	4.42
400 K	157	78.6	3.86	.68	4.13

[1] Only two replications included.

In the N series there was a significant stunting of growth with 300 p.p.m. Comparison of level means indicates no significant differences in total seedling dry weight between 50, 100, and 200 p.p.m. N. At 300 p.p.m. N, total seedling dry weight was close to that obtained at 25 p.p.m.—about half of the dry weight at the three best levels.

The relationship of growth to foliar nutrient content is important (fig. 1). Although wide variation occurred, trends are evident for foliar N and K. The inhibitory effect of high N is especially striking. The relation of growth to foliar P was weak.

The data suggest the following foliage concentrations as indicators of the best and lowest

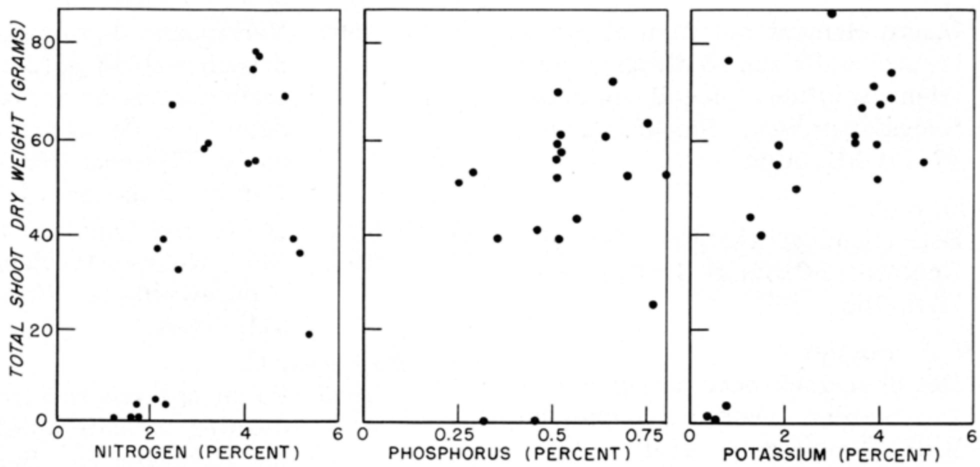

Figure 1.—*Relations between foliar nutrient contents (percent by weight) and shoot dry weights.*

acceptable growth under the conditions of the study:

	Best	Lowest acceptable
	Percent	*Percent*
N	3.5-4.5	3.0
P	.5- .7	.3
K	3.0-4.0	1.2

Seedlings grown with 0 p.p.m. of individual nutrients exhibited deficiency symptoms typical of agronomic crops. N deficiency was characterized by chlorosis, which was most pronounced between leaf veins. Some chlorosis was evident even at the 25-p.p.m. level. P-deficient shoots were small with a red pigmentation, which was strongest on the leaf margins and petioles. K deficiency was characterized by burning of leaf margins, which extended between primary veins almost to the leaf midribs. The entire leaf surfaces on K-deficient plants had a crinkled appearance.

Position in the greenhouse (blocks) had no significant effect on plant growth.

DISCUSSION

In general, the foliar nutrient contents associated with best growth were higher than those reported for most other tree species grown in nutrient culture *(4)*. However, our values compare favorably with foliage contents of N, P, and K from young *Populus* trees sampled in May-July in Europe *(7, 8)*. The lowest acceptable level of K from our study is also close to published values for K deficiency: 0.7 percent for *P. tremuloides (9)*, 1.0 percent for *P.* × *robusta (6)*, and 1.7 for *P.* × *'canadensis'* cv. 214 *(2)*.

The sand-culture results must be translated into nutrient relationships for seedlings grown in soil. Growth characteristics of sand-culture plants can be altered by factors independent of the relationship between yield and nutrient supply *(3)*. Aside from the atypical conditions of the greenhouse, makeup of nutrient solutions and method of irrigation can influence results. The present study, for example, would probably have been more valuable if additional low levels of P had been tested. Research with seedlings grown in soil is now under way.

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