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FOLIAR NITROGEN AND POTASSIUM VARIATION IN COTTONWOOD AS AFFECTED BY GENETIC AND SITE FACTORS

James B. Baker and W. K. Randall[1]

Abstract.--Genetic and soil factors accounted for 49 percent of the variation in foliar N and 60 percent of the variation in foliar K among four good and four poor cottonwood clones grown on productive and unproductive soils in Mississippi. Variation in foliar N was associated primarily with the clone X soil interaction; variation in foliar K was related chiefly to clonal differences.

Additional keywords: *Populus deltoides*, soil N, soil K, clonal selection, N fertilization.

Significant variation in foliar nitrogen (N) and potassium (K) concentrations for mature eastern cottonwood trees (*Populus deltoides* Bartr.) growing on a variety of sites has previously been demonstrated.[2] However, it was not known whether the variation was due to genetic or site differences or both.

The present investigation sought to determine foliar N and K variation in eight clones from 4-year-old cottonwood plantations growing on soils of high and low productivity and to relate the variation to genetic or site factors.

MATERIALS AND METHODS

Eight clones were selected for this study from an 80-clone test planted at two locations in west-central Mississippi. The eight clones were equally divided into two classes, designated "good" and "poor" on the basis of previous growth.

The locations had contrasting soil types. The soil at one location was Commerce silt loam, a member of the fine-silty, mixed, nonacid, thermic family of Aeric Fluvaquents. This soil is considered highly productive

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[1] Soil Scientist and Silviculturist at the Southern Hardwoods Laboratory, which is maintained at Stoneville, Miss., by the Southern Forest Experiment Station, USDA Forest Service, in cooperation with the Mississippi Agricultural & Forestry Experiment Station and the Southern Hardwood Forest Research Group.

[2] Broadfoot, W. M. The nutrient relationships of eastern cottonwood (*Populus deltoides* Bartr.). II. Comparison of nutrients in cottonwood foliage and stems on Commerce and Sharkey soils. Final Report FS-SO-1106-4.11, on file at South. Hardwoods Lab., Stoneville, Miss. 1968.

for cottonwood (S.I. = 120+ ft at 30 years). Sharkey clay, a member of the very fine, montmorillonitic, nonacid, thermic family of Vertic Haplaquepts, was the soil at the other location. This soil is relatively low in cottonwood productivity (S.I. = 90 ft at 30 years).

Three sample trees of each clone were selected from each location, thus providing a total of 6 sample trees per clone and 48 sample trees for the study.

Leaf samples were taken from the 48 test trees in August. Ten mature leaves were picked from the mid-crown position in each of the four cardinal directions. The 40 leaves from each tree were composited, dried (70° C), weighed, ground in a Wiley mill, and analyzed for N and K concentrations. Nitrogen was determined by the standard Kjeldahl procedure, and K was assessed by flame photometry after dry ashing.

The surface 12 inches of soil was sampled at four equidistant points around each test tree. The four samples taken for each tree were composited, air-dried, sieved through a 2-mm screen, and analyzed for N and K concentrations. Total N was determined by the standard Kjeldahl procedure; exchangeable soil K was determined by flame photometry after ammonium acetate extraction.

Each variable was subjected to analysis of variance with tests performed at the 0.05 level of probability. Only statistically significant findings are reported here.

RESULTS AND DISCUSSION

Soil N and K

The poor (Sharkey) soil contained more N and K in the surface foot than the good (Commerce) soil. The Sharkey soil averaged 0.17 percent total N (or about 85 p/m available N) and 400 p/m exchangeable K in the surface foot; the Commerce soil averaged only 0.11 percent total N (or about 55 p/m available N) and 353 p/m K. Both soils, however, contained adequate quantities of each element for good cottonwood growth; N and K concentrations at both sites were within the optimum levels determined by Bonner and Broadfoot (1967). Thus, differences in productivity of the two sites apparently were not related to N and K levels of the soils but to other growth limiting factors, i.e., soil physical properties, moisture availability, drainage, and aeration.

Foliar N

Together the clonal and clone X soil variances accounted for 49 percent of the variation in foliar N. Of this amount, the major part (41 percent) was associated with the clone X soil interaction. The clonal component of variance accounted for only 8 percent of the variation. Since the estimate for the soil component was negative, it was not used in calculating these percentages (table 1).

Table 1.--Summary of variance components for foliar N and K concentrations in eight cottonwood clones on two soils

	Variance				
	Soil	Clonal	Clone X soil	Subplot error	Within soil error
Character	σ^2_s	σ^2_c	σ^2_{cs}	σ^2_1	σ^2_2
Foliar N	---[a/]	0.004	0.020	0.022	0.003
Foliar K	0.006	0.014	0.004	0.016	<0.001

[a/] The estimate for this component was negative.

Despite considerable differences in total N content of the two soils, mean foliar N levels of trees at both sites averaged about 2 percent (table 2). However, mean foliar N levels differed among clones; the range was 1.75 to 2.13 percent. There were also differences among the four good clones when they were grown on the poor site (table 2).

Table 2.--Foliar N and K levels in cottonwood as related to clonal and soil differences

	Good clone class					Poor clone class					
	Clone					Clone					Soil
Soil	1	2	3	4	Mean	5	6	7	8	Mean	mean
					Foliar N concentration (%)						
Commerce (good)	2.07	2.03	1.83	2.11	2.01	1.70	2.18	1.77	2.03	1.92	1.97
Sharkey (poor)	1.72	2.23	1.67	1.98	1.90	2.06	2.01	1.95	2.00	2.01	1.96
Mean	1.90	2.13	1.75	2.05	1.95	1.88	2.10	1.86	2.02	1.97	1.97
					Foliar K concentration (%)						
Commerce (good)	.70	.91	.79	.78	.80	.78	.71	.96	1.10	.89	.85
Sharkey (poor)	.96	.90	.84	.75	.86	1.07	.93	.92	1.31	1.06	.96
Mean	.83	.91	.82	.77	.83	.93	.82	.94	1.21	.98	.91

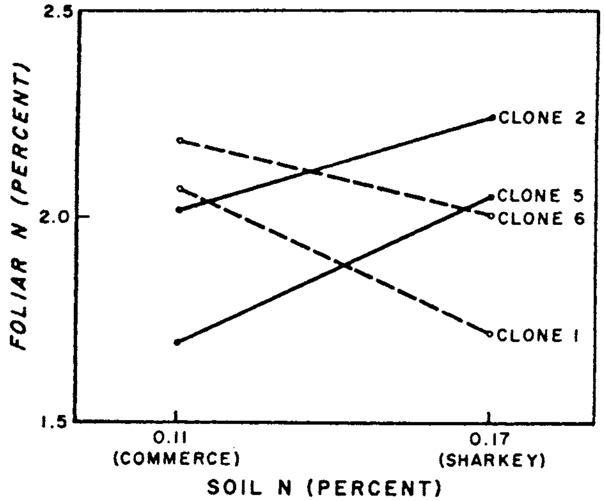

Figure 1.--Clonal X soil interaction for foliar N variation.

The clone X soil interaction is best illustrated by clones 1, 2, 5, and 6 (fig. 1). Foliar N of clones 2 and 5 increased with increases in soil N, but foliar N in clones 1 and 6 varied inversely with changes in soil N. This finding suggests that clones 2 and 5 should respond well to N fertilization but clones 1 and 6 probably would not. Curlin (1967) reported clonal differences in growth response to N fertilization. Because he also observed a clone X fertilizer interaction for cottonwood growth, he concluded that responses of experimental populations to fertilization must be interpreted with caution. The interaction between clones and soil that we observed also implies that the response of clones to soil N levels or to N fertilization should be tested on more than one soil.

Foliar K

The soil and clonal components of variance and their interaction accounted for 60 percent of the variation observed in foliar K. Of this amount, the major part (35 percent) was associated with the clonal component. The soil and the clone X soil components were 15 percent and 11 percent of the variation (table 1).

Foliar K levels were higher for trees grown on the Sharkey soil (0.96 percent) than for those on the Commerce soil (0.85 percent) (table 2). This difference may be partly due to luxury consumption of K since the Sharkey soil contained more K than the Commerce soil.

Differences in mean foliar K levels (ranging from 0.77 to 1.21 percent) occurred among clones and between the good and poor clone classes (table 2). Trees in the poor class contained more foliar K (0.98 percent) than trees in the good class (0.83 percent). Correlation analysis indicated a correlation ($r = 0.50$) between foliar K concentrations and diameter growth. The large difference in foliar K of the good and poor clone classes and the correlation between foliar K and growth suggest that selection for cottonwood growth could be based on foliar K levels.

However, in this study, the difference in foliar K levels between the two clone classes may have been caused in part by a dilution effect since poor trees were smaller than good trees. At age 4, the good clones averaged 37 feet in height and 4.8 inches in dbh; the poor clones averaged only 30 feet in height and 3.4 inches in dbh.

To determine whether variation in foliar K was due primarily to clonal or dilution effects, leaf samples were collected from trees of uniform size in a 1-year-old clonal nursery. Potassium analyses were performed on the leaf tissue with the following results:

	Foliar K concentration (%)	
Sample no.	Good clones	Poor clones
1	1.70	2.02
2	1.91	2.02
3	1.73	1.97
4	1.97	2.27
5	1.79	2.11
6	-	2.04
Mean	1.82	2.07
$S_{\bar{x}}$ =	0.03	0.03

Mean foliar K concentration for the good clone class was 25 percent lower than that for the poor class. Apparently, variation in foliar K levels was related primarily to clonal differences and not to dilution.

After further research, foliar K levels might be considered as part of the selection index in a cottonwood improvement program.

CONCLUSIONS

Foliar N

1. Foliar N levels varied little from one soil to the other and averaged about 2 percent at both sites.

2. Foliar N varied considerably among clones, ranging from 1.75 to 2.13 percent.

3. The majority of the observed variation in foliar N was associated with the clone X soil interaction.

Foliar K

1. Foliar K levels were consistently higher in all clones on the high K (Sharkey) soil.

2. Foliar K levels varied significantly among clones, ranging from 0.77 to 1.21 percent.

3. Foliar K was consistently higher in poor clones than in good clones; therefore, foliar K levels might be a good criterion for selection in cottonwood improvement programs.

4. The majority of the observed variation in foliar K was associated with clonal differences.

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