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ODC 160.21:176.1 *Liriodendron tulipifera*

NUTRIENT COMPOSITION OF BLADES, PETIOLES, AND WHOLE LEAVES FROM FERTILIZED AND UNFERTILIZED YELLOW-POPLAR

Abstract. – Nitrogen (N) and phosphorus (P) concentrations in leaf blades and petioles obtained from three fertilized and three unfertilized yellow-poplar sample trees were determined annually during a 4-year period. Concentrations were substantially higher in blades than in petioles. Fertilization increased N and P concentrations in blades, but petioles showed only a slight increase in N and a decrease in P. Because blades were more responsive to changes in external nutrient supply than petioles, and because fertilization affected the composition of blades and whole leaves unequally, blades give a more sensitive and accurate measure of nutrient concentration than petioles or whole leaves.

Key words. Foliar sampling material, *Liriodendron tulipifera.*

Nutrient concentrations in leaves from forest trees are used increasingly to evaluate possible response to fertilization. For accurately judging deficiencies, the tissues used for nutrient determinations should be sensitive to changes in external nutrient supply and relatively independent of other influencing factors.

Nutrient concentrations in blades and petioles of many agricultural plants are often so different that either one or the other should be used for diagnostic purposes *(Goodall and Gregory 1947, Kwong and Boynton 1959, Bould 1961 and 1964, Cassidy 1970)*. For forest trees, Guha and Mitchell *(1965)* reported that the composition of petioles was appreciably different from that of blades for *Acer pseudoplatanus* L. and *Aesculus hippocastanum* L., and that combining these tissues produced noticeable differences for some nutrients. Finn *(1966)*, using pot-culture tests, observed a fourfold increase in N concentration for yellow-poplar leaf blades versus petioles over a wide range of N levels.

In this study, N and P concentrations in blades, petioles, and whole leaves from fertilized and unfertilized yellow-poplar trees *(Liriodendron tulipifera* L.) were compared, and the suitability of each plant part for diagnostic purposes was evaluated by comparing its sensitivity to applied fertilizers.

Methods

Three fertilized and three unfertilized codominant yellow-poplar trees of similar size, age, and form were selected from test plots in a uniform 34-year-old stand near Parsons, West Virginia. The soil was Barbour fine

Table 1.—Fertility of the study soil[a]

Horizon	Depth	Texture	pH	Total N	Exchangeable P	Exchangeable K	Exchangeable Ca	Exchangeable Mg	Exchangeable Mn
	Inches			%	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*
A_1	0-4	sl	4.8	0.139	14	33	322	30	62
A_3	4-8	ls	4.8	.070	6	23	80	18	48
C	8+	ls	4.8	.044	6	24	90	22	44

[a]Values are based on composite samples obtained from 8 soil pits: pH by glass electrode, N by Kjeldahl, P extracted with 0.002 *N* H_2SO_4, cations extracted with NH_4OA_c.

sandy loam, which had formed in deep well-drained alluvium deposited in a narrow valley bottom. The site was flat, uniform in surface configuration, and of moderate fertility (table 1). Plots were thinned so that tree crowns were exposed to full sun on all sides. The yellow-poplar stand averaged 7.7 inches dbh, was 75 feet tall, and had a site index of 100.

The fertilized plot was treated with 450 lb./acre of N from ammonium nitrate in the spring of 1967 and 50 lb./acre of N the next spring. In the fall of 1966, P and K were broadcast at 92 and 176 lb./acre from 0-20-20; Mg and S at 66 and 88 lb./acre from Epsom salts; and hydrated lime at 2,500 lb./acre.

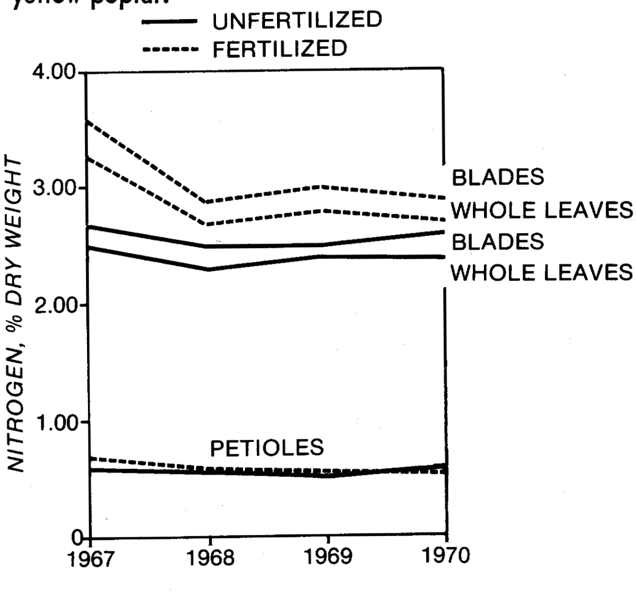
Two separate foliage samples from each of the six trees were collected annually for 4 years, on August 27 each year. Samples consisted of 20 mature leaves free from insect damage and disease, obtained from two separate branches on the upper 8-foot section of crown on the south side. Only the largest of the mature leaves on current-season twigs were sampled.

Petioles and leaf blades (midrib retained) were separated, dried at 70°C, weighed, ground to pass a 20-mesh screen, and stored in glass jars. After the fourth collection, all samples were redried and analyzed for N and P. Nitrogen was determined by the Kjeldahl procedure and P by the vanadomolybdophosphoric yellow method after wet ashing. Nutrient concentrations of whole leaves were calculated by weighting N and P concentrations in blades and petioles by their respective dry weights.

Results

Nitrogen. — Nitrogen concentrations differed markedly among blades, petioles, and whole leaves (fig. 1). Concentrations in blades were about five times greater than concentrations in petioles for fertilized trees, and four times greater for unfertilized trees. As a result, concentrations in whole leaves (blades and petioles) were lower than concentrations in blades alone by 0.23±0.04% N for fertilized trees and 0.18±0.02% N for unfertilized trees. Differences in concentration between fertilized and unfertilized whole leaves resulted not only from changes in blade composition, but also from fertilizer-

Figure 1.—N concentrations in blades, whole leaves, and petioles of fertilized and unfertilized yellow-poplar.



induced differences in dry-weight ratios between blades and petioles (table 2).

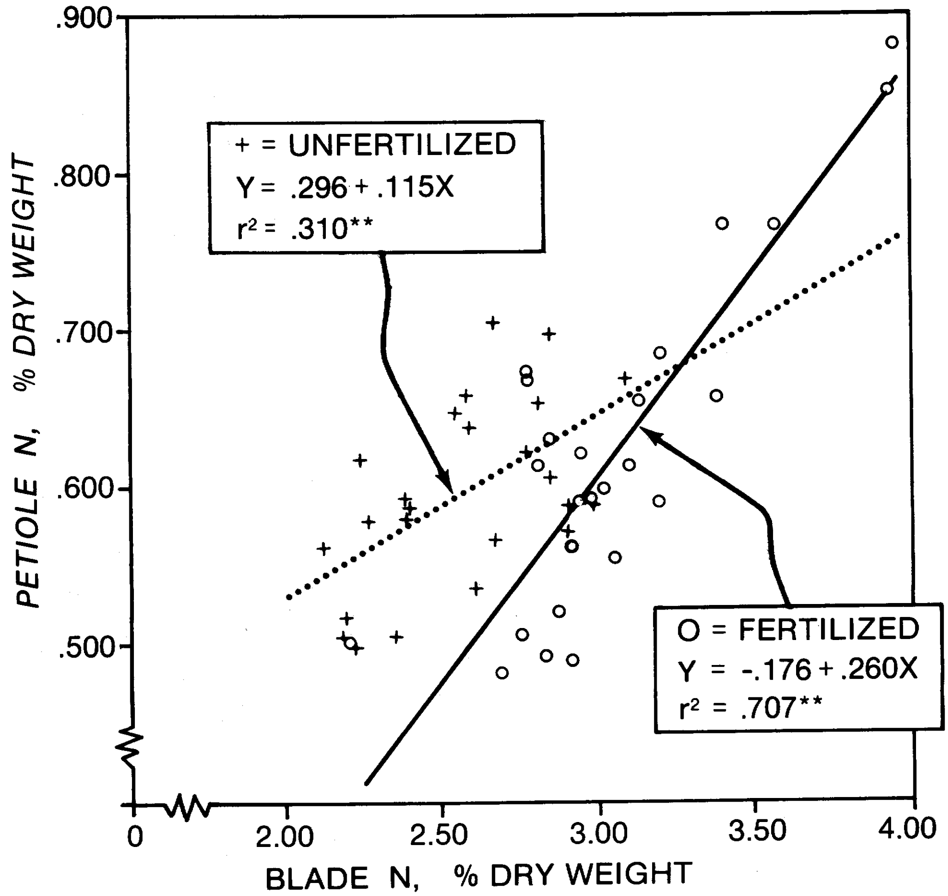
Leaf blades were considerably more sensitive to changes in external N supply than petioles, and whole leaves were slightly less sensitive than blades only. Nitrogen concentrations in blades rose almost 1.0% N during the season when fertilizers were first applied (1967) and averaged 0.4% N higher than controls during the following three seasons (significant at 0.05 level). In contrast, N in petioles rose only 0.15% N in the first season (not significant), and was essentially identical in the following years (fig. 1).

Table 2.—Dry weights and dry-weight ratios of blades and petioles from fertilized and unfertilized yellow-poplar

Year	Fertilized			Unfertilized		
	Blade	Petiole	Ratio	Blade	Petiole	Ratio
	mg.	*mg.*		*mg.*	*mg.*	
1967	925	103	9.0/1	721	70	10.3/1
1968	921	96	9.6/1	685	65	10.5/1
1969	1,130	108	10.5/1	900	88	10.2/1
1970	1,110	109	10.0/1	844	85	9.9/1

Nitrogen concentrations in blades and petioles were linearly correlated, but the slopes and levels of the regression lines differed significantly between fertilized and unfertilized tissues, and the relationship was stronger for fertilized trees than for unfertilized trees (fig. 2). Compositing petioles with blades could therefore lead to increased sample

Figure 2.—Relationships between petiole N and blade N for fertilized and unfertilized yellow-poplar. Sample points from all 4 years of observation.

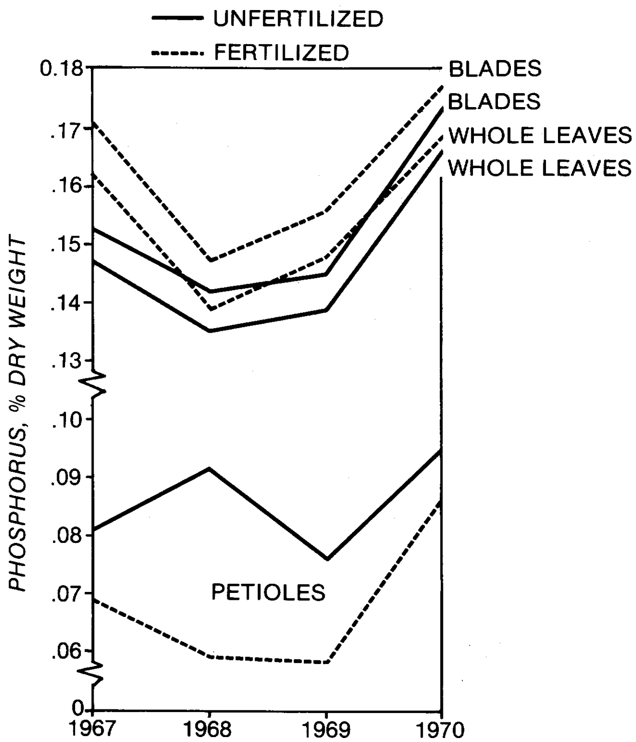


variation and could have unequal effects on whole-leaf concentrations obtained from fertilized and unfertilized trees.

Phosphorus. — Phosphorus concentrations were highest in blades and lowest in petioles (fig. 3), indicating that inclusion of petioles with blades will yield lower concentrations than blades alone. Concentration differences for the 4-year period averaged slightly less than 0.01% P for the whole leaves compared to blades only. The difference in concentration between whole leaves and blades only was not significant.

Fertilization significantly (0.05 level) increased P concentrations in blades in 1967, but thereafter only smaller non-significant differences occurred. In contrast, petioles responded negatively to fertilization, with significant (0.01 level) decreases in concentration lasting for 3 years after fertilizer treatment. Because the actual quantities of P in petioles from both fertilized and unfertilized trees remained nearly identical, this indicates that incorporation of P into petiole tissue of fertilized trees did not keep pace with increases in petiole dry weight (table 2). This shows that petioles are insensitive to changes in external supply of P, particularly where a response in petiole dry weight results from fertilization.

Figure 3.—P concentrations in blades, whole leaves, and petioles of fertilized and unfertilized yellow-poplar.



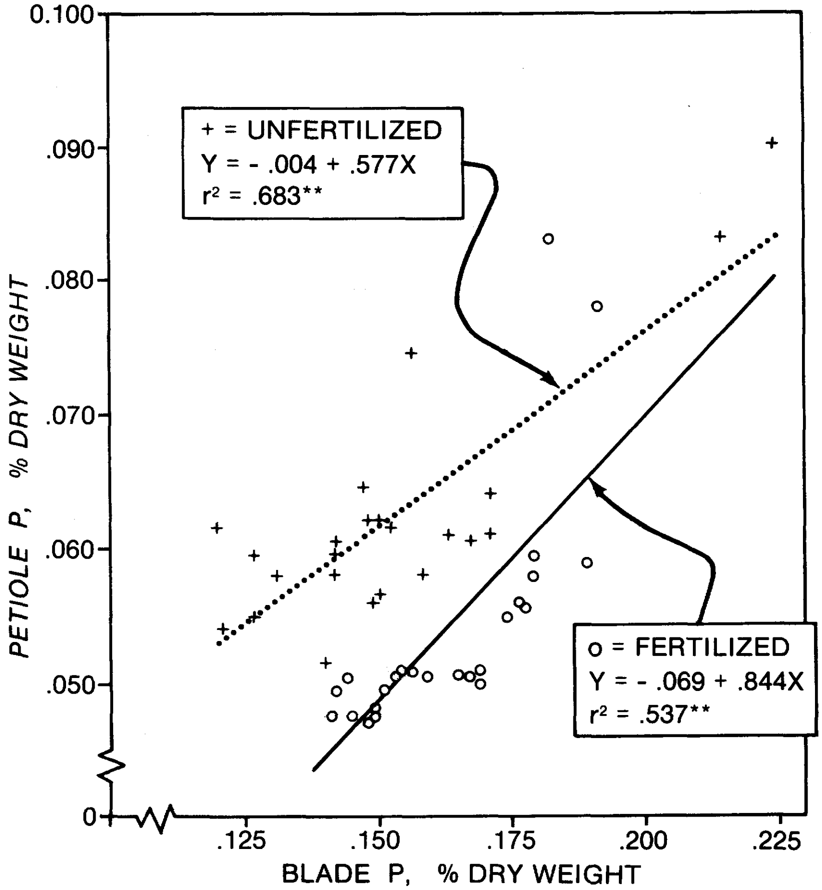
The relationship between blade P and petiole P was closer than that for N (fig. 4). This means that less sample variation would occur for whole leaves analyzed for P than similar samples analyzed for N. The slopes of the regressions were similar, but the P levels were significantly higher for unfertilized trees — indicating that a dilution effect had occurred in the leaf petiole.

Conclusions

This study of N and P concentrations in blades, petioles, and whole leaves from fertilized and unfertilized yellow-poplar trees has shown that:

1. N concentrations are 4 to 5 times higher in blades than in petioles.
2. P concentrations are nearly 3 times higher in blades than in petioles.
3. Combining petioles and blades for N and P determinations will produce concentrations that are lower for whole leaves than for blades only. This reduction is greater in magnitude for N than for P.
4. Fertilization did not affect the nutrient concentrations of whole leaves and blades equally because of unequal changes in composition of petioles and blades and a change in petiole-blade dry-weight ratios.
5. Concentrations in petioles were not precisely related to concentrations in blades, and these relationships for fertilized and unfertilized foliage were different. Therefore, the use of whole leaves would make nutrient comparisons between fertilized and unfertilized trees less reliable and would add to sample variability.
6. Although this study was based on a small number of sample trees, these findings suggest the need for a standard sampling

Figure 4.—Relationships between petiole P and blade P for fertilized and unfertilized yellow-poplar. Sample points from all 4 years of observation.



tissue for diagnosing nutrient deficiencies in yellow-poplar. It is recommended that petioles not be included with blades in determining nutrient-concentration data, to improve the comparative values generated by different laboratories.

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