Pecan Leaf Tissue Nutrient Concentrations: Temporal Relationships and Preliminary Standards

James Walworth and Michael Kilby

Abstract

Leaf samples were collected from five trees each of Bradley, Cheyenne, Sioux, Western Schley, and Wichita at Picacho, Arizona and five trees each of Bradley, Western Schley, and Wichita at Las Cruces, New Mexico, and analyzed nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, copper, manganese, boron, and copper at two-week intervals from mid-May to Mid-October, 2000. Yield, average nut weight, and percent kernel data were collected for each individual tree. Leaf tissue analysis indicated that concentrations of nitrogen, phosphorus, potassium and sulfur decreased. The overall trends were for zinc levels to declined, although they increased at the end of the season. Boron, calcium, magnesium and manganese, and iron concentrations increased during the growing season. Copper concentrations were variable. Preliminary nutrient standards are presented and compared to existing standards. Most nutrients were within recommended ranges, but magnesium levels were much higher than the top of the Arizona and New Mexico sufficiency ranges. Manganese was higher than the Arizona sufficiency range, but within that of New Mexico, whereas zinc was higher than the New Mexico range, but within that of Arizona.

Introduction

Leaf sampling provides an excellent means for evaluating plant nutrient status because leaf tissue composition is a direct reflection of the amount of nutrients actually taken up and assimilated by the plant. Thus leaf tissue analysis has been widely used for nutrient evaluation of a large range of crop species, and is particularly useful for monitoring long-term fertility management in perennial crops such as pecans.

For leaf tissue analysis to be useful, nutrient levels must be compared against standard nutrient values to evaluate nutrient status. It is critical that appropriate standards be used for interpretations to be valid. This may mean that standards must be established for individual varieties, environments, and most importantly, plant growth stage. It is well known that nutrient concentrations in leaf tissues change with leaf age. Concentration of water-soluble nutrients, such as nitrogen, phosphorus, and potassium tend to decrease as leaves age. Concentrations of other nutrients, such as calcium and boron tend to increase with time. Standards must be developed for each stage of growth during which leaf samples are to be collected and analyzed. Comparison of nutrient analysis results with incorrect standards can lead to significant errors in interpretation and subsequent fertilization.

Several states have established leaf nutrient standards for pecans. These standards have generally been established for a single stage of the growing season, usually late July. Standard values from Arizona and New Mexico are shown in Table 1 (Dr. Michael Kilby, personal communication). However, growers who want to initiate fertilization programs earlier in the season may want to collect leaf samples substantially earlier, and it is desirable

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to collect leaf samples when problems occur, regardless of the date. Accurate and useful interpretation of early or late season leaf samples is difficult, if not impossible, without appropriate standards. Alternatively, a quantitative description of the directions and rates of change of nutrient concentrations (i.e. whether nutrient concentrations increase or decrease as the plant ages, and how rapidly these changes occur) can be used to normalize nutrient concentration data to a standard sampling date. Our research is designed to quantify nutrient concentration changes, and to determine 'normal' nutrient levels over the entire span of the season.

Materials and Methods

Five trees each of Bradley, Cheyenne, Sioux, Western Schley, and Wichita at Picacho, Arizona and five trees each of Bradley, Western Schley, and Wichita at Las Cruces, New Mexico were selected for this study. Pecans are alternate-bearing; this report is for data collected in 2000, an off year for the selected trees. Leaf tissue samples were collected at two-week intervals, beginning in early May, and continuing until the end of the growing season, in mid-October. Approximately 50 leaflets were collected from each tree. Sampled leaflets were collected from the middle of the leaf, and represented youngest full expanded leaves. Leaves were immediately placed on ice for transport to the laboratory. Leaves were washed in a mild (~2%) detergent solution by hand, and rinsed in distilled water to remove surface contamination. Leaves were then dried at 65^{o}C until weight loss ceased, and ground in a mortar and pestle.

One gram of dried, ground leaf tissue was ashed for three hours at 500^{o}C, dissolved in 2N HCl, diluted to 50 ml with distilled water, and heated to re-dissolve all nutrients. Resulting solutions were assayed for P, K, Ca, Mg, Fe, Cu, Mn, B, and Cu by ICP. Dried leaf tissue was analyzed for S and N by automated combustion analysis with a Leco CNS2000. Mature nuts were harvested by hand following mechanical shaking. Yield, average nut weight, and percent kernel data were collected for each individual tree.

Results and Discussion

Average nutrient levels in pecan leaves from Arizona and New Mexico are shown in Table 2. The most striking differences between the two locations were the higher levels of Cu, Fe, and Zn in the New Mexico samples, and the much higher Mn in the Arizona samples. Higher Cu and Fe in pecans from New Mexico were likely due to lower soil pH levels, whereas Zn levels were probably strongly influenced by foliar Zn spray management. The cause of the very high levels of Mn (593 ppm) in the Arizona pecans is not known, although the levels were within the recommended levels for New Mexico, but not Arizona.

Concentrations of most nutrients changed as the season progressed. Nitrogen and boron concentrations are shown in Figures 1 and 2 as examples; figures for other nutrient are not shown. Nitrogen concentrations decreased during the season (Figure 1), as did phosphorus, potassium and sulfur. Zinc levels declined slightly, then increased dramatically at the last sampling (from 98 on JD 287 to 258 on JD 304). Boron levels increased throughout most of the season (Figure 2), although in the New Mexico samples it peaked in late August and declined slightly during the remainder of the season. Other nutrients with increasing concentrations were calcium, magnesium, manganese, and iron. Copper concentrations were variable throughout the season.

Yields were plotted versus tissue nutrient concentrations for the various sampling dates. The resulting plot for tissue nitrogen versus nut yield for Julian Date 201 is shown in Figure 3 as an example. Also on Figure 3 is a "boundary line" confining the points, and subjectively defining the data set (Webb, 1972). A boundary line can be used to graphically describe a relationship controlled by numerous, unmeasured parameters. In this case, for example, it is recognized that nitrogen is not the only yield determining variable, so regression analysis relating tissue nitrogen to nut yield would be inappropriate. Instead, a boundary line confining the points can delineate yield/nutrient concentration combinations that exist from those that do not. If the points in a set of data represent a normal distribution, the mean will estimate the peak of the boundary line, and can be used to determine optimum (Kenworthy, 1967). Furthermore, coefficients of variation associated with such means can be used as a measure of the width of the boundary line, and are useful in describing the relationship between nutrient concentration and yield. The data set represented in Figure 3 is not complete enough for delineating an accurate boundary, nor are the data complete enough to generate precise nutrient optima, so subsequent years' data will be added as they become available.

Means of the nutrient levels for each sampling date were regressed against sampling date to quantify the relationship between nutrient level and time. The resulting relationships are shown in Table 3. Note that the r^2 values for copper and zinc are very low, but that other equations have reasonably good fits. The last sampling date was omitted from the regressions for sulfur and manganese, as this resulted in considerably better regression fits. Julian date 200 (July 18 for the year 2000) was used to generate preliminary optimum values shown in Table 3. Note that the peak of the boundary line in Figure 3 fell at about 2.50% nitrogen, and that the regression equation gives a value of 2.44, so the two methods were in relatively close agreement. These nitrogen values were at the lower end of the currently recommended levels. Phosphorus and potassium concentrations fell within the guidelines from both Arizona and New Mexico. Magnesium levels were much higher than the sufficient range for either state. Calcium was also above the Arizona standard. Manganese was higher than the Arizona standards, but within those of New Mexico. Zinc levels were higher than the New Mexico sufficiency range, but within that for Arizona. Copper was below the minimum recommended by New Mexico (standard values are not available for Arizona).

The data presented here are preliminary. Additional data will be added to the data base as they become available, and eventually can be used to revise the pecan leaf nutrient concentration standards. However, it is important that the data base eventually contain data from a range of soils, environments, and cultivars. Our data will be useful for evaluating tissue samples collected any time during the growing season, so growers can make timely adjustments to their fertilization programs.

References

Webb, R.A. 1972. Use of the boundary line in the analysis of biological data. J. Hortic. Soc. 47: 309-319

Kenworthy, A.L. 1967. Plant analysis and interpretation of analysis for horticulture crops. In M. Stelly (ed.), Soil Testing and Plant Analysis, Spec. Pub. 2. Soil Science Society of America, Madison, WI.

Table 1. Currently recommended pecan leaf tissue nutrient levels.

Nutrient		Arizona	New Mexico
Nitrogen		2.5 – 3.2	2.5 - 3.9
Phosphorus		0.08 – 0.13	0.12 – 0.30
Potassium	%	0.9 – 1.2	0.75 – 1.25
Calcium		>1.0	0.70 – 1.50
Magnesium		0.18 – 0.43	0.30 - 0.60
Boron		30 - 200	20 - 45
Copper		N.A.*	10 - 30
Iron	ppm	N.A.	50 - 300
Manganese		30 - 40	100 - 800
Zinc		60 - 300	50 - 100

*Standards are not available for these nutrients.

Table 2. Average pecan leaf nutrient levels from study sites in Arizona and New Mexico.

Nutrient		Arizona mean	Arizona CV	New Mexico mean	New Mexico CV
Nitrogen	%	2.33	7.57	2.48	6.17
Phosphorus	%	0.13	14.61	0.11	9.00
Potassium	%	1.02	18.53	1.16	13.54
Calcium	%	2.17	12.00	2.27	15.63
Magnesium	%	0.54	10.35	0.54	10.65
Sulfur	%	0.11	14.00	0.12	11.49
Boron	ppm	146	17.78	176	12.82
Copper	ppm	6.6	28.71	12.0	25.91
Iron	ppm	50.4	18.46	72.8	20.60
Manganese	ppm	593	30.16	102	31.68
Zinc	ppm	90	47.86	216	48.57

Table 3. Regression equations for nutrient concentration versus time, r^2 values, and preliminary nutrient optima at the standard sampling time (late July).

Nutrient		Regression Equation	r^2	Optimum at JD=200
Nitrogen	%	N = 3.134 - 0.00353 * JD	0.904	2.44
Phosphorus	%	P = 0.201 - 0.000340 * JD	0.715	0.13
Potassium	%	K = 1.831 - 0.00411 * JD	0.854	1.01
Calcium	%	Ca = 1.022 + 0.00598 * JD	0.886	2.22
Magnesium	%	Mg = 0.462 + 0.000415 * JD	0.629	1.29
Sulfur	%	S = 0.134 - 0.000120 * JD	0.774	0.55
Boron	ppm	B = -4.275 + 0.683 * JD	0.967	132
Copper	ppm	Cu = 6.687 + 0.00652 * JD	0.064	7.99
Iron	ppm	Fe = 30.89 + 0.117 * JD	0.635	54.3
Manganese	ppm	Mn = 250.7 + 1.31 * JD	0.891	513
Zinc	ppm	Zn = 134.8 - 0.110 * JD	0.044	113

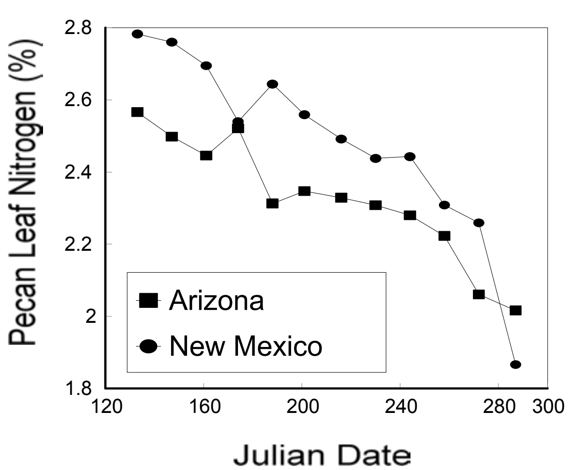

Figure 1. Changes in pecan leaf nitrogen concentrations over time.

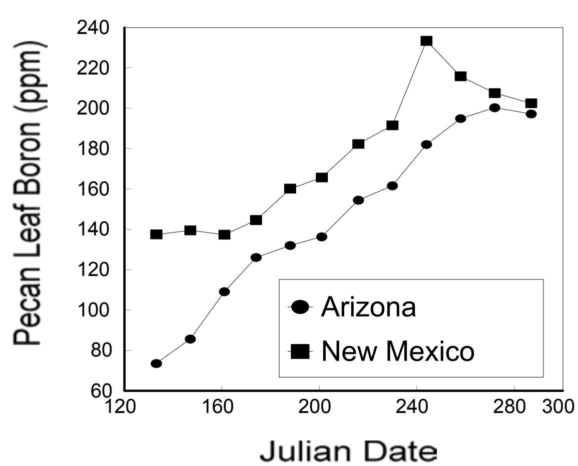

Figure 2. Changes in pecan leaf boron concentrations over time.

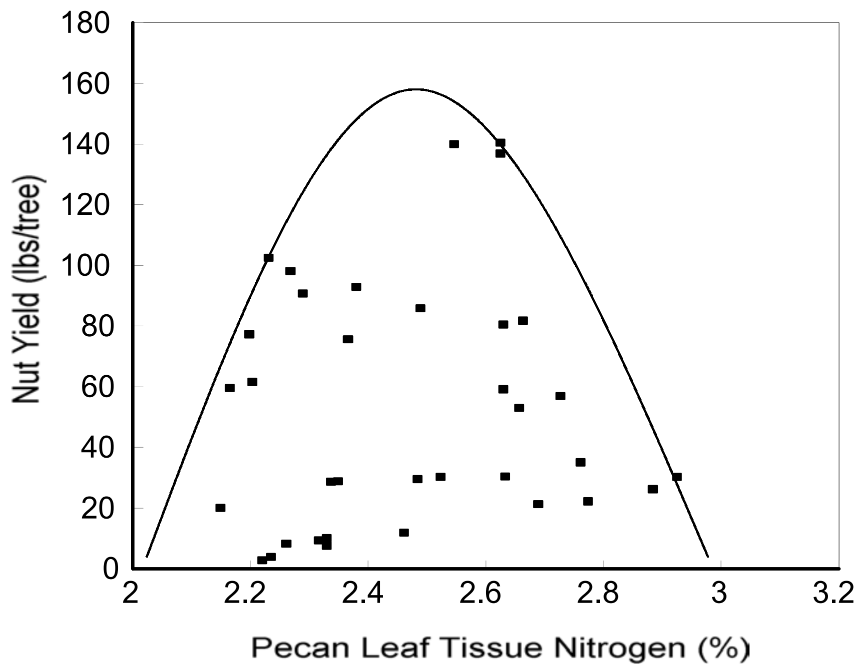

Figure 3. Pecan leaf nitrogen concentrations on JD 201 versus nut yield, and a hand-drawn boundary line confining the data points.

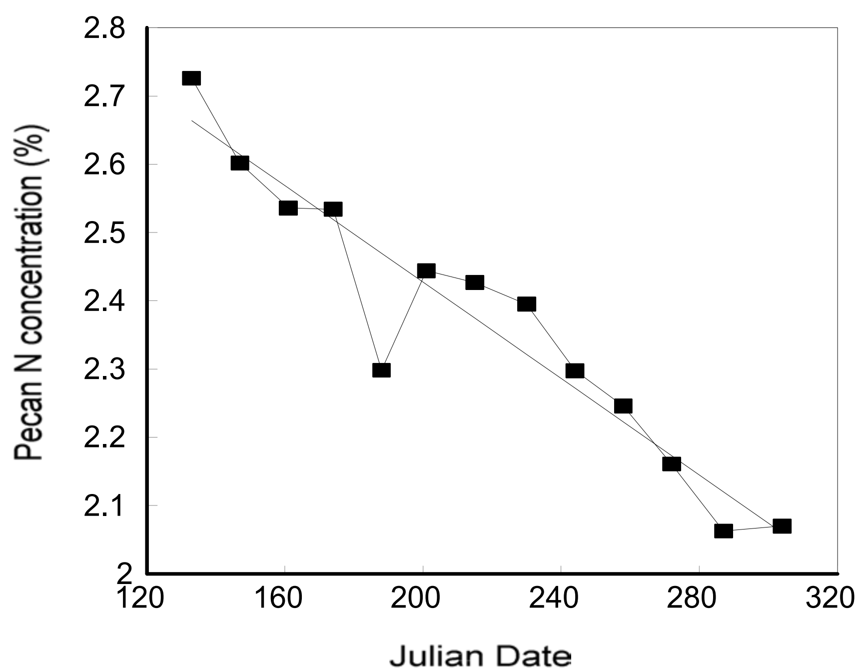

Figure 4. Average nitrogen concentrations over time, and the corresponding regression equation ($N = 3.134 - 0.00353 * JD$, $r^2 = 0.904$).