Table 1. Minimum, maximum and average leaf concentrations of total nitrogen, by percent, in 25 landscape tree species.

Tree Species	Minimum	Maximum	Average % N[a]
Silver Maple *(Acer saccharinum)*	2.02	3.37	2.52
White Alder *(Alnus rhombifolia)*	1.90	2.55	2.27
White Birch *(Betula pendula)*	2.16	3.39	2.69
Deodar Cedar *(Cedrus deodara)*	1.00	1.39	1.42
Chinese Hackberry *(Celtis sinensis)*	1.42	2.75	2.04
Camphor Tree *(Cinnamomum camphora)*	1.17	1.96	1.56
Eucalyptus *(Eucalyptus spp.)*	1.84	2.09	1.96
Raywood Ash *(Fraxinus oxycarpa)*	2.05	2.91	2.39
Modesto Ash *(Fraxinus velutina* 'Modesto')	1.75	2.69	2.26
Honey Locust *(Gleditsia triacanthos)*	2.33	3.13	2.76
Maidenhair Tree *(Ginkgo biloba)*	1.38	2.38	1.86
Goldenrain Tree *(Koelreuteria paniculata)*	1.88	3.54	2.65
Crape Myrtle *(Lagerstroemia indica)*	1.13	3.51	2.02
Tulip Tree *(Liriodendron tulipifera)*	1.20	2.81	2.03
Southern Magnolia *(Magnolia grandiflora)*	1.02	3.47	1.31
White Mulberry *(Morus alba)*	2.04	3.56	2.86
Olive *(Olea europa)*	1.27	1.88	1.59
Chinese Pistache *(Pistachia chinensis)*	1.64	3.00	2.28
London Plane Tree *(Platanus acerifolia)*	1.44	2.64	1.94
Bradford Pear *(Pyrus calleryana 'Bradford')*	1.12	1.92	1.56
Chinese Tallow Tree *(Sapium sebiferum)*	1.73	2.65	2.17
Holly Oak *(Quercus ilex)*	1.30	2.83	1.64
Valley Oak *(Quercus lobata)*	2.14	2.85	2.32
Cork Oak *(Quercus suber)*	1.54	2.18	1.88
Zelkova *(Zelkova serrata)*	1.81	2.82	2.19

[a]Average of 20 trees.

A Survey to Determine the Baseline Nitrogen Leaf Concentration of Twenty-Five Landscape Tree Species

Ed Perry and Gary W. Hickman

Fertilization of landscape trees continues to be a poorly understood cultural practice. Throughout much of the United States, nitrogen-containing fertilizers are often applied on the basis of visual symptoms, or annually as "insurance," rather than on the basis of need. The practice is justified by the relatively low cost of purchasing and applying nitrogen-containing fertilizers. However, applying nutrients without knowing they are deficient wastes time and money, and can lead to excessive soil salts and water pollution (Harris 1992). McClure (1991) reports that certain sucking pests are favored by excessive nitrogen fertilization.

The use of visual symptoms alone to diagnose nitrogen deficiencies may lead to unnecessary fertilizer use, considering the difficulty of accurate visual diagnosis. Smith (1978) states that anything which restricts root growth, such as soil diseases, insects, root pruning, soil compaction, adverse soil temperatures, low oxygen and poor drainage may reduce nutrient uptake. Such root problems may produce symptoms, including chlorotic leaves, smaller and fewer leaves, and reduced shoot growth, all of which resemble nitrogen deficiencies. Recent research (Perry and Hickman 1998) shows that visual diagnosis of nitrogen deficiency in landscape trees is unreliable.

Leaf tissue analysis is a quantitative method for detecting nutrient deficiencies and evaluating fertilizer programs seldom used by arborists and landscape managers. It has been used for years in tree fruit production as a guide for determining nutrient deficiencies and timing of fertilizer applications. Critical nutrient levels have been established for most major fruit tree crops (Childers 1966, Reisenauer 1983) and for a number woody ornamental species grown as container nursery stock (Smith 1972). In the Netherlands, Kopinga and van den Burg (1995) report that chemical leaf analysis has become more important than soil analysis in studies on the supply of nutrient elements to trees; they also report values for tissue content of nitrogen,

Table 2. NO_3^--N (ppm) in fresh and frozen landscape tree leaves as determined by a Cardy Nitrate Meter and by analytical lab analysis.

Tree Species	Cardy Meter (fresh leaves)	Cardy Meter (frozen leaves)	DANR Lab[a]
White Birch *(Betula pendula)*	[b]	129	20
Deodar Cedar *(Cedrus deodara)*	316	116	50
Camphor Tree *(Cinnamomum camphora)*	[b]	339	130
Eucalyptus *(Eucalyptus spp.)*	678	294	40
Raywood Ash *(Fraxinus oxycarpa)*	[b]	520	210
Maidenhair Tree *(Ginkgo biloba)*	127	768	50
Honey Locust *(Gleditsia triacanthos)*	[b]	565	150
Crape Myrtle *(Lagerstroemia indica)*	[b]	746	50
Chinese Pistache *(Pistachia chinensis)*	271	249	160
London Plane Tree *(Platanus acerifolia)*	746	520	140
Bradford Pear *(Pyrus calleryana 'Bradford')*	[b]	249	70
Coast Live Oak *(Quercus agrifolia)*	[b]	542	90
Valley Oak *(Quercus lobata)*	[b]	429	40
Coast Redwood *(Sequoia sempervirons)*	475	188	120
Zelkova *(Zelkova serrata)*	[b]	339	70

[a]Division of Agriculture and Natural Resources Analytical Lab, University of California, Davis
[b]Unable to extract sufficient liquid from fresh leaves for meter reading.

phosphorus, potassium and magnesium of 48 landscape tree species. In their plant analysis handbook, Mills and Jones (1996) report leaf concentrations of various elements for 252 forest and landscape trees. However, many of the values reported are from trees growing in container or field nurseries, which may be significantly different from landscape trees in regard to leaf nitrogen concentrations.

As concerns about excessive fertilizer use increase, leaf analysis may become a more commonly used management practice. Smith (1978) reports that in landscape plant culture, plant tissue analysis has become a valuable tool in identifying mineral deficiencies and in designing an efficient fertilization program. Harris (1992) states that we must document more correlation among tissue analysis, plant symptoms, and fertilizer responses before meaningful standards can be developed for determining the nutrient status and needs of woody landscape plants.

The main objective of this survey was to determine the baseline leaf nitrogen concentrations for 25 commonly used landscape tree species in California. Additionally, a Cardy Ion Meter (Spectrum Technologies, Inc.) was used to determine ppm NO_3^- Nitrogen (nitrate-nitrogen) in a representative sample of the trees. The purpose of this procedure was to determine if there is a correlation between nitrate-nitrogen and total nitrogen in leaf tissue. A secondary purpose was to evaluate the accuracy of the meter for practical field application by comparing analyses obtained by the meter to laboratory analyses.

Materials and Methods

Twenty mature trees (over 10 years old) of 25 common landscape species were sampled. Trees sampled were typical for the species and of good vigor, with no visual disease symptoms or insect infestations. Trees were sampled in Modesto, Stockton and Lodi California. Trees sampled were located primarily in irrigated landscapes, in lawns or ground covers. Most of the trees were street trees in the front yards of residences. Approximately 30 leaves were collected from each tree, taken at random from throughout the low to mid crown. Samples consisted of the most recently matured leaves near the shoot tips on the current season's growth (Harris et al. 1977). All samples were taken between June 10, 1999 and August 4, 1999. The samples were dried in a forced air drying oven at 112° F, ground, then sent to the University of California Division of Agriculture and Natural Resources Analytical Lab in Davis for analysis of total nitrogen.

Leaf samples from 15 tree species were collected in Modesto to test the effectiveness of the Cardy Meter in analyzing for NO_3^- Nitrogen. The Cardy Meter is a self-contained, portable digital meter. A small drop of liquid extracted from leaves using a hand-held garlic press was placed on the meter sensor, and a reading of NO_3^- Nitrogen in parts per million (ppm) was immediately displayed in a window. Fresh leaves were analyzed with the meter in the field on July 22, 1999.

It was suggested by the meter distributor that by first freezing the leaf samples, more liquid could be extracted for analysis. Therefore, a sub-sample of leaves were frozen and analyzed with the meter in the lab on July 30, 1999. The meter was calibrated before the beginning of each test, and recalibrated twice during testing both fresh and frozen leaf samples. As a check on the accuracy of the meter, additional samples were dried, ground and shipped to the UC Analytical Lab in Davis for analysis of ppm NO_3^- Nitrogen.

Results and Discussion

The average leaf nitrogen concentrations ranged from 1.31 percent for magnolia to 2.86 percent for fruitless mulberry (Table 1.). Because only visually healthy trees were sampled, it is assumed that the adequate range for total leaf nitrogen falls between the minimum and maximum concentrations for each species.

The Cardy Meter was not an effective device for analyzing ornamental tree leaves for ppm NO_3^- Nitrogen (Table 2.). Although only a drop of liquid is necessary to obtain a meter reading, considerable effort was required to extract sufficient liquid from the fresh leaves. Only 6 of the 15 species tested in the field yielded enough liquid for a reading. Much less effort was required to extract liquid from frozen leaves. All 15 species tested yielded adequate liquid when frozen leaves were pressed. There were considerable differences in readings between fresh and frozen leaves. There were vast differences in the readings obtained by the meter compared to those determined by the analytical lab.

Conclusions

There are a number of practical uses for the information developed from this project. The list of tree species and their corresponding leaf nitrogen ranges will allow arborists and landscape maintenance professionals to more effectively use leaf analysis for designing fertilizer programs and for diagnosing nitrogen deficiency, much as critical leaf nutrient level guides are currently used in the fruit and nut tree industries. By comparing a leaf analysis to the landscape tree "standard," the arborist can obtain a much more accurate picture of a tree's nitrogen status. More accurate diagnosis would result in fewer unnecessary nitrogen fertilizer applications. Homeowners, public parks and commercial property owners would benefit from reduced fertilizer costs, and the environment would benefit from less potential nitrogen-related pollution.

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