Zusammenfassung: Mit eingesammelten Daten von Nord-Kentucky Starkstromleitung Korridoren wurden die langfristigen Wirkungen von wiederholteten Auslaubungen bei Holzpflanzen-Gesellschaften beobachtet. Die Resultate deuten an, dass die wiederholteten Auslaubungen, dem *Robinia pseudoacacia* und *Fraxinus americana* begünstigen, während andere Arten mit höchst unterschiedlichen Schattentoleranzen und Lebensgeschichten auch fortbestehen. Obwohl wiederholtete Auslaubung keine erfolgreiche Methode von der Hemmung Baumwiedererzeugung ist, darf es etwas Nützlichkeit haben, abhängend von den Verwaltungszielen und anderen Verwaltungsanwendungen, die in Verbindung mit Auslaubung verwendet sind.

COMPARISON OF TRUNK INJECTED AND SOIL APPLIED MACRONUTRIENTS

by E. Thomas Smiley, Bruce R. Fraedrich, Donald C. Booth

Abstract. Macronutrients (N,P,K,) deficient willow oaks (*Quercus phellos*) grown in parking lot islands were fertilized by trunk or soil injection. Foliar nitrogen levels improved significantly in soil fertilized trees. Foliar color improved most in the soil fertilized trees and not at all in the controls.

Fertilization of shade trees is a common arboricultural practice which improves tree growth (5,6). In areas with limited space for root development, such as along streets, parking lots and sidewalks, many arborists contend that trunk injection of macronutrients is more effective than soil application. Trunk injections is effective for microelements (3,4) nevertheless, no experimental data have been published for macronutrient (N,P,K) deficiencies and, thus, it is viewed more skeptically (7). This study was conducted to determine if trunk injection is more effective than soil application of macronutrients in areas of limited root space.

Methods

Twenty five willow oaks (*Quercus phellos*) established in parking lot islands of the Springs Recreation Complex in Ft. Mill, South Carolina were exhibiting general chlorosis symptoms and had foliar nutrient levels lower than optimum thus were considered to be macronutrient deficient. Trees were paired for size and chlorosis rating prior to randomly assigning treatments. The trees had an average diameter (dbh) of 9.3 inches and average height of 37 feet. The turf area within the dripline not covered by pavement and available for soil fertilization ranged from 63 to 1118 square feet (17-100% of the area within the dripline). The average area available was 443 square feet and 63% of the dripline area.

A 0.4-0.6-0.6 (NPK) soluble fertilizer marketed as Mauget Stemix Hi-Vol (Table 1) was injected at the product labeled rate on July 18, 1989 and April 24, 1990. Leaves were fully expanded at the time of each treatment. Feeder tubes and capsules were applied within four inches of the soil line according to manufacturers instructions.

A 28-9-9 suspension grade slow release fertilizer (Table 1) was injected eight inches below the soil surface in holes spaced three feet apart within the dripline on July 18, 1989. The application rate was equal to 5.6 pounds of nitrogen per 1000 square feet. Only turf covered areas were fertilized, no adjustment was made for paved surface within the dripline. Control trees were not treated.

Foliar samples were collected from the south side outer branches between 15 and 20 feet above the ground line on July 17 (pretreatment), September 21, 1989 and June 25, 1990. Foliar nutrient levels were analyzed by the Clemson University Plant and Soil Analysis Laboratory. Foliar color was rated for each tree independently by three observers before treatment, September 21, 1989 and July 20, 1990. Color ratings were: 1-very chlorotic, 2-Moderately chlorotic, 3-slightly chlorotic, 4-light green, 5-dark green.

Results

Foliar nitrogen levels increased consistently in trees receiving soil applied fertilizer. Average nitrogen levels in both the stem injected treated and control trees decreased in 1989, but increased slightly in 1990 (Table 2). Only soil fertilized trees had nitrogen levels that increased significantly (P =.10) compared to the pretreatment levels.

There were no statistically significant improvements in phosphorus or potassium levels for either treatment.

Comparing each tree before and after treatment, the number of trees improving in color was highest in the soil fertilized trees; none of the control trees displayed a color improvement (Table 3). Typical improvement was one color class.

Rainfall was five inches above the 15 inch normal for the June-September 1989 period and six inches below normal for the same period in 1990.

Discussion

Trees with limited rooting area often lack essential elements, resulting in chlorosis and dieback. There has been controversy about which method of fertilization is most effective for these trees. In this trial, one soil application of a complete slow release fertilizer increased the foliar nitrogen level and improved color more than two applications of trunk injected macronutrients. Increases in nitrogen levels from soil fertilization may have been even greater if there had been more rain during the summer of 1990. Precipitation levels should not affect leaf assimulation of trunk injected nutri-

Table 1 . Analyses and rates of fertilizers used

Element	Fertilizer analysis (%) Mauget Stemix Hi-Vol	Soil fertilizer
Total N	0.470	28.00
Available phosphoric) acid (P_2O_5	0.680	9.00
Soluble potash(K_2O)	0.610	9.00
Copper	0.068	0.05
Iron	0.272	0.10
Manganese	0.068	0.05
Zinc	0.272	0.05
Rates	3 ml/inch dbh (1 capsule/ 2 in dbh)	10 g/sq ft (5.6 lbs/1000 sq ft)

Table 3. Number of willow oaks that improved in color rating

	Treatment: Trunk injected	Soil fertilized	Control
1989	2 of 9	6 of 8	0 of 8
1990	1 of 9	4 of 8	0 of 8

Table 2. Average percent foliar nutrient levels in willow oaks

Treatment	Trunk injection			Soil fertilized			Control		
	N	P	K	N	P	K	N	P	K
Pretreatment	1.45	.09	.75	1.43	.08	.67	1.37	.07	.69
September 1989	1.37	.11	.59	1.52*	.10	.55	1.34	.11	.63
June 1990	1.63	.09	.83	1.74	.10	.80	1.50	.09	.72

Statistically significant from pretreatment values at P = .10

ents.

The reason for good results with trunk injected micronutrients (3,4) and poor results with macronutrients has to do with the quantity of the nutrient injected and amount required by the tree. For example, a typical manganese (Mn) deficient red maple will have less than 30 ppm of manganese in the leaves (6) while a non-symptomatic tree may have 100 ppm. For a 10" dbh tree with 25 lbs. (10 kg) dry weight of leaves, it would require about 0.025 ounces (0.7 g) of manganese to increase this amount. Using 2% Mn solution in five 6 ml capsules, the added manganese would be nearly what is required.

Macronutrient deficient trees may start with 1.4% nitrogen and need to be raised to 2.0%. For the same 10" dbh tree 2.1 ounces of nitrogen (60 g) would be required to make this change. Using a 0.4% N Solution in five 6 ml capsules this tree would receive 0.005 ounces (0.12 g) of nitrogen, not enough to relieve the deficiency. To inject the entire 60 g of nitrogen, 2500 capsules would be required.

There are two ways to improve injection efficiency, by using higher nitrogen concentrations or by using higher volumes. With current soluble fertilizers, phytotoxicity is encountered long before the necessary concentration can be achieved with small volumes (i.e. 6 ml). A high volume, low concentration trunk injection may be a feasible alternative.

With soil applied nitrogen fertilizers, it is generally believed that 50-90% of the nitrogen is taken up by the plant (1). To achieve the uptake of 60 g N, application of up to 120 g may be required. At an application rate of 5.6 lbs. N/1000 sq. ft. (2440 g N/1000 sq. ft.) 49 sq. ft. or a 7 ft. x 7 ft. area would be required to take up the necessary nitrogen, assuming the very conservative 50% uptake rate.

Planting trees in no less than 100 sq ft. area with 3 feet of depth is the current standard recommendation (2). Using this 100 sq. ft. guideline, soil applied fertilizer should provide adequate nutrients especially if yearly applications are made. In areas with less than 50 square feet of soil surface, replacing large growing trees with smaller species may be the best management option. In these very small spaces water is usually more limiting than nutrients and lack of rooting space may lead to poor anchorage thus a potentially hazardous situation.

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Résumé. Les chênes-saules (*Quercus phellos*) présentant des déficiences en macro-éléments (N,P,K) étaient fertilisés au moyen d'injections dans le tronc ou le sol. Les arbres fertilisés depuis le sol présentaient des augmentations significatives du degré d'azote foliaire. La couleur du feuillage s'améliorait le plus chez les arbres fertilisés dupuis le sol et aucunement pour les sujets-contrôles.