ROOT COMPETITION: GRASS EFFECTS ON TREES

by A. Steven Messenger

The decline and mortality of forest-grown trees upon which a lawn setting has been imposed is an all too common event. Thousands of forest remnant oaks have succumbed in northeastern Illinois lawns and parks in recent years. In many cases, soil compaction, severe physical root damage, or some combination of these disturbances are suspected as the factors initiating tree decline. Some deaths appear to have been caused by such physical disturbances, but others cannot be explained by these mechanisms nor can they be attributed to insects, pathogens, or nutrient deficiencies manifested by classical symptoms. Studies underway at The Morton Arboretum suggest that one of the common soil types in forests of the Chicago region has properties which compel shallow rooting of several native tree species, thus setting the stage for an escalation of competition-induced stress as well as other detrimental effects of soil surface modification. The fact that grass is associated with most of the inexplicable deaths suggests the necessity of exploring the literature for data and case histories implicating grass in the decline and/or mortality of trees.

The deleterious effect of one plant on another may be collectively termed *interference,* but the effect may evolve by one or both of two distinctly different mechanisms. One mechanism, termed *allelopathy,* involves the production by one plant of a chemical compound toxic to certain other plants. The second mechanism of interference is *competition* (Rice, 1974). This paper is addressed to a major aspect of root competition.

Competition among plants may be for (a) *water* (when soil moisture is suboptimal for even part of the year), (b) *nutrients* (when the concentration of one or more nutrients is suboptimal, (c) *light* (when luminous energy is suboptimal for one plant as a result of shading by another, (d) *heat* (in cold environments when radiant energy is intercepted by the canopy of one plant to the detriment of another, providing light wave-lengths alone are not involved, (e) *carbon dioxide* (in dense vegetation at times when photosynthesis is vigorous, (f) *oxygen* (as with roots in soil), and (g) *space* (as with algae requiring surfaces to attach holdfasts) (Daubenmire, 1968).

The concept of interspecific (between species) competition has long been a concern in ecological and evolutionary thinking, yet the nature of this competition and its effects on the species involved are little known areas of ecology. Species differ widely in their genetic capacities to cope with these consequences of crowded conditions. Almost any adaptation that helps the plant cope with the total complex of environmental factors confers a measure of competitive advantage, at least indirectly (Smith, 1966; Daubenmire, 1968).

The competitive capacity of a given kind of plant is subject to environmental modification, and this varies from one habitat type to another. Furthermore, the severity of competition commonly varies with the season. For example, when one species starts growth early, after a period of general dormancy, severe competition for moisture, light, and nutrient supplies may begin when associated species break dormancy. Similarly, if one species is quick to incorporate most of the supply of a nutrient into its tissues, other associated plants that take up this nutrient more slowly may be critically weakened.

While the effect of competition on aerial organs may be quite conspicuous, the effect on roots can be easily overlooked. Deleterious effects on the aerial organs of a less successful competitor may restrict its root growth, leaving it access only to soil already partially exhausted of nutrients reflected in its lower nutrient content. More direct root competition between species may occur when dicots with relatively high CEC (cation exchange capacity) roots cannot obtain the large amounts of K required for normal growth from soil colloids, especially at low per cent K saturation, whereas many monocots can (Drake, 1967). Studies on root competition affecting tree physiology have concentrated on soil moisture and indicated its widespread importance. However, root competition between trees and grass has been dealt with in only a few studies (Daubenmire, 1968; Kramer and Kozlowski, 1960).

Competition by grass (*Koeleria cristata, Calamagrostis canadensis,* and *Andropogon gerardi*), as reflected by seedling height growth of several northern conifers, was shown to be more detrimental to the trees on loamy sand than on sand. The detrimental effect was attributed partly to shading and partly to root competition for an undetermined substance (Sims and Mueller-Dombois, 1968).

Bould (1970) reports that it has been known for a long time that grass cover crops influence tree growth and tree nutrition, considered at first to be a toxic effect, but later studies indicating that competition for water and nutrients were the major causes.

Bould and Jarrett (1962) obtained data indicating that cover crops, especially in the first few years after seeding, depressed apple tree growth, yield, and foliar nitrogen (N) concentrations, and elevated foliar phosphorus (P) concentrations despite similar applications of NPK fertilizers. They also concluded that depression of tree growth and yield and competition for N was less by *Trifolium repens* than by *Poa pratensis* L., *Lolium perenne,* and a natural sward composed mainly of *Poa annua* and *Agrostis stolonifera.* Table 1 illustrates the effects of these cover crops on apple tree foliar N in late summer of several years following cover crop establishment on cultivated soil plots in April, 1955. Note the severe and prolonged depression of foliar N following *P. pratensis* L. and *L. perenne* establishment. Optimum growth, crop yield, and fruit color were associated with a foliar nitrogen concentration of 2.0-2.2%. Similarly, Van der Boon *et al* (1963) reported that apple trees show higher yields for several years and have higher foliar N concentrations in plots where the grass sward (*Poa trivialis* and *Poa pratensis*) was broken and then maintained in a clean cultivated condition as compared to apple trees growing on plots with an intact grass sward.

Table 1. Effect of Cover Crops on Foliar Nitrogen of Apple Trees (from Bould and Jarrett, 1962)

Treatment and Year	**Foliar N (as % dry weight) of Apple Trees**
1954 (cultivated soil)	2.49
1955 (*T. repens*)	1.70
1956 (*T. repens*)	2.24
1957 (*T. repens*)	2.62
1958 (*T. repens*)	2.92
1954 (cultivated soil)	2.55
1955 (natural sward)	1.77
1956 (natural sward)	1.90
1957 (natural sward)	2.10
1958 (natural sward)	2.31
1954 (cultivated soil)	2.53
1955 (*P. pratensis* L.)	1.67
1956 (*P. pratensis* L.)	1.48
1957 (*P. pratensis* L.)	1.56
1958 (*P. pratensis* L.)	2.04
1954 (cultivated soil)	2.48
1955 (*L. perenne*)	1.60
1956 (*L. perenne*)	1.28
1957 (*L. perenne*)	1.46
1958 (*L. perenne*)	2.04

Richardson (1953), following several years' research using a root observation chamber at Wageningen, Holland, came to the following conclusions:

1. The presence of *Lolium perenne* depresses root growth rate, shortens the period of active growth, reduces the density of root hairs, and restricts both rooting depth and lateral spread of *Acer pseudoplatanus* transplant roots. Shoot growth, leaf development, and lammas shoot formation are also inhibited by *L. perenne.*

2. A deficiency of N reduces the size and growth of *A. pseudoplatanus* roots, but increases the elongation of *L. perenne* roots.
3. Active growth of *L. perenne* roots starts some three weeks earlier in the spring than that of *A. pseudoplatanus* roots, and is considerably more rapid.
4. The absorbing surface of *L. perenne* roots is greater than that of *A. pseudoplatanus* in the same volume of soil. The absorbing life of *L. perenne* roots is longer.
5. Both deficiency and *L. perenne* increase the root/shoot dry weight ratio in *A. pseudoplatanus* transplants.

In general, Richardson felt his research provided clear evidence that *L. perenne* root competition for N had a detrimental effect on *A. pseudoplatanus.*

Whitcomb and Roberts (1973) noted that *Acer saccharinum* roots were eliminated from the upper centimeter of soil following seeding of *Poa pratensis* L. The fate of the eliminated roots was a puzzle to the researchers since the soil surface was not disturbed at the time of bluegrass seeding.

Harris (1966) recorded a decrease in girth and height growth of *Magnolia grandiflora* and *Zelkova serrata* cultivars attributable to the effect of an established *Festuca arundinacea* turf. Nitrogen fertilization was particularly effective in increasing the growth of the trees which had turf growing right up to their trunks.

The above studies, diverse as they are, make it clear that shallow, lateral roots of trees may compete with grass roots for essential substances, especially nitrogen, and that all parts of the trees may be adversely affected. This generalization leads one to speculate that keen root competition between trees and grass may exist for *any* essential substances which have an uptake potentiality largely restricted to surface soil horizons if the concentrations of these substances are suboptimal for the *combined* demands of both associates.

Ware (1970) and Ware and Howe (1974) state that stress, decline and death of residual native oaks frequently follow building construction and lawn establishment in northern Illinois forests. The growth potential of forest trees is chiefly affected by the amount of soil occupied by tree roots and by the availability of water and nutrients in this limited space. Characteristics of the surface horizons are important when this space is small, and relatively unimportant when it is great (Spurr and Barnes, 1973). The question that logically follows, then, is "Do certain lawn trees often become decadent or die prematurely from the direct or indirect effects of their competition with grass for essential substances in the soil in cases where root-restricting layers compel trees to be shallow-rooted?"

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