Horticultural Research Institute

This Journal of Environmental Horticulture article is reproduced with the consent of the Horticultural Research Institute (HRI – www.hriresearch.org), which was established in 1962 as the research and development affiliate of the American Nursery & Landscape Association (ANLA – http://www.anla.org).

HRI's Mission:

To direct, fund, promote and communicate horticultural research, which increases the quality and value of ornamental plants, improves the productivity and profitability of the nursery and landscape industry, and protects and enhances the environment.

The use of any trade name in this article does not imply an endorsement of the equipment, product or process named, nor any criticism of any similar products that are not mentioned.

Copyright, All Rights Reserved

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-07-18 via free access

Susceptibility of 'Skyline' Honeylocust to Cankers Caused by *Nectria cinnabarina* Influenced by Nursery Field Management System[1]

James B. Calkins and Bert T. Swanson[2]
Department of Horticultural Science, University of Minnesota
1970 Folwell Avenue, St. Paul, MN 55108

Abstract

The influence of five nursery field management treatments including alternative, sustainable practices (ie. companion crops, allelopathic cover crops/mulches) on the incidence of stem cankers caused by *Nectria cinnabarina* (Tode:Fr.) Fr. on 'Skyline' thornless honeylocust (*Gleditsia triacanthos* L. var. *inermis* Willd. 'Skyline') was monitored in Minnesota. Although considered a stress related disease, field management treatments that reduced tree vigor (ie. growth), decreased susceptibility to attack by *N. cinnabarina* while treatments which promoted vigorous growth increased susceptibility. The observed vulnerability of honeylocust trees to *N. cinnabarina* may be related to plant cold hardiness and subsequent winter injury to root and crown tissue as affected by nursery field management treatment. Moisture stress late in the growing season, resulting from root injury during the previous winter, mechanical root injury from cultivation, and high summer soil temperatures may have increased susceptibility to *N. cinnabarina* for honeylocust trees grown in bare soil field production systems. Moisture stress in late summer may not be reflected in plant growth, but may increase the susceptibility of honeylocust trees to attack by *N. cinnabarina*.

Index words: *Gleditsia triacanthos* var. *inermis*, cover crops, companion crops, living mulches, herbicide management, cultivation, cold hardiness, soil temperature, moisture stress.

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-07-18 via free access

Significance to the Nursery Industry

Nectria cinnabarina, a widely distributed, stress-related, canker-causing fungus with a broad host range, can be a serious pathogen on honeylocust trees in the nursery and landscape. Nursery field management practices influenced the incidence and severity of cankers caused by *N. cinnabarina* on 'Skyline' honeylocust trees. Infection rates were higher for trees grown under herbicide management, and to a lesser extent cultivation, compared to trees grown with vegetative groundcovers such as bird's-foot trefoil, winter rye, and grass sod. Susceptibility was increased for honeylocust trees grown in bare soil treatments even though these trees were most vigorous. Disease incidence and severity may have been in response to stress caused by delayed cold hardiness development and subsequent winter injury or root injury caused by cultivation and soil temperature extremes associated with bare soil conditions.

Introduction

Thornless honeylocust (*Gleditsia triacanthos* L. var. *inermis* Willd.) and selected cultivars have been planted extensively as landscape and boulevard trees. The popularity of honeylocust is driven by its desirable production and landscape characteristics including a relatively fast growth rate, reliable transplant success, an upright spreading habit, attractive foliage, good yellow fall color, minimal leaf litter, and diffuse shade which permits growth of underlying turf. The variety *inermis* has the added benefits of being both thornless and seedless. One important, but often overlooked consideration is winter hardiness since most cultivars are marginally hardy in USDA hardiness zone 4 (20). A more recent concern is the susceptibility of thornless honeylocust cultivars to attack by *Nectria cinnabarina* (Tode:Fr.) Fr., which causes cankers and can be a serious problem on honeylocust (8).

The ascomycete fungus, *N. cinnabarina*, normally exists as a harmless saprophyte, but can become parasitic when host plants are predisposed by stress (5, 7, 28). The disease is commonly known as coral-spot Nectria canker. Plant stresses resulting from root damage or loss, moisture and nutrient deficiencies, temperature extremes, and other stress-related factors can increase host susceptibility to canker diseases (34, 35). The severity of cankers caused by *N. cinnabarina* on honeylocust trees is enhanced by stress (6, 7). Vigorous trees are normally able to respond to wounds and infection quickly, while stressed trees lack such abilities resulting in severe infection (5, 28). Cankers caused by *N. cinnabarina* are usually annual in nature; however, if the host is stressed and the defense response is weak, the fungus can remain active for several years causing large disruptive cankers (5). Honeylocust susceptibility to *N. cinnabarina* is subject to genetic variability (6, 22). The species and the thornless variety (var. *inermis*) appear to be considerably more resistant to canker development than the more commonly planted cultivars 'Skyline', 'Imperial', and 'Sunburst' (6) suggesting that the best control measure would be selection and introduction of resistant cultivars.

Nursery production and landscape practices that cause wounds, or injure tree root systems and otherwise limit water availability, can increase susceptibility to and severity of diseases caused by canker causing fungi (7, 17, 40). Established honeylocust trees growing under typical urban conditions are likely subject to environmental stresses throughout the growing season with moisture stress being paramount (17). Concomitant with a larger study investigating the over-

[1]Received for publication on July 15, 1996; in revised form September 20, 1996. Paper No. 21,021 of the Scientific Journal Series, Minnesota Agricultural Experiment Station. Research supported in part by the Minnesota Agricultural Experiment Station, Minnesota Nursery and Landscape Industry, University of Minnesota Graduate School, Minnesota Extension Service, and the University of Minnesota Computer Center.

[2]Post–Doctoral Research Associate and Professor, respectively.

all effectiveness of conventional and alternative nursery field management systems (11), a field management system influence on the susceptibility of 'Skyline' honeylocust to parasitic infection by *Nectria cinnabarina* was discovered.

The research was designed to evaluate three cover/companion crop systems as alternatives to conventional nursery field production practices. Cultivation and herbicide field management treatments were included because they are standard methods of weed control in the nursery industry even though these practices leave soil in a bare, unprotected state and result in substantial erosion potential. 'Norcen' bird's-foot trefoil was included as a nitrogen fixing leguminous companion crop treatment. It was chosen based on concerns regarding competition for nitrogen by cover/companion crops and its desirable groundcover characteristics. 'Wheeler' winter rye was selected as a cover crop/mulch treatment based on research which has shown its potential for use in minimum tillage. 'Wheeler' rye and its residues are allelopathic (3, 4) and, thus, may have potential to inhibit weed growth in nursery production settings. A non-mowed grass companion crop (sod) was included because of its ease of establishment, wear tolerance, cold hardiness, longevity, and easy maintenance. Grass is, however, considered to be highly competitive and often competes excessively with the primary crop and reduces growth. Because of these characteristics, a grass plot provides a good basis for comparison of the suitability and competitiveness of other cover/companion crop options. The influence of field management treatment on the incidence and severity of cankers caused by *N. cinnabarina* is the focus of this paper.

Materials and Methods

A field plot [Waukegan silt loam (fine silty, mixed, mesic, Typic Hapludoll)with a pH of 6.9, 4.3% organic matter, 1.0 ppm NO_3-N, 181 ppm P, and 445 ppm K] was established at the University of Minnesota, St. Paul Campus nursery facility. Sordan 79 hybrid sorghum sudangrass [*Sorghum bicolor* (L.) Moench x *Sorghum sudanense* (Piper) Stapf] was sown as a cover crop during the previous year to increase soil organic matter content and reduce perennial weed populations. Prior to initiation of the test plots, the field was cultivated and divided into four blocks.

Six commonly grown tree species including *Gleditsia triacanthos* var. *inermis* 'Skyline' were planted in rows by species across blocks. Trees [honeylocust; 1.5 to 1.8 m (5 to 6 ft) branched whips] were planted 3.1 m (10 ft) apart in rows spaced 2.8 m (9 ft) apart across each block.

Five field management treatments were imposed: cultivation (3–5 cultivations/year); herbicide management (oxadiazon); legume companion crop—'Norcen' birdsfoot trefoil (*Lotus corniculatus* L. 'Norcen'); winter cereal cover crop/mulch—'Wheeler' winter rye (*Secale cereale* L. 'Wheeler'); and grass sod—80% 'Eton' perennial ryegrass (*Lolium perenne* L. 'Eton') and 20% 'Ruby' red fescue (*Festuca rubra* L. 'Ruby'). Field management treatments were assigned at random within each block resulting in a randomized, split-plot (species = main plots; treatments = subplots) experimental design with four replications. Each treatment plot measured 9.1 m (30 ft) by 16.5 m (54 ft) and included three trees of each of the six species evaluated.

The cultivated treatment consisted of 3 to 5 cultivations/year depending on seasonal weed growth (approximately once each month during the growing season). Plots were cultivated to a depth of 10 to 15 cm (4 to 6 in) using a walk-behind tiller. The 10 cm (4 in) area surrounding each tree trunk was hand hoed.

Oxadiazon (3-[2,4-dichloro-5-(1-methylethoxy)phenyl]-5-(1,1-dimethylethyl)-1,3,4-oxadiazol-2(3H)-one), a pre-emergent, granular herbicide (Ronstar 2G; Rhône-Poulenc Chemical Co., Research Triangle Park, NC), was used for the herbicide treatment. The oxadiazon was applied each spring using a walk-behind spreader at 3.92 kg ai/ha (3.5 lb ai/A) followed by irrigation.

Bird's-foot trefoil seed was seeded at 7.85 kg/ha (7 lb/A). Seed was scarified and inoculated with the appropriate *Rhizobium* spp. (LiphaTech, Milwaukee, WI) prior to planting.

Winter rye cover crop/mulch plots were cultivated prior to seeding in mid September of the establishment year. 'Wheeler' rye was seeded at 134.5 kg/ha (120 lb/A). To limit competition between the rye cover crop and the trees, the rye was killed the following spring using fluazifop-P (butyl ester of (R)-2-[4-[[5-trifluoromethyl)-2-pyridinyl] oxy]phenoxy]propanoic acid) (Fusilade 2000 1E; Zeneca Ag Products, Wilmington, DE) applied at 0.43 kg ai/ha (0.38 lb ai/A) just before trees resumed growth each spring (early to mid May). The herbicide was applied using a N_2-pressurized, back-pack sprayer calibrated to apply 1,524 liters of water/ha (163 gal/A) at 207 kPa (30 PSI) of pressure. The resulting rye mulch was left on the soil surface during the growing season. Subsequent to the establishment year, rye was reseeded directly into the existing mulch each fall without additional soil preparation.

A grass mixture containing 'Eton' perennial ryegrass (80%) and 'Ruby' red fescue (20%) was selected based on ability to produce a quick cover, cold hardiness, mature height, minimal maintenance requirements, and adaptability. The grass mixture was seeded at 67.3 kg/ha (60 lb/A). The grass sward was not mown.

The cultivated, herbicide, bird's-foot trefoil companion crop, and grass companion crop treatments were initiated immediately following tree planting in early May. The rye cover crop/mulch treatment was initiated in September of the establishment year. All seed was broadcast using an over-the-shoulder, hand cranked seeder and was lightly raked in to improve soil contact. Trees were grown under the various field management treatments for 7 years. To enable evaluation of the field management treatments regarding their effects on soil fertility, moisture status, and plant performance in the absence of complicating factors, the field was not fertilized and was only irrigated the first year during the period of cover crop establishment. Supplemental fertilization may have also negated the nitrogen fixing ability of the legume companion crop. The trees were not pruned.

Field management treatment effects were determined for a wide variety of plant and soil characteristics beyond the scope of this paper (11). Specific to this report, plant growth (height and caliper) was measured at the end of each growing season. Caliper was measured 15 cm (6 in) above the soil line. Air and soil temperatures were measured daily using permanently installed, copper-constantan thermocouples. Air temperature was measured 1.2 m (4 ft) above the soil surface and soil temperatures were measured at the surface and at depths of 10, 25, and 50 cm (4, 10, and 20 in) within each treatment. Temperatures were measured at 0900 hours during the winter and at 1400 hours during the summer. Soil moisture content (% oven dry wt) was determined on a weekly

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-07-18 via free access

basis for 15 cm (6 in) incremental soil cores to a depth of 90 cm (36 in).

The influence of nursery field management treatment on disease incidence was monitored by surveying each tree on an annual basis (August) for disease symptoms. In the case of cankers caused by *N. cinnabarina*, the number and location of cankers found on each tree was recorded each year. Cankers were screened to confirm the identity of the pathogen involved (University of Minnesota, Department of Plant Pathology).

Results and Discussion

Nursery field management treatment influenced infection frequency and crown mortality of 'Skyline' honeylocust trees caused by *N. cinnabarina* (Table 1). Macro and microscopic examination confirmed *N. cinnabarina* as the causal agent (9). Cankers were first observed during the fourth growing season and became increasingly prevalent thereafter (Table 1). After six growing seasons, 42% of the honeylocust trees grown under cultivation and 75% of the trees grown under herbicide management exhibited cankers caused by *N. cinnabarina*. After one more year, the incidence of infection for the same treatments increased to 75% and 100% respectively. Cankers were generally located on the lower scaffold branches or main stem and were usually centered on branch crotches. Since the trees were not pruned, pruning wound infection centers were not involved. In most cases, cankers continued to develop over several years while the number of cankers present also increased. Treatment effects on crown mortality caused by *N. cinnabarina* were also significant; 33% of the trees from the cultivated plots and 67% of the trees from the herbicide plots were killed after seven growing seasons. Death of the crown was usually in response to girdling of the main stem or scaffold branches by perennial, or more recently developed, but aggressive, cankers. Mortality usually occurred over the winter suggesting a concomitant effect on cold hardiness may have been involved. Roots of these trees remained alive as new growth was initiated in the form of suckers. The presence of cankers on trees grown in the trefoil companion crop, rye cover crop/mulch, and grass sod treatments was minimal compared to bare soil treat-

Table 1. Effect of field management treatment on the incidence of cankers caused by *Nectria cinnabarina* on 'Skyline' thornless honeylocust trees during a 7–year study.

Field management treatment	No. of trees with cankers[z]	Percent infection	No. of new cankers	Total no. of cankers	Average no. of new cankers/tree	Average no. cankers/tree (cumulative)
Year 4[y]						
Cultivated	2	17	2	2	0.17b[x]	0.17b[x]
Herbicide	4	33	7	7	0.58a	0.58a
Trefoil	0	0	0	0	0.00b	0.00b
Rye	0	0	0	0	0.00b	0.00b
Grass	0	0	0	0	0.00b	0.00b
Year 5						
Cultivated	2	17	3	5	0.25b	0.42b
Herbicide	7	58	8	15	0.67a	1.25a
Trefoil	1	8	1	1	0.08b	0.08b
Rye	0	0	0	0	0.00b	0.00b
Grass	0	0	0	0	0.00b	0.00b
Year 6						
Cultivated	5	42	8	13	0.67b	1.08b
Herbicide	9	75	28	43	2.33a	3.58a
Trefoil	2	17	1	2	0.08b	0.17c
Rye	1	8	1	1	0.08b	0.08c
Grass	2[w]	17[w]	2[w]	2[w]	0.17b[w]	0.17c[w]
Year 7						
Cultivated	9	75	3[v]	16[v]	0.38b[v]	1.33b[v]
Herbicide	12	100	4[u]	47[u]	1.00a[u]	3.92a[u]
Trefoil	2	17	0	2	0.00b	0.17c
Rye	2	17	1	2	0.08b	0.17c
Grass	2[w]	17[w]	0	2[w]	0.00b	0.17c[w, t]

[z]There were a total of 12 trees/treatment.

[y]No cankers were observed during the first 3 years of the study.

[x]Treatment means within columns and years separated by Duncan's Multiple Range Test (p = 0.05).

[w]These trees may have been predisposed to infection because of damage to their root systems caused by pocket gopher activity.

[v]Crown of 4 trees lost to mortality caused by *N. cinnabarina*: cankers on these trees included in total number of cankers at the end of year 7; new cankers are for the remaining 8 trees only.

[u]Crown of 8 trees lost to mortality caused by *N. cinnabarina*: cankers on these trees included in total number of cankers at the end of year 7; new cankers are for the remaining 4 trees only.

[t]1 tree with a canker lost to mortality caused by pocket gopher feeding; the canker on this tree included in total number of cankers at the end of year 7.

Downloaded from https://prime-pdf-wa

Table 2. **Effect of field management treatment on height and caliper growth of 'Skyline' thornless honeylocust (*Gleditsia triacanthos* var. *inermis* 'Skyline').**

Treatment	Height (cm)[z]	Caliper (cm)[y]
Cultivated	442b[x]	12.2a
Herbicide	532a	9.6b
Trefoil	409c	7.8c
Rye	428c	8.8bc
Grass	425c	8.5bc

[z]Height and caliper measured at the end of the sixth growing season of a seven year study; crown dieback of severely infected trees over the subsequent winter was too severe to obtain reliable growth data at the end of the seventh and final growing season.

[y]Caliper measured at 15 cm (6 in) above the soil line.

[x]Treatment means within columns separated by Duncan's Multiple Range Test ($p = 0.05$).

ments (Table 1). None of the diseased trees in the trefoil, rye, and grass treatments died except for one tree in the grass treatment which had its roots eaten off by pocket gophers.

Coral-spot Nectria canker is generally considered to be a stress related disease (5, 6, 7, 28). The results of this study would at first glance seem to contradict this hypothesis. Honeylocust trees were more vigorous when grown under bare soil conditions (cultivation and herbicide management) compared to trees grown together with groundcovers (Table 2). The most vigorous trees, however, exhibited the highest incidence of infection by *N. cinnabarina* (Table 1). Infection, based on numbers of new cankers observed each year and cumulative numbers of cankers over time, was highest for trees grown under herbicide management even though these trees had grown faster and were taller than trees in the other field management treatment plots. Trees grown in the cultivated plots were also more vigorous than trees grown with groundcovers (Table 2). While the number of new cankers observed annually for these trees was also greater than for trees grown with groundcovers, the difference was nonsignificant. Based on cumulative numbers of cankers per tree, however, there was an increase in infection by the sixth year of the research.

It is evident that some effect of the herbicide and cultivated field management treatments predisposed honeylocust trees to attack by *N. cinnabarina*. Assuming the disease is stress related, these trees must have been subject to sufficient stress at some critical point during the growing season to increase their susceptibility to attack by this normally nonaggressive, facultative parasite. The observation that existing cankers were not inhibited, but rather continued to expand during subsequent years, further supports the existence of a stressed condition within the host since the fungus was apparently able to evade compartmentalization and persist resulting in the development of large, disruptive, perennial cankers (5).

One possible source of stress may be explained by the level of cold hardiness inherent for honeylocust. The native range of *Gleditsia triacanthos* var. *inermis* in North America extends from Pennsylvania to Nebraska and south to Mississippi and Texas (26). The species is considered borderline hardy in the northern plains and all named cultivars are considered to be less hardy than the species (20). It is proposed that winter injury to the crown (cambium, phloem, xylem ray parenchyma) and/or roots of honeylocust trees growing in the bare soil treatments predisposed these trees to attack by the omnipresent *N. cinnabarina* fungus. Seemingly minor injuries to stem tissues caused by freezing temperatures might weaken healthy, as well as previously infected trees, sufficiently to reduce host defenses, increase colonization, and delay compartmentalization of existing cankers, but not reduce growth. Freezing stress has previously been indicated as a disease predisposing factor (34) and has been specifically shown to increase *N. cinnabarina* infection in another host, *Euonymus alatus* (35). Although freezing stress in *Euonymus* was not sufficient to produce detectable freezing injury, either visually (bud kill, dieback, tissue discoloration) or by differential thermal analysis, increased susceptibility to infection ensued. A similar response is hypothesized for the increased susceptibility to infection by *N. cinnabarina* observed for honeylocust in this research.

Field management practices can influence plant cold hardiness through a variety of effects on the plant environment including effects on soil temperature (18). Soils maintained in a bare condition are subject to greater temperature extremes especially during severe winters with little snowcover (10, 15, 21, 30, 37, 38). Soil temperatures measured during the winter were cold enough to injure roots (16, 26) and minimum soil temperatures in the root zone were always colder for the herbicide and cultivated plots compared to cover/companion crop treatments (Table 3). Tree growth was not, however, reduced in response to low soil temperatures (Table 2). Although differences in minimum soil temperatures between treatments may not appear large, once the critical range is reached, a difference of as little as a degree or two can make the difference between root survival or death. Winter injury to roots would, therefore, have been more likely to occur for trees grown in these bare soil treatments. Injury to roots by cold temperatures would also be more likely under conditions where surface rooting is enhanced such as in herbicide managed soils (18). If root injury resulted from low winter soil temperatures, plant performance may not have been affected until mid-summer when soil moisture is more likely to become limiting, but after most height growth has already occurred. Such injury may not be reflected in growth measurements (height), yet trees could be stressed sufficiently late in the season to permit infection and canker development and enlargement. Effects of field management practices on the plant environment may also influence plant cold acclimation and subsequent cold hardiness levels. The relatively high levels of soil fertility and moisture normally maintained in nursery production systems and landscape situ-

Table 3. **Maximum/minimum soil temperatures measured at various depths within the soil profile as affected by field management treatment over a seven-year period.**

	Soil temperature (max./min.), C[z]			
	Thermocouple depth (cm)			
Treatment	Surface	10	25	50
Cultivated	+46.7/–8.3	+30.6/–8.3	+24.4/–6.7	+21.7/–1.7
Herbicide	+53.9/–8.9	+35.0/–9.0	+28.3/–7.6	+22.8/–2.8
Trefoil	+32.2/–7.8	+23.9/–5.9	+21.1/–4.3	+19.4/–1.7
Rye	+36.7/–7.2	+26.1/–6.7	+23.3/–5.6	+21.7/–1.7
Grass	+23.9/–5.0	+22.8/–3.9	+21.1/–2.8	+19.4/ 0.0

[z]Soil temperature measured by permenantly installed, copper–constantan thermocouples.

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-07-18 via free access

ations may promote late season growth and delay cold acclimation (13, 14, 24, 31). That hardiness development was delayed for trees in the cultivated and herbicide treatment plots was evidenced by delayed fall coloration and leaf abscission compared to trees grown together with groundcovers (11). Actual measurements of cold hardiness levels obtained from freeze tests (data not shown) also support delayed cold acclimation and reduced hardiness for trees in the bare soil treatments compared to trees grown with groundcovers (11). Any reduction in cold hardiness of an already borderline hardy species might be expected to increase winter injury and this may have been the case for honeylocust in this study. Employment of cover/companion crops which actively compete with perennial horticultural crops for excess nutrients and moisture may be a viable option by which cold hardiness might be enhanced and losses to winter injury reduced.

Soil temperatures were higher in summer and lower in winter for bare soil treatments compared to cover/companion crop/mulch based field management treatments (Table 3). Soil temperatures were most variable for the herbicide plots and least variable for the grass plots. Not surprisingly, differences in maximum and minimum soil temperatures between field management treatment were greatest near the soil surface, but a maximum temperature spread of more than 7C (13F) and minimum temperature spread of nearly 5C (9F) remained at a depth of 25 cm (10 in). Differences in maximum/minimum soil temperatures between treatments in excess of 2.8C (5F) were still evident at a depth of 50 cm (20 in). The high soil temperature extremes observed during the summer for bare soil treatments compared to cover treatments (Table 3) may have caused moisture stress and/or root injury. This may have been especially valid for herbicide treatment plots, which exhibited the highest soil temperatures, and where an increased portion of the root system would be located near the soil surface (18, 36, 39) and subject to injury by high soil temperatures. Although surface soil temperature would be less critical for trees maintained under cultivation, where roots are removed from the cultivated surface zone, damage to roots caused by cultivation itself would be expected to increase plant stress. In contrast, trees grown together with cover crops tend to develop deeper root systems and have fewer surface roots which might be injured by high soil temperatures near the soil surface (12, 18, 19, 27). Temperatures of 40C (104F) to 45C (113F) can injure roots (16, 26). Temperatures measured in the root zone during the summer for the herbicide management and cultivated treatments were high enough to have resulted in root injury (Table 3). This was not the case for any of the groundcover plots. As with root damage caused by low winter soil temperatures, stress associated with such injury may not reduce plant growth because the stress is typically manifest later in the summer after the spring growth flush has been completed. Although such stress would be ameliorated with the return of cooler, wetter conditions in the fall, it might be sufficient to weaken host defenses and promote infection and enlargement of existing cankers. Field management practices that promote warmer soil temperatures during the fall, might also promote late season growth, delay cold acclimation, and subsequently increase winter injury.

Evidence that root injury occurred for trees grown under herbicide management may be illustrated by plant growth data (Table 2). Trees from the herbicide management plots were the most vigorous based on height growth, however, the same plants were less vigorous than trees from cultivated plots based on caliper growth. Herbicide plots had the highest summer and lowest winter soil temperatures both of which could have caused root injury (Table 3). Most height growth occurs in spring while caliper growth occurs later in the growing season when stress from such root injury is often compounded by reduced soil moisture levels. This may explain the reduced caliper growth observed for trees from herbicide management treatment plots. Soil moisture data indicated soil moisture levels near the surface were indeed lower for the herbicide and cultivated treatments compared to soil maintained with vegetative groundcovers and mulch (Table 4). This evidence supports the hypothesis that increased susceptibility to *N. cinnabarina* was stress related and mediated by root injury associated with field management treatment effects on the growing environment.

Increased susceptibility of honeylocust trees grown under herbicide management may have also been related to herbicide stress. Herbicides have been implicated in interactions between pathogens and hosts and can increase or decrease disease severity (2, 23, 25, 29). Herbicides can influence pathogen/host relationships by altering the virulence of the pathogen, altering the virulence of pathogen antagonists/competitors, or by changing the physiology of the host plant (23).

Another reason for increased infection rates for trees grown in bare soil treatments might be that vigorous, succulent plant tissues are often more susceptible to disease; for example, fireblight on shoot terminals and watersprouts of apple (1). Cultural practices, including use of cover/companion crops, can reduce the production of succulent, susceptible tissues and thereby increase disease resistance (1, 32, 33). Although it is generally accepted that Nectria canker is a stress-related disease, it is possible that the increased incidence of cankers caused by *N. cinnabarina* observed was not stress related at all. The possibility that faster-growing, vigorous, non-stressed trees may be more susceptible to attack by *N. cinnabarina* must also be considered.

Colonization of honeylocust trees by *N. cinnabarina* seemed to increase their susceptibility to winter injury. In many cases, infected trees were alive at the end of the growing season, but were dead the following spring. In such cases, stress associated with infection by *N. cinnabarina* may have interfered with cold acclimation resulting in crown mortality in response to the combined effects of the disease and winter injury.

Table 4. Effects of five field management treatments on average soil moisture levels at various depths within the soil profile.

Field management treatment	Soil moisture (% dry wt) Sample depth (cm)					
	0–15	15–30	30–45	45–60	60–75	0–45
Cultivated	17.3c[z]	22.6b	23.9bc	21.6a	21.8a	21.3bc
Herbicide	15.4c	21.5b	21.3c	19.7b	20.1a	19.4c
Trefoil	24.2ab	23.8b	22.7bc	20.3ab	20.9a	23.6b
Rye	27.4a	27.6a	28.6a	22.8a	21.5a	27.9a
Grass	23.1b	22.3b	24.0b	21.6a	21.7a	23.1bc

[z]Treatment means within columns separated by Duncan's Multiple Range Test (p = 0.05).

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-07-18 via free access

Negative factors affiliated with field management practices that maintain field soils in a bare condition (mechanical root damage, exposure of roots to injurious soil temperatures, delayed cold acclimation, reductions in the availability of soil moisture, and perhaps excessive plant vigor) can predispose trees to attack by diseases such as *N. cinnabarina*. In addition to other production and environmental benefits associated with cover/companion crops, potential effects of field management practices on the susceptibility of plants to disease, such as the decreased susceptibility of honeylocust trees to infection by *N. cinnabarina* when grown with vegetative covers compared to trees grown in bare soil documented by this research, should further encourage consideration of such alternative field management strategies for use in woody plant field production systems.

Literature Cited

1. Agrios, G.N. 1969. Plant Pathology. Academic Press, New York, NY. p. 341.

2. Altman, J. and C.L. Campbell. 1977. Effect of herbicides on plant diseases. Ann. Rev. Phytopath. 15:361–385.

3. Barnes, J.P. and A.R. Putnam. 1983. Rye residues contribute weed suppression in no-tillage cropping systems. J. Chem Ecol. 9:1045–1057.

4. Barnes, J.P. and A.R. Putnam. 1986. Evidence for allelopathy by residues and aqueous extracts of rye (*Secale cereale*). Weed Sci. 34:384–390.

5. Bedker, P.J. and R.A. Blanchette. 1984. Identification and control of cankers caused by *Nectria cinnabarina* of honey locust. J. Arboriculture 10:33–39.

6. Bedker, P.J. and R.A. Blanchette. 1984. Control of *Nectria cinnabarina* cankers on honey locust. Plant Disease 68:227–230.

7. Bedker, P.J. and R.A. Blanchette. 1983. Development of cankers caused by *Nectria cinnabarina* on honey locusts after root pruning. Plant Dis. 67:1010–1013.

8. Bedker, P.J., R.A. Blanchette, and D.W. French. 1982. *Nectria cinnabarina*: The cause of a canker disease of honey locust in Minnesota. Plant Dis. 66:1067–1070.

9. Bedker, P.J. and M.J. Wingfield. 1983. Taxonomy of three canker-causing fungi of honey locust in the United States. Trans. Brit. Mycol. Soc. 81:179–183.

10. Bouyoucos, G.J. 1916. Soil temperature. Michigan Agric. Exp. Sta. Tech. Bull. 26.

11. Calkins, J.B. 1991. Effects of conventional and alternative nursery field management systems on chemical and physical soil characteristics and on tree growth and development. Ph.D. Thesis. University of Minnesota, St. Paul.

12. Coker, E.G. 1959. Root development of apple trees in grass and clean cultivation. J. Hort. Sci. 34:111–121.

13. Davies, F.S., D.W. Buchanan, and J.A. Anderson. 1981. Water stress and cold hardiness in field-grown citrus. J. Amer. Soc. Hort. Sci. 106:197–200.

14. Edgerton, L.J. 1957. Effect of nitrogen fertilization on cold hardiness of apple trees. Proc. Amer. Soc. Hort. Sci. 70:40–45.

15. Emerson, R.A. 1903. Experiments in orchard culture. III. Root killing of apple and cherry stocks in relation to soil moisture and soil covers. Nebraska Agric. Exp. Sta. Bull. 79:26–33.

16. Fitter, A.H. and R.K.M. Hay. 1981. Environmental Physiology of Plants. Academic Press, New York, NY.

17. Halverson, H.G. and D.F. Potts. 1981. Water requirements of honey locust (*Gleditsia triacanthos* f. *inermis*) in the urban forest. U.S. For. Ser. Res. Paper NE-487. 4 pp.

18. Haynes, R.J. 1980. Influence of soil management practice on the orchard agro-ecosystem. Agro-Ecosystems 6:3–32.

19. Hill, R.G. 1966. Relationship of soil management practices and nitrogen fertilizations to the root distributions of peach. Proc. 17th Intern. Hort. Congr., Maryland 1:24

20. Hoag, D.C. 1965. Trees and Shrubs for the Northern Plains. Lund Press, Minneapolis, MN.

21. Howard, R.F. 1924. The relation of low temperature to root injury of the apple. Nebraska Agric. Exp. Sta. Bull. 199.

22. Jorgensen, H.A. 1952. Studies on *Nectria cinnabarina* hosts and variation. R. Agric. Col. Contrib. Dept. Plant Pathol. Copenhagen 35:57–120.

23. Katan, J. and Y. Eshel. 1973. Interactions between herbicides and plant pathogens. Residue Rev. 45:145–177.

24. Kelly, J.D. 1972. Nitrogen and potassium rate effects on growth, leaf nitrogen and winter hardiness of *Pyracantha coccinea* 'Lalandi' and *Ilex crenata* 'Rotundifolia'. J. Amer. Soc. Hort. Sci. 97:446–448.

25. Lee, M. and J.L. Lockwood. 1977. Enhanced severity of *Thielaviopsis basicola* root rot induced in soybean by herbicide chloramben. Phytopathology 67:1360–1367.

26. Levitt, J. 1972. Responses of Plants to Environmental Stresses. Academic Press, New York, NY.

27. Mitchell, P.D. and J.D.F. Black. 1968. Distribution of peach roots under pasture and cultivation. Austral. J. Exp. Agric. Animal. Husb. 8:106–111.

28. Neely, D. 1970. Healing of wounds on trees. J. Amer. Soc. Hort. Sci. 95:536–540.

29. Norris, R.F. 1986. Weeds and integrated pest management systems. *In*: Proceedings of the Symposium on Interplanting in Horticultural Systems. 81st ASHS Annual Meeting, Vancouver, B.C., August 8, 1984. HortScience 21:402–410.

30. Oskamp, J. 1917. The role of soil temperature in tree growth. Proc. Amer. Soc. Hort. Sci. 14:118–126.

31. Ouellett, C.E. and R.L. Desjardins. 1981. Interpretation des relations entre le climat et la survive a' l'hiver de la luzerne par l'analyse des correlations. Can. J. Plant Sci. 61:945–954.

32. Parker, K.G., N.S. Luepschen, and E.G. Fisher. 1961. Tree nutrition and fireblight development. Phytopathology 51:557–560.

33. Powell, D. 1966. Fighting fireblight in 66. Amer. Fruit Grower 86:36–38.

34. Schoeneweiss, D.F. 1975. Predisposition, stress, and plant disease. Ann. Rev. Phytopathol. 13:193–211.

35. Schoeneweiss, D.F. and E.G. Wene. 1977. Freezing stress predisposes *Euonymus alatus* stems to attack by *Nectria cinnabarina*. Plant Dis. Rep. 61:921–925.

36. Stott, K.G. 1976. The effects of competition from ground covers on apple vigour and yield. Ann. Appl. Biol. 83:327–330.

37. Tumanov, I.I. and N.N. Khavalin. 1967. Causes of poor cold-resistance in roots of fruit trees. Soviet Plant Physiol. 14:763–770.

38. Upshall, W.H. 1937. Freezing of fruit tree roots. Can. Hort. and Home Mag. 60(5):138–139.

39. Watson, G.W. 1988. Organic mulch and grass competition influence tree root development. J. Arboriculture 14:200–203.

40. Watson, G.W. and E.B. Himelick. 1982. Root distribution of nursery trees and its relationship to transplanting success. J. Arboriculture 8:225–229.

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-07-18 via free access