Evaluation of Trunk-Insulating Wraps on Cambium Temperature Fluctuations and Peach Tree Short Life Development

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ABSTRACT

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Four trunk-insulating wraps in four orchards were used to evaluate cambium temperature fluctuations on peach tree short life (PTSL) development. A clear plastic bubble material trapped solar radiation, increased cambium temperatures, and resulted in cambial browning, sour sap odor, and tree death similar to PTSL. Insulation materials that reduced temperature fluctuations did not affect minimum cambium night temperatures but did decrease maximum day temperatures compared with noninsulated checks. Armiflex foam, normally used to insulate water pipes, and Reflectix, polyethylene plastic bubbles with aluminum foil bonded to both sides, were the most effective insulation materials. None of the materials consistently decreased the percentage of PTSL. If cambium temperature fluctuations contribute to PTSL development, more effective insulation materials are required to decrease the incidence of PTSL.

Cold injury is a serious problem for peach trees (*Prunus persica* (L.) Batsch) in the eastern United States. Cold injury to the woody tissue of peach trees in the northern growing areas usually occurs in late fall or early winter before trees have fully acclimated (5) or during periods of extreme minimum temperatures after full acclimation (4,11). In the Southeast, peach trees usually have sufficient time to reach maximum cold hardiness before freezing temperatures occur. Cold injury, which is often associated with peach tree short life (PTSL), occurs in late winter after the rest period has been broken and physiological activity resumes (16). In a normal season, sufficient chill hours have accumulated by late January to achieve dormancy for most peach varieties, and peach trees can lose hardiness after periods of warm weather in the dormant season (5,7).

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Peach tree short life is a disease complex that often kills 3- to 5-yr-old trees (18). There are several factors that predispose trees to PTSL, but the actual cause of death is usually attributed to bacterial canker (*Pseudomonas syringae* pv. *syringae* van Hall) or cold damage (23), with cold injury causing the most tree losses (21). The first symptom of cold injury is cambial browning, usually on the southwest side of the tree, often appearing during late winter dehardening (3,16). *Criconemella xenoplax* (Raski) Luc & Raski nematodes predispose trees to PTSL (15,17,22) and may be a factor in increased cold damage to peach trees. Trees growing in soils with large populations of nematodes are less cold hardy than trees growing in soils treated with nematicides (14,18). Carter (2) suggested that elevated levels of indoleacetic acid (IAA), which were related to large *C. xenoplax* populations, were responsible for the predisposition of trees to cold injury and PTSL. Because of the difficulty and expense of control measures, nematicides are not often used. Thus, an alternative means of reducing PTSL, regardless of *C. xenoplax* populations, is needed.

Large and rapid fluctuations in trunk temperatures may be as important as absolute minimum temperature (3,13). Trunk cambium temperatures are greater on bright sunny days in winter than at any other time of the year (7,10). On sunny, calm days in January, trunk cambium temperatures on the southwest side of the tree can reach 30–35 C (6,21). Consequently, sudden declines in temperature can damage dehardened trees.

If large and rapid fluctuations in temperature are a contributing factor to cold injury, avoiding high temperatures while there is a risk of occurrence of extreme low temperatures may be a means of reducing tree death (12). One method of reducing trunk cambium temperatures is with the use of reflective or insulating trunk wraps. Savage (21) reported that insulation of the trunk and larger branches prevented cold injury under most circumstances. Painting the trunk to increase reflectivity of the surface has been shown to diminish cambial temperatures by as much as 16 C (6,8,10,19). Materials that combine both reflectance and insulation characteristics should result in greater stabilization of trunk cambium temperature fluctuations. Jensen et al (10) found that white paint, aluminum foil, and insulated foil all decreased trunk cambium temperature fluctuations in Georgia compared with the untreated checks, but the insulated foil was the most effective.

Painting or insulating tree trunks is recommended for fruit trees in the northern United States and for citrus in Florida. In the Southeastern peach-growing region, neither paint nor insulation is recommended, although Savage (21) reported fewer tree deaths attributable to PTSL when trees were insulated. The purpose of this study was to determine which insulation materials were most effective in decreasing cambium temperature fluctuations, the effect of insulation on the incidence of PTSL, and whether trunk insulation should be recommended in the Southeast for peach orchards with a history of PTSL.

MATERIALS AND METHODS

A preliminary test (orchard 1) was conducted at the USDA research station in Byron, GA, during the winter of 1985–1986. Armiflex foam (Armstrong Inc., Three Rivers, MI) insulation painted white was used to decrease temperature fluctuations. Clear polyethylene plastic bubble material supplied in 46 × 76 cm sheets was used to increase temperature fluctuations. Three-year-old Sunland scions on Lovell rootstock were arranged in a completely randomized design with 48 trees in each insulation treatment and 12 noninsulated check trees. Twelve of the insulated trees per month were pruned in October, December, February, or March. The 12 noninsulated check trees were pruned in March.

Three orchards with a history of PTSL were used to test the effectiveness of three insulating materials on cambium temperatures and tree death attributable to PTSL. Insulating materials were Armiflex foam, normally used to insulate water pipes; Reflectix (Reflectix Co., Markleville, IN), polyethylene plastic bubbles with aluminum foil bonded to both sides; and nondiluted white exterior latex paint. There were also noninsulated check trees in each orchard. Orchard 2 was located at the Clemson University Sandhill Research and Education Center near Pontiac, SC. Suwanee scions on Lovell rootstocks were planted in January 1986 and treatments began in November 1986. There were 88–91 trees in each insulation treatment. One-half of the trees in each treatment were pruned in November and the other half were pruned in February. Orchards 3 and 4 were located in central Georgia. Orchard 3 was planted in January 1985 with Junegold on Lovell rootstock. There were 80 trees in each insulation treatment and 80 noninsulated check trees. Orchard 4 was planted in December 1986 with Redhaven scions on Nemaguard or Lovell rootstocks. In orchard 4, there were 30 trees in each insulation treatment and 30 noninsulated check trees on Nemaguard. There were an additional 30 noninsulated trees on Lovell rootstock.

Insulation was applied in November of each year. The foam and Reflectix were removed each April. A randomized complete block design was used in orchards 2, 3, and 4. In orchard 2, there were seven or eight trees per treatment and six blocks. In orchard 3, there were four trees per treatment and 20 blocks. In orchard 4, there were five trees per treatment and six blocks. Trees were rated for PTSL symptoms in April and May, and the percentage of PTSL trees was determined for each plot. Chi-square statistics using maximum likelihood ratios were performed for analyses of data, and individual contrasts were performed to test treatment differences (20).

Trunk cambium temperatures in orchards 1, 3, and 4 were recorded periodically throughout the winter to determine the relative effects of insulation on cambium temperatures. Temperatures were recorded every 15 min with a Grant digital meter/logger (Science/Electronics, Dayton, OH) and catheter mini-thermistor probes that have a resistance of 2,000 Ω at 25 C. The probes were inserted into the cambium about 30 cm above the soil through small L-shaped slits in the bark on the southwest side of the trees. Temperatures were measured on four trees per insulation treatment with one probe per tree. In the preliminary test in orchard 1, temperatures were monitored from 2 January through 23 March 1986. In orchard 3, temperatures were monitored from 26 January through 6 February 1987 and from 8 February through 19 February 1988. Temperatures were recorded in orchard 4 from 5 January through 23 January 1987 and from 4 January through 5 February 1988. Solar radiation was measured with a LiCor 1776 Solar Monitor (LiCor Inc., Lincoln, NE).

Nematode samples were obtained by compositing 10–12 soil probes per plot per replication. Nematodes were extracted from 100-cm^3 soil samples using elutriation (1) combined with centrifugal flotation (9).

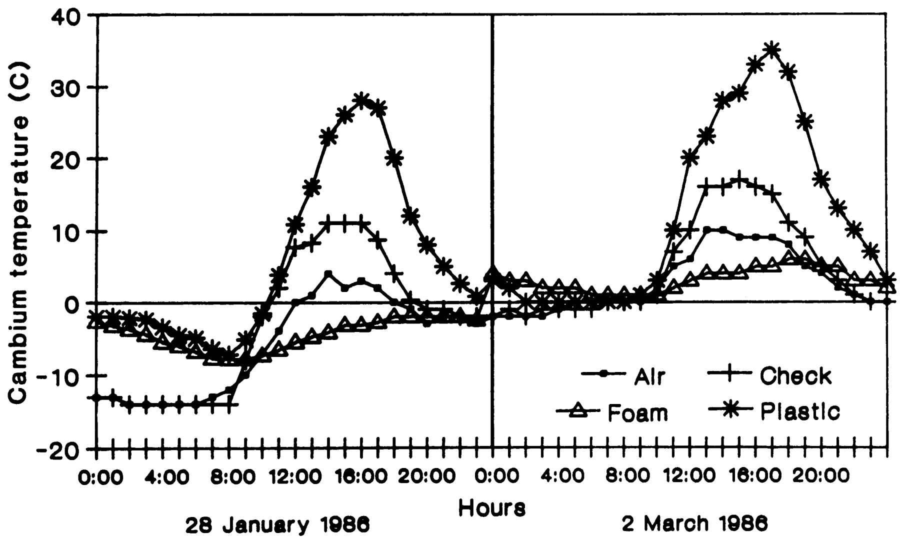

Fig. 1. Effect of trunk wraps on peach tree cambium temperatures in orchard 1 on 28 January and 2 March 1986. Foam = Armiflex foam insulation, plastic = clear polyethylene plastic bubble.

RESULTS AND DISCUSSION

The preliminary test in orchard 1 was conducted on a non-PTSL site. Average *C. xenoplax* populations per insulation treatment ranged from 77 to 131 nematodes per 100 cm^3 of soil. The effects of insulation on cambium temperatures in orchard 1 are shown for 28 January, an overcast day with 1,580 W/m^2 solar radiation, and for 2 March, a sunny day with 5,400 W/m^2 solar radiation (Fig. 1). The maximum temperatures were greater on 2 March than on 28 January, but the relative effects of insulation were the same on both days. Clear plastic insulation increased cambium temperatures about 17 C, and foam insulation decreased temperatures about 12 C compared with noninsulated checks (Fig. 1). The relative effects of insulation were consistent throughout the measurement period. The average maximum cambium temperature during January 1986 was 21 C for noninsulated check trees. This was 14 C cooler than the clear plastic insulated trees and 15 C warmer than foam-insulated trees. Cambial browning, sour sap odor, and increased incidence of PTSL with fall pruning are characteristic symptoms of PTSL (18,23), and the clear plastic insulation, which increased temperature fluctuations, resulted in symptoms similar to PTSL. Twenty-seven (56%) of the plastic bubble-insulated trees exhibited cambial browning and sour sap odor. Nine of the injured trees were pruned in October and 11 were pruned in December. Of the 27 trees that exhibited PTSL symptoms, only two pruned in October and two pruned in December actually died. None of the noninsulated check trees and one tree pruned in October with foam insulation exhibited PTSL symptoms. The injury and death with plastic bubble insulation probably resulted from the extremely high cambium temperature (35 C) and not true PTSL. However, the results do suggest that high cambium temperature or large, rapid fluctuations in cambium temperatures may play a role in PTSL development.

The effects of insulation on cambium temperatures in orchards 3 and 4 were similar, and only the temperatures recorded from orchard 3 are shown (Fig. 2). Insulation treatments had little effect on minimum night temperature. On 27 January, minimum air temperature was −7 C and minimum cambium temperature ranged from −5.7 C with foam to −8.6 C with paint (Fig. 2). The foam and Reflectix insulation resulted in similar cambium temperatures, and both maintained maximum daytime cambium temperatures less than ambient air temperature (Fig. 2). Maximum cambium temperatures with foam or Reflectix insulation averaged 3 and 10 C cooler than ambient air temperatures and maximum cambium temperatures in noninsulated check trees, respectively. Cambium temperatures of painted trees averaged about 3 C cooler than noninsulated check trees, but both painted and check trees were warmer than ambient air temperature (Fig. 2).

The cause of tree death in the PTSL disease complex is usually attributed to bacterial canker or cold damage (18). Insulation did not consistently affect tree death attributable to either cause. Bacterial canker killed 52% of the trees in orchard 2 in 1987, 1 yr after planting (Table 1). The increased incidence of PTSL in trees pruned in November (57.7%) over those pruned in February (47.0%) agrees with other reports concerning the effects of time of pruning on PTSL development (2,14,22). Insu-

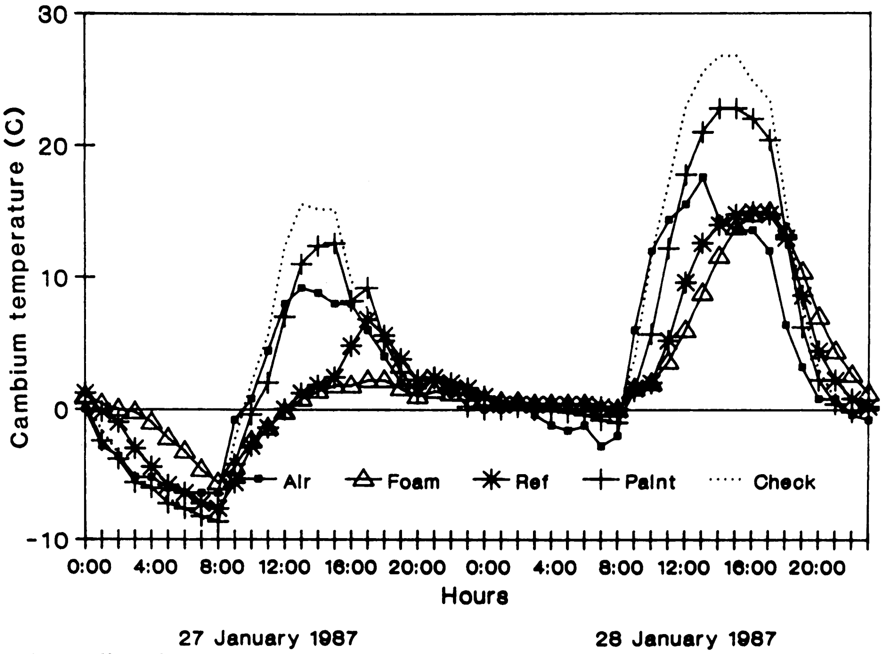

Fig. 2. Effect of trunk wraps on peach tree cambium temperatures in orchard 3 in 1987. Foam = Armiflex foam insulation, ref = plastic bubble bonded with aluminum foil on both sides, paint = white exterior latex paint, and check = noninsulated trees.

Table 1. Chi-square analysis on the effect of insulation and time of pruning on the percentage of trees with bacterial canker (*Pseudomonas syringae*) in orchard 2

Time of pruning	Noninsulated check	Percent PTSL/Insulation method[a] Paint	Foam	Reflectix
November	62.2	55.5	50.0	63.0
February	53.3	42.2	45.7	46.7
Analysis of contrast		df	χ^2	P
Check vs. paint		1	1.43	0.231 NS[b]
Check vs. Reflectix		1	0.15	0.702 NS
Check vs. foam		1	1.78	0.183 NS
Check/Nov.[c] vs. paint/Nov.		1	0.41	0.521 NS
Check/Nov. vs. Reflectix/Nov.		1	0.01	0.936 NS
Check/Nov. vs. foam/Nov.		1	1.31	0.252 NS
Check/Feb. vs. paint/Feb.		1	1.11	0.292 NS
Check/Feb. vs. Reflectix/Feb.		1	0.40	0.527 NS
Check/Feb. vs. foam/Feb.		1	0.54	0.464 NS

[a]Paint = white exterior latex pain, foam = Armiflex pipe insulation, and Reflectix = plastic bubble bonded with aluminum foil on both sides.
[b]NS = Not significant.
[c]Nov. = pruned in November; Feb. = pruned in February.

Table 2. Chi-square analysis for effects of insulation treatments on percent PTSL in orchards 3 and 4

Insulation[a]/rootstock	df	Percent PTSL Orchard 3 χ^2	Orchard 3 P	Orchard 4 χ^2	Orchard 4 P
Check/Lovell		37.5		0.0	
Check/Nemaguard		···		33.3	
Paint		32.5		23.3	
Reflectix		16.3		43.3	
Foam		26.3		66.7	
Analysis of contrast					
Check/Lovell vs. check/Nemaguard	1	···	···	5.30	0.021 *[b]
Check vs. paint	1	0.44	0.508 NS	0.73	0.392 NS
Check vs. Reflectix	1	8.78	0.003 **	0.63	0.427 NS
Check vs. foam	1	2.31	0.128 NS	0.07	0.787 NS

[a]Paint = white exterior latex paint, Reflectix = plastic bubble bonded with aluminum foil on both sides, and foam = Armiflex pipe insulation.
[b]* = Significant at the 0.05 level of probability, ** = significant at the 0.01 level of probability, NS = not significant.

lation treatments did not significantly affect PTSL development compared with noninsulated check trees pruned in November or February (Table 1).

In orchards 3 and 4, there were no visual symptoms of bacterial canker, and tree deaths were attributed to cold injury. Because Reflectix and foam resulted in similar cambium temperatures, they should have given similar control of PTSL. Reflectix, however, was the only treatment to significantly decrease PTSL compared with noninsulated check trees and only in orchard 3. The incidences of PTSL in orchard 3 were 16 and 38% for Reflectix and noninsulated check trees, respectively (Table 2). In orchard 4, however, Reflectix resulted in the greatest percentage of PTSL (43.3%). Neither paint nor foam insulation significantly decreased PTSL compared with check treatments in orchards 3 or 4 (Table 2).

Nematode population densities were not determined in orchard 3, but in orchard 4, *C. xenoplax* did not appear to affect the relative incidence of PTSL in trees on Nemaguard rootstock. The mean *C. xenoplax* population numbers in each of the insulated treatments and for noninsulated trees on Nemaguard rootstock were greater than 3,000 per 100 cm^3 of soil. Noninsulated check trees on Lovell rootstock did not develop PTSL, although *C. xenoplax* population numbers were large (2,000 per 100 cm^3 of soil). The lack of consistent control with Reflectix insulation and the failure of foam insulation to decrease PTSL clearly shows that decreasing maximum cambium temperatures had no effect on the severity of PTSL in orchards with large *C. xenoplax* populations. In orchard 4, none of the insulation treatments on Nemaguard rootstocks compared favorably with noninsulated trees planted on Lovell rootstock (Table 2).

The original hypothesis was that high trunk cambium temperatures during sunny days decrease tree dormancy and increase susceptibility to cold damage and PTSL. The results from the preliminary test in orchard 1 seemed to support this hypothesis. Orchard 1 was a non-PTSL site with trees on Lovell rootstocks. Under these conditions, PTSL would be less likely to develop, yet high cambium temperatures or large temperature fluctuations under clear plastic resulted in symptoms similar to PTSL. If this hypothesis is correct, however, then greater regulation of trunk temperatures than was achieved in the test is required. The Reflectix and foam insulation reduced maximum cambium temperatures by 12–15 C compared with the noninsulated trees but did not affect PTSL development. This indicates that trunk insulation should not be recommended in the Southeast. Minimum nighttime temperatures were not affected by insulation, and the minimum night temperatures may be a more important factor in PTSL development than maximum day temperatures.

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