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Peach Tree Short Life: A Complex of

Peach trees (*Prunus persica* [L.] Batsch) have a relatively short life span compared with other deciduous fruit trees. Peach orchards, although known to survive 25–30 years in North Carolina and other southeastern states, frequently are lost in the third or fourth year after planting. Trees planted in sandy soils or old orchard sites have not survived as well as trees planted in clay soils or land in which peach trees have not been grown previously. The productive life of an orchard in sandy soils is 4–10 years and in clay soils, about 10–15 years.

Certain cultural practices and environmental factors greatly influence the occurrence of peach tree death. For instance, the possibility of tree death from the bacterial canker–freeze injury complex is greater with root-knot-resistant rootstocks (Shalil, Yunnan, S-37, and Nemaguard) than with root-knot-susceptible rootstock (Lovell). The practice of pruning trees in November or December, rather than in February or March, markedly increases the probability of injury if a sudden drop in temperature follows warm weather during the dormant season.

Peach Tree Short Life Defined and Misuse of Other Terms

The term "peach tree short life" (PTSL) has been misused to refer to the death of trees caused by anything, known or unknown. In the early 1970s, the Peach Tree Short Life Work Group agreed to restrict use of the term to the disease syndrome characterized by collapse and death of trees above the soil line in late winter and spring following freeze injury and/or bacterial canker (caused by *Pseudomonas syringae* van Hall). Bacterial canker-damaged or freeze-injured bark is invariably invaded and colonized by *Cytospora* canker fungi (*Leucostoma persoonii* [Nits.] Hohnel and *L. cincta* [Pers. ex Fr.] Hohnel).

Other terms that have been used synonymously with peach tree short life—peach tree replant problem, peach tree decline, and peach tree survival—are often indefinite and misleading because interpretations differ and ideas conflict. In many situations more than one agent or causal factor is involved, and some merely contributing or predisposing factors are implicated as the causal agent. For instance, pruning in November or December has been described as causing peach tree death. Fall pruning may increase tree death from freeze injury and/or bacterial canker but does not kill trees. The term "peach tree replant problem" in a broad sense refers to all causes of poor growth encountered in planting a new peach orchard on the same site as an old one. In a narrow sense, the term could refer only to unknown or unexplainable factors causing stunting or poor growth of young trees planted on old sites. For some, stunting or death of young trees from root knot (caused by *Meloidogyne* spp.) in an old orchard site might be considered a part of the replant problem. For others, this might be called a peach root-knot problem. The term "peach tree decline" is even more confusing because it fails to convey anything of value to understanding why trees die or survive. "Peach tree survival" might be the term that should be used because it reflects a positive rather than a negative approach. These terms are still being misused, and reports of poor survival of peach trees have been made without the cause of tree death being accurately diagnosed. Thus, the literature on peach tree death must be read carefully to be interpreted accurately.

Symptoms of PTSL

Trees that were apparently healthy the preceding fall may collapse suddenly after bloom and foliation in early spring as though individual branches or the entire tree is experiencing a water deficiency. Frequently, affected trees fail to bloom or leaf out, and symptoms are sometimes delayed until late spring or early summer.

Trees are killed only to the soil line. Later in the spring, new shoots may grow from the base of the tree. Droplets of yellow or orange exudate often ooze from the bark on the trunk, crotch, and branches (Fig. 1). Removal of the outer bark reveals discolored inner bark, cambium, and xylem. A "sour-sap" odor is often associated with this discolored tissue. Such less obvious symptoms and signs as water-soaked appearance of twigs, exudation from lenticels, shot-hole borer holes, cracks in the bark, and discolored cambial tissue may be observed several weeks before bloom. Trees with these early symptoms may never bloom or leaf out, may show typical PTSL symptoms, or may grow as if healthy.

Direct Causes of the Syndrome

The sudden early spring death of trees that appeared healthy the preceding fall has been described as mysterious or of unknown cause. Actually, it is mysterious only if the dying trees are not carefully examined at the proper time—just as symptoms first appear. The immediate causes of tree death are now recognized and function either singly or in combination. The PTSL syndrome can result from freeze injury, from *P. syringae* (bacterial

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Interacting Factors

canker), or from both; injured tissue is commonly invaded and colonized by *Cytospora* spp.

Freeze injury. Injury from freezing is a common phenomenon in the northern peach-growing regions of the United States, where temperatures of −18 to −16 C (0 to −15 F) may cause fruit bud loss without further tree injury. In the Southeast, minimum temperatures are seldom below −18 C (0 F), yet severe injury to the tree can occur without

Fig. 1. Droplets of orange exudate oozing from bark on the trunk, crotch, and branches of a freeze-injured peach tree.

Fig. 2. Discolored tissue and separated bark caused by severe freeze injury.

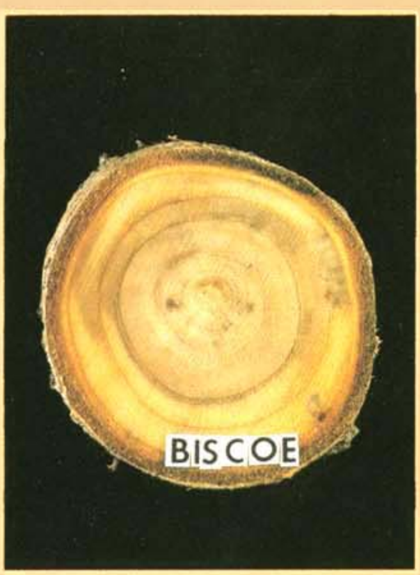

Fig. 3. Grayish areas associated with or between annual growth rings in cross section through the trunk of a peach tree represent several years of freeze injury.

Fig. 4. Peach tree with bacterial canker caused by *Pseudomonas syringae*.

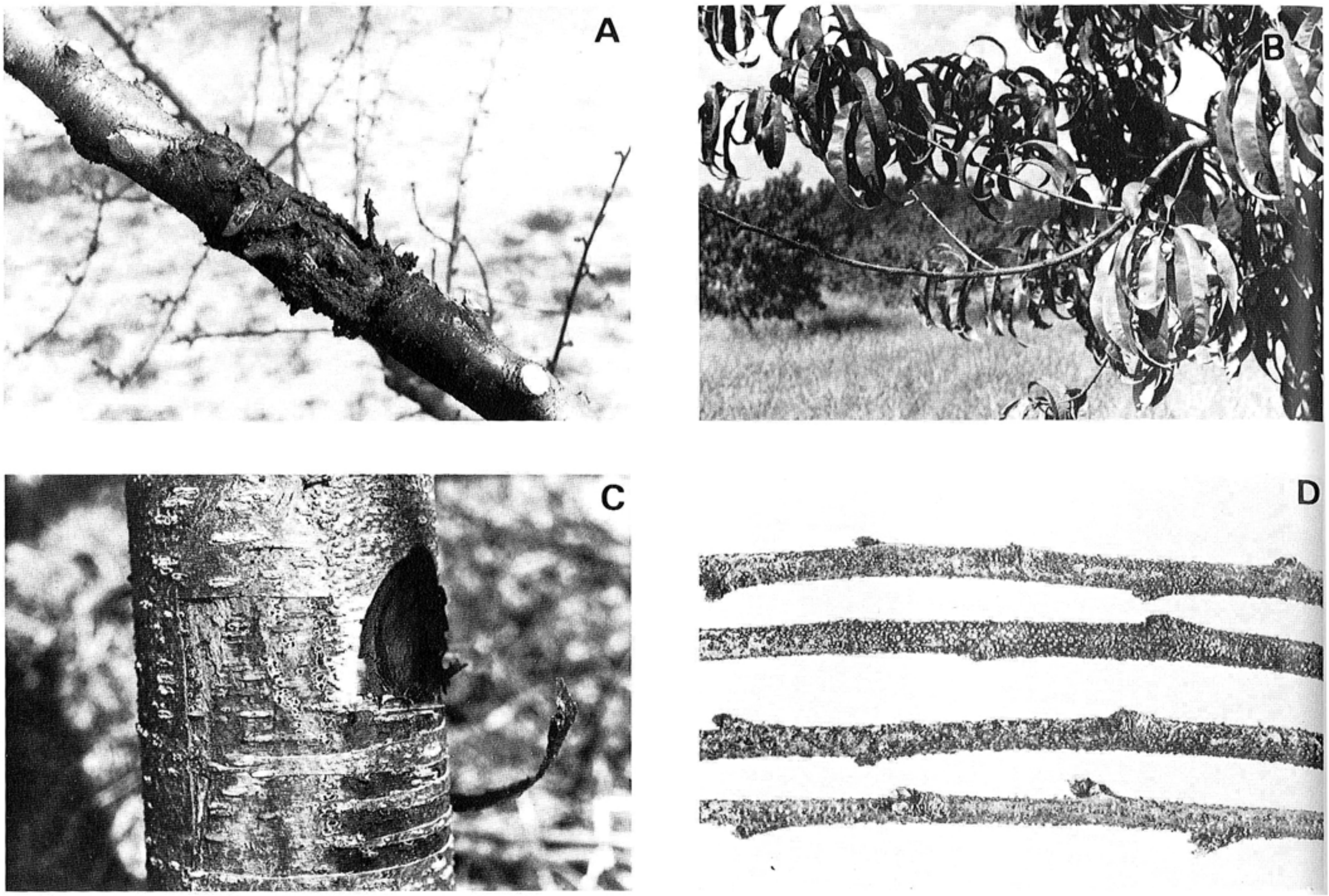

Fig. 5. Symptoms of *Cytospora* infection of peach trees include (A) perennial canker, (B) twig dieback, and (C) bark invasion on trunk. (D) Sporulating pycnidia on twigs.

Table 1. Relationship between rootstocks and death of trees from peach tree short life in 10 experiments at Sandhills Research Station, Jackson Springs, NC[a]

Experiment number[b]	Age of trees (yr)	Percent of dead trees on seedling rootstocks	
		Lovell[c]	Nemaguard[d]
1	8	25	78
2	6	0	75
3	8	20	90
4	5	20	55
5	8	5	60
6	3	2	16
7	8	0	...[e]
8	8	0	90
9	8	30	95
10	5	0	55

[a] C. N. Clayton, unpublished.
[b] Experiments were conducted over a period of three decades using hundreds of trees.
[c] Root-knot susceptible.
[d] Root-knot resistant.
[e] Nemaguard was not included in this experiment.

significant fruit bud damage. To accurately diagnose freeze injury, observations must be made during the early stages.

Freeze injury causes a generally widespread brown discoloration of the cambial layer beneath the bark. When the injury is severe, the bark is easily separated from the wood (Fig. 2). Warm periods conducive to physiological activity in the tree are common during the winter in the Southeast. Also, extended periods of soil freezing usually do not occur. Generally, the top few centimeters freeze during the night and thaw during the day, and root activity continues throughout the winter. Some of the most severe tree losses occur in January or February when temperatures reach 22 C (72 F) or higher for several successive days, then drop rapidly to the low 20s F (−6 C) or lower (9,11).

Studies have shown that cold hardiness can be influenced by such cultural factors as fall pruning (2,3,8,12), soil fumigation (8,17), rootstocks (16,17), and nitrogen levels (9). Even though freeze injury can kill trees outright, those with extensive cambial tissue injury often survive and grow as if unaffected. A cross section through the trunk of one such tree (Fig. 3) shows that approximately 20% of the cambial tissue was injured during the first winter after planting and 90% during the second winter. Yet growth was substantial during the third and fourth seasons, and the tree did not die until the beginning of the fifth season. Such observations suggest that tree survival after freeze injury sometimes depends on other factors.

Bacterial canker. *P. syringae* is an ubiquitous phytopathogenic bacterium that causes disease of many herbaceous plants and canker or blast of most *Prunus* spp., including peaches. *P. syringae* kills dormant peach buds, twigs, branches, and trees (4,5,10) (Fig. 4). Bacterial canker symptoms must be observed during the early stages to be distinguished from those of freeze injury. Like freeze injury, bacterial canker affects only the tree above the soil line. Infected bark is reddish brown and cankers are elongated with a definite margin, differentiating diseased bark from apparently healthy bark. Peach trees predisposed by freeze injury, nematodes, or other factors are more susceptible to *P. syringae* infection. In many instances, the data suggest that predisposition is necessary for infection (4–7,10,14).

Cytospora. *Cytospora* is generally considered a secondary invader of damaged tissue rather than a primary invader of healthy, intact trees. Several symptoms are associated with *Cytospora* infection: 1) the perennial canker phase (Fig. 5A), 2) the dieback phase on twigs (Fig. 5B), and 3) the bark invasion phase on the trunk and major limbs (Fig. 5C). In North Carolina, *Cytospora* invariably invades and colonizes bark damaged by freezing or bacterial canker. When this occurs in the trunk, crotch, or major limbs, the tree is usually dead within a month or so. Under moist conditions, the surface of infected tissue is nearly covered with cirri extruding from the pycnidia just beneath the bark surface (Fig. 5D).

Factors Contributing to PTSL

The major factors contributing to or increasing susceptibility of peach trees to freeze injury and bacterial canker are: 1) rootstocks, 2) time of pruning, 3) preplant and postplant soil fumigation, 4) nematodes, and 5) inherent characteristics of the orchard site. The two that have contributed the most to—but not caused—death of peach trees from PTSL in the Southeast during the past four decades are the use of root-knot-resistant rootstocks and the practice of pruning before January.

Rootstocks. Root-knot nematodes (*Meloidogyne* spp.) are present throughout the Southeast in many old peach sites and cultivated sandy soils. If not controlled, they will stunt or kill young peach trees and reduce the yield of trees that survive. Preplant soil fumigation greatly reduces root-knot nematode populations but does not eradicate them. Thus, when susceptible rootstocks are

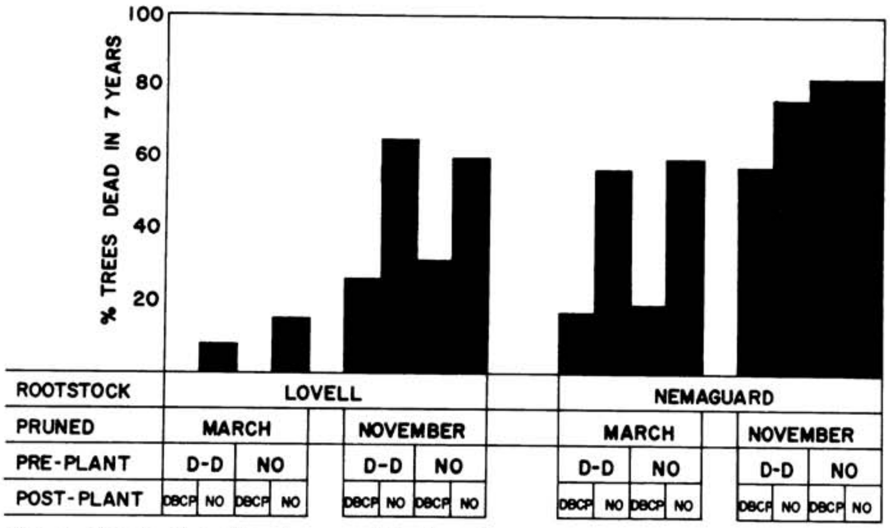

Fig. 6. Effects of root-knot-susceptible (Lovell) vs. root-knot-resistant (Nemaguard) rootstocks, spring (March) vs. fall (November) pruning, preplant soil fumigation with D-D vs. no preplant fumigation, and postplant fumigation with DBCP vs. no postplant fumigation on tree survival in an old peach orchard site. (From *Fruit South*, January 1977)

planted in such soil, root knot can again become a serious problem within a few years. Therefore, root-knot-resistant rootstocks should be highly advantageous. During the past 40 years, several root-knot-resistant rootstocks (Shalil, Yunnan, S-37, and Nemaguard) were introduced. Trees propagated on these rootstocks, however, were more susceptible to what is now termed PTSL (Table 1, Fig. 6). Nemaguard has performed well in some areas, including Florida and California, possibly because of fewer freeze-injury problems (13). Root-knot-resistant rootstocks are more affected by ring nematode (*Macroposthonia xenoplax* [Raski] Loof and De Grisse), freeze injury, and bacterial canker than are root-knot-susceptible rootstocks such as Lovell (7,17).

Time of pruning. Pruning trees before January (fall pruning) has been associated with tree death the following spring (3,9,12) (Fig. 6). Sometimes trees can be fall-pruned and suffer no adverse effects, but these years are unpredictable. Fall pruning appears to interfere with dormancy in peaches through stimulation of indole-3-acetic acid production (2). Wounds from fall pruning have shown partial healing in midwinter, indicating active cambium, which is very sensitive to freeze injury. Fall-pruned trees might be predisposed to *P. syringae* or *Cytospora* infection either directly through the pruning wounds or indirectly by increased tree susceptibility to freeze injury.

Soil fumigation. Preplant and postplant soil fumigation of sites where peach trees died has been very effective in preventing PTSL (Figs. 6 and 7) (8,17). Preplant soil fumigation with dichloropropane-dichloropropene mixture (D-D), ethylene dibromide (EDB), or 1,2-dibromo-3-

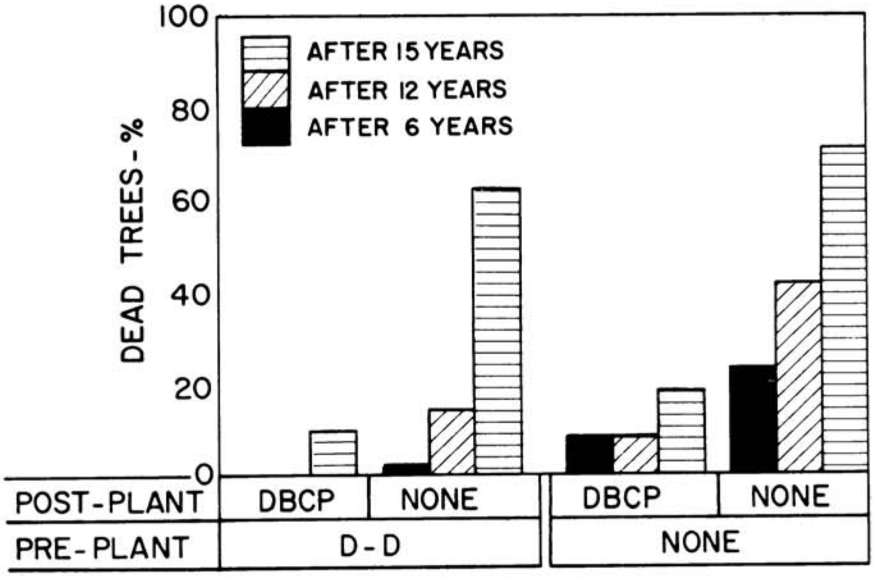

Fig. 7. Effects of preplant fumigation with D-D and postplant fumigation with DBCP on survival of Coronet peach trees on root-knot-susceptible Lovell rootstock over a 15-year period. (From *Fruit South*, January 1977)

chloropropane (DBCP) reduces nematodes to a level that allows trees excellent growth during their early years. Fumigants with broad-spectrum activity may provide additional benefits. Use of chloropicrin or methyl bromide, for instance, improves growth of trees propagated on root-knot-resistant rootstocks.

For maximum tree survival, postplant soil fumigation treatments with DBCP are needed every 2–3 years (Fig. 8). DBCP can be applied to the root zone of living plants without harming the roots and still provide nematode control. In the last 10 years, the use of DBCP in peach orchards has been suspended or canceled twice by the Environmental Protection Agency; the suspension issued in October 1979 is still in effect. No other available postplant chemical protects trees against PTSL as effectively as DBCP.

Nematodes. Numerous species of nematodes have been detected in association with peach roots. The most common are root-knot (*Meloidogyne* spp.) and ring (*Macroposthonia xenoplax*) nematodes (1). The three major species of *Meloidogyne* affecting peaches are *M. incognita* (Kofoid & White) Chitwood, the most widespread of the three; *M. javanica* (Treub) Chitwood; and *M. arenaria* (Neal) Chitwood. Root-knot and ring nematodes are more prevalent in the sandy soils of the southeastern United States than in clay soils.

Root-knot nematodes in old peach orchards and cultivated sandy soils kill or stunt young trees and reduce the yield of surviving trees. Whereas the symptoms of the root-knot nematode are very obvious on infected roots, the damaging effects of the ectoparasitic ring nematode are more subtle, being primarily restricted to necrosis and suppression of growth of young feeder roots (6,17). High populations of ring nematodes associated with the root systems increase the susceptibility of trees to bacterial canker and freeze injury (6,12,15,17). This situation could be interpreted as evidence that PTSL is a complex, involving many interacting factors.

Orchard site. PTSL is more common on land where peaches had been grown previously, or old cultivated land, than on newly cleared land (9,15,16). This fact has led to the hypothesis that predisposing factors persist on cultivated land and old peach orchard sites after tree removal, making new trees more susceptible to *P. syringae* infection and freeze injury. Soil pH may be one such factor. Some soils in southeastern peach orchards commonly have a pH of 4.8–5.2, and liming them enhances tree growth and vigor. Furthermore, soil pH may affect root growth, soil and root microflora, nematodes, and susceptibility to *P. syringae* (14). Physical structures of the soil, such as a hardpan, may also deter tree growth and survival. Inherent characteristics in an orchard site affect tree growth and survival, but whether they also contribute to tree death resulting from PTSL remains to be proved.

The PTSL Work Group

Although millions of trees had died previously, the death of more than 500,000 peach trees, primarily under 6 years of age, in Georgia, North Carolina, and South Carolina during 1972–1973 was the reason representatives from these three states met at Clemson, SC, on 15 and 16 June 1972 to discuss the problem. From this meeting the Peach Tree Short Life Work Group (PTSLWG) was formed and the term "peach tree short life" devised. The group again met at Southern Pines, NC, on 14 and 15 September 1972. A news release was drafted defining the problem and proposing possible causes and controls based on research that had been conducted in the individual states. In a meeting at Byron, GA, in April 1973, the PTSLWG outlined what is now known as the 10-point program (Table 2) based on research developed in the cooperating states and the United States Department of Agriculture. The practices outlined in

Fig. 8. Trees growing in soil fumigated with DBCP (right) compared with trees growing in soil not treated by postplant fumigation.

Fig. 9. Peach tree short life site (left) in 1968 with 10-year-old trees and (right) in 1978 with 9-year-old trees, after use of recommended controls.

this program are beneficial not only in controlling PTSL but also in establishing and maintaining long-lived, economically productive peach orchards. The PTSLWG has continued to meet annually in conjunction with the Southeastern Professional Peach Workers Conference. These meetings provide a setting for peach research and extension personnel, on a regional basis, to keep abreast of the current status of annual tree losses and to present new research information relating to causes, development, and control of PTSL.

Table 2. The 10-point program for controlling peach tree short life[a]

1. Apply lime before planting to adjust pH to at least 6.5.
2. Subsoil before planting to break up hardpans and promote improved root development.
3. In sandy soils where peach trees have been planted previously and in other soils where nematodes are a problem, fumigate the soil before planting.
4. Plant trees that have been grown in fumigated soil or certified to be free of nematodes.
5. Plant trees propagated on Lovell rootstock. (Halford rootstock has also performed well in southeastern research plots.)
6. Apply nutrients and lime as needed based on soil tests, foliar analyses, and local recommendations.
7. Prune as late as possible, never before January 1 and preferably after February 1. If earlier pruning is unavoidable, prune older trees first. Early pruning is especially hazardous on old peach tree land. Discontinue summer pruning (including topping and hedging) by September 15.
8. Use recommended herbicides for weed control. Keep cultivation (if needed) shallow to avoid root injury.
9. In sites where preplant fumigation is necessary, postplant fumigate at approximately 2-year intervals or as indicated by nematode populations.
10. Promptly remove and burn all dead or dying trees.

[a] With the exception of point 9, this program is currently recommended not only to control PTSL but also to establish and maintain a long-lived, productive peach orchard.

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Regional Project S-97

The PTSLWG members realized that PTSL was related to several factors and that rootstocks were an important component. Independent rootstock projects that existed in a few of the southeastern states concentrated primarily on root-knot-nematode resistance and general vigor. The PTSLWG initiated development of a regional peach rootstock project, and in 1974 Southern Regional Project S-97, "Development and Evaluation of Peach Rootstocks," was approved. The three major objectives were to: 1) evaluate promising existing *Prunus* rootstock material for desirable characteristics necessary for peach production in the Southeast, 2) breed to improve peach rootstocks by combining desirable characteristics of *Prunus* rootstock material, and 3) develop procedures for testing and measuring the characteristics necessary in a superior rootstock. Because the development and evaluation of peach rootstocks can involve decades, it was emphasized that this should be a long-term project.

In 1976, uniform, standardized plantings of two cultivars on eight seedling rootstocks were established in Alabama, Arkansas, Florida, Georgia, North Carolina, and South Carolina. This was the first uniform comparison of peach rootstocks regionally. During the early stages of this project, standardized techniques for evaluating different peach rootstock characteristics were developed. Current members of the project represent Alabama, Arkansas, Florida, Georgia, Indiana, Missouri, North Carolina, South Carolina, Tennessee, and the USDA.

Future Directions

Research during the last 30 years has shown that peach trees can be grown successfully on old peach orchard sites (Figs. 6, 7, and 9). A major reason for this success was postplant treatment of soil with DBCP every 2–3 years. If the use of DBCP is permanently banned and no effective substitute is found, the life span of peach trees in old peach sites will decline to the level where orchard replacement costs and investments will be greater than can be recovered during the productive years. In the Southeast, every chemical that has shown nematicidal activity and can be used without tree injury has been or is being tested. So far none is comparable to DBCP.

Better understanding of how predisposing factors interact with direct causes of PTSL is essential to designing productive experiments and correctly interpreting the results. PTSL must be understood as the result of not just a single factor but of a complex of interacting factors.

A major step toward solving PTSL would be a nematode-resistant rootstock that produces a vigorous, productive, long-lived, healthy tree. To develop such a rootstock will require a long-term, coordinated effort like Project S-97.

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