FACTORS CONTRIBUTING TO EARLY DECLINE OF PEACHES IN SOUTH CAROLINA

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ABSTRACT

Detailed health surveys were made on 36,630 peach trees in 39 orchards 4 years old and older in Edgefield County, South Carolina. Estimated productivity decreased sharply with increasing age of trees. Losses of bearing limbs in young trees apparently were caused mainly by agricultural implements and fruit overloads. Later limb losses and trunk deterioration apparently resulted from the weakening effects of wood-rotting fungi, canker-producing bacteria, and other pathogens. Thirty-five percent of the trees had no signs of weakness, disease, or major injury; 26% were in a state of decline (seriously weak, diseased, or badly damaged); 12% had severe localized damage to limbs, trunk, or both; 20% had been lost; and 7% were new trees planted where a tree had been lost. Growers eliminated orchards when they had lost 60% or more of their estimated productivity. The potential productivity of the trees that remained, as well as the percentage of the trees lost, apparently were factors that growers considered to be important.

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The average age of commercial peach (Prunus persica) orchards in Edgefield County, South Carolina, where this study was made, is a little more than 6 years. Extensive losses have occurred in the past in that county and other counties of the State, and special efforts have been made recently to apply a management system to avoid them (1). We studied the general conditions in orchards in potential full production, and the relative importance of factors that reduce their productivity.

MATERIALS AND METHODS

The peach area evaluated lies in the Atlantic Coastal Plain and includes nearly level, undulating, hilly, and broken areas. It has a mean annual temperature of 17.6° C; short, mild winters; long, warm summers; and, usually, well-distributed and adequate rainfall (2).

We used as aids in our study previous records of orchard histories, data on populations of ring nematodes (Macroposthonia xenoplax (Raski) Loof de Grisse), county soil maps, and aerial color infrared photographs of the orchards taken in May 1975 and May 1976. Analysis of the data was facilitated by the use of computers. No yield data were available to estimate productivity losses; we assumed that symptomless trees lost no productivity, those in decline lost 25%, and those trees with missing limbs lost productivity in direct proportion to the percentage of total limbs lost. When trees were both in decline and had limbs missing, the two appropriate deductions were totaled. Old replants were assigned a productivity loss of 25%; recent replants, 50%; and trees with trunk damage only, 0%. Productivity loss of dead or missing trees was considered to be 100%.

Summer survey, July-August 1976: The 24 km^2 that constitute the commercial peach area of the county had 402 orchards 4 years old and older. The 39 orchards were chosen from a random-order list by selecting every tenth orchard on the list. In these orchards, two persons on opposite sides of each tree recorded any sign of disease, major injury, or weakness. Each tree was listed according to its position in the orchard. Observations for 36,630 tree positions were recorded.

Winter survey, November 1976-January 1977: Soil types, erosion, drainage, subsurface water levels, and topography of each orchard were observed and outlined on aerial photographs. The data were compared with those of the 1976 summer survey to determine whether there was

any association between the characteristics and the distribution of death, disease, and major injury. Samples were taken of fruiting bodies of fungi associated with wood rots in limbs and trunks and were sent for identification to J. L. Lowe, Syracuse University.

Spring survey, March-May 1977: A detailed count was made of present and missing scaffold limbs of each tree. Cankers, presumably caused by *Pseudomonas syringae* van Hall, were noted as bacterial canker when the canker affected a small portion of a tree, and when the bacterial infection was associated with death of most or all of the tree. This lethal condition, short life, is the result of a combination of the bacterial infection, nematode and cold damage, and other factors (1, 3, 5).

Summer survey, June 1977: Six orchards 4 to 6 years old that had been evaluated the previous summer were re-evaluated to detect changes in their condition. A detailed survey of two different orchards was also made to determine the incidence of crown galls caused by *Agrobacterium tumefaciens* (Smith & Townsend) Conn at the base of each tree.

RESULTS AND DISCUSSION

General characteristics: The 39 orchards we studied were well distributed throughout the 24 km^2 area, and their ages followed closely the distribution found in the entire population (Fig. 1A). There was a steady and sharp decrease in numbers of orchards with increasing age. In the summer of 1976, 35% of the trees in the 39 orchards had no outward signs of weakness, disease, or major injury; 12% had severe localized damage to limb, trunk, or both; 26% were in a state of decline (seriously weak, diseased, or damaged); 20% had been lost; and 7% were new trees planted where a tree had been lost (Fig. 1B).

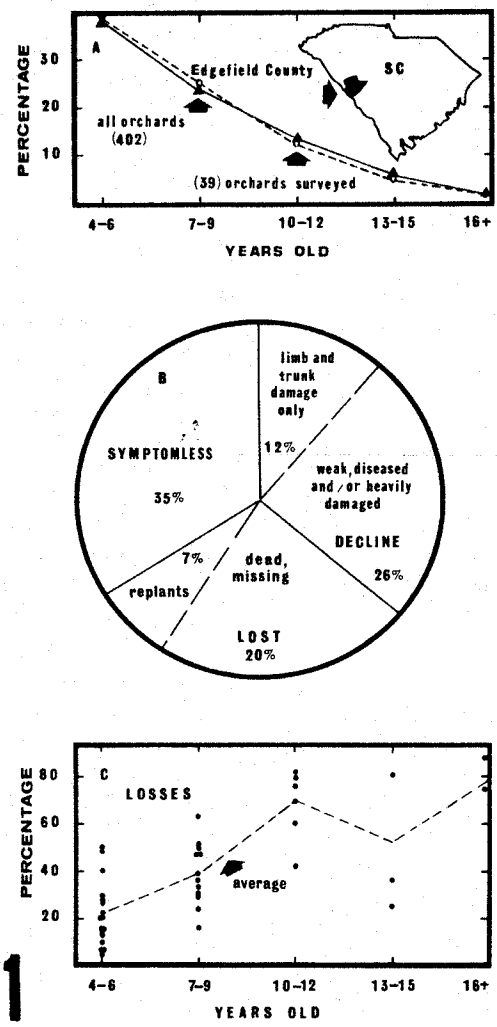
Estimated losses in productivity increased rapidly with age of the orchard. Estimated losses were 20% or less in 11 of the 17 orchards in the 4- to 6-year-old group, but were more than 40% in all orchards in the 10- to 12-year-old group. Estimated losses were more than 70% in 7 of the 11 orchards older than 9 years, and were more than 80% in four of these (Fig. 1C).

Large differences in the characteristics under study were noted among the orchards within an age group as well as between age groups, which made evaluation of contributing factors difficult. The range in productivity losses was wide in the orchards within each age group, perhaps because of the great diversity in orchard histories. The 39 orchards were owned by 22 growers, were located in 10 soil types, and contained 22 fruiting cultivars and four types of rootstocks. Fifty-one percent of the rootstocks were unknown, 18% were of "cannery origin," 25% were cultivar Nemaguard, and 5% were cultivar Lovell. Soil fumigation for control of ring nematodes also varied: 54% of the orchards had no fumigation, 15% had preplant fumigation only, 24% had postplant fumigation only, and 12% had both preplant and postplant fumigation. Of the 27 orchards in which the ring nematode population was known, five had 100 to 199, ten had 200 to 499, eight had 500 to 699, and four had more than 700 ring nematodes per 100 ml of soil.

The analysis of variance and the chi-square test showed no statistically significant relationships between soil population of ring nematodes and "short life" or bacterial canker, or between soil type and general health group (symptomless, in decline, and missing). Significantly ($P < 0.01$) more trees died in areas seriously affected by erosion or poor drainage, and trees that remained in those areas declined significantly ($P < 0.05$) faster than trees in less affected or unaffected areas. Of the trees examined, 6.5% were in areas that were seriously eroded and 8.3% in areas that were poorly drained (a total of 5,438 trees). About 85% of the orchards needed erosion and drainage control in at least part of their area. The possible detrimental effects of less severe soil deficiencies were probably masked by the high variation in other factors.

Age and health: Orchard age appeared to be inversely related to orchard health, especially when orchards were grouped by age. The percentage of symptomless trees decreased most rapidly between ages 6 and 7, ranging from 32 to 92%, 39 to 78%, and 18 to 57% in the 5-, 6-, and 7-year-old orchards, respectively. An average of 13% of the trees in the 12-year-old orchards were symptomless (Fig. 2A).

The average percentage of trees that were in decline varied from 7% in the youngest orchards to 52% in the 12-year-old orchards. Some 7-year-old orchards had less than 6% of their trees in decline, but some 6-, and 7-year-old orchards had 30 and 40% of their trees in decline (Fig. 2B). The average percentage of trees lost ranged from 15 to 37% (Fig. 2C). The largest variations were in orchards aged 5 and 7; these were mainly due to 60% losses in a 5-year-old orchard suffering from severe erosion and to heavy losses in a 7-year-old orchard that in previous years had been used to demonstrate the lethal effects of untimely pruning (3). Usually no new trees were replanted in lost positions in orchards more than 7 years old.



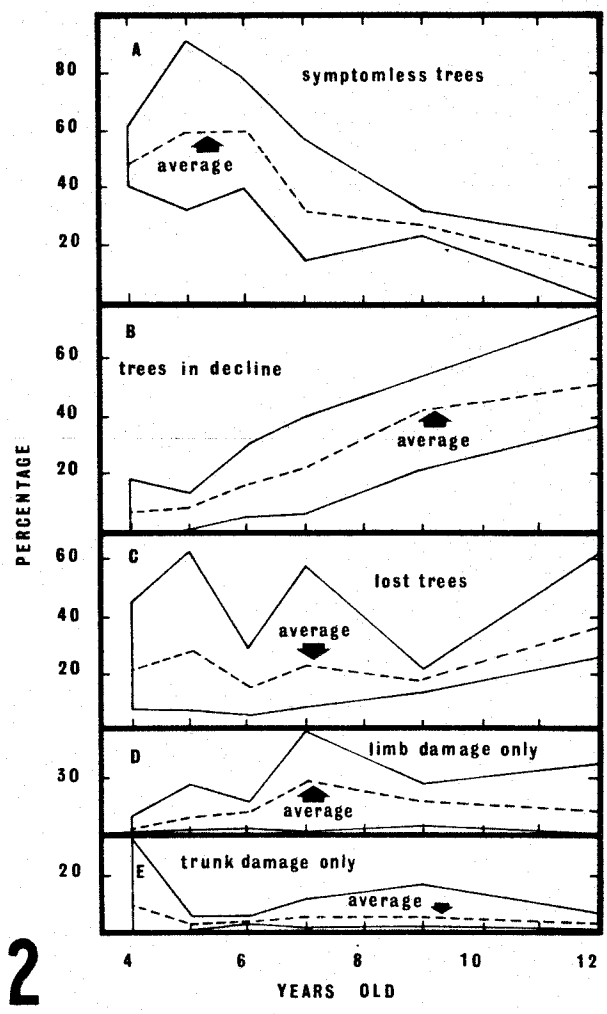


FIGURE 1. A -- Age distribution of peach orchards in Edgefield County, South Carolina in 1976. B -- Proportion of main categories observed in 39 orchards surveyed in 1976. C -- Estimation of productivity losses in orchards evaluated in 1976 and 1977.

FIGURE 2. Distribution of tree characteristics in peach orchards 4 to 12 years old in 1976. A -- Proportion of symptomless trees. B -- Trees in decline. C -- Lost trees. D -- Trees with limb damage only. E -- Trees with trunk damage only.

Trees that had only limb and trunk damage were found in orchards of all ages (Fig. 2D). The average percentage of trees with limb damage only was highest, 17%, with a range of 1 to 36% at age 7. The average decreased to 8% by age 12. Trees with trunk damage only were most numerous at age 4, when the range was 0 to 30% and the average 8% (Fig. 2E). The average percentage of trees with only trunk damage varied little after age 7. The loss of limbs per tree and per orchard in ages 4 and 12 varied on the average from 31 to 39% and 2 to 22%, respectively (Fig. 3A). Variations among individual orchards in regard to limb loss was especially high in those 6 to 9 years old. We noticed a great deal of damage by agricultural implements in the lower limbs of trees 4 to 7 years old. Limb damage and breakage also often resulted from fruit overload. The low tree structure, with limbs arising about 30 to 60 cm from ground level, contributed to this problem.

Early limb damage was soon compounded by the weakening infections of wood-destroying fungi. Wood rots appeared in damaged trees at age 4, and their incidence increased sharply

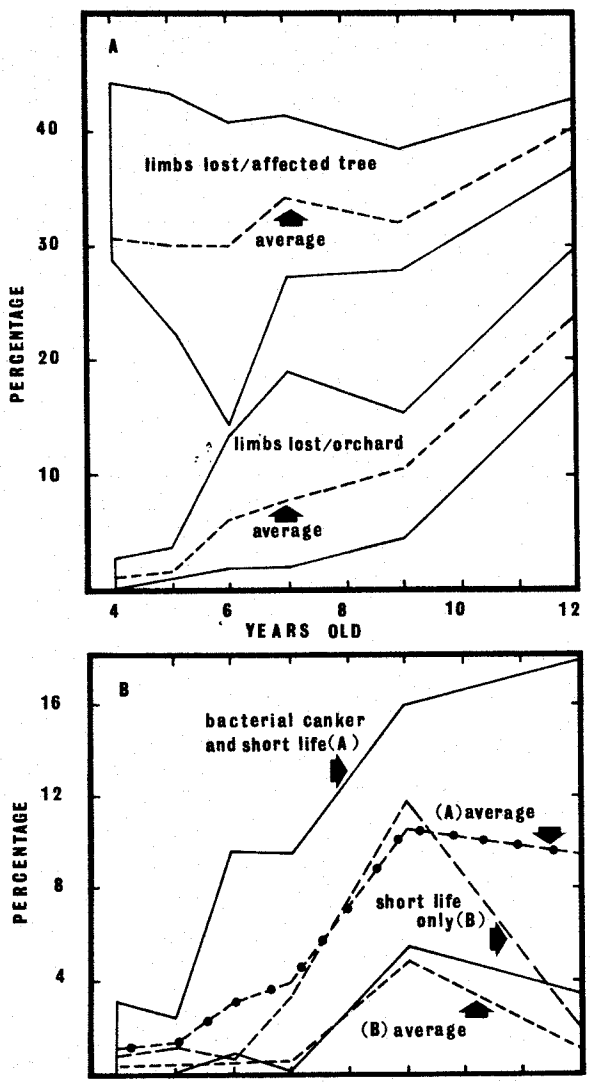


FIGURE 3. A -- Distribution of limb loss per tree and per peach orchard in South Carolina in spring 1977. B -- Distribution of all bacterial cankers in orchards (A) and bacterial canker associated with short life only (B) in 1977.

with tree age. In orchards 9 years old and older, the supporting structure of many trees was weakened enough that a relatively light fruit load caused limb loss or even collapse of the entire tree. Most fungal species associated with wood rots were those already reported by Petersen in peach trees of South Carolina (4).

Much of the limb injury was due to bacterial canker. Sometimes infections were limited to terminal branches or to small portions of the limbs closer to the main tree axis; sometimes the entire limb was affected, or the entire tree died. Prevalence of bacterial canker ranged from 0 to 18%, with an average of 0.8% at age 4 and 9% at age 12. Average prevalence generally increased sharply with age (Fig. 3B). Variation was high, especially at age 6 and above. Bacterial canker associated with death of most or the entire tree was not prevalent during our observations. Of the 39 orchards, 24 had no short life and 8 had less than 1%, and for both years of the study (1976 and 1977) trees affected by short life constituted less than 1% of the total. The prevalence of short life was highest in two orchards that also had high populations of ring nematodes (2500 and 850 per 100 ml of soil), a high prevalence of crown gall (50% of the trees galled near soil surface), and heavy structural damage. The prevalence of short life in these two orchards ranged from 4 to 10% and 2 to 6% during the 2 years of observation, respectively. No statistically significant association was found between prevalence of short life and previous use of the land for peaches.

Of the 274 trees affected by short life, most had crown gall, oak root rot (presumably caused by Clitocybe tabescens (Scop. ex Fr.) Bres.), borers, or heavy structural damage. In some trees all of these conditions were found together. Variation in the death rate from oak root rot was like that found for short life: 22 orchards had none, 13 had less than 1%, and one orchard had 8.3%, for an average of 0.6%. The total prevalence of trees with symptoms of stem pitting, phony, and rosette was less than 0.5%, and was spotty in distribution. Infection by Xanthomonas pruni (Smith) Dowson was widespread, but was serious in only one orchard. Many limbs affected by bacterial canker and trees killed by short life were also infected with Cytospora spp.

1977 findings vs. 1976 findings: The health of the six young orchards surveyed in the summer of 1977 had deteriorated only slightly since the survey the previous summer. There was some increase in structural damage, and some lost positions had been replanted. Bacterial canker and short life remained minimal, but one orchard lost several trees from fruit overload. The trunks of these trees were split to ground level so that the trees would not recover and needed elimination.

Four orchards that had lost 60% or more of their estimated productive capacity had been eliminated. Loss of trees in these orchards had previously ranged from 24 to 62%, percentages not unlike those in some orchards that were not eliminated. The major difference was that orchards that were eliminated contained proportionately more trees in decline. Two other orchards which had sustained large losses because of severe erosion or poor drainage were partially eliminated in 1977. Thirteen percent of the area evaluated was lost from the elimination of orchards by growers, a greater percentage than that lost from disease during our observations.

Our data on the 39 orchards in potential full production are presumably representative of all 402 orchards 4 years old and older in Edgefield County. The data illustrate the high variation in health status in the area, which precluded the satisfactory evaluation of a number of variables such as soil types, soil-water relations, and nutritional deficiencies that are assumed to influence orchard health. A specially designed study is necessary to evaluate these variables.

The death rate from disease was low during our observations, but has been high in this area in other years. The special efforts made by the State and Federal governments in the county were due to a high death rate from short life in the past. New plantings undoubtedly will better reflect the application of improved management practices (1). Our observations suggest that the high incidence of mechanical damage to trees and poor soil conditions contributed much to the rapid deterioration of the orchards. In years when the death rate is high because of short life or other diseases, the vulnerability of the orchards is demonstrated.

The prevalence of crown gall and oak root rot with short life suggests that in this area multiple infections may be important. The effects of the insidious pathogens that cause crown galls and root rots over a relatively long period need study. The effects of severe stresses such as poor draining and erosion were clear in our studies; the effects of less severe but long-term stresses need further evaluation.

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