root growth in the field indicated slight reductions in total root growth in paclobutrazol treatments, but roots were otherwise normal. Fruit color was normal in comparison to checks. Leaf petioles and fruit pedicels and peduncles were greatly shortened. Green leaf color was intensified in treated plants with no apparent phytotoxicity.

Soil application of paclobutrazol to greenhouse grown plants substantially suppressed growth in 'Raritan' with reduced crown, leaf and root dry weights (Figs. 3, 4), compared to foliar application in 1982. The degree of plant growth suppression increased with increasing paclobutrazol, up to 2.0 mg/plant. Similar results were obtained with 'Guardian' (data not shown) except that crown weight was not affected by either foliar or soil application of paclobutrazol. Roots in soil-treated pots generally were normal in color but were reduced in diameter, more numerous with substantially increased numbers of fine roots and root hairs.

In field tests, runner development was inhibited at all application rates in 'Raritan' when applied in July, about 3 weeks after renovation of the planting (Fig. 5). Extent of runner control was directly related to concentration. Runnering was not suppressed by application in mid-August after the initial runners were established and rooted.

Paclobutrazol offers exciting possibilities for strawberry plant growth control, particularly runner control in either matted row or close spaced systems. Field application rates below 0.5 kg/a.i./ha are likely to provide adequate runner suppression and minimize adverse effects on leaf and fruit stem elongation.

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Rating Scales to Assess Cold Injury and Bacterial Canker Development in Peach Trees in the Field

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Additional index words. *Prunus persica*, *Pseudomonas syringae*, peach tree short life, cold hardiness, cambial browning, dormacy

Abstract. **Visual rating scales were developed for evaluating tissue injury in peach trees [*Prunus persica* (L.) Batsch] in the orchard due to cold/winter temperatures and bacterial canker (*Pseudomonas syringae* van Hall) development. The numerical ratings on a scale of 1 to 9 separately describe key stages of damage and its severity due to cold and bacterial canker and are portrayed pictorially for clarity. Accurate estimation of tree status at very early stages of injury and good correlation with ultimate tree survival have been possible through the use of these rating scales. This information has been incoporated in the data collection for a regional research project dealing with the development and evaluation of rootstocks for peach in the southern United States and also is under consideration for use in another regional project involving peach in addition to apple, pear, and cherry.**

Under growing conditions in the southeastern United States, winter/cold injury and bacterial canker development pose the greatest threats to peach tree survival and, in association with certain other factors, comprise the syndrome known as peach tree short life or PTSL (1, 7). Although a number of attempts have been made to reproduce and quantify these 2 problems in the laboratory, results do not correlate reliably with field observations. Therefore, it has been necessary to obtain quantitative information on tree status in the field, with the goal of evaluating the extent of tissue injury from the earliest possible date following its occurrence.

Information on the extent and intensity of discoloration of peach trunk cambial areas due to cold has been reported (6), where the ratings ranged from 1 = dead or nearly dead tissue to 5 = no discoloration, indicating healthy tissue. The authors did not present information distinguishing between injury from cold and that from bacterial canker. A scale from 0 to 5 for natural tissue browning of apple bark due to cold injury also has been described (4). This scale was based on death of portions of the tissue area, with 1 = death of 10% to 20% area, and 5 = death of 80% to 100% area. A recent report (5) on sweet cherry (*Prunus avium* L.) and its resistance to bacterial canker caused by *Pseudomonas mors-prunorum* Wormald, established 4 distinct classes of seedling resistance to the pathogen, where class I indicated no canker damage on tissue and class IV signified severe tissue damage.

These rating scales lack precision, since the categories or classes used are broad, subjective and greatly influenced by the evaluator's judgement. A rating system based on a scale from 1 to 9 (0 = no data) reported by Fogle (3) for evaluating fruit tree performance, seems to be precise, adequately detailed, and logical for use with modern data handling systems. In practice, accurate estimation of tree damage status at a very early stage of injury and good correlation with ultimate tree survival have been possible through the trunk cambial browning (TCB) and bacterial canker (BCR) ratings on a 1 to 9 scale (2, 7, 8). This article provides descriptive details of key stages of damage severity and portrays these stages pictorially for further clarity (Table 1, Fig. 1 and 2).

Experience has shown that peach trees should be examined for cold injury and bacterial canker damages in late winter following completion of the rest period (physiodormancy), when temperature fluctuation typically promotes tree dehardening. A 2nd examination, usually for confirmation, should be made after new shoots have begun to elongate, at which time most bacterial canker damage will have appeared to eliminate confusion between cold and/or canker damage. The procedure for tissue ex-

Received for publication Mar. 12 1984. This research was financially supported by the USDA/CSRS project 701-15-04E of the Fort Valley State College. The authors acknowledge the cooperation of the USDA/ARS, S.E. Fruit & Nut Research Laboratory, Byron, GA 31008. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.

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Colour

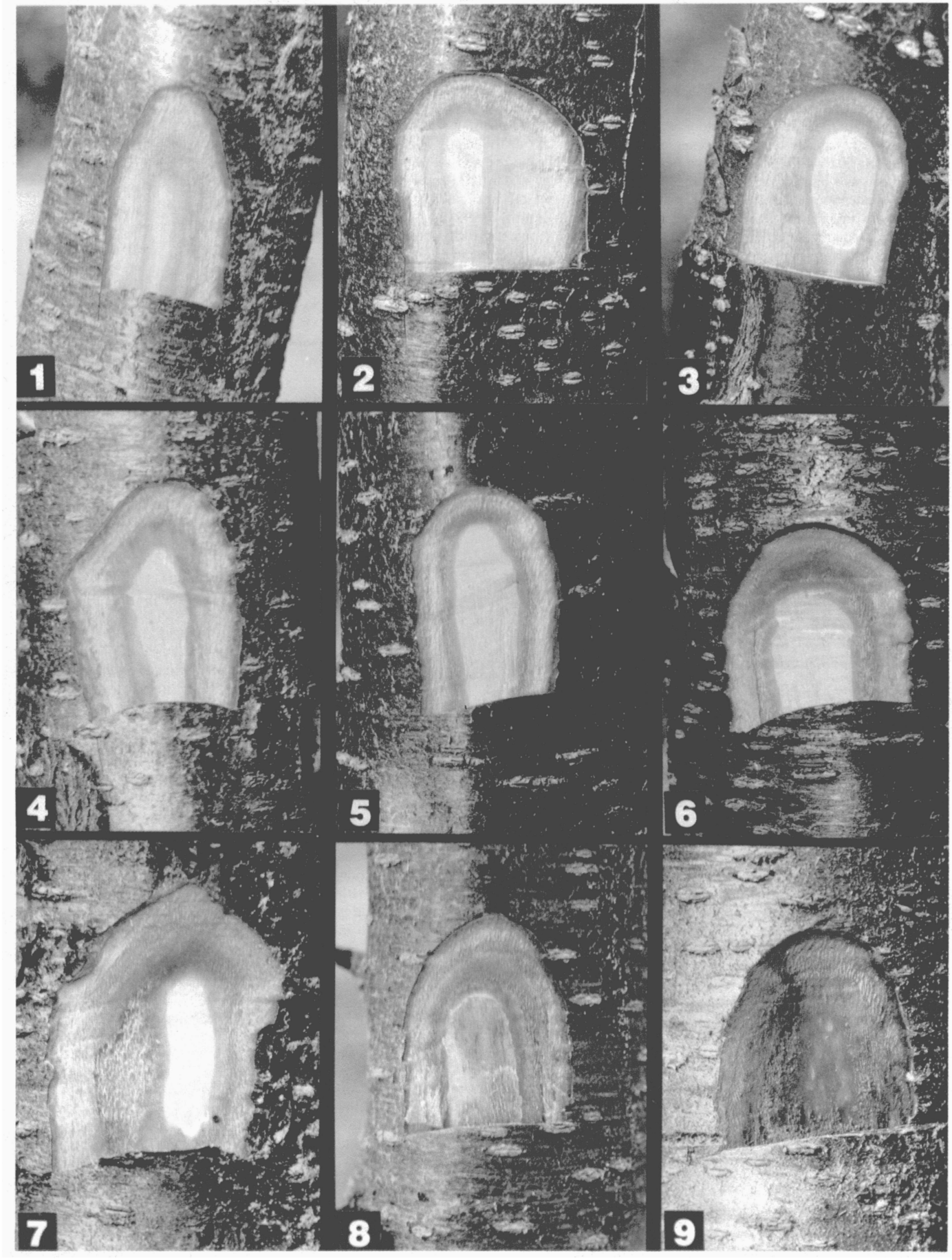

Fig. 1. Stages of cold injury to peach tree trunks as expressed by trunk cambial browning (TCB) ratings on a scale of 1 to 9. See Table 1 for explanation of this scale.

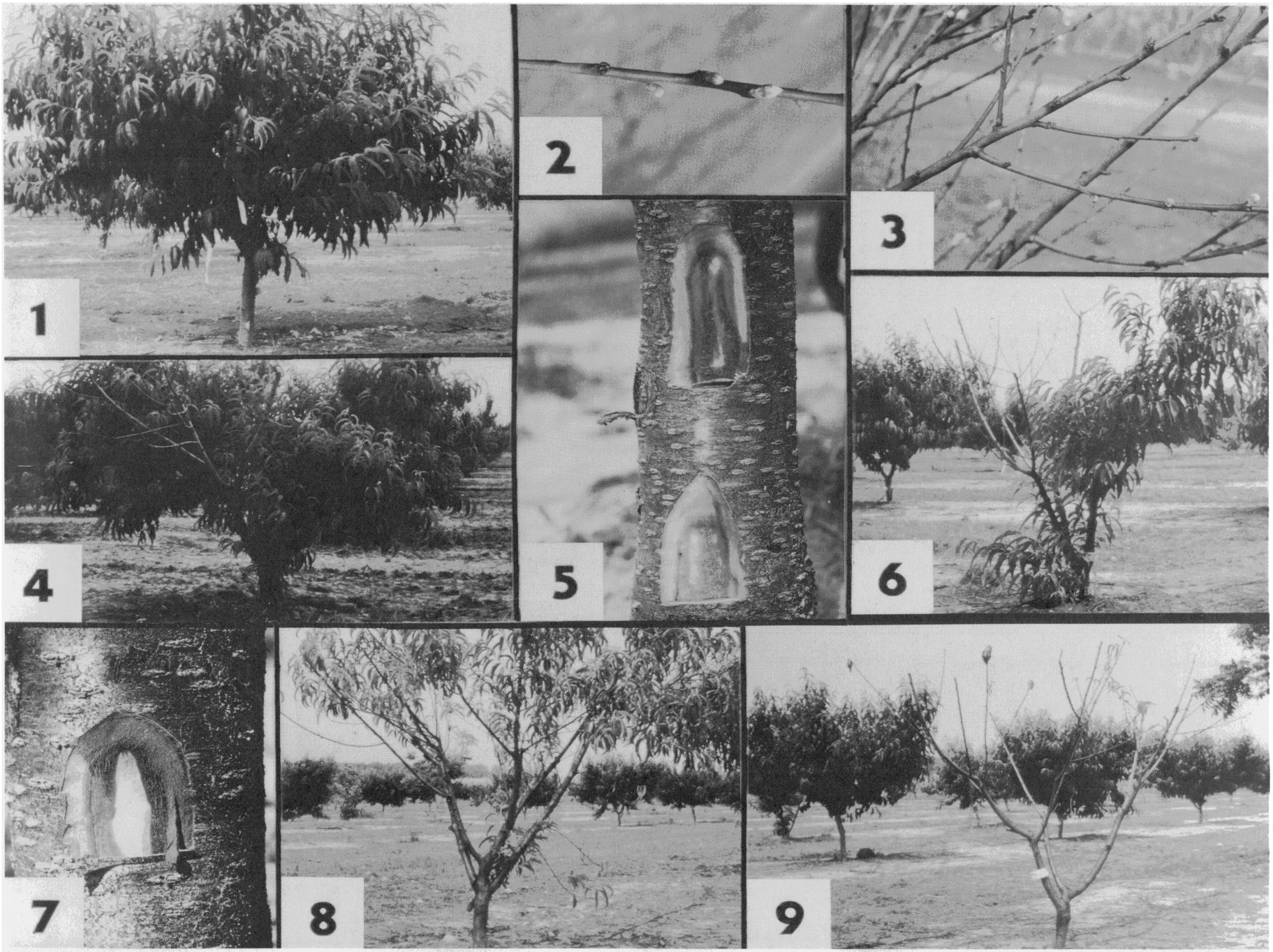

Fig. 2 Stages of bacterial canker development as expressed by the ratings for bacterial canker (BCR) on a scale of 1 to 9. See Table 1 for explanation of this scale.

Colour

Table 1. Descriptive interpretation of field ratings on a scale of 1 to 9 for quantitating tissue damage by bacterial canker ratings (BCR) and cold injury as estimated by trunk cambial browning (TCB).

Bacterial canker		Trunk cambial browning	
Rating	Visual description	Rating	Visual description
1	Tree in perfect health with no apparent bacterial canker damage on any part of the tree (**Fig. 2-1**).	1	White or normally dull looking tissue with no apparent cambial discoloration—healthy tissue (**Fig. 1-1**).
2	Only a few twigs or branches affected or killed by the bacterial canker (**Fig. 2-2**).	2	Very slight discoloration in cambial region — nearly healthy tissue (**Fig. 1-2**).
3	Bacterial canker damage has spread to may twigs and/or branches (**Fig. 2-3**).	3	Slight discoloration in the cambial area — slightly injured tissue (**Fig. 1-3**).
4	Canker affected or killed one or 2 scaffold limbs, sunken bark in many cases (**Fig. 2-4**).	4	Slight to moderate browning of cambium — minor injury to tissue (**Fig. 1-4**).
5	Canker caused slight to moderate trunk damage, less than 50% of trunk area is affected or killed (**Fig. 2-5**).	5	Moderate browning in the cambial zone — pronounced injury to tissue (**Fig. 1-5**).
6	Canker has spread to 3 or more scaffold limbs all of which show a sunken bark (**Fig. 2-6**).	6	Moderate to severe browning of cambium and some bark discoloration — very pronounced injury (**Fig. 1-6**).
7	Severe trunk damage and more than 50% of the trunk affected or killed by canker (**Fig. 2-7**).	7	Severe browning of cambium, bark splitting in some cases — severe injury to tissue (**Fig. 1-7**).
8	Canker has affected or killed all limbs, but a portion of trunk is still alive (**Fig. 2-8**).	8	Severe to complete browning of cambium, discoloration has spread to bark and wood — very severe injury (**Fig. 1-8**).
9	Entire tree is killed by the bacterial canker (**Fig. 2-9**).	9	All tissues are completely brown, bark separated — dead or dying tree (**Fig. 1-9**).

amination involves cutting 2 or more bark flaps per tree trunk with a sharpe knife at a 10° to 15° angle to expose a plane of tissue in the cambial zone at a height of 20 to 30 cm above ground. Immediate visual evaluation (within 10 sec) of tissue discoloration is then accomplished, using the TCB rating scale of Table 1. A judgement must be made as to whether cold injury and/or bacterial canker damage is present. If bacterial canker is suspected, further tree limb examination is indicated. In the early stages of development, cold injury and bacterial canker are easily distinguishable even when they occur in the same tree (Table 1, Fig. 2). After warm weather has induced tree growth and injured trees have exhibited visible symptoms of collapse, however, the 2 types of injuries may become indistinguishable and masked by invading saprophytes. Several symptoms may be used to distinguish between the 2 types of injuries. Cold injury is characterized by the darkening of bark in severe cases, the cambial layer showing varying degrees of brown discoloration which usually appear uniform over wide areas of the trunk with no sharp delineation between healthy and injured tissue. The bark often becoming separated from wood easily, and there is no evidence of injury extending below ground level. On the other hand, bacterial canker is diagnosed when bark seems reddish-brown in color. It may ooze or be slightly sunken, produces a typically strong sour-sap odor when cut, and becomes very difficult to separate from wood. Cankers are elongate with definite margins between diseased and healthy tissue and may be present only on one side or in a small area of trunk. Elongated cankers with sunken bark often girdle affected limb(s) or branches, and twig cankers usually exhibit light tan-colored bark with a water-soaked appearance and a strong sour-sap odor.

The rating scales described in Table 1 and Fig. 1 and 2 are based on certain assumptions. In the case of cold injury, an ordinarily-innocuous minimum temperature in the neighborhood of -10°C is often sufficient, under our climatic conditions, to damage the sensitive cambial zone of partially-dehardened peach trees. Depending on the severity of the injury, the cambial cells may not regenerate, thereby girdling areas of the trunk and leading to tree death some weeks or months later. Therefore, the most severely-browned trunk area is assumed to be the limiting factor in eventual tree recovery and health. Our experience shows that a rating of 7 on the TCB scale indicates marginal survival chances, while the ratings of 8 and 9 consistently indicate tree death (7, 8).

Bacterial canker often appears in several areas of the tree and is caused by a systemic pathogen *Pseudomonas syringae* van Hall, whose virulence often is increased by external stress, such as cold injury and/or other tree weakening or predisposing factors. Girdling from cankers often occurs, but cellular breakdown also releases some phytotoxic substances like syringomycin, which intensify surrounding tissue injury. The rating system for bacterial canker (BCR) is based on the assumption that canker damage to a given part of the tree will kill that portion of the tree above the damaged area; that is, if one side of the tree trunk is damaged by canker, the limbs on that side of the tree will probably die in due course. Therefore, if more than one portion of a tree is injured or seriously affected by bacterial canker, the evaluator must judge which type of injury is most harmful to the tree.

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