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Relationship of Chilling Requirement in *Prunus persica* (L.) Batsch to Peach Tree Short Life[1]

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Abstract

On a non-fumigated peach tree short life (PTSL) site, low chill peach cultivars had more winter mortality than medium and high chill cultivars. However, many cultivars having a high vegetative rest requirement or genetic cold-hardiness also had high mortality. Other physiological mechanisms besides rest completion appear to affect winter mortality in peach trees on PTSL sites.

Introduction

Peach tree short life (PTSL) is a disease syndrome causing early peach tree mortality on replant sites in the southeastern United States. The syndrome is characterized by death of the above ground portion of the tree from cold injury or bacterial canker (*Pseudomonas syringae* pv. syringae van Hall) and is associated with ring nematode (*Criconemella xenoplax* (Raski) Luc & Raski) root parasitism (3, 4, 9). Differences in susceptibility to PTSL have been reported among commercial rootstocks (6, 11, 15). It is not clear, however, if cultivar differences exist. Low chill varieties are thought to be more susceptible to PTSL because they usually complete their winter rest requirement long before the cessation of subfreezing temperatures that injure dehardened cambial tissue. Conversely, high chilling varieties should be less affected by PTSL. The objective of this study was to determine the relationship between chilling requirement of peach (*Prunus persica* (L.) Batsch) and PTSL mortality.

Materials and Methods

A collection of 143 *Prunus* cultivars, rootstocks, naturalized seedlings, and breeding lines from the subgenera Amygdalus and Euprunus were assembled and propagated by seed or cuttings in 1981 and 1982 for a PTSL screening test. The trees were planted 12,13 January 1983 at a 4.9 X 0.6 m spacing in a randomized block design with 8-tree plots and 6 replicates. The orchard site is a non-fumigated Lakeland fine sand at the Sandhill Research and Education Center near Pontiac, South Carolina and has been planted in peaches for many years. The soil has a large endemic population of ring nematodes (*Criconemella xenoplax*) and is conducive to PTSL.

From the PTSL screening test, 28 open-pollinated peach families were selected based on their presumed chilling requirement as judged by the bloom date of the parent trees. The chilling requirements for their flower and vegetative buds were subsequently measured during 3 dormant seasons. The chilling requirement was estimated by cutting four 30-cm terminal shoots from each of 4 labeled trees per plot per sampling date. Three replicates were used for a total of 12 trees per family. Sampling times corresponded to attainment in the field of approximately 300, 400, 500, 600, and 700 chill units according to an Omnidata Biophenometer (Omnidata International, Logan, Utah) which uses the Rich-

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ardson model (5) for rest completion. Sample shoots were placed in water, and the flower, terminal, and lateral vegetative buds evaluated for swelling and leaf emergence after 14 days in a warm (20-27°C) greenhouse. Shoots were recut and the water changed every 2 days to minimize xylem vessel plugging by microorganisms.

Rest was considered completed when an average of at least 50% of the buds had reached the pink stage for flowers and the green tip stage for leaf buds. Chilling requirement was scored as 1 = < 300 chill units (CU), 2 = 300-400 CU, 3 = 401-500 CU, 4 = 501-600 CU, 5 = 601-700 CU, and 6 = > 700 CU. The chilling requirement data were averaged for plots and then for replicates to give annual mean values for each family. Three years of data were averaged. Cultivar mortality from PTSL in the 6 replicates of the screening test was recorded each April and tabulated for 5 years in percent. All percent mortality data were angular transformed to degrees for analysis of variance by the General Linear Models procedure of the Statistical Analysis System (SAS Institute Inc., Cary, NC), and Pearson correlations were generated between cultivar chilling requirement and PTSL mortality.

Results and Discussion

The estimated chilling requirement of the flower and vegetative buds of the 28 families and their respective percent PTSL mortality are listed in Table 1. The chill units needed for rest completion of the terminal vegetative buds were similar to the flower buds for each family and thus are not listed. The chilling requirement of the flower buds was equal to or less than that required to complete rest in the lateral vegetative buds which is generally accepted as the normal sequence in deciduous fruit trees (7).

Relative chilling requirement scores (i.e., 1.0-6.0) for the flower and vegetative buds were significantly correlated (r = .95) at the 1% level. Chilling requirement of the flower buds was not significantly correlated (r = -0.32) with PTSL mortality, whereas there was a significant inverse relationship at the 5% level between time of rest completion of the lateral vegetative buds and incidence of PTSL (r = -0.43). The negative correlation showed that low chill varieties had higher PTSL mortality which might suggest that completion of rest of vegetative buds could be used as a preliminary indicator of potential cultivar susceptibility to PTSL.

High chill varieties, however, were also susceptible to PTSL. As a group, they had a higher average mortality than medium chill varieties (Table 1). It could be argued that since the data were collected from open-pollinated families, the genes controlling chilling requirement may have segregated widely in the F_1 seedlings and consequently all the low chill offspring may have died early, thereby biasing the survival data. However, observations of the bloom and leafout dates of these families suggested that within-family variation was insignificant for these traits. This is not surprising since peach cultivars generally self-pollinate and only infrequently outcross. Furthermore, all 3 chill groups had cultivars with high PTSL mortality. Among families, there were highly significant differences in PTSL mortality (range = 4 to 96%). The mean PTSL mortality of all 143 cultivars in the screening test (34%) was exceeded in the chill study by 86% (6 of 7), 58% (7 of 12), and 56% (5 of 9) of the low, medium, and high chilling cultivars, respectively. This difference between the sample and population means may be due to an unknown bias from selecting cultivars based on bloom dates

Table 1. Chilling requirement for rest completion of flower and vegetative buds of 28 peach cultivar families and their respective PTSL mortality.

Cultivar	Origin	Relative Chilling Requirement[z]	Chill units needed for rest completion of buds[y]		% PSTL mortality[x]
			Flower	Vegetative	
FL 14-11	Florida	Low	1.0	2.5	30
Saharan Pur #1	India	Low	1.9	2.8	50
China Flat	India	Low	1.5	2.5	50
Angel	S. Africe	Low	1.3	2.4	50
Shau Thai Tao Sdlg.	China	Low	1.0	1.0	60
Killiekrankie	S. Africa	Low	1.3	1.7	73
FL 15-122	Florida	Low	1.5	1.5	92
					$\bar{X}$ 58
Lovell	California	Medium	4.5	4.9	4
Gaschina Novembre	Italy	Medium	4.2	5.1	4
Baladi #1	Israel	Medium	3.6	4.2	9
Transvaal Yellow	S. Africa	Medium	4.5	4.7	11
Nemaguard	Georgia	Medium	4.1	5.1	13
Redglobe	Maryland	Medium	4.4	5.4	22
Tos China #1	China	Medium	4.2	5.3	29
Shalil	India	Medium	3.2	3.3	38
Bolivian Cling	Bolivia	Medium	4.1	4.9	55
Siberian C	China	Medium	4.5	4.8	58
P. davidiana	China	Medium	3.0	3.0	61
Yunnan	China	Medium	3.9	4.8	68
					$\bar{X}$ 31
Boone County Sdlg.	Nebraska	High	5.1	5.5	4
Chui Lum Tao	China	High	4.6	5.4	17
Rutger's Redleaf	New Jersey	High	4.5	5.5	24
Violette Hative	England	High	5.2	5.4	25
Mao Tao Sdlg.	China	High	5.1	5.1	34
Tzim Pee Tao	China	High	6.0	6.0	40
Genovese	Italy	High	4.5	5.3	47
Ferganenis #02446	USSR	High	4.7	5.4	52
Pi Tao	China	High	5.5	5.5	96
					$\bar{X}$ 38

[z]Cultivars were arbitrarily assigned to the high chill category if their chill unit score was at least 4.5 for flowers and 5.0 for vegetative buds.
[y]1.0, 2.0, 3.0, 4.0, 5.0, and 6.0 equals <300, 301-400, 401-500, 501-600, 601-700, and >700 chill units, respectively.
[x]Statistically significant among cultivars at the 1% level.

alone or more likely may be explained by the fact that 22 of the 28 cultivars in the sample population originated from outside of North America and thus may not have been climatically adapted.

A possible physiological basis for the large variation in survival among the medium and high chill cultivars may be partly attributed to the difference between cultivars in their post-rest heat accumulation requirement needed for budbreak and subsequent vegetative growth. Werner *et al.* (10) found that differences in bloom time of 2 cultivars was explained by their

base temperature for heat accumulation and not their chilling requirement. Thus, some medium and high chill cultivars may have lower base temperatures for heat accumulation and would thereby deharden earlier and be more sensitive to late winter or early spring subfreezing temperatures. This does not explain why the 3 most cold hardy rootstocks (1), Chui Lum Tao, Tzim Pee Tao, and Siberian C had 17, 40, and 58% PTSL mortality, respectively. These rootstock cultivars required 600+ chill units for rest completion which does not occur with 90% probability until 15 February in Pontiac, SC (2). Therefore, inherent genetic cold resistance during the true dormancy stage and a high chilling requirement did not significantly reduce PTSL in these cultivars.

Another factor, the root system, may also play an important role in dormancy release of the scion and subsequent dehardening of the cambial tissue. Young and Werner (14) found that peach roots did not need chilling for scions to resume growth but some rootstocks, such as Siberian C, increase chilling requirement and retard flower bud development in the scion peach cultivars (13). These effects, which were attributed to a delay in an increase of flower bud moisture content and xylem water potential, would tend to prolong rather than accelerate dehardening. This suggests that if peach rootstocks decrease scion cold-hardiness it would be from something other than physiological mechanisms regulated by environmental chilling. A plausible, but yet undocumented, dehardening mechanism would be an increased production of growth promoting phytohormones by the roots when parasitized by ring nematodes or stimulated by some other environmental factor. Cytokinins and gibberellic acids (GA) are thought to accelerate the late dormancy phase, which is 1 of 5 dormancy phases defined by Saure (8). Translocation of newly manufactured or membrane-released cytokinins and GA from the roots to the scion during warm winter periods could shorten the late dormancy phase of medium and high chill cultivars and thereby reduce their late winter cold-hardiness. In contrast, predisposition to cold injury in low chilling cultivars may be influenced as much as or more by chilling requirement than by a rapid dehardening in the late dormancy phase, since the deep dormancy phase of true dormancy is satisfied sooner for low chill than for higher chilling cultivars.

The weak association ($r = -0.43$) between a cultivar's vegetative chilling requirement and PTSL and the mediocre to poor survival of cold hardy, high chill cultivars indicates that the role of chilling requirement in tolerance to PTSL is of lesser importance than other unknown physiological and biological factors. Furthermore, there is no conclusive evidence to suggest that low chill cultivars are more susceptible to PTSL because of their early rest completion. Other factors such as phytohormone imbalances and ring nematodes (12) probably play a key role in predisposing peach to winter cold injury and bacterial canker. The data from this study suggest that chilling requirement alone did not indicate potential susceptibility of medium and high chill peach cultivars to PTSL. Therefore, other physiological mechanisms in addition to chilling requirement must influence peach tree susceptibility to PTSL.

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Effects of Hydrogen Cyanamide on Bloom Advancement in Female Pistachio (*P. vera* L.)

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Abstract

Inadequate pollination in pistachio trees is usually due to the unstable period (delayed and/or prolonged) of blooming of the female trees, especially in areas with mild winters, as well as to the absence of the middle and late flowering *Pistacia vera* pollinators. Spraying female trees with hydrogen cyanamide during the their rest period advanced bloom by about 19 days. This advance was sufficient to allow overlap with both *P. vera* 'B' and 'C' in areas with mild winters and *P. terebinthus* and *P. vera* 'A' in cold region orchards where the middle and late flowering pollinators are usually absent. Using hydrogen cyanamide as a dormancy breaking agent the female trees produce commercial yields.

Introduction

The pistachio is dioecious, that is the staminate and pistilate flowers are on separate trees. Therefore pistachio must always be cross-pollinated. Since pollen is carried from male to female trees by light winds, male trees must be interspersed in the orchard. The standard recommendation is for one male to 7 or 8 female trees. For successful pollination the blooming of female and male trees must coincide. Male trees of the species *P. terebinthus* and *P. vera* are used as pollinators in Greece, but pollen of *P. vera* is preferred because it increases shell splitting, a characteristic highly desirable for commercially purposes. Pollen of *P. terebinthus* is shed too early to be useful in pollinating pistachio cultivars. The male *P. vera* cultivars used as pollinators in Greece are 'A' (early flowering), 'B' (middle flowering) and 'C' (late flowering).

In many pistachio orchards inadequate pollination occurs and consequently the yield is poor. This is usu-

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