of tolerance to *X. fastidiosa* (6). Entries 'AU-Amber,' 'AU-Rosa,' and 'AU-Rubrum' which were reported previously as having high levels of tolerance, in our study had mean ratings of 4.1, 3.5, and 1.9, respectively, compared to 0, 1, and 1 as previously reported (6). These relatively higher ratings in this study suggest that true resistance is still an elusive goal in plum breeding.

Two entries in the EVSRC trial, 'Methley' and 'AU-Amber,' had higher readings in 1994 than in 1995. This may be due to an uneven distribution of the pathogen in tissue of these cultivars. Hutchins et al. (3) found this to be a particular problem with peach, which may also occur in plums. 'AU-Rubrum's evaluation went up from 1994 to 1995 which may also indicate this uneven distribution in plant tissue or a natural progression of the disease.

Literature Cited

1. Boyhan, G. E., B. R. Abrahams, J. D. Norton, and H. Huang. 1996. Budding method affects transmission of *Xylella fastidiosa* in plum. HortScience 31:89-90.
2. Hutchins, L. M. 1933. Identification and control of the phony disease of the peach. Ga. Official State Entomol. Bul. 78.
3. Hutchins, L. M., L. C. Cochran, W. F. Turner, and J. H. Weinberger. 1953. Transmission of phony disease virus from tops of certain affected peach and plum trees. Phytopathology 43:691-696.
4. Kleweno, D. D. and W. T. Placke (eds.) 1995. Alabama Agricultural Statistics. Ala. Agr. Statistics Service. Montgomery, Ala.
5. Latham, A. J., J. D. Norton, and M. W. Folsom. 1980. Leaf scald on plum shoots growing from disease-free buds. Plant Dis. 64:995-996.
6. Norton, J. D., T. L. Kamps, and T. E. Conaty. 1988. Disease resistance an advantage of new Auburn plum varieties. Ala. Agr. Expt. Sta. Highlights of Agr. Res. 35:10.
7. Sherman, W. B., Yonce, C. E., Okie, W. R., and Beckman, T. G. 1989. Paradoxes surrounding our understanding of plum leaf scald. Fruit Var. J. 43:147-151.
8. Wells, J. M. 1995. Phony Peach, pp. 53-54. In: J. M. Ogawa, E. I. Zehr, G. W. Bird, D. F. Ritchie, K. Uriu, and J. K. Uyemoto (eds.): Compendium of stone fruit diseases. AFS Press, St. Paul, Minn.

Fruit Varieties Journal 51(1):35-39 1997

Effect of Periodical Cicada Injury and Degree of Fire Blight Severity on Asian Pear Cultivars

T. VAN DER ZWET[1] E. W. BROWN[1] AND P. ESTABROOK[2]

Abstract

Sixteen Asian pear cultivars grown at Virginia Gold Orchard near Natural Bridge, VA were evaluated for shoot damage from the seventeen-year cicada (*Magicicada septemdecim* L.), followed by fire blight infection by the bacterium *Erwinia amylovora* [(Burr.) Winsl. et al.]. The Japanese pear cultivars, 'Yoi nashi' and 'Ichiban nashi,' proved to be the most susceptible; whereas two Korean types, 'Ar-rirang 1' and 'Korean Giant,' were most resistant. Two Japanese cultivars, 'Shinko' and 'Singo,' proved to have intermediate resistance. All cultivars exhibited some degree of cicada damage and 68% showed a strong correlation between cicada injury and fire blight severity. Those with the softest woody branches were attacked and injured most severely.

Asian pears [*Pyrus pyrifolia* (Burm.) Nak.] and their hybrids have been grown in Japan, China and Korea for at least 1,000 years. The fruit are known as "nashi," "li," and "beh," respectively. In addition, they have been known in North America by the term "sand pears," in reference to the stone cells

[1]Research Plant Pathologist and Microbiologist, USDA-ARS, Appalachian Fruit Research Station, Kearneysville, WV 25430.
[2]Proprietor, Virginia Gold Orchards, Natural Bridge, VA 24578.

Figure 1. Characteristic injury on one-year-old shoot of Asian pear by seventeen-year cicada followed by infection with the fire blight bacterium.

and high fiber flesh of some of the poorer quality cultivars. However, good quality varieties have a unique crisp, juicy texture quite different from European pears, and have gained good market acceptance by many Americans after an initial taste introduction. The first Asian pear made its move to the United States with immigrants during the gold rush and slowly, but surely, the fruits made their way into the fruit markets with the introduction of better varieties. Today, Asian pears are grown in the United States and several other countries outside of Asia and have become extremely popular on both the East and West coasts of North America (1, 6, 11). The Korean and Japanese types mature on the tree and do not require ripening after harvest, as do the buttery European pear (*P. communis* L.) cultivars. Fruit can be maintained in cold storage "ready to eat" for extended periods. Under optimum storage conditions, some cultivars maintain good eating quality for up to 6 months.

Soon after the introduction of Asian pears to North America, it became obvious that many cultivars were very susceptible to fire blight, caused by the bacterium *Erwinia amylovora* (Burr.) Winsl. et al. (7). This disease is indigenous to North America and has never been reported from China or Korea. However, its presence in Japan has been speculative, since a bacterial shoot blight of 'Mishirazu' pear (a Chinese pear of unknown pedigree), caused by *E. amylovora* pv *pyri*, was recently reported from Japan (12).

The seventeen-year (*Magicicada septemdecim* L.) or periodical cicada is an insect that occurs in large numbers and can inflict severe damage to branches of fruit trees. The female has a long, sword-shaped ovipositor which is used to lay its eggs in deep cuts in branches of last year's and current season's growth. The eggs hatch about 6 weeks later and the young drop to the ground, enter the soil, and feed on tree roots for 17 years before re-emergence.

The objective of this study was to determine the degree of damage the periodical cicada could inflict on different Asian pear cultivars and to study the correlation between this cicada damage and the degree of fire blight.

Materials and Methods

All observations of locust damage and fire blight infection were made in the Virginia Gold Orchards near Natural Bridge Virginia. The main orchard was designed to consist of 33 rows, 6 meters apart, with 100 trees spaced 3 meters within each row. The 16 cultivars under observation were located randomly throughout the orchard and not in any planned, replicated block design. The number of trees (nearly 900) varied from 3 for Desert to 157 for Shinseiki.

Irrigation water was separately controlled for each row and each tree had a micro-spray irrigation outlet. The irrigation water was supplied to sup-

Table 1. Degree of shoot injury inflicted by the seventeen-year cicada in relation to the degree of fire blight damage on Asian pear cultivars.

Cultivar	Tree no.	Cicada injury score[1]	Fire blight damage score[2]	Combined weighted score[3]	Overall rating[4]
Ar-rirang 1	130	4.2	10.0	18.4	R
Korean Giant	28	4.3	10.0	18.6	R
Singo	75	4.7	9.2	18.6	R
Shinko	27	4.3	8.9	17.5	R
Chojuro	44	4.0	8.7	16.7	MR
Shinsui	48	3.9	8.3	16.1	MR
Desert	3	3.7	8.3	15.7	MR
Shinseiki	157	3.8	8.0	15.6	MR
Han Gum beh	27	3.2	8.5	14.9	MR
Kosui	39	4.0	7.5	15.5	S
Seuri	10	3.6	7.8	15.0	S
Nijisseiki	52	4.0	6.7	14.7	S
Hosui	153	3.6	5.7	12.9	S
Ya li	13	2.9	4.8	10.6	S
Ichiban nashi	30	2.6	4.8	10.0	VS
Yoi nashi	43	1.2	3.9	6.3	VS

[1]Rating score for cicada: 5 = no damage, 4 = light (1-5 cuts), 3 = moderate (6-12 cuts), 2 = severe (13-25 cuts), and 1 = very severe (more than 25 cuts).
[2]USDA fire blight rating score: 10 = no blight, 9 = 1-3%, 8 = 4-6%, 7 = 7-12%, 6 = 13-25%, 5 = 26-50%, 4-1 = 51-100% of trees blighted.
[3]Combined weighted scores (2 times cicada + fire blight).
[4]R = resistant, MR = moderately resistant, 5 = susceptible, and VS = very susceptible.

plement rainfall in the dry months of July and August. Water needs for each row were checked manually by handheld moisture meter, and by observations of the trees and a visual estimate of the soil moisture conditions under the trees. A continuous ground cover of orchard grass and red clover was maintained between the rows. Short white clover was planted in the tree rows to prevent erosion of the clay soils in the heavy spring rains. Mechanical mowing was used to control the ground cover throughout the growing season, and the mowed material was allowed to remain in the tree rows.

Fire blight was first observed in the young trees in 1991, and has been observed each following year. This disease is also present in the immediate local area on wild hosts. Within the orchard, fire blight has been controlled through the use of a copper spray mixture in late dormant followed by streptomycin during the growing season. In 1995, a biocontrol product named "BlightBan" *Pseudomonas fluorescens* A-506 (Plant Health Technologies, Lathrop, CA) was used instead of the copper compound. Weather was monitored continuously and recorded each hour during the growing season and the data were entered manually into a computer modeling program each day. The program, "MARYBLYT," was used as an aid for fire blight prediction and spray timing, with the result that each year only a few strikes of blossom blight occurred. Blossom and twig blight on the spring growth were the usual forms of fire blight occurring within the orchard in all years. Isolates of *E. amylovora* were recovered in 1993 and placed in AFRS storage.

The periodical cicada made its appearance in May 1995, producing open wounds, which served as ideal infection sites for the bacterium. Cicada activity continued for about 4-5 weeks and resulted in many oozing wounds. Streptomycin and BlightBan were used to limit the spread of fire blight soon after the first infections were observed. Because of the potential fruit thinning action of Sevin on the trees, no insecti-

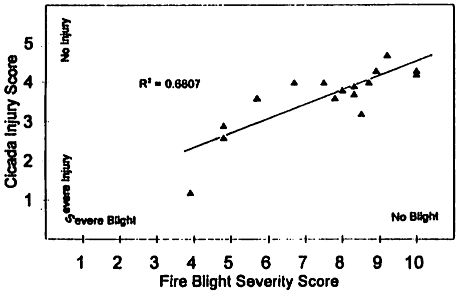

Figure 2. Correlation analysis between cicada injury and fire blight severity.

cide was used to destroy the cicadas and their invasion was allowed to run its natural course.

Data on cicada damage and degree of fire blight infection were recorded on September 28, 1995. Observations were recorded on the oldest fruit bearing trees. These trees were approximately 2.5-3.5 m (8-12 feet) high. The damage caused by cicada was recorded, using the following scoring system based upon an approximate count of the number of wounds: score 5 = no injury; score 4 = light damage (1-5 cuts); score 3 = moderate (6-12 cuts); score 2 = severe (13-25 cuts); score 1 = very severe (more than 25 cuts per tree). The length of the cuts, resulting from the drilling action by the female cicada to lay eggs, varied from 2 cm to as much as 10 cm (Fig. 1). The degree of fire blight was recorded with the USDA blight scoring system (10), in which score 10 = a tree without any blight symptoms; score 9 = 1-3%; score 8 = 4-6%; score 7 = 7-12%; score 6 = 13-25%; score 5 = 26-50%; score 3 = 76-88%; score 2 = 89-99% of tree blighted, and score 1 = a tree dead from blight.

Since the cicada rating system was based on scores 5 to 1 and fire blight on scores 10 to 1, a combined weighted score was prepared by adding a double cicada score with a single fire blight score. This calculation also aided the resistance ranking of the pear cultivars. To show a possible association between cicada damage and fire blight incidence, a cluster analysis and correlation coefficient was prepared to reveal grouping of the cultivars.

Results and Discussion

Of the sixteen Asian pear cultivars examined for combined cicada and fire blight damage, two cultivars ('Yoi nashi' and 'lchiban nashi') appeared to be the most susceptible, whereas, the two Korean ('Ar-rirang 1' and 'Korean Giant') and the two Japanese cultivars ('Shinko' and 'Singo') were most resistant (Table 1). For 'Shinko,' this confirms observations in Alabama (2), South Carolina (5), and in southern France (4). All cultivars had some degree of cicada damage ranging from average score 4.7 to score 1.2. Aside from the two worst and the four best cultivars mentioned above, the remaining 10 cultivars were generally divided into two groups: one moderately resistant (cicada scores 4.0 to 3.2 with fire blight scores 8.7 to 8.0) and the other moderately susceptible (cicada scores 4.0 to 2.9 with fire blight scores 7.8 to 4.8).

A correlation analysis of cicada damage versus fire blight severity revealed a distinct grouping of pear cultivar resistance (Fig. 2). Sixty-eight percent of all the cultivars showed a strong correlation between cicada injury and the incidence of fire blight. In general, cultivars (like Kosui) with the softest woody branches were damaged worst by the cicada. Cicada damage on the most susceptible cultivars also appeared to affect fruit size, sugar content and flavor. In Spring 1996, a severe lack of fruitbuds was observed on branches affected by the cicada, regardless of the variety or overall degree of severity.

Naturally, any form of tissue injury offers an excellent pathway for a bacterium to enter and cause infection. This has been demonstrated extensively with the fire blight bacterium following hail damage (3, 8). The fact that epiphytic *E. amylovora* bacteria are present, whether or not an orchard or an area has experienced several years of fire blight, has also been documented (9). All recordings of fire blight were directly associated with the cicada wounds. In retrospect, the antibiotic spray program should have been started with the arrival of the first cicadas, about one week prior to the onset of fire blight symptoms.

Literature Cited

1. Beutel, J. A. 1985. Asian years. Wash. State Hort. Assoc. Proc. 81:183-188.
2. Beyl, C. A. 1990. Fire blight susceptibility in a young Asian pear planting. Advances in New Crops; Proc. First Nat. Symp. New Crops, 8 pp.
3. Keil, H. L., B. C. Smale, and R. A. Wilson. 1966. Role of injury and longevity of *Erwinia amylovora* in the epidemiology of fire blight of pear. Phytopathology 56:464-465.
4. Lecomte, P. 1992. Shoot susceptibility to fire blight *(Erwinia amylovora)* of Asian pear cultivars. Eighth Intern. Conf. Plant Path. Bact., pp. 825-829.
5. Reighard, G. L. 1995. Evaluation of commercial potential of Asian pear cultivars in South Carolina. HortScience 30:793.
6. Rohse, E. D. 1988. Asian pears new venture for Willamette Valley grower. Goodfruit Grower, Dec. pp. 20-21.
7. van der Zwet, T. and S. V. Beer. 1995. Fire blight—its nature, prevention, and control. U.S. Dept. Agric. Inf. Bull. 631, 91 pp.
8. van der Zwet, T. and H. L. Keil. 1972. Importance of pear tissue injury to infection by *Erwinia amylovora* and control with streptomycin. Canad. Jour. Microbiol. 18: 893-900.
9. van der Zwet, T., H. L. Keil, and B. C. Smale. 1969. Fire blight in the Magness pear cultivar in North Central Arkansas. Pl. Dis. Reptr. 53:686-689.
10. van der Zwet, T., W. A. Oitto, and H. J. Brooks. 1970. Scoring system for rating the severity of fire blight in pear. Pl. Dis. Reptr. 54:835-839.
11. Walsh, C. S. 1990. Asian pear culture. Mass. Fruit Growers Assoc. Ann. Mtg. 96:127-129.
12. Yoshizawa, O. 1994. Eradication of bacterial shoot blight of years in Hokkaido. Plant Protect. 48(3):42-44.

Fruit Varieties Journal 51(1):39-43 1997

Colorimetric Characterization of Red Pear Cultivars

MARIA CLAUDIA DUSSIE,[1,2] DAVID SUGAR,[1,3] ANITA NINA AZARENKO,[1] AND TIMOTHY L. RIGHETTI[1]

Abstract

Fruit color was characterized in eight red pear cultivars by measurement using the Commission Internationale d'Eclairage L* a* b* color space coordinates. Color was measured on sun-exposed and shaded fruit surfaces at mid-summer and three times during harvestable fruit maturity. All cultivars gained red color (a* value) on the sun-exposed surface during the growing season, but varied in yellowness (b* value). Hue angles calculated from these values described differences in color change and color at final harvest. Color response on the shaded fruit surface varied among cultivars to a greater extent than on the sun-exposed surface. 'Rosired Bartlett' and 'Rogue Red' became darker (decreased in L* value) and redder (decreased in hue angle) with maturity on both sun-exposed and shaded fruit surfaces. All other cultivars became lighter and less red with maturity. 'Rogue Red' and 'Cascade' showed the greatest difference in hue between sun-exposed and shaded fruit surfaces, indicating a strong degree of bi-color. The least contrast between fruit surfaces was in 'Starkrimson' and 'Gebhard Red Anjou.'

Introduction

Red pear cultivars grown commercially in the United States originated either as bud mutations on green-fruited trees (e.g., 'Max Red Bartlett,' 'Sensation Red Bartlett,' 'Rosired Bartlett,'

[1]Department of Horticulture, Oregon State University, Corvallis, OR 97331.
[2]Current address: Facultad de Ciencias Agrarias, Universidad Nacional de Comahue, CC85, (8303) Cinco Saltos, Rio Negro, Argentina.
[3]Southern Oregon Research and Extension Center, 569 Hanley Rd., Medford, OR 97502.
Oregon Agricultural Experiment Station Technical Paper No. 11,052.