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Annual Deblossoming Increases Fire Blight Susceptibility of 'Golden Delicious'/M.9 Apple Trees[1]

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Abstract

A natural infection of fire blight occurred in 1987 in a mature planting of 'Jonathan,' 'Paulared,' 'Delicious,' and 'Golden Delicious' on M.9 rootstocks. The 'Golden Delicious'/M.9 apple trees were: 1) mechanically root pruned on two sides at a distance of 50 cm from the trunk to a depth of 40 cm; or 2) manually deblossomed. The treatments were applied annually at full bloom and arranged as a 2 x 2 factorial. 'Golden Delicious' had the most severe injury followed by 'Jonathan' and 'Paulared,' while 'Delicious' had hardly any strikes. 'Golden Delicious' that were not deblossomed and carrying a full crop had very little infection, while trees which had been deblossomed had numerous strikes which penetrated into older wood, often including main scaffold branches. In addition to the strikes on the scion, 71% of the deblossomed trees had infected M.9 rootstocks, while the slight injury to cropping 'Golden Delicious' trees was confined to current season's growth. Root pruning had no effect on fire blight susceptibility. Deblossomed trees had lower photosynthesis and transpiration rates than cropping trees both before and after the infection period, indicating that the physiological status of these trees was altered. The lower photosynthesis and transpiration in these trees has been previously linked to high foliar levels of starch, chloroplast disruption and lowered stomatal conductance. The susceptibility of 'Golden Delicious'/M.9 apple trees to fire blight appears to be greatly dependent upon the cropping status of the tree.

Introduction

It has long been recognized that the physiological status of apple and pear trees has an important impact on their relative susceptibility to fire blight (2, 10). The principle recommendations have been to reduce succulent vegetative growth through moderation of pruning, irrigation and nitrogenous fertilizers (2, 5, 10). Little has been reported on the influence of fruiting on fire blight susceptibility except to note that the reduction in vegetative vigor that accompanies the onset of fruit tree cropping is beneficial (2). Ferree et al. (4) have reported severe tree loss to fire blight in Ohio apple orchards on M.9 or M.26 rootstocks and C6 or M.9 interstems as they began to come into bearing, while nearby mature orchards on the same rootstocks or interstems had fire blight symptoms but no tree loss. Most tree losses occurred with 'Golden Delicious' which is not known for extreme blight susceptibility.

In 1987, southern Ohio apple orchards exhibited severe fire blight infections, however, injury to apple plantings at OARDC in Wooster, OH was limited to one isolated orchard described herein.

Materials and Methods

The planting was established in 1978 with 6 tree blocks of 'Jonathan,' 'Smoothee Golden Delicious' and 'Oregon Spur Delicious' arranged randomly within 6 north-south rows of 40 trees with 'Paulared' guard trees between each block. Guard rows of 40 'Paulared' trees were planted at the center and eastern side of the orchard. All trees were on M.9 rootstocks and trained to central leader with posts for support.

In May 1984, thirty-two 'Golden Delicious' trees were selected for uni-

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formity and assigned the following treatments: 1) control; 2) root pruned; 3) deblossomed; 4) root pruned and deblossomed. Root pruning was applied with a tractor-mounted root pruner on 2 sides of the tree at a distance of 50 cm from the trunk at a depth of 40 cm. Deblossoming was done using grape shears to sever the flower pedicels. All treatments were annually applied at full bloom and were arranged as a split-plot with root pruning as the main plot and deblossoming as the sub-plot treatment with 8 replications. At the end of the 1986 growing season one replicate was dropped from the study due to loss of the central leader in the root pruned tree due to overcropping.

Net photosynthesis (Pn) and transpiration (Tr) were measured on May 13, 1987, before the fire blight infection, and on June 19 after the twig blight phase was completed. Measurements were made on 3 fully expanded, apparently healthy shoot leaves of approximately the same age on each tree. All measurements were made on leaves in the outer well exposed portions of the canopy between 1300 and 1500 hr and with leaves exposed to direct sunlight in excess of that required for saturation of the photosynthetic system. CO_2, humidity, cuvette temperature and photosynthetically active radiation were measured using an Analytical Development Co. Model LCA-2 portable infrared gas analyzer equipped with a 6.25 cm^2 leaf chamber. The air flow rate was regulated at 300 ml/min and ambient CO_2 concentrations were 333 and 321 ppm for 5/13 and 6/19, respectively.

Fire blight severity was evaluated using the scoring system of the USDA Pear Breeding Program developed by van der Zwet, et al. (17). Each tree was rated from 10 (= no blight symptoms) to 1 (= dead from blight), based on the number of infections, age of wood infected and percent of tree blighted.

Results and Discussion

Of the 4 cultivars, 'Golden Delicious' was the most severely infected, followed by 'Jonathan' and 'Paulared,' while 'Delicious' exhibited hardly any strikes (Table 1). With the exception of 'Golden Delicious,' these findings are in close agreement with previous cultivar rankings for fire blight susceptibility (1, 5, 14). 'Golden Delicious' ratings were highly variable (Table 1) and this variability was attributed to treatment (Table 2). Cropping 'Golden Delicious' trees had very little infection, while trees which had been annually deblossomed were severely infected (Table 2). Root pruning had no effect on susceptibility to fire blight. Deblossomed trees had numerous strikes in shoots which often penetrated into older wood and into the main scaffolds. In addition, 71% of the deblossomed trees had oozing cankers in the M.9 rootstock (Fig. 1). None of the cropping 'Golden Delicious' trees were found to have fire blight injury in the rootstock or scaffold branches as injury was usually confined to current season growth.

'Golden Delicious' is generally considered only moderately susceptible to fire blight (1, 5, 14) and this was the case for bearing trees. However, annual deblossoming greatly increased the susceptibility of 'Golden Delicious' to fire blight. Similarly, Ferree et al. (4) found high tree loss of 'Golden Delicious' and highly susceptible cultivars, on M.9 rootstocks as they first came into bearing. Thus, it appears

Table 1. Fire blight injury to 4 apple cultivars on M.9 rootstocks.

Cultivar	No. Trees rated	Fire Blight rating[z]	Coefficient of variation (%)
Golden Delicious	34	7.4	36
Jonathan	33	7.6	14
Paulared	33	8.4	13
Delicious	30	9.7	5

[z]Fire blight rated: 10 = no injury to 1 = dead from blight (17).

Table 2. Effects of deblossoming and root pruning on fire blight injury, photosynthesis and transpiration of 'Golden Delicious'/M.9 apple trees.

		May 13		June 16	
	Fire Blight	Pn	Tr	Pn	Tr
Control	9.4	14.3[y]	1.9	26.2a[x]	3.9
Root Pruned	9.7	11.8	1.7	21.9a	3.5
Deblossomed	4.6	9.4	1.5	8.0b	1.9
Root Pruned & Deblossomed	4.3	11.2	1.6	14.5b	2.7
Main Effects					
Root Pruning	NS	NS	NS	NS	NS
Deblossoming	**	*	NS	**	*

[z]Fire blight rated: 10 = no injury to 1 = dead from blight (17).
[y]Pn = $mgCO_2dm^{-2}hr^{-1}$; Tr = $gH_2Odm^{-2}hr^{-1}$.
[x]Mean separation by LSD at the 5% level.
* **Significant at the 5 and 1% levels, respectively.

that cropping status has an especially strong influence on the susceptibility of this cultivar.

Fire blight is spread by insects, rain and pruning (3). The deblossoming was done with hand shears on April 27. However, fire blight was not observed until 1 month later, May 25, and entry of the pathogen appeared to be through vegetative shoots (twig blight) not through spurs (blossom blight). All the trees in this study were actively growing at the time of infection and there were no differences in shoot elongation between deblossomed trees and controls (12), so the relative absence of fire blight on the cropping trees was not for lack of succulent growth.

Deblossoming stimulated a second bloom as previously reported (11). Thus, insects visiting these late blooms may have been vectors for the bacteria. Fire blight of rat tail bloom has been a similar problem in California pear orchards and these blossoms are reportedly more susceptible to fire blight than normal bloom (15). Strikes were found where the initial infection appeared to be in blossoms but the majority of the strikes were in vegetative tissue.

The lesions went much deeper into older wood in the deblossomed trees than in cropping trees, suggesting that the physiological status of these trees enhanced the migration of the pathogen through the host tissue, as well as its entry.

The deblossomed trees had lowered Pn and Tr rates prior to and during the

Figure 1. Fire blight infection of M.9 rootstock of deblossomed 'Golden Delicious' tree.

infection period (Table 2). Lower Pn and Tr were also detected in the previous growing season in which it was demonstrated that the reductions were associated with the accumulation of many starch granules in the chloroplasts, plastid disruption and the disappearance of chlorophyll (12). Little information is available regarding fire blight susceptibility associated with high starch levels in vegetative tissues. Nightingale (9) reported that nitrogen-deficient trees which contained high levels of starch and sugars and were not actively growing. Trees which had adequate nitrogen had lower carbohydrates. Thus it appears that the growth status of the plant and not the carbon or nitrogen nutrient levels may have been the important factor. Hewett (7) reported that greater susceptibility to fire blight was associated with high levels of starch and "other fermentable substances," but actual nutrient levels were not presented. *Erwinia amylovora* moves through the stem in the phloem (8) penetrating the intercellular spaces by mass diffusion as cell contents are undisturbed at first, followed by the rapid disappearance of starch prior to their collapse (3). *Erwinia amylovora* is unable to utilize starch as a carbon source in culture (16). However, the relationship between pathogen and host carbon metabolism is not completely understood. It can be theorized that the rapid spread of the pathogen would be accelerated in the presence of an unlimited supply of substrate.

The lower Tr in deblossomed trees was highly correlated with lower stomatal conductance and associated with less negative leaf water potentials (12). Shaw (13) found a positive relationship between host plant intercellular humidity and fire blight susceptibility. It could be that the lower Tr and water deficit in the deblossomed trees provided a more favorable moist intercellular microenvironment for the pathogen.

Four years of annual deblossoming increased the susceptibility of 'Golden Delicious' such that the trees sustained more damage than 'Jonathan,' a highly susceptible cultivar in the same planting. Deblossomed trees, while having about the same growth periodicity, had physiological differences compared to fruiting trees and a number of these have been implicated in this report.

In 1987, fire blight damage was worst in southern Ohio, less in midstate and low in northern Ohio. This corresponds closely with the pattern of crop loss due to frost in 1986. The findings in this report suggest that frosted trees without a crop in 1986 in southern Ohio may have been predisposed, possibly due to higher carbohydrate levels, to fire blight infection this spring. Young plantings on the dwarfing rootstocks M.9, M.26 or C6 have been devasted by fire blight before producing a crop, but are relatively insensitive to infection once regular cropping has begun (4, 6). This transformation seems to be especially dramatic in 'Golden Delicious.' A clearer understanding of the influence of cropping and the associated shifts in fruit tree physiology on fire blight susceptibility is needed and it is hoped that this report will stimulate investigations in this area.

Literature Cited

1. Aldwinckle, H. S. 1974. Field susceptibility of 46 apple cultivars to fire blight. Plant Dis. Rept. 58:819-821.
2. Aldwinckle, H. S. and S. V. Beer. 1979. Fire blight and its control. Hort. Rev. 1:423-474.
3. Anderson, H. W. 1956. Diseases of Fruit Crops. McGraw Hill, NY. pp. 86-101.
4. Ferree, D. C., M. A. Ellis and F. R. Hall. 1983. Tree loss due to fire blight infections of rootstocks and interstems in Ohio apple orchards. Compact Fruit Tree. 16:116-120.
5. Funt, R. C., M. A. Ellis, D. L. Goleman and F. R. Hall. 1987. Commercial tree fruit spray guide. OH Coop. Ext. Serv. Bul. 506A:37.
6. Hall, F. R., M. A. Ellis and D. C. Ferree. 1982. Influence of fire blight and ambrosia beetle on several apple cultivars on M9 and M9 interstems. Fruit Crops 1982: A Sum. of Res. OARDC Res. Circ. 272:20-24.

7. Hewitt, J. L. 1913. Twig blight and blossom blight of the apple. Ark. Agr. Exp. Sta. Bul. 113:493-505.
8. Lewis, S. and R. N. Goodman. 1965. Mode of penetration and movement of fire blight bacteria in apple leaf and stem tissue. Phytopath. 55:719-723.
9. Nightingale, A. A. 1936. Some chemical constituents of apple associated with susceptibility to fire blight. N. J. Agri. Expt. Sta. Bul. 613.
10. Schroth, M. N., S. V. Thomson, D. C. Hildebrand, and W. J. Moller. 1974. Epidemiology and control of fire blight. Ann. Rev. Phytopath. 12:389-412.
11. Schupp, J. R. and D. C. Ferree. 1987. Deblossoming stimulates second bloom in 'Golden Delicious' apple trees. Hort. Sci. 23 (in press).
12. Schupp, J. R. and D. C. Ferree. 1987. The influence of root pruning and deblossoming on the physiology of apple trees. II. photosynthesis, carbohydrates and water relations. J. Amer. Soc. Hort. Sci. (in press).
13. Shaw, L. 1935. Intercellular humidity in relation to fire blight susceptibility in apple and pear. Cornell Univ. Agr. Expt. Sta. Memoir 101.
14. Thompson, J. M. 1972. Fire blight ratings, bloom dates, and precocity of apple varieties tested in the southeast. Fruit Var. Hort. Digest 26:84-97.
15. Thomson, S. V., M. N. Schroth, W. J. Moller, and W. O. Reil. 1975. Occurrence of fire blight of pears in relation to weather and epiphytic populations of Erwinia amylovora. Phytopath. 65:353-358.
16. van der Zwet, T. and H. L. Keil. 1979. Fire Blight: A bacterial disease of *Rosaceous* plants. USDA Agric. Handbook 510. U. S. Govt. Printing Off., Washington, D. C. pp. 48-49.
17. van der Zwet, T., W. A. Oitto and H. J. Brooks. 1970. Scoring system for rating the severity of fire blight in pear. Plant Dis. Reptr. 54:835-839.

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Trends of Production, Cultivars and Planting Systems on Apples and Pears in Western Europe

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Normal production of 7 million tons from the EEC member countries results in about a 10% over production in a normal crop year in relation to the balance of production to consumption. The top country concerning apple as well as pear production is Italy, whereas in France the new planting rates indicate a reduction. Regarding the area covered by fruit trees within the EEC, since 1977 the apple area decreased from 212,000 ha to less than 200,000 ha and pears also are decreasing. However the small yearly reductions are generally overcompensated by the increase in productivity in modern orchards.

The most important apple cultivars, by country, are as follows: Italy—Golden Delicious 40%, Delicious 20%, and Imperative 15%; France—Golden Delicious 65%, Delicious 10%, and Granny Smith 8%; F. R. Germany—Golden Delicious, Bos Koop and Cox's Orange; Netherlands—Golden Delicious 30%, Bos Koop and Cox's Orange; Belgium—similar to Netherlands with Jonagold 10%; United Kingdom—Cox's Orange and Bramley's Seedling.

Italy produces more pears than the total of all the other countries with Conference as the main cultivar.

High density planting systems on dwarf to medium rootstocks are more and more preferred in all areas, but individual preference by area do still exist and will continue, influenced by local tradition and ecological reasons—mainly differences in radiation.

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