New Considerations for Pruning in Management of Fire Blight in Pears

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ABSTRACT

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The efficacy of pruning infected pear tissues to combat fire blight (caused by *Erwinia amylovora*) was evaluated in two sets of experiments conducted during 1999 to 2001 in Israel. In the first set of two experiments, diseased tissues were removed soon after the observation of blossom infections. Pruning was effective in 0 to 50% of the treated trees, and resulted in complete eradication of *E. amylovora*. In the remaining trees, pruning not only did not result in eradication of the bacteria from the tree tissues, it made the situation worse, as the disease had invaded the main branches and limbs of a significantly larger proportion of pruned trees than of non-pruned ones, because of alteration of the physiological status of the host plant by pruning. In the five experiments of the second set, the efficacy of pruning fire blight infections on main branches and limbs was studied; the time of pruning varied among the experiments. Effectiveness of cutting and removing infected branches and limbs was linearly related to time of treatment: the efficacy of pruning improved significantly with lateness of the treatment. The best results were obtained when pruning was carried out while the trees were dormant, in December: none of these trees had a severely infected canopy the following spring. Based on the results obtained in this study, it was concluded that factors related to all three components of the disease triangle (i.e., pathogen, host, and environment), rather than only the actual presence of diseased tissues, should be taken into account in considering the need for cutting and removing fire blight-diseased tissues. Accordingly, recommendations for Israeli growers were revised and updated.

Fire blight, caused by the bacterium *Erwinia amylovora*, is the most destructive disease of pears and other pome fruit trees worldwide. The pathogen may infect all plant parts: leaves, blossoms, fruit, shoots, limbs, and trunks (24). Primary infection usually affects blossoms or young shoots. The pathogen then progresses from initially infected organs to supporting perennial branches and may advance further to the main limbs of the tree. Infected tissues exhibiting the typical decaying symptoms of fire blight may eventually die. The consequences of fire blight infections on main limbs are devastating, as not only is the current-year yield impaired, but normal development of the tree and its future growth and production are also affected. Moreover, if the pathogen invades the trunk, the entire tree may die (19,22,23).

Management of fire blight is a difficult task and includes several "defense lines". The first is preventive: measures include choice of orchard site and variety, proper fertilization and irrigation, tree training and pruning, shortening the duration of flower-

ing, and prevention of off-season blooming. The next defense line is protective: bactericides are applied during bloom, to protect the blossoms and to ward off infections. If fire blight infections have occurred and disease symptoms have been detected in the orchard, then a curative measure is activated and diseased tissues are cut and removed. The last defense line, utilized between growing seasons, aims to reduce the amount of initial inoculum in the orchards before the next bloom (16,19,24).

Recommendations for cutting and removing diseased tissues during the course of the season generally instruct the growers to make the cuts at a healthy branch union, at least 20 to 30 cm below any visible symptoms, and to surface-sterilize the pruning tools between cuts with copper, alcohol, or bleach solutions (19). Prompt removal of infected shoots as soon as symptoms are detected is just as important as how the cuts are made: the longer infected shoots remain in the orchard, the greater the damage inflicted on the trees and the greater the likelihood of secondary inoculum dispersal to other locations in the infected trees and throughout the orchard (5,19).

Even though timely and frequent cutting of diseased tissues is recommended to pear growers worldwide, there have been few quantitative data to support these recommendations. Moreover, the results of published studies are inconsistent and some-

times controversial (22). Some studies have demonstrated that if pruning is done as soon as blight infection is observed, it eventually eliminates the diseased tissue as well as the inoculum that provides bacteria for infection (5,23). Other authors found the results of pruning disappointing; for example, Clarke et al. (4) reported that even though the recommendations for pruning were followed strictly, 12% of the cut stubs on pruned trees still harbored *E. amylovora*, and Lake et al. (12) demonstrated that pruning of apples in Minnesota in early June markedly enhanced, rather than decreased, fire blight infections.

With respect to the current recommendations for pruning fire blight-infected tissues, the only factor taken into account is the actual existence of the disease; recommendations do not consider the phenological or physiological status of the host or the environmental conditions at the time of pruning. Moreover, the type of diseased organ (i.e., blossom clusters, lateral shoots, main branches, or limbs), likelihood that the disease would continue to progress in the woody tissues of the tree, and its survival toward the following season are not considered. However, it can be assumed that these factors should be taken into account when considering the need for pruning and eradication. Results of a study conducted recently in Israel (3) demonstrated that under local conditions, factors related to host phenology and physiology govern the progression of fire blight and the resulting damage in perennial pear branches. It was found that in the spring, fire blight symptoms seldom progressed from infected blossom clusters or succulent shoots to supporting branches in trees that exhibited low vigor (i.e., those in which few or no succulent shoots were produced on terminal branches). On the other hand, in trees exhibiting high vigor (i.e., those bearing numerous succulent shoots on most terminal branches), the disease progressed rapidly on perennial branches and so endangered the health of the tree. These findings raise questions regarding the need for eradicating fire blight symptoms from trees that exhibit low vigor.

Recommendations for pruning are based on the assumption that fire blight is detected soon after the occurrence of infection. By that time, disease symptoms are usually apparent on the blossoms and succulent shoots, and possibly also on the supporting lateral branches. Sometimes, however, by the time disease symptoms are

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first observed, the disease has already invaded the main branches and limbs of the trees. This may happen, for example, when growers were not aware that infections had occurred during the spring bloom, and identified the disease several months later. In Israel, this may also happen following the occurrence of autumn infections. As autumn blooming is not uncommon in pear orchards in Israel, and the environment at that time is occasionally conducive to *E. amylovora* development, fire blight infections also occur in autumn. It was found that, following autumn infections, fire blight symptoms progress steadily in perennial branches until the following spring (3). Growers who do not inspect their crops in the autumn and winter occasionally detect the disease only the following spring, by which time the disease has already invaded the main branches and limbs of the trees. These situations create problems for both growers and extension personnel, who do not know the best action for protecting tree health: to cut and remove infected branches and limbs as soon as they are observed (as is supposedly implied by the current recommendations) or to postpone the cutting to some later time. In the present study, we examined these questions and concentrated on the contribution of pruning to tree health. Preliminary reports of part of the data were published previously (18,25).

MATERIALS AND METHODS

The efficacy of pruning pear tissues infected with fire blight was evaluated in experiments conducted in 1999 to 2001, in pear orchards located at Shpheia (Samaria region, central Israel) and Kibbutz Dvir (the northern Negev, southern Israel). The orchards were planted in 1990 and 1992, and consisted of 500 and 300 trees, respectively. The main cultivar in both orchards was Spadona, a local cultivar that is highly susceptible to *E. amylovora*. The trees were cultivated (i.e., irrigated, fertilized, pruned, etc.) and maintained (i.e., by weed and pest control, etc.) as recommended to pear growers in Israel. The trees in these orchards were not treated with bactericides against fire blight, and the blossoms were naturally infected with *E. amylovora*. Unless stated otherwise, the number of infected blossom clusters and succulent shoots in each tree ranged from many dozens to a few hundred.

Experimental design. The experimental unit used in all the experiments described in this report was the individual tree. As occasionally happens in commercial orchards in Israel, trees in the experimental orchards varied markedly in size and vigor. Accordingly, before conducting the experiments, trees were inspected and rated on the basis of their agronomic characteristics (i.e., tree size and vigor) as well as the intensity and severity of fire blight infections (i.e., number and type of infected

organs [blossoms, lateral shoots, branches, main limbs, trunks]). Trees with similar characteristics were divided into groups, which then served as blocks in the experiments. Thus, all experiments were conducted according to a complete block design, but the trees assigned to each block were not necessarily adjacent to each other. There were six to 10 replicates (individual trees) in each treatment.

In all the experiments described in this report, infected tissues were pruned by making the cuts in a healthy portion of the branches or limbs, approximately 30 cm below the site of visible fire blight symptoms. The tools used for pruning were disinfected with sodium hypochlorite (2%) before and after cutting. When large branches or limbs (>5 cm diameter) were cut, sodium hypochlorite was sprayed or poured onto the cut stubs soon after cutting. If not stated otherwise, all blighted tissues were removed, and after pruning, the trees seemed (visually) not to be infected.

Pruning diseased blossom clusters and lateral shoots. The efficacy of pruning fire blight-infected tissues soon after the observation of symptoms in the blossoms was tested in two field experiments. The first was conducted in 2000 in Shpheia and the other in 2001 in Kibbutz Dvir. The first disease symptoms (i.e., abundant excretion of ooze and discoloration of blossom stalks) were observed on 17 April 2000 and 5 April 2001, respectively. Both experiments were laid out within the following 3 days. All trees in the 2000 experiment exhibited low vigor, and they were divided into two treatments, i.e., nonpruned (untreated control) and pruned. The 2001 experiment included trees with low vigor and, for comparison, trees with high vigor; trees in both vigor groups were either nonpruned or pruned. Trees were classified as exhibiting low vigor if succulent annual shoots did not develop on most terminal branches or if annual shoots were short (<10 cm) and thin. Trees that had numerous, long (>30 cm) and thick succulent annual shoots on most terminal branches were classified as exhibiting high vigor.

In late July, after the growth of annual shoots had ceased and the progression of fire blight symptoms on the perennial branches had stopped (3), the extent of fire blight progression on the diseased perennial branches was determined visually according to a five-level scale, as follows: (i) healthy trees—those in which no fire blight infections were seen on the canopy; (ii) fire blight symptoms remained restricted to the spurs; (iii) symptoms had progressed for ≤ 10 cm in perennial branches; (iv) symptoms had progressed for 10 to 30 cm in perennial branches; and (v) symptoms had progressed for >30 cm in perennial branches. In addition, observations of symptoms on the main branches and limbs of the trees were noted. Evalua-

tions were made visually by two or three individuals. Trees allocated to category (v) were considered to be exhibiting expanded infections. For data analysis, the proportions of trees in each treatment with expanded infections and with symptoms on the main branches and limb were calculated. Differences between pruned and nonpruned trees in the proportions of expanded infections and limb invasion were determined by applying a χ^2 test (at $P \leq 0.05$).

Pruning diseased main branches and limbs. The efficacy of pruning main branches and limbs that exhibited fire blight symptoms was tested in five experiments: one experiment in Kibbutz Dvir (in 2000) and four in Shpheia (two experiments in 1999, one in 2000, and one in 2001). Trees in the Dvir orchard bloomed in autumn 1999, and some of the blossoms were naturally infected with *E. amylovora*. Fire blight infections progressed from the blossoms to the supporting branches, and symptoms continued to progress during autumn 1999, winter 1999 to 2000, and spring 2000. Infections were observed by the grower only after trees had started sprouting in early April 2000, by which time large branches and, in some cases, main limbs exhibited typical fire blight symptoms. The trees were inspected carefully, and those exhibiting similar types of infections were selected for the experiment. In these trees, there was only one infected main branch, and the visible symptoms were located at least 120 cm from the trunk. The location for pruning (i.e., in a presumably healthy section approximately 30 cm below the lowest site of visible symptoms) was marked on each tree with colored paint. The trees were then randomly designated to the two treatments included in the experiment, i.e., nonpruned (untreated control) and pruned, and pruning was carried out. The main branches, limbs, and trunks were inspected for the presence of fire blight symptoms on the cut stubs and for the further progression of symptoms at 1- to 2-month intervals until the following spring (late March 2001). Lengths of cankers, from the cut stub (in pruned trees) or from the painted mark (in nonpruned trees) to the edge of the symptoms, were measured with a ruler. At the start of the following spring, superficial cuts were made with sharp knife to determine if cankers had determinate or indeterminate edges (1); those with indeterminate edges and a typical reddish-brownish color were considered to be active, and those with determinate edges and dark-brown color were considered to be inactive. The data were used to calculate the proportions of trees in which canker length exceeded 80 cm and of trees bearing active cankers. The effects of pruning were determined by comparing these proportions between pruned and nonpruned trees by means of a χ^2 test (at $P \leq 0.05$).

The four experiments conducted in Shpheia were similar, in general. Blossoms in this orchard were naturally infected in March of each year. By the initiation of the experiments, the disease had progressed from infected blossom clusters and had invaded the branches and, in some cases, the main limbs. Each experiment included one treatment in which the trees were not pruned (untreated control) and two (in 1999 and 2000) or three (in 2001) treatments in which all diseased organs were cut and removed. Treatments in the various experiments differed with respect to time of pruning. Infected branches were cut: during fruit set and growth (in May or June) in the 1999-I and 2001 experiments; after harvesting (in August) in the 1999-II and 2001 experiments; just before trees approached dormancy (in November) in the 1999-II and 2000 experiments; and while trees were dormant (in December) in the 2000 and 2001 experiments.

The contribution of pruning to tree health was determined in the subsequent springs, as follows. Two individuals inspected the trees from both sides and determined the amount of damage inflicted on the canopy by fire blight. Damage to the canopy included those branches that had been devastated by the disease in the previous season as well as branches and limbs that exhibited systemic symptoms and wilting in the current season. Symptoms induced by new blossom infections could be easily distinguished and were not considered in the assessments. The following six-category scale was used: (i) healthy tree—no fire blight symptoms were observed on the canopy; (ii) only lateral branches were infected and $\leq 5\%$ of the canopy exhibited symptoms; (iii) up to

three large branches were infected or up to 20% of the canopy of the tree exhibited symptoms; (iv) three or more large branches and at least one limb were infected or $\leq 40\%$ of the canopy exhibited symptoms; (v) several limbs were infected or $\leq 80\%$ of the canopy exhibited symptoms; and (vi) a dead tree. Trees allocated to categories (iv) to (vi) were considered to be exhibiting severely infected canopy. The proportion of trees with severely infected canopy was calculated for each treatment, and the contribution of pruning to tree health was determined by comparing the proportions obtained in pruned trees with those of nonpruned trees using a χ^2 test (at $P \leq 0.05$). Pruning efficacy (PE, %) was then calculated for each treatment on the basis of the proportions of severely infected trees among pruned and nonpruned trees (P_t and P_n , respectively) according to the formula: $PE = 100 - (P_t/P_n) \times 100$. Then the relationship between pruning efficacy and time of pruning was determined by means of a linear regression analysis.

RESULTS

Pruning diseased blossom clusters and lateral shoots. The efficacy of removing diseased tissues soon after the observation of blossom infections was examined in two experiments. As expected, in nontreated trees that exhibited low vigor, most fire blight symptoms remained restricted to spurs and did not invade the lateral shoots and branches or the main limbs of the trees. On the other hand, in all nontreated trees that exhibited high vigor, fire blight symptoms had progressed more than 30 cm on the lateral shoots and branches (Fig. 1A). Nevertheless, no disease symptoms

were observed on the main branches and limbs of either group of trees (Fig. 1B).

All trees included in the experiments bore dozens to several hundred infected blossom clusters. To eradicate all infections, many cuts were made on each tree, and a large proportion of the canopy was removed. As a result of pruning, excessive new growth of succulent shoots was initiated in all pruned trees. In fact, trees that were initially assigned to the low vigor group produced such a vast number of sprouts and succulent shoots after pruning that they were then better suited to the high vigor group. Sprouting and shoot growth in the pruned trees continued until late July to early August, about 6 to 8 weeks longer than was observed in the comparable nonpruned trees.

Among trees exhibiting low vigor, pruning was effective and resulted in complete eradication of *E. amylovora* in 50 and 42.8% of the treated trees in 1999 and 2001, respectively. In the rest of the trees, however, pruning was not effective, and fire blight symptoms were apparent on the cut stubs within 2 to 4 weeks. In these trees, not only did the pruning not result in eradication of the bacteria from tree tissues, it made the situation worse: the disease had invaded the main branches and limbs of a significantly larger proportion of pruned trees than of nonpruned trees (Fig. 1B). The harmful consequence of pruning was more notable in trees with high vigor than in those with low vigor: *E. amylovora* was not eradicated by pruning from any of the trees with high vigor, and in 80% of them the disease had invaded the main branches and limbs of the trees (Fig. 1).

Pruning infections on main branches and limbs. Six months after initiation of

Fig. 1. Effects of pruning blossom clusters and lateral shoots infected by *Erwinia amylovora* (causal agent of fire blight) on the health of pear trees, as influenced by their growth vigor. **A**, Proportion of trees in which symptoms had progressed 30 cm or more on the branches, 6 months after pruning. **B**, Proportions of trees where symptoms were apparent on main branches and limbs, 6 months after pruning. An asterisk indicates a significant difference ($P \leq 0.05$) between pruned and nonpruned treatments (for each growth vigor group), as determined by a χ^2 test.

the 2000 experiment, fire blight symptoms were observed below the painted marks of all untreated trees and on the cut stubs of all pruned trees. Disease symptoms had progressed by an additional 80 cm or more in three of the eight nonpruned trees (37.5%), but this amount of progression was observed in all eight trees (100%) from which the blighted branches were cut

Fig. 2. Effects of pruning main pear branches infected by *Erwinia amylovora* (causal agent of fire blight) on further progression of disease on main limbs of trees. Infections occurred in autumn 1999, and pruning was carried out in spring 2000. Advanced symptoms: trees in which symptoms had progressed by more than 80 cm on main branches and limbs, 6 months after pruning. Active symptoms: trees with active (indeterminate) cankers on trunks 1 year after pruning. An asterisk indicates a significant difference ($P \leq 0.05$) between pruned and non-pruned treatments, as determined by a χ^2 test.

and removed (Fig. 2). By that time, indeterminate (active) cankers were observed in two and five (25 and 62.5%), respectively, of the tree trunks in the two treatments. One year after the experiment was set up (in late March 2001), there were still significant differences between the treatments, and the proportion of trees bearing active cankers on the trunks was higher in pruned than in nonpruned trees (Fig. 2).

In the next four experiments, the contribution of pruning to tree health was evaluated the following spring. In nontreated trees, the proportion of trees with severely infected canopy ranged from 60 to 83%. Pruning in May and June, during fruit set and growth, significantly improved tree health in the following spring as compared with the nontreated trees, but the improvement was inadequate (40% of the trees had severely infected canopy). Pruning after harvesting (in August) improved tree health further (17 to 20% with infected canopy), and cutting just before the trees approached dormancy (in November) was even more effective (12 to 17% infected). However, the best results were obtained when pruning was carried out in December, while the trees were dormant: none of those trees had severely infected canopy the next spring (Fig. 3). Effectiveness of cutting and removing infected branches and limbs was linearly related to time of treatment: pruning efficacy improved significantly as the treatment was postponed (Fig. 4).

DISCUSSION

The only factor taken into account in the current recommendations for eradicating pear tissues exhibiting fire blight symptoms is the presence of the disease (15,19,22,24). Similar recommendations are also common for other fruit trees that

are subject to invasion by plant pathogens that endanger the health of perennial branches, e.g., mango malformation, caused by *Fusarium subglutinans* (11,14), mal secco disease of citrus, caused by *Phoma tracheophila* (15), and bacterial canker and decline of European hazelnut, caused by *Pseudomonas avellanae* (17). However, results of the present study show that other factors, such as physiological and phenological status of the host and the time of pruning, affect the success of pruning and its contribution to tree health. Because of these factors, there are situations in which pruning can be expected to improve tree health, but there are also cases in which pruning would make no difference, as the disease would not endanger the host plants if left untouched. Furthermore, it was found that sometimes it was preferable not to cut at all, because pruning affected tree health negatively.

In our experiments, despite the fact that pruning was carried out as recommended to growers (that is, using disinfected tools and making the cuts in a healthy area, about 30 cm below the site of infection), pruning did not result in successful eradication of the pathogen in all cases. There are several possible reasons for this lack of success. First, it is well documented that *E. amylovora* cells colonize symptomless tissues beyond the sites of visible symptoms (6,8,9,19). Some authors reported that the pathogen was recovered in symptomless tissues at distances greater than 30 cm. For example, Gowda and Goodman (7) isolated *E. amylovora* 70 cm from the point of inoculation in the stem apex, and Suleman (20) isolated the bacterium up to several meters ahead of any visible symptom during the growing season. Thus, the existence of bacteria cells well beyond the site of cutting may explain why pruning

Fig. 3. Effects of time of pruning pear branches infected with fire blight (caused by *Erwinia amylovora*) on health of trees in spring of the following year. Four experiments were carried out in 1999 to 2001. Infections occurred in spring, and by the time of pruning, disease had progressed to main branches and limbs of trees. -, untreated (nonpruned) trees. May to Dec.: time of pruning in the various experiments. An asterisk indicates a significant difference ($P \leq 0.05$) between pruned and nonpruned treatments, as determined by a χ^2 test.

did not successfully eradicate the pathogen from treated trees. Steiner (19) and Keil and van der Zwet (9) used the capability of *E. amylovora* to persist in symptomless tissues to explain the frequent development of the disease after removal of blighted parts of the tree by pruning. Second, it is possible that, despite the fact that the pruning tools were disinfected with sodium hypochlorite between cuts, some bacterial cells still remained viable and colonized the cut stubs. It is well known that infected pruning tools may infect healthy pear tissues with *E. amylovora* (2,10,11,21). Finally, it is possible that the bacteria invaded the host tissues directly through the wounds created during pruning (19). Regardless of which of these possibilities applied, the fact is that, in our experiments, pruning was not successful in eradicating the bacteria from most treated trees. Since pruning was not successful in an experimental situation, it is unlikely that pruning would be more successful in commercial situations. In light of similar observations, a modified cutting procedure, called "ugly stub cutting", was proposed by Steiner for apples (19). According to this procedure, growers are advised to make cuts 20 to 30 cm below visible symptoms in wood that is at least 2 years old, with unsterilized tools. However, instead of making the cut as usual at a healthy branch union, the cut is located so as to leave a 10- to 12-cm naked stub. These stubs are removed during the dormant pruning operation.

In the present study, in some of the cases in which pruning did not successfully eradicate the pathogen from the host tissues, fire blight affected the pruned trees more aggressively than the nonpruned trees. In pruned trees, the disease progressed to greater distances on perennial branches, invaded the main branches and limbs, and remained active in the trunks of significantly more trees. A possible explanation for this result lies in the effect of pruning on the host trees, which in turn affected the aggressiveness of the pathogen that still colonized the host tissues. In most trees included in our study, the number of infection sites (i.e., blossom clusters, succulent shoots, or lateral branches) ranged from several dozens to a few hundred; therefore, in order to eradicate all infected tissues, many cuts were made and a vast amount of host tissue was removed. The immediate response of the host trees to such pruning was the initiation of excessive new growth. Sprouting and shoot growth in pruned trees continued until late July or early August, about 6 to 8 weeks beyond that observed in the comparable nonpruned trees. Apparently, the modification to the physiological status of the host trees that resulted from pruning made them more vulnerable to the pathogen. In a study conducted recently (3), it was found that the disease progressed more rapidly and extensively in perennial branches of trees

that exhibited high vigor than in those of low vigor. Moreover, it was found that following spring infections, the disease continued to progress in perennial shoots as long as the annual succulent shoots were actively growing; when shoot growth stopped, the progression of fire blight also ceased (3). Nevertheless, our present results do not suggest that pruning should never be employed for fire blight management. We repeatedly found in nonreplicated observations that when the trees were bearing only a small number of infections, cutting and removing infected tissues did not alter the host physiology, and pruning (if the diseased tissues were eradicated) was successful. Experience gained by commercial pear growers in Israel in recent years corroborates these observations.

Results obtained in the present study suggest that the contribution of eradication of diseased branches and limbs to tree health in the succeeding season was related to the phenological stage of the host at the time of pruning: the best results were obtained when pruning was performed while trees were dormant. Our results corroborated those found by Lecomte (13), who concluded that the best period to prune pear trees to prevent fire blight is the full dormant period. Dormant pruning is routinely practiced during winter to maintain a high proportion of fruiting wood and to control tree size and shape. Similarly, Steiner (19) indicated that removal of all visibly infected limbs and, where necessary, whole trees is imperative if any fire blight management program is to reduce the number and distribution of primary sources of inoculum. However, postponing the cutting of fire blight-infected tissues to winter may create two problems. First, if not removed immediately on detection, the pathogen may continue to progress in the

infected tissues and result in increasingly greater damage. However, results of the present study suggest that postponement of pruning to winter improved, rather than impaired, tree health. Moreover, in the experiment conducted in Kibbutz Dvir in 1999, in-season pruning was associated with increased damage. The second problem imposed by postponing the cutting is that infected tissues may serve as an active source of inoculum, which could endanger the orchard until they are pruned. However, as the host tissue most susceptible to *E. amylovora* is the blossoms, the probability of secondary infections in orchards with no rat-tail or autumn blossoms is not markedly increased. Where off-season blossoms are apparent, special care should be taken to prevent their infection.

Based on the results presented in this report, it was concluded that factors related to all three components of the disease triangle (i.e., pathogen, host, and environment), rather than only the actual presence of diseased tissues, should be taken into account in considering the need for cutting and removing fire blight-diseased tissues. Accordingly, recommendations for Israeli growers were revised and updated. The new, current recommendations distinguish between situations in which the disease is detected on blossom clusters, succulent shoots, or lateral branches, on one hand, and situations in which the disease is first detected on main branches and limbs. In the first situation, growers are advised to make a distinction between spring and autumn infections. In the spring, recommendations are not to touch trees with limited growth vigor. On these trees, fire blight infections are likely to be restricted to the spurs and not to invade the main branches of the trees. Cutting these infections off, if it did not successfully eradicate

Fig. 4. Relationship between time of pruning pear branches infected with fire blight (caused by *Erwinia amylovora*) and efficacy of treatment. Results were obtained in four experiments conducted in 1999 to 2001.

the bacteria from the trees, could make the situation worse. If trees with vigorous growth are infected, growers need to differentiate between those bearing few and those bearing numerous infections. In the case of the former, they are advised to eradicate the infections by cutting in a healthy section of the plant, about 50 to 60 cm from the site of visual symptoms. If numerous infections are observed on vigorous trees, the experience gained in our present study suggests that the eradication efforts are likely to be unsuccessful and may even aggravate the situation. Thus, to avoid investment in probably unsuccessful pruning efforts, growers are advised to postpone the pruning to winter. If symptoms are observed subsequent to autumn infection of blossoms or shoots, growers are recommended to cut and eradicate these infections immediately, as autumn infections in Israel are more dangerous and devastating than spring ones (3). In cases where the disease has already invaded main branches and limbs by the time it is detected, it is recommended to mark the infections with colored paint and to make the cuts in winter, when the plants are dormant.

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