Vol.37, No.1, pp.26-34, 2025

Journal of Agricultural, Life and Environmental Sciences

RESEARCH ARTICLE

pISSN 2233-8322, eISSN 2508-870X
https://doi.org/10.22698/jales.20250003

An Analysis of the Bacterial Diseases Outbreak on Apple and Asian Pear in Gangwon State in 2021 - 2023

Heon-Seop Won[1*], Youn-Gi Moon[1], Gwang-Jae Lee[1], Jae-Hong Lee[1], Se-jeong Hwang[1], Sung-Hee Kang[1], Seung-Min Ham[1], Sun-Joo Lee[1], Seung-Jae Lee[2], Duck-Hwan Park[3,4]

[1]Researcher, Gangwon State Agricultural Research & Extension Services. Chuncheon, 24203, Korea
[2]Worker, Daejeon Insectarium Agricultural Life Policy Division. Daejeon 35204, Korea
[3]Professor, Interdisciplinary Program in Smart Agriculture, Kangwon National University, Chuncheon 24341, Korea
[4]Professor, Plant Medicine Program, Division of Bioresource Sciences, College of Agriculture and Life Sciences, Kangwon National University, Chuncheon 24341, Korea

***Corresponding author:** Heon-Seop Won (E-mail: whs1@korea.kr)

Received: 25 January 2025
Revised: 20 February 2025
Accepted: 27 February 2025

A B S T R A C T

This study conducted a comprehensive analysis of the temporal and regional characteristics of fire blight (*Erwinia amylovora*) and black shoot blight (*Erwinia pyrifoliae*) outbreaks in Gangwon State from 2021 to 2023. Fire blight was first observed in Wonju, Pyeongchang, and Yeongwol in 2021. The introduction of infected seedlings was identified as a major factor contributing to the spread in Yeongwol, while in Pyeongchang and Wonju, climatic conditions, such as temperature and humidity, were found to significantly promote the outbreaks. In 2022, fire blight occurred in Wonju, Pyeongchang, and Hongcheon, where the first recorded simultaneous occurrence of fire blight and black shoot blight was observed, complicating disease control measures. In 2023, new fire blight cases were reported in Jeongseon and Yanggu, with young trees in Yanggu exhibiting increased susceptibility, leading to concentrated infections. The rapid growth of shoots and flowers facilitated pathogen spread, resulting in a rapid escalation of disease incidence. Black shoot blight was first detected in Wonju and Chuncheon in 2021, with unsanitary use of farm tools identified as the primary factor for disease spread. In 2022, additional cases were reported in Yeongwol and Chuncheon; however, the disease remained confined to isolated orchards, particularly in Chuncheon, where no further spread to surrounding orchards was observed. In 2023, black shoot blight emerged in Hwacheon, where inadequate orchard management and lack of farmer education accelerated the spread of the disease. This study provides crucial information for understanding the occurrence and influencing factors of fire blight outbreaks in Gangwon State. Establishing preventive measures, continuous pattern analysis, and proactive surveillance are essential to mitigate the spread of bacterial diseases in orchards.

Keywords: Black shoot blight, Fire blight, Regional characteristics, Seedling, Simultaneous occurrence

Introduction

Among bacterial diseases that severely impact Rosaceae hosts such as apples and Asian pears, fire blight (*Erwinia amylovora*) and black shoot blight (*Erwinia pyrifoliae*) are particularly significant. Fire blight spreads

through flowers and shoots, potentially leading to the complete destruction of orchards. In the United States, fire blight causes annual economic losses exceeding one million dollars. The disease was first reported in New York State in 1780 and subsequently spread to Western Europe, Northern Europe, and the Mediterranean region, beginning with the United Kingdom in 1957 (Bonn and van der Zwet, 2000). In 2006, outbreaks were reported in Morocco (Fatmi et al., 2008), and in Asia, cases were documented in Kazakhstan and Kyrgyzstan, near China's western border (Drenova et al., 2012). In South Korea, fire blight was first reported in May 2015 in an Asian pear tree in Anseong, Gyeonggi Province (Park et al., 2016).

Black shoot blight was first observed in South Korea in 1995 in an Asian pear (Pyrus pyrifolia cv. "Shingo") orchard near Chuncheon, Gangwon State. While the disease exhibits characteristics highly similar to fire blight, analyses of the pathogen's cultural, serological, and genetic properties confirmed that it is distinctly different from *Erwinia amylovora*, the causal agent of fire blight (Seo et al., 1999). Both diseases are designated as quarantine pathogens under Article 31 of the Plant Protection Act and Rural Development Administration (RDA) Notice No. 2024-31. Consequently, the government implements official control measures in affected orchards. Although variations exist across different years, the 2024 guidelines for fire blight and black shoot blight surveillance and control outline specific management methods based on incidence rates. If the incidence rate in an affected orchard exceeds 10%, complete orchard removal is mandatory, whereas lower incidence rates may allow for partial removal or in-ground burial of infected trees. Chemical control measures involve preventive spraying of registered pesticides once before flowering and twice during the flowering period. To prevent the spread of bacterial diseases in fruit trees, it is crucial to conduct regular and precise surveillance and monitoring in affected orchards and neighboring farms. Timely diagnosis of symptomatic trees and rapid response measures are essential in containing disease outbreaks. Therefore, this study aims to investigate the incidence and characteristics of bacterial diseases in fruit trees in Gangwon State from 2021 to 2023, analyzing the challenges faced by affected orchards.

Materials and Methods

Investigation of the Characteristics of Affected Orchards

To investigate the characteristics of bacterial disease outbreaks in orchards from 2021 to 2023 in Gangwon State, cooperation was sought from the Agricultural Technology Extension Division of the Gangwon State Agricultural Technology Institute. After gathering orchard information for the affected cities and counties, field visits were conducted to survey the orchard area, number of trees, number of affected trees, and incidence rate. Subsequently, the outbreak distribution structure for each orchard was compiled.

Diagnosis of Suspected Infected Trees with Bacterial Diseases

The suspected bacterial disease samples collected from the affected orchards were subjected to DNA extraction using the APrep^{TM} Total DNA kit (APBIO, Namyangju-si, Gyeonggi-do, KOR). The extraction method involved

cutting the samples into approximately 5 mm diameter pieces using a sterilized scalpel, followed by adding 200 μL of TL buffer to a 1.5 mL tube. The tube was vortexed for 2 seconds, and then 20 μL of Proteinase K and 10 μL of RNase A were added, followed by 2 seconds of vortexing. The sample was incubated at room temperature for 2 minutes. Next, 200 μL of BL buffer was added to the reacted sample and vortexed for 2 seconds. The sample was then heated at 56°C for 10 minutes using a heating block. Afterward, 200 μL of absolute ethanol was added to the reacted sample and vortexed. The supernatant was collected and transferred to a spin column, which was centrifuged at 10,000 g for 30 seconds. The filtrate from the spin column was discarded, and the column was reassembled. Then, 600 μL of AW buffer was added to the column and centrifuged again at 10,000 g for 1 minute. The filtrate was discarded, and the column was reassembled. Subsequently, 600 μL of TW buffer was added, and the column was centrifuged at 10,000 g for 1 minute. The filtrate was discarded again, and the column was reassembled. The final step involved centrifuging the column at 13,000 g for 1 minute. The fully filtered column was then dismantled and dried at room temperature for more than 1 minute. The upper part of the column was then combined with a new 1.5 mL tube, 50 μL of EA buffer was added, and the sample was reacted for 1 minute. Afterward, the sample was centrifuged at 13,000 g for 1 minute to extract the DNA.

The extracted DNA was tested for positivity using cross-validation with the ToMics™-D-Erwinia sp. Detection Kit v4 (BIOLEAP, Yuseong-gu, Daejeon, KOR) and the HelixDtec™ EAEP-T100 Kit Ver. 4 (NanoHelix, Yuseong-gu, Daejeon, KOR). The diagnostic method involved dispensing 19 μL (BIOLEAP) and 12.5 μL (NanoHelix) of the PCR mixture from the kits into microtubes. Then, 1 μL of DNA, positive control, and negative control were added to each tube, and the total volume was adjusted to 20 μL (BIOLEAP) or 25 μL (NanoHelix). The microtubes were then sealed and centrifuged. Prepared PCR products were processed using the QuantStudio 5 (Thermo Fisher SCIENTIFIC, Waltham, USA) according to the kit's manual to perform PCR, and the presence of positivity was confirmed.

Results and Discussion

Investigation of Outbreak Characteristics of Affected Orchards

Analysis of Fire Blight Outbreak Characteristics: Over the three-year period from 2021 to 2023, a total of 21 orchards in Gangwon State were affected by fire blight (Table 1). An analysis of the annual outbreak trends reveals that, in 2021, fire blight was reported in four orchards in Wonju, one orchard in Pyeongchang, and, for the first time, in one orchard in Yeongwol (Table 1). Regarding the specific outbreak characteristics by county, the orchard in Yeongwol was diagnosed with suspected plants collected from an apple orchard in Nam-myeon, where a confirmed diagnosis was made on May 25. Detailed information for the affected orchard in Yeongwol includes a cultivation area of 0.8 hectares, an orchard age of 12 years, 751 trees planted, and 30 trees showing symptoms, which resulted in a disease incidence rate of 4.0%. According to the 2021 surveillance guidelines, if fire blight is detected in even one tree, the entire orchard must be removed, regardless of the number of trees planted or the incidence rate.

Table 1. Occurrence of Fire Blight in orchards in the Gangwon State

Year	Serial No.	Confirmation Date	Orchard Address	Fruit	Cultivated Area (ha)	Tree Age	Number of Trees Cultivated	Number of Affected Trees	Infection Rate (%)
2021	1	May 25	Nam-myeon	apple	0.8	12	751	30	4
	2	Jun. 2	Gwirae-myeon	apple	0.2	8	250	85	34
	3	Jun. 2	Munmak-eup	apple	0.3	16	224	55	24.6
	4	Jun. 3	Pyeongchang-eup	apple	0.2	12	330	4	1.2
	5	Jul. 5	Gwirae-myeon	apple	0.3	6	350	12	3.4
	6	Jul. 5	Gwirae-myeon	apple	0.2	13	370	9	2.4
2022	7	May 25	Pyeongchang-eup	apple	0.1	13	588	34	5.8
	8	May 30	Munmak-eup	apple	0.2	10	677	71	10.5
	9	May 30	Heungeop-myeon	pear	0.2	4, 20	290	30	10.3
	10	Jun. 21	Seomyeon	apple	0.3	6	280	6	2.1
2023	11	May 19	Munmak-eup 1	apple	0.2	10	214	56	26.2
	12	May 19	Munmak-eup 2	pear	0.4	30	182	15	8.2
	13	Jun. 16	Jeongseon-eup 1	apple	1.3	10	1,000	5	0.5
	14	Jun. 16	Jeongseon-eup 2	apple	0.4	10	400	4	1
	15	Jun. 20	Haean-myeon 1	apple	0.5	2	396	170	42.9
	16	Jun. 20	Haean-myeon 2	apple	0.3	6	226	46	20.3
	17	Jul. 4	Haean-myeon 3	apple	0.4	9	560	2	0.4
	18	Jul. 26	Haean-myeon 4	apple	1.8	4	1,000	18	1.8
	19	Aug. 3	Haean-myeon 5	apple	8.2	3	8,000	40	0.5
	20	Aug. 3	Haean-myeon 6	apple	24.8	5	24,000	707	2.9
	21	Aug. 8	Haean-myeon 7	apple	1.4	1−9	2,645	81	3.1

Consequently, all trees in the Yeongwol orchard were buried, and the orchard was removed. The disease mainly affected one- and two-year-old branches, and symptoms of blossom wilt and cold damage were also observed (Fig. 1A, B, C). The source of the infection in the Yeongwol orchard is suspected to have been tools used in neighboring orchards that were infected. The orchard in Yeongwol had two varieties, Hongro and Fuji, but the disease occurred only in the Hongro variety. An investigation revealed that pruning work for the Hongro variety was carried out using external workers from nearby Jecheon, and genetic analysis of the pathogens from the infected Hongro trees in Yeongwol showed the highest genetic relationship with the pathogens from Hongro in Bongyang-eup, Jecheon (data not shown). In the Wonju area, outbreaks occurred at three sites in Gurae-myeon and one site in Munmak-eup. All of the outbreaks in Gurae-myeon occurred in apple orchards. Although the disease incidence rate in these orchards was less than 5%, according to the 2021 surveillance and control guidelines, if the number of trees planted exceeds 100 and the number of infected trees exceeds five, the orchard must be removed. As a result, both orchards underwent removal. Additionally, on July 5, the agricultural technology center's surveillance found that fire blight had occurred at the orchard of the same grower, who owned orchards in other regions. The orchard was immediately removed, so the exact disease situation could not be determined. It was assumed that the disease had

Fig. 1. Symptoms of the Orchard in Nam-myeon, Yeongwol-gun: infection of 2 yr branches (A), Symptom of Blossom blight (B) and Cold Injury (C).

spread through tools and equipment, as the distance between the first infected orchard and the second infected orchard was about 1 km. The orchard in Munmak-eup had two land parcels within the same plot, and the investigation revealed a 24.6% incidence, leading to its removal. The orchard in Pyeongchang had fewer than five affected trees, so the affected trees were excavated and buried, and the orchard was designated as one requiring management.

In 2022, fire blight occurred at two farms in Wonju, one farm in Pyeongchang, and one farm in Hongcheon (Table 1). In terms of location, the incidents in Wonju occurred in Munmak-eup and Heungeop-myeon, both of which were confirmed on May 30. The orchard in Munmak-eup, Wonju, was located in a remote mountainous area, with beehives around the orchard, suggesting various potential infection routes, including insect vectors and neighboring host plants in the surrounding forest. The disease exhibited symptoms of fire blight infection, including cankers and lesions on branches over two years old, and it appeared that the disease had been present for some time, based on the observed infection patterns within the orchard. Heungeop-myeon was the site of the first fire blight incident in an Asian pear orchard in Gangwon State. Various symptoms, such as blossom blight, cankers, and oozing of sap from new shoots, were observed, and both orchards had over 10% of affected trees, resulting in their removal. In Pyeongchang, additional outbreaks occurred in Jujin-ri, a previously affected orchard from the previous year, and new cases were reported in a neighboring orchard. An analysis of the outbreak suggests that the infection spread around the trees that were partially buried the previous year. Both locations showed typical fire blight symptoms, including new shoot infections and stem cankers. Finally, in Hongcheon, an outbreak was reported in Seomyeon, marking the first fire blight occurrence in the region. Despite an incidence rate of 2.1%, the orchard was ultimately removed on July 5 following surveillance guidelines. A distinctive feature of this orchard was the simultaneous occurrence of fire blight and black shoot blight in the same orchard. During the investigation, fire blight was diagnosed in the first tree of the tenth row, while black shoot blight was diagnosed in the twelfth tree of the same row (Fig. 2, Table 2). This case is consistent with findings suggesting that when both fire blight and black shoot blight infect the same host plant, fire blight tends to dominate (Park et al., 2016). In the case of the Hongcheon orchard, the grower passed away in 2021, making direct interviews impossible. However, there was interaction

Table 2. The Results of coinfection in 942-2 Palbong-ri, Seomyeon

Sample No.	NANOHELIX		BIOLEAP	Result
	Fluorescence	Ct value	Tm (°C)	
10-1	FAM	33.9	60.5	*E. pyrifoliae*
10-12	VIC	16.6	68.7	*E. amylovora*

※ Diagnostic standards for positive results by test kit: NANOHELIX (Fire blight: FAM, Ct value ≤ 38; black shoot: VIC, Ct value ≤ 38), BIOLEAP (Fire blight: Tm = 65 − 72°C; black shoot: Tm = 59 − 63°C)

Fig. 2. Characteristic of the orchard in Seomyeon, Hongcheon-gun. Red circle indicates a fire blight-infected tree; Blue circle indicates a black shoot blight-infected tree (A). Symptoms of fire blight (B) and Black shoot blight (C).

between growers of the same variety and seedling suppliers, indicating that contamination of work tools cannot be ruled out. The current grower started managing the orchard in the second half of 2021, and pruning and thinning were conducted by the grower's family. It is likely that contaminated tools may have been used during these tasks.

In 2023, outbreaks occurred in two orchards in Wonju, two in Jeongseon, and seven in Yanggu (Table 1). Regarding regional outbreak characteristics, one site in Munmak-eup, Wonju, belonged to the same grower as the Munmak-eup orchard affected in 2021. The new outbreak site was located approximately 30 meters from the previously affected orchard, close enough for movement by foot. Due to this proximity, it is presumed that after the 2021 outbreak, the pathogen was transferred from the affected orchard to nearby host plants in the surrounding forest via insects or rainwater. After overwintering, the pathogen likely spread to adjacent fields through intermediate hosts such as insects, leading to the development of canker symptoms. Additionally, incomplete removal of infected trees before flowering may have further facilitated the spread of the disease. The second site in Munmak-eup was an adjacent farm located within 2 km of the Munmak-eup site affected in 2022. Most canker symptoms were observed on branches that were at least two years old, and based on the outbreak conditions in the field, it is presumed that the disease had been present for several years. In Jeongseon, two orchards were affected in 2023, and as they were the first outbreak sites in the region, both were completely removed (Table 1). One site in Jeongseon-eup experienced a simultaneous outbreak of valsa canker and fire blight. The orchard had been pruned and thinned annually by workers from Jecheon, and it is suspected that the pathogen was introduced through contaminated tools, clothing, or equipment used by these workers. The second site in Jeongseon-eup was located

about 500 meters from the initial outbreak orchard, and it is believed that the pathogen spread through insects or wind. In Yanggu, seven orchards were affected in 2023, marking the first outbreak in the region. Among them, six orchards were completely buried, while one was partially buried (Table 1). In previously unaffected areas, the standard protocol requires complete burial regardless of the incidence rate or the number of infected trees. However, since the 2022 surveillance guidelines introduced the concept of control zones, even in newly affected areas, orchards can be designated as control zone orchards and exempt from burial if they meet at least two of the following four conditions: 1. Canker symptoms indicate that the pathogen was introduced long before detection, 2. At least two additional cases are confirmed in neighboring orchards, 3. At least one additional case is found beyond a 2 km radius, 4. Epidemiological investigations suggest a high risk of further spread. The Haeran-myeon Site 3 met conditions 1 and 2; therefore, it was partially buried and designated as an orchard requiring management. The characteristics of the affected orchards in Haean-myeon revealed that Site 1 had been left abandoned to the extent that it required closure. Canker symptoms were observed on branches over three years old, and based on the outbreak conditions in the field, it is presumed that the disease had been present for several years. Additionally, fire blight progressed through floral infection, affecting young branches and immature fruits. The failure to remove infected trees before conducting pruning work likely contributed to the spread of the disease. For the five additional outbreak sites, including Site 2 in Mandae-ri, burial operations had already been completed before orchard visits, making it impossible to fully analyze the outbreak characteristics. However, investigations by the relevant center revealed that in the case of Site 2 in Mandae-ri, the grower's residence was located in Inje-gun, while the orchard itself was on state-owned land in Yanggu-gun, leading to frequent changes in lessees. Under such conditions, disease management was found to be inadequate. Additionally, interviews with farmers indicated that they were unable to distinguish between valsa canker and fire blight, which likely resulted in missing the optimal timing for disease control, leading to further spread. In Yanggu-gun, outbreaks were confined solely to Haean-myeon, with a common characteristic among affected orchards: most trees were under ten years old. This aligns with research findings indicating that younger trees are more susceptible to fire blight (Ham et al., 2023), suggesting that tree age may have been a contributing factor to the localized outbreak in Haean-myeon.

Black Shoot Blight Characteristics Analysis: Over the past three years (2021－2023), a total of seven farms in Gangwon State were affected by black shoot blight (Table 3). By year, four farms were confirmed in 2021—two in Wonju and two in Chuncheon. In Wonju's Buron-myeon, suspected fire blight symptoms had appeared two to three years prior, but farmers mistook them for blossom rot, failing to remove infected trees early, which allowed the disease to spread. At the second site in Gwirae-myeon, burial had already begun at the time of the visit, making it impossible to determine the orchard's structure and infection status. According to the farm interview, no symptoms were observed the previous year, but based on the center staff's opinion that the current outbreak primarily affected 2-3-year-old branches, it was determined that the infection likely started as early as the previous year. In 2022, cases were confirmed at one farm in Chuncheon and another in Yeongwol County (Table 3). Both orchards had an incidence rate of less than 10% and were partially buried before being designated as orchards requiring

Table 3. Occurrence of Black Shoot Blight in orchards in the Gangwon State

Year	Serial No.	Confirmation Date	Orchard Address	Fruit	Cultivated Area (ha)	Tree Age	Number of Trees Cultivated	Number of Affected Trees	Infection Rate (%)
2021	1	Jun. 2	Buron-myeon	apple	1.0	10	1,087	120	11
	2	Jun. 2	Gwirae-myeon	apple	0.6	16	850	317	37.3
	3	Jun. 9	Seo-myeon	apple	0.004	6	5	5	100
	4	Jun. 11	Seo-myeon	apple	0.07	6	80	1	1.3
2022	5	Jun. 7	Seo-myeon	apple	0.1	11	710	9	1.3
	6	Jun. 13	Mureungdowon-myeon	apple	0.5	13	1,740	6	0.3
2023	7	Jun. 14	Sanae-myeon	apple	0.16	5	220	30	13.6

management. Regarding the outbreak characteristics by orchard, the orchard in Chuncheon was not surrounded by other orchards or forests, so the disease did not spread to surrounding areas. Most of the infected trees were in 1-2-year-old branches, suggesting that fire blight was the main cause of the infection. The orchard in Yeongwol County, like the one in Chuncheon, was a solitary orchard located in the mountains. In some infected trees, blossom rot occurred alongside fire blight, and many infection cases were confirmed in 1-2-year-old shoots. In 2023, the disease occurred only in Hwacheon County, where no other orchards were nearby. Since the incidence rate exceeded 10%, the orchard was removed. The infection was mainly observed in 1-2-year-old branches. The farmer in question was a new settler who was not registered in the apple growers' association, meaning they did not receive essential information such as pest control training or chemical support. The lack of basic knowledge about the disease was identified as a major factor contributing to the spread of the disease.

Fire blight and black shoot blight are designated as quarantine pathogens under the Plant Protection Act and are subject to official control measures, requiring partial or complete burial of infected plants depending on the severity of the outbreak. Consequently, effective prevention strategies are essential to mitigate the spread of these diseases. The first critical measure involves the disinfection of orchard tools to maintain proper orchard hygiene. According to Lim et al. (2024), the most effective disinfection method for preventing fire blight is immersing tools in 70% ethanol for 60 seconds, which has been shown to completely eliminate the bacteria. Additionally, as pruning operations can facilitate the rapid spread of infection through diseased trees, the timely removal of infected trees is crucial. Specifically, branches should be pruned at least 20 cm beyond the visibly infected tissue to ensure the complete removal of the pathogen. Failure to extend the pruning range beyond this threshold increases the likelihood of pathogen persistence, which may lead to disease recurrence (Han et al., 2016). Furthermore, it is essential to establish surveillance teams at the municipal level to conduct continuous monitoring of affected areas and orchards with the same cultivation practices. Since partial removal of infected plants prior to official control measures can help prevent further spread, on-site diagnosis using rapid diagnostic kits enables the prompt identification and management of suspected cases (Heo et al., 2017). Additionally, the early application of microbial agents containing Bacillus spp. during the flowering stage can effectively prevent fire blight and black shoot blight. These beneficial microorganisms proliferate on floral surfaces in advance, thereby occupying potential

colonization sites and preventing the growth of *Erwinia amylovora*, the causative agent of fire blight (Farkas et al., 2012). However, the proliferation of microbial agents within floral tissues exhibits low reproducibility due to various environmental factors. Consequently, in regions where fire blight and black shoot blight are prevalent, it is necessary to apply highly effective chemical control agents, such as the antibiotic streptomycin, to ensure disease management (Ham et al., 2023; Sundin et al., 2009). In particular, the most effective strategy for preventing floral infections by *Erwinia amylovora* is the application of chemical agents based on predictive risk information for fire blight infection in blossoms (Namkung and Yun, 2023).

Acknowledgement

This study was carried out with the support of Cooperative Research Programs (Project No. RS-2020-RD009337) from the Rural Development Administration, Republic of Korea.

References

Bonn, W. G., van der Zwet, T. (2000) Distribution and economic importance of fire blight. pp. 37-53. In: Fire Blight: The Disease and its Causative Agent, *Erwinia amylovora* (Vanneste J., ed.). CAB International. Wallingford, UK. https://doi.org/10. 1079/9780851992945.0037

Drenova, N. V., Isin, M. M., Dzhaimurzina, A. A., Zharmukhamedova, G. A., Aitkulov, A. K. (2012) Bacterial fire blight in the Republic of Kazakhstan. Plant Health Res Pract 1:44-48.

Farkas, Á., Mihalik, E., Dorgai, L., Bubán, T. (2012) Floral traits affecting fire blight infection and management. Trees 26:47-66. https://doi.org/10.1007/s00468-011-0627-x

Fatmi, M., Bougsiba, M., Saoud, H. (2008) First report of fire blight caused by *Erwinia amylovora* on pear apple and quince in Morocco. Plant Dis 92:314. https://doi.org/10.1094/PDIS-92-2-0314A

Ham, H. H., Lee, M. H., Roh, E. J., Lee, W. H., Choi, H. W., Yang, M. S., Lee, Y. H. (2023) Effect of the registered control agents for fire blight on fire blight disease at flowering stage of apple in Korea. Korean J Pestic Sci 27:344-351. https://doi.org/10.7585/kjps.2023.27.4.344

Han, K. S., Yu, J. G., Lee, H. B., Oh, C. S., Yea, M. C., Lee, J. H., Park, D. H. (2016) Controlling by Effective Pruning of Twigs Showing Black Shoot Blight Disease Symptoms in Apple Trees. Res Plant Dis 22:269-275.

Heo, G. I., Shin, D. S., Son, S. H., Oh, C. S., Park, D. H., Lee, Y. K., Cha, J. S. (2017) On-Site Diagnosis of Fire Blight with Antibody-Based Diagnostic Strips. Res Plant Dis 23:306-313.

Lim, Y. J., Ham, H. H., Lee, M. H., Lee, W. H., Lee, Y. H. (2024) Disinfection Methods of Pruning Scissor for Preventing Transmission of Fire Blight. Res Plant Dis 30:194-198.

Namkung, K.-B., Yun, S. C. (2023) Improvement of fire blight blossom infection control using Maryblyt in Korean apple orchards. Plant Pathol J 39:505-512.

Park, D. H., Yu, J. G., Oh, E. J., Han, K. S., Yea, M. C., Lee, S. J., Myung, I. S., Shim, H. S., Oh, C. S. (2016) First report of fire blight disease on Asian pear caused by *Erwinia amylovora* in Korea. Plant Dis 100:1946.

Seo, S. T., Won, S. Y., Park, D. H., Kim, Y. S., Hur, J. H., Lim, C. K. (1999). Bacterial Shoot Blight of Apple Caused by Pseudomonas syringae. Plant Dis Agric 5:46-49.

Sundin, G. W., Werner, N. A., Yoder, K. S., Aldwinckle, H. S. (2009). Field evaluation of biological control of fire blight in the Eastern United States. Plant Dis 93:386-394.