Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 23, Issue 3, 2023
PRINT ISSN 2284-7995, E-ISSN 2285-3952

ECONOMIC IMPORTANCE AND PHYTOSANITARY MONITORING OF FIRE BLIGHT

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Abstract

Fire blight (FB) caused by Erwinia amylovora, is a bacterial plant disease that poses a significant threat to pome fruit production worldwide. It can cause extensive losses in fruit yields, damage orchards and lead to trade restrictions on fruit exports. Fire Blight (FB) can also affect the longevity and productivity of fruit trees, further exacerbating the economic burden on growers and increasing management expenses. Because Erwinia amylovora is a regulated pest in most countries of the EPPO region its phytosanitary monitoring is mandatory in order to prevent the disease extension and new outbreaks. The inspections were required during the growing season (from after flowering until late summer), when the signs were obvious to find the disease. Thus, during 2022 a phytosanitary monitoring plan of Fire Blight was organized by Phytosanitary Office from Dolj County, Romania and the results emphasized that the apple area infected with Erwinia amylovora represents 3.85% from the total apple trees area (1,558 ha), 27% from the total surface of pear trees (36 ha) and 100 % for quince trees (2 ha). Comparatively with the results of Fire Blight monitoring realized previous year (2021), in 2022 was identified one new outbreak, but only for apple trees. Also, among all assessed trees (348) 260 trees include Malus domestica (apple). Among the measures applied for Fire Blight control the most effective were reducing the bacterial inoculum by manual removal of infected shoots and even uprooting of trees.

Key words**:** *Erwinia amylovora, Fire Blight, apple, economic impact, integrated management*

INTRODUCTION

Fire Blight (FB) or Twig Blight of Apple (TBA) caused by *Erwinia amylovora* (Burrill), is a bacterial plant disease that poses a significant threat to pome fruit production worldwide, causing extensive losses in fruit yields, damage orchards, and lead to trade restrictions on fruit exports [4][24][30][28].
First reported in the United States in 1780 in the Hudson Valley, New York State, the disease has become a major concern for fruit growers due to its rapid spread, high infection rates, and potential to cause severe economic losses [3]. Since Fire Blight (FB) has spread around the world at date the disease has been officially recorded in more than 50 countries, mainly in western and eastern Europe and the eastern Mediterranean region, but also in South America, most African and Asian countries and Australia [10, 11].
The first signs of Fire Blight in Romania were discovered in the country's southern region in 1992 [22].
According to [15] the years 2016–2018 in the southern part of Romania were very favourable for the apple Fire Blight attack.
According to European and Mediterranean Plant Protection Organization, the pathogen is "black" listed as quarantine pest, code ERWIAM (Annex III), RNQP (Annex IV), 2022, (EPPO, http://www.eppo.org/QUARANTINE/quarantine.htm) [12]. Currently, the best ways to slow

the development of disease and prevent losses are phytosanitary control and early eradication of any Fire Blight.

Fire Blight (FB) infect apple (*Malus domestica*), pear (*Pyrus communis*), quince (*Cydonia oblonga*), crab apple (*Malus sylvestris*), hawthorn (*Crataegus*), cotoneaster (*Cotoneaster divaricatus*), mountain ash (*Sorbus aucuparia*), firethorn (*Pyracantha coccinea*) and some other members of the Rosaceae family [5][16].

Among all host plants, apple (*Malus domestica*) and pear (*Pyrus communis*) are the most affected worldwide, especially in favourable climatic conditions for bacterial disease development (4°C–37 °C), the optimal temperature being 28 °C [29]. Thus, the Fire Blight epidemics depends on favourable environmental conditions, the amount of bacteria inoculum and host susceptibility.

The disease can be spread easily by vectors (wind, rain, insects, birds), but also by contaminated pruning tools and infected plant material [25]. However, the bacteria that cause Fire Blight are capable of surviving in the orchard without infecting or manifesting symptoms on apple trees.

Bacteria swiftly multiply and invade tissue that is vulnerable once the favourable environmental conditions are established, leading to infection and disease.

[20] came to the conclusion that the risk of spreading *E. amylovora* through commercial apple fruits to disease-free areas is negligible using a predictive model under several scenarios.

The symptoms of the disease might vary depending on the plant section and phenological stage, including blossoms, leaves, shoots, branches and roots, being able to devastate apple trees within one season, especially on sensitive genotypes [13]. Also, the bacteria *Erwinia amylovora* attacks fruits in all stages and reduces their size and quality [18][19].

Only infected host plants experience overwintering by the Fire Blight (FB) virus. When the average temperature rises over 15°C in early spring, apple trees often start to exhibit their first signs. Blossoms that are infected get soggy, shrivel, wilt, and turn orange or brown to black. Additionally, peduncles can appear water-soaked, turn dark green, then turn brown or black, occasionally oozing sticky bacterial exudates in the infectious process. It's possible for the oozing from infected apple branches to be golden colour [1]. Infected leaves wilt and apple whole spurs turn brown or black, as well as young fruitlets that continue to be attached to the tree. Cankers that are brown to black and somewhat depressed develop on the bark of diseased trees' trunks, branches, and twigs. Later, these cankers develop fissures along the boundary between the diseased and healthy tissue.

The endophytic *E. amylovora* can spread to bacterial-free areas by attaching to interior tissues of multiplication material. Thus, the host plants that are latently infected or have invisible cankers are the principal vehicles for the Fire Blight pathogen's long-distance transmission.

One of the most effective ways to reduce the spread of Fire Blight and fruit tree losses is phytosanitary control. The development of warning systems based mostly on meteorological data has been made possible by the need to effectively and economically control the disease [14].

Considering the aspects above mentioned, the paper provides a comprehensive overview of the economic importance of Fire Blight (FB) and its broader implications for the agricultural sector and international trade, as well as crop surveillance and monitoring of the disease and its impact on apple trees in the conditions of integrated disease management.

MATERIALS AND METHODS

The current study's research, which is reported in this paper, used a qualitative informational methodology that included books, scientific publications, news items, reports, and websites. Thus, to offer an integrated assessment of the current state of knowledge on the topic of the paper, pertinent literature was found and synthesized [26].

To achieve this goal, systematic, semi-systematic, and integrative research

approaches were used to compare current literature, papers, studies, reports, and statistics [23]. Additionally, the text mining approach, a well-known text analysis methodology used to draw connections and knowledge from a vast number of textual sources, was applied.

During 2022 a phytosanitary monitoring of Fire Blight (FB) was organized in Dolj County, Romania in apple, pear and quince orchards for preventing the spread of *E. amylovora* into uninfested areas. The monitoring was organized during the growing season when the symptoms were visible in the orchards.

There was assessed the total number of Fire Blight infections per apple tree. Fresh samples of diseased young shoots, flower clusters, leaves, and fruits with visible Fire Blight symptoms (necrosis, wilting, and bacterial ooze), were taken for the pathogen isolation and identification. Isolation of the pathogen was made from fresh samples (symptomatic shoots, flowers, leaves, fruits) according to the EPPO protocol (EPPO, 2013) [10]. Detection of the bacterium was done using PCR assays and MALDI-TOF mass spectroscopy protocols [21][27].

RESULTS AND DISCUSSIONS

Fire blight can cause severe economic losses for fruit producers due to reduced crop yields, fruit quality deterioration, and increased management expenses.

Even Fire Blight (FB) outbreaks may be sporadic due to specific environmental conditions (springs characterized by an extremely warm and wet weather), when they occur, they can cause significant losses in terms of lost trees or lost money. Moreover, Fire Blight (FB) is not only harmful to the trees that will be harvested this year, but it is also quite dangerous to the trees themselves. The

loss of fruiting spurs has a substantial impact on productivity the next year as well.

The economic impact is difficult to quantify because it depends on the intensity of the epidemic and a Fire Blight attack can have repercussions over several years.

Infected orchards may experience up to 60-90% yield losses and costs of controlling Fire Blight (FB) exceed $100 million annually, leading to decreased revenues and profitability for growers [17].

The disease also affects the longevity and productivity of fruit trees, further exacerbating the economic burden on growers. For example, in 2000, in Michigan, USA, serious Fire Blight issues occurred and that led to a $42 million regional economic loss and the eradication of 350,000–450,000 apple trees that covered roughly 626–930 ha. Previously, in 2019, the Fire Blight outbreak in Michigan, USA, resulted in losses of over $3.8 million. Also, apple and pear growers reported losses of over $68 million in 1998 as a result of fire blight outbreaks that were detected in Washington and northern Oregon, USA [6]. In Switzerland, the financial impact of control measures (from quarantine to diagnostics), along with compensation payments for destroyed trees, were estimated to be 35 million EUR over a 14-year period, from 1989 to 2003 [8]. Economic losses due to Fire Blight impact worldwide include direct losses from reduced yields and quality, as well as indirect losses from trade disruptions and management costs. This increases year by year from $500 million in 2018 to $800 million in 2022. Fire Blight (FB) has also far-reaching consequences for international trade in tree fruits (Table 1).

Table 1. Economic Losses Caused by Fire Blight in Tree Fruit Agriculture Worldwide

Year	Total Global losses (USD Million)	No. of Affected Countries	Yield loss (%)	Management costs (USD million)	Trade Disruptions (USD million)
2018	500	25	30	150	50
2019	600	30	35	180	70
2020	700	35	40	210	100
2021	750	40	45	225	120
2022	800	45	50	240	150

Source: own calculations.

Countries worldwide have imposed stringent phytosanitary regulations to prevent the introduction and spread of *Erwinia amylovora*.

Outbreaks of fire blight in exporting regions can lead to temporary or permanent trade embargoes, disrupting established supply chains and affecting economies on a global scale. Loss of market access may result in surplus fruit in affected regions, leading to lower prices and economic hardships for local growers. The interconnectedness of the global economy makes it susceptible to disruptions caused by fire blight outbreaks. Supply chain vulnerabilities in the tree fruit industry can be exposed when key exporting regions are affected. These vulnerabilities may result in food shortages, increased prices, and adverse economic impacts, especially in regions heavily reliant on tree fruit imports.

Moreover, the economic impact of Fire Blight (FB) can extend beyond the tree fruit industry to affect related sectors, such as logistics and retail, making the overall economic consequences even more complex to quantify accurately. Despite the sporadic occurrence of Fire Blight (FB), there is a trend toward increasingly frequent and destructive outbreaks, which can be associated to a number of aspects that have enhanced the susceptibility to Fire Blight, such as: a)increased orchard density (currently, fruits growers plant up to ten times as many apple trees per ha - 250-1,500 -instead of the previous 100-200 trees/ha); b) rootstocks susceptibility (M.9 and M.26 are two of the most popular rootstocks, but they are also quite vulnerable to fire blight); c) varieties (many of the most popular apple varieties that meet the demands of the fresh fruit market (e.g., Gala, Fuji, Jonagold, Braeburn, Pink Lady, Idared, Jonathan) are also highly susceptible to Fire Blight; d) unusual weather conditions in spring, which included a heat wave during bloom followed immediately by frost [14]. The injuries caused by Fire Blight in apple trees have a long-term effect because it is occasionally necessary to remove substantial pieces of the tree and thus the risk of dieback for the entire tree is increased.

Actually, during a fire blight outbreak, infections can occur in one of five different ways (Canker, flower, shoot, trauma, and rootstock blight). Meanwhile, not all infection types, manifest themselves throughout every disease outbreak. The sources of the inoculum, the tissues that are affected, and the meteorological factors that affect the infection process vary among these types. The signs of each form of infection can be very distinct, but once an epidemic is under way, it gets harder to differentiate them apart.

It is crucial to be able to identify the infection type in order to choose the best control strategy because not all infection types respond to the same control measures.

The infection spreads through susceptible hosts so quickly that once infected, trees cannot be saved, even by immediate and drastic surgery, and they die shortly after exhibiting the first signs of infection. Therefore, inspections are required during the growing season (from after flowering until late summer), when the signs are obvious, to find the disease. Thus, during 2022 in Dolj County, Romania the Fire Blight monitoring was done on 522 ha with the most susceptible hosts (500 ha apple, 200 ha pear and 2 ha quince).

The assessed surface was considered contaminated with *Erwinia amylovora* after pathogen isolation and positive results of laboratory test using PCR assays and MALDI-TOF mass spectroscopy protocols [21][27]. The results emphasized that the apple area infected with *Erwinia amylovora* represents 3.85% from the total apple trees area from the whole county (1,558 ha), 27% from the total surface of pear trees (36 ha) and 100 % for quince trees (2 ha).

Comparatively with the results of Fire Blight monitoring realized previous year (2021), in 2022 were identified new outbreaks only for apple trees. Also, among all assessed trees (348) 260 trees include *Malus domestica* (apple). Almost 26 ha of apple trees recorded moderate infection with *Erwinia amylovora* (20% attack degree), while 70 ha of apples recorded low infection level with the pathogen (5% attack degree) (Table 2).

Table 2. The Phytosanitary Monitoring of Fire Blight in 2022 in Dolj County, Romania

April – September 2022	Total orchard area (ha)	Assessed area (ha)	Complete monitoring area (ha)	Contaminated area (ha)	New outbreaks (ha)	No.of infected trees	Percent of area affected by Fire Blight				
							1	2	3	4	5
Apple	1,558	500	90	60	1	260		60		26	
Pear	36	20	10	10	-	60		10			
Quince	2	2	2	2	-	28			2		
TOTAL	1596	522	102	72	1	348		70	2	26	

Source: Dolj Phytosanitary Office, 2022 [7].

Previous research emphasized that Fire Blight progress in concerning issue in Africa too since 2013. [2] reported that Fire Blight has progressed most in rosaceous region from Morrocco affecting a total area of about 4,000 ha. Also, the Moroccan Plant Protection services reported that, he area of uprooted and incinerated orchards in the various affected provinces across the country was in the order of 2,312 ha [3].

Current control methods are diverse, but each has a limited effectiveness. Phytosanitary control and reducing the bacterial inoculum by manual removal of infected shoots or even uprooting of trees, seems to be the most effective (Table 3).

Table 3. The applied measures as a result of Phytosanitary Monitoring of Fire Blight in 2022, Dolj County, Romania

Host	**Fire Blight infected area (ha)**	**Trees uprooting (ha)**	**Non curative Manual removal of infected shoots (ha)**	**Curative Manual removal of infected shoots (ha)**
		April-Sept. 2022	April-Sept. 2022	April-Sept. 2022
Apple	60	10.5	60	170
Pear	10	0	10	120
Quince	2	0	2	80
Total	72	10.5	72	370

Source: Dolj Phytosanitary Office, 2022 [7].

Previous findings show that continuous monitoring, research, and international collaboration are essential to mitigate the economic impact of fire blight and ensure sustainable tree fruit production worldwide.

CONCLUSIONS

Fire blight, caused by *Erwinia amylovora*, is a critical concern for the global tree fruit industry, significantly impacting fruit producers and international trade. Understanding the economic importance of the disease and its implications on global trade is essential for designing sustainable strategies to mitigate losses and secure the supply of pome fruits in the global marketplace. Efforts to manage and control Fire Blight (FB) come with considerable financial investments. Growers often implement measures such as pruning infected branches, applying antibiotics, and using resistant cultivars. These approaches not only incur direct costs but may also require specialized training and equipment. The financial burden is particularly challenging for small-scale farmers, potentially leading to reduced competitiveness and consolidation in the industry. Addressing the economic importance of fire blight requires collaborative efforts and proactive strategies. Research and development focused on identifying resistant cultivars and exploring alternative control measures can reduce the reliance on chemical interventions and enhance long-term sustainability. Implementing early detection and surveillance systems can help contain outbreaks and prevent further spread, minimizing economic losses. However, effective policy frameworks at national and international levels are essential to coordinate efforts in fire blight management and trade facilitation. Collaboration among stakeholders and continuous research efforts are necessary to safeguard the economic viability of the tree

fruit industry and ensure food security on a global scale.

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