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Possibility of appearance of fire blight *Erwinia amylovora* in Estonia

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Abstract. Fire blight *(Erwinia amylovora)* is one of the most harmful diseases of the *Rosaceae* fruit trees. At the moment fire blight is absent in Estonia. This condition is proved by three years of monitoring surveys by taking and analysing 933 samples.

The present article studies the possibility and danger of appearance of this bacterial disease in Estonia.

General influence for fire blight are climatic conditions, and key factors for appearance of the disease are temperature and humidity during the flowering season of its host plants.

Climatic conditions of 35 years (1966–2000) from two meteorological stations – inland Võru and coastal Lääne-Nigula were analysed.

It became obvious that a possibility of appearance of fire blight in Estonia has been present most of the years studied. If fire blight already actively existed in an area, possibility of infection would be high in both the meteorological stations.

Danger of fire blight infection has existed in Estonia most years. Therefore it is necessary to protect the territory of Estonia with special regulations. This can be made possible by establishing a fire blight pest free area, or, in case Estonia joins the European Community, a fire blight protected zone in the whole territory of Estonia.

Key words: degree hour; four-day degree hour total; low, moderate, high, extreme infection risk; active canker, pest free area, protected zone

INTRODUCTION

In this article the rateable probability of appearance of fire blight in Estonia is evaluated by analysing the meteorological conditions as the main factor in fire blight appearance.

Fire blight is a harmful bacterial disease that stems from North America and has spread also in European countries. The disease is the most important bacterial disease of seed-corn fruit trees, causing relevant economical damage by destroying fruit trees and rosaceous ornamental plants in appropriate climatic conditions.

The causal agent for fire blight is the bacterium *Erwinia amylovora*. The areas nearest to Estonia with findings of fire blight are Poland, Denmark, Sweden, Norway, Germany (Smith et al., 1997; Crop..., 2002). Fire blight has not been found in Estonia and its neighbouring countries Finland, Russia, Latvia and Lithuania (Survey..., 2002; 2002 surveys..., 2003; Smith et al., 1997; Crop..., 2002; Situation..., 2002).

The optimum conditions for the growth of the bacteria are air temperature above 18°C and relative air moisture over 70% (Методические указания …). Occurrences of the disease have been observed even in cases when air temperature has not exceeded 13°C during the flowering of host plants. The pathogen can multiply at 4–32°C, reproduction occurs most quickly at 24–29°C (van der Zwet, Beer, 1991).

Damage of a diseased plant looks like a fire damage. All aboveground plant parts can be infected by the disease – flowers, shoots, leaves, fruits, crown, stem. From overwintering stem cankers, caused by fire blight, the bacteria spread into a flower by wind, splashing rain and insects. Insects are attracted by the sweet bacterial ooze. Bacteria can grow and multiply epiphytically on flower surfaces and be transmitted to other flowers with pollinating insects, mainly honey bees. Epiphytical reproduction continues until the bacteria become pathogenic because of favourable conditions (temperature, flowers wetting). Primary infection starts in flowers. The bacteria enter a flower through natural holes – pistils, nectaries. The reproduction and spread of the bacterium into a plant causes plant cell destruction and plant tissue necrosis.

Pathogenic bacteria spread into other flowers, young shoots, leaves and fruits mainly by pollinating and by insects sucking plant juice. They enter the plant through natural holes and damages caused by insects, hail, wind, or human activities.

It is characteristic of *Erwinia amylovora* to exude at first milky white, later brown, bacterial ooze from diseased plant parts. Infected shoots develop the diagnostic "shepherd's crook", typical of fire blight. Browned leaves and mummified fruits remain in the tree. Cankers emerge on the stem.

Host plants of fire blight belong to the family *Rosaceae,* subfamily *Maloidea* (*Pomoidea*). The most important host plants, the growing and spreading of whose propagating material is regulated by legislation, are *Chaenomeles*, *Cotoneaster*, *Crataegus*, *Cydonia*, *Eriobotrya*, *Malus*, *Pyrus*, *Sorbus (*except *Sorbus intermedia*), *Mespilus*, *Stranvaesia* (Ohtlike…2000; Council …, 2000).

The bacteria spread to long distances by fruit-eating migratory birds from the order *Passeriformes* (Spina et al., 1993), and with human activities (tools, machines, host plant propagating material). Latent *Erwinia amylovora* may appear in plant tissues without external disease symptoms. Therefore, spread by propagating material is probable. Local spread is done by insects, wind, rain and human activities.

The Plant Health Department of Estonian Plant Production Inspectorate has conducted a fire blight survey on the basis of instructions prepared in the department in 2000–2002. The survey is based on 933 samples collected by the regional inspectors of the Plant Production Inspectorate and tested in the Plant Health Laboratory of Estonian Control Centre of Plant Production. One test sample was analysed in Naktuinbouw laboratory in the Netherlands. The analysed samples contained no *Erwinia amylovora* (2001. a ohtlike …, 2002; Järelevalve…, 2003). On the basis of the survey results, it can be concluded that fire blight is absent in Estonia.

The Plant Protection Inspectorate will continue observing host plants of fire blight and collecting samples in the case of appearance of any disease symptoms.

The infection results from coinfluence of three factors – susceptible host plants, favourable environmental conditions and presence of infection. Infection does not occur if one of the factors is absent. Though in Estonia fire blight has not yet appeared, its occurrence and spread is possible as:

- Fire blight host plants are cultivated and grown in Estonia.

- By joining the European Union Estonia becomes a part of the integrated market and the free movement of goods includes movement of propagating material. Fire blight appears in several countries of the European Union.
- Migratory birds are probable agents introducing fire blight bacteria. Birds (order *Passeriformes*) nest in Estonia, hibernate in South Europe and North Africa and migrate through European countries.
- Meteorological conditions in general are favourable for development of the bacteria.

The most relevant environmental factors are temperature during the blooming of host plants, precipitation and air moisture. Inoculation and further development of the disease are affected by a relative air moisture over 70% and twenty-four-hour mean temperature over 15.6°C. Frequency of host plants in an area, appearance and quantity of pollinating and sucking insects are important factors.

This article seeks to demonstrate the possible danger of fire blight in Estonia, based on 35 years of temperature and precipitation records from two meteorological stations of Estonian Meteorological and Hydrological Institute – Lääne-Nigula and Võru. Records from the two meteorological stations at a distance of about 230 kilometres from each other cannot be used to generalise data on the territory of Estonia. Records from these two stations, situated in different meteorological conditions (Lääne-Nigula is located near the sea, about 6 kilometres from Haapsalu gulf and Võru in the southeastern inland of Estonia), can be compared for obtaining an overview of the possible risk of fire blight.

Possibility of inoculation in the case of accidental appearance of bacteria on host plants is analysed comparatively with regard to temperature, precipitation and the general blooming period of host plants. It is presumed, that the case area has previously not been infected with fire blight and the bacteria exist in the area in active form. Miscellaneous other influences are not taken into consideration. The article does not analyse further development of the disease.

MATERIALS AND METHODS

Because of the occasional appearance of fire blight – in some years at destructive bursts, in the meantime with latent incubation periods – warning systems for forecasting a risk of fire blight have been created. The system is based on assessment of climatic conditions, relevant for development of the disease: air temperature and air humidity. The warning system allows to carry out preventive actions in the critical period.

The current article is based on the conditions applied in computer program MARYBLYT, introduced in 1992 in USA for forecasting appearance of fire blight (Turechek et al., 2001) and fire blight risk assessment program COUGARBLIGHT (Smith, 2000).

Minimum conditions for a possibility of appearance of fire blight are:

- Open healthy flowers.

  Since first flowers opened, collect constant exceeds 18.3°C amount of four-day degree hour total. When the flower opens, the bacteria have three to five days to penetrate pistils and nectarines for reaching the flower. A higher air temperature speeds development of the bacteria (Smith, 2002).

If fire blight has previously been absent in an area, a risk of primary infection appears at 110, is low at 110–200, moderate at 200–270, high at 270–430 and extreme at over 430 amount of four-day degree hour total.

If fire blight has occurred in the same place or in the neighbourhood during the previous year, the risk of infection is low until 110, moderate at 110–160, high 160–270, and extreme at over 270 amount of four-day degree hour total.

If active cankers of fire blight occur on host plant stems in the same area or in the neighbourhood the risk of infection is low until 30, moderate at 30–110, high at 110–200 and extreme at over 200 amount of four-day degree hour total (Smith, 2000).

In this work the first and last situation are analysed.

- Precipitation of the same day is at least 0.25 mm, or on the previous day at least 2.5 mm.
- 24-hour-average temperature exceeds 15.6°C. The bacteria, epiphytically multiplied in flowers at a low temperature, become pathogenic when temperature rises to 14.4–16.7 degrees (van der Zvet, Beer, 1991).

To determine the probability of appearance of fire blight, May and June records from the period of 35 years (1966–2000) from two stations of Estonian Meteorological and Hydrological Institute (Lääne-Nigula and Võru) are analysed.

Basic records used in this work are:

- 24-hour air temperature observed at an interval of 3 hours – at 00.00; 03.00; 06.00; 09.00; 12.00; 15.00; 18.00; 21.00.
- 24-hour sum of precipitation (mm).
- Number of rainfall days.

Calculated values:

- Measured value of periodical temperature is attributed to three hours and calculated by 24-hour temperature level over 18.3°C. The degree hour total of four sequential days in May and June (May 1–4; 2–5; …June 27–30) is classified on the assumption of fire blight absence or presence before.

If fire blight has not previously occurred, the four-day degree hour total
under 110 risk of infection is absent (0);
110–200 low risk of infection (1);
200–270 moderate risk of infection (2);
270–430 high risk of infection (3);
over 430 extreme risk of infection(4).

If fire blight already exists in an area and there are active stem cankers of fire blight, then
until 30 low risk of infection (1);
30–110 moderate risk of infection (2);
110–200 high risk of infection (3);
over 200 extreme risk of infection (4) occur.

Table 1. Flowering season of apple (Aasa, 2001).

Meteorological station	Flowering			
	Earliest	Latest	Average beginning	Average cease
Türi	5.12	6.30	5.29	6.07
Jõhvi	5.15	7.04	5.30	6.08
Karja	4.29	7.02	5.30	6.11
Kuusiku		6.30	6.02	6.10
Võru	5.05	6.26	5.24	6.03

Table 2. Flowering season of natural host plants of fire blight (Ahas, 2001).

Species	Beginning of flowering	Full flowering	Cease of flowering
Chaenomeles japonica	5.22	5.31	6.17
Cotoneaster lucidus	5.30	6.07	6.21
Crataegus crus-galli	6.13	6.16	6.27
Crataegus curvisepala	6.04	6.09	6.17
Crataegus douglasii	5.28	6.02	6.07
Crataegus submollis	5.29	6.02	6.07
Malus baccata	5.28	5.31	6.06
Malus domestica	5.26	5.30	6.06
Malus sieversii	5.27	5.30	6.07
Malus sylvestris	5.26	5.30	6.06
Sorbus aucuparia	5.30	6.05	6.14
Sorbus decora	6.02	6.09	
Sorbus pouhashanensis	5.30	6.02	6.05

In this article the observed values of 1966–2000 are:

- Sum of degree hours > 30; > 110; > 200; > 270; > 430.
- Appearance of precipitation.
- Dates May 01–June 30, when the host plants of fire blight bloom. The blooming period of different plant species is different. In general fire blight host plants bloom in May–June. Massive blooming of fire blight host plants occurs in the last week of May and first week of June.

Table 1 outlines the period of apple blooming on the basis of existing observation data of Estonian Meteorological and Hydrological Institute from 1949–1999 and according to the agrophenological calendar (Aasa, 2001), from the earliest beginning of blooming until the latest ending. Natural blooming period of host plants, introduced on the basis of dendrophenological observations in Järvselja Training and Experimental Forest Centre (Ahas, 2001), is introduced in Table 2.

RESULTS

To see to what extent it is possible to generalise the results for the territory of Estonia, temperatures (over 18.3°C four-day degree hour total) and precipitation in two meteorological stations are compared. The risk of infection is observed at first only on the basis of temperature and then on the basis of coinfluence of temperature and precipitation.

Differences of temperatures in the observed meteorological stations are noticeable, but periods of higher temperature (four-day over 18.3°C degree hour total) are in general similar (Figures 6, 7, 8). On the basis of temperature, the risk of infection is higher in the area of Võru meteorological station as in the case of temporally close periods degree hour total in Võru is higher than the degree hour total in Lääne-Nigula.

By comparing the quantity of precipitation and number of rainfall days, a difference in the data of the two meteorological stations can be outlined. Table 4 presents amounts of data of May and June of ten years of higher risk, the quantity of precipitation and number of rainfall days, therefore, there are more potentially risky days in Võru (Table 3). The relative air moisture and 24-hour average temperature have a relevant role in development of the disease. Those factors are not discussed in this work.

When generalising the results of two meteorological stations in the territory of Estonia it must be considered that favourable conditions for the disease even in one area could lead to further spread of the bacteria. The following years, favourable for the bacteria, can result in a distribution of the bacteria. Absence of the disease can be presumed, when the appropriate conditions do not occur in either of the stations. The possibility of absence of primary infection of the disease can be presumed in five of the 35 years (Table 4). Generalisation of the data would be possible, if the operative data from all meteorological stations were entered into a model for calculations.

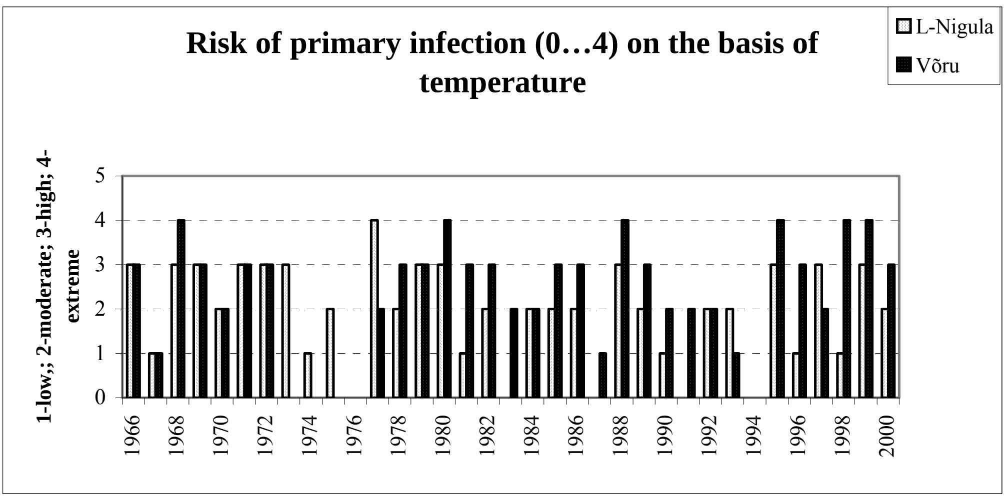

Fig. 1. Probability of primary occurrence of fire blight on the basis of temperature.

Table 3. Amount of precipitation (mm) and rainfall days in May and June.

Year	Võru		Lääne-Nigula	
	Amount of precipitation (mm)	Days of precipitation	Amount of precipitation (mm)	Days of precipit ation
1966	146.9	25	48.9	19
1968	90.8	26	94	24
1972	110.1	24	124.3	23
1978	81	23	74,4	21
1980	66.8	22	119.1	21
1986	102.3	20	44.3	19
1988	85	21	49.6	20
1995	152.6	28	174.6	31
1998	251.8	33	159.6	25
1999	124.4	22	43.9	13
Sum	**1,212**	**244**	**933**	**216**
Average	**121.2**	**24.4**	**93.3**	**21.6**

A risk of primary infection only on the basis of temperature data (degree hours) is represented on the diagram of Fig. 1.

From the data of 35 years (1966–2000) it becomes evident that a risk of infection in both stations was absent in five years (14%). A primary risk of infection was absent in both stations in two (6%) of the thirty-five years – 1976 and 1994. In six years (17%) there occurred an extreme risk of primary infection in the Võru station area and in one year in the Lääne-Nigula station area.

What would be the situation if fire blight appeared actively in the area?

On the diagram of Fig. 2 a risk of occurrence of fire blight is demonstrated on the basis of ground temperature of the precedent occurrence years of the disease in the region. The bacteria hibernate in the stem cankers and spread in spring. The possibility of distribution of the disease is present every year. In Lääne-Nigula an extreme risk of infection occurred in twenty-one (60%) in Võru in twenty-four of the thirty-five years. In both areas a high risk of simultaneous infection occurred in nineteen years (54%). Accordingly, a high risk of infection was in Lääne-Nigula in eight years (23%) and in Võru in five years (14%). A moderate risk of infection was in both areas in five years and a low risk of infection in one year (3%).

A diagram about the risk of primary infection of fire blight on the basis of coinfluence of temperature and precipitation is demonstrated on Figure 3. The risk of infection was absent in Lääne-Nigula in nine years (26%), in Võru in eight years (23%). According to data from both stations the risk was absent simultaneously in three years (9%). The risk of infection was low in Lääne-Nigula in twenty-two years, in Võru in seven years (19%). The risk of infection was moderate in Lääne-Nigula in two years (6%), in Võru in nine years (26%), high in Lääne-Nigula in two years (6%), in Võru in eight years (23%), and extreme in Võru in three years (9%).

Table 4 demonstrates periods of primary infection (when the bacteria becomes pathogenic) on the basis of temperature and precipitation. Potential period of infection is a period when the degree hour total of four days accrues precipitation, on the same day at least 0.25 mm or on the previous day at least 0.25 mm.

By generalising the data on temperature and precipitation for the territory of Estonia, it may be concluded, that a risk of infection was absent in five years (14%). The risk of infection was low in eleven years (31%), moderate in nine years (26%). In ten years (29%) the risk of infection was high or extreme (the data shown bold in the table). In three years of ten, 1968, 1980 and 1995 the risk of infection was extreme. The risk could be higher, when the period was simultaneous with the massive blooming period of host plants, the period was longer or periods of higher risk were successive at an interval of few days.

The risk of active infection of fire blight on the basis of temperature and precipitation is demonstrated on the diagram of Fig. 4.

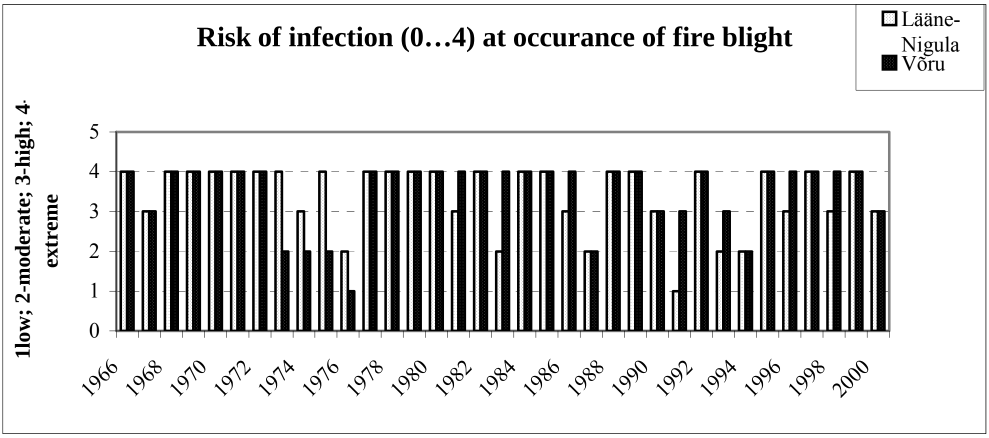

Fig. 2. Risk of occurrence of fire blight on the grounds of the precedent occurrence of the disease in the region.

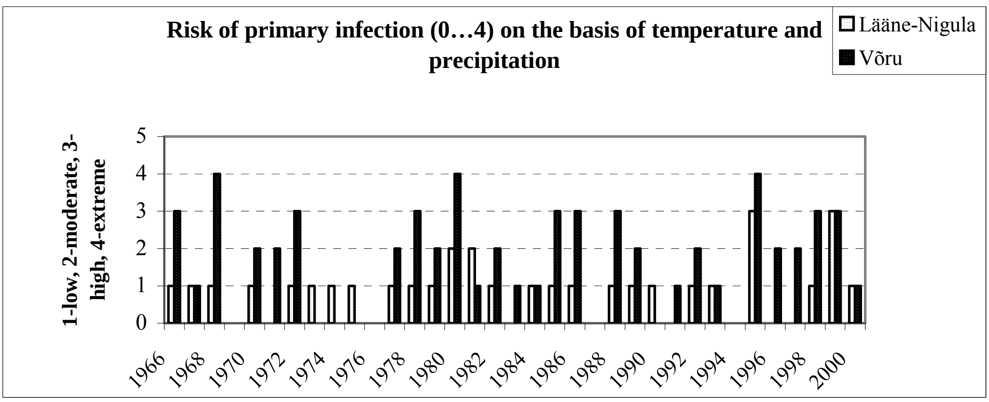

Fig. 3. Risk of primary infection of fire blight on the basis of coinfluence of temperature and precipitation.

Table 4. Periods of primary infection on the basis of temperature and precipitation.

Year	Risk of infection					
	Lääne-Nigula		Võru		Estonia	
	Period	Risk	Period	Risk	Period	Risk
1966	**5.21; 6.25–26**	**1**	**5.21; 6.17; 6.22–28**	**3**	**Since 5.21**	**1–3**
1967	6.21–22	1	6.28–29	1	Since 6.21	1
1968	**6.06; 6.21–22**	**1**	**6.06-08; 6.20–23**	**1;4**	**Since 6.06**	**1–4**
1969	-	-	-	-	-	-
1970	6.11–12	1	6.6–7; 6.11–12; 6.26–28	2	Since 6.06	1–2
1971	-	-	5.19–21; 5.28–29	2	Since 5.19; continental	2
1972	**6.09; 6.14–16**	**1**	**6.09; 6.15–17**	**3**	**Since 6.09**	**1–3**
1973	6.02–04; 6.10	1	-	-	Since 6.02; coast and isles	1
1974	6.18–20	1	-	-	Since 6.18, coast and isles	1
1975	6.09–12; 6.18–21	1	-	-	Since 6.09; coast and isles	1
1976	-	-	-	-	-	-
1977	6.08–09	1	6.07–08	2	Since 6.07	1–2
1978	**6.08–09**	**1**	**5.17-18; 6.01; 6.08-10; 6.14-15; 6.23-28**	**1–3**	**Since 5.17**	**1–3**
1979	5.24; 6.09–10; 6.27–28	1	5.19–20; 5.26–27; 6.14–16	1-2	Since 5.19	1–2
1980	**6.01–03; 6.19–20**	**2**	**6.11–12; 6.18; 6.21–22**	**1-4**	**Since 6.01**	**1–4**
1981	5.24–25; 6.24–30	2	5.12; 5.21–29; 6.10–12; 6.25-30	1	Since 5.12	1–2
1982	6.06–07	1	5.29; 6.06–07	1-2	Since 5.29	1–2
1983	-	-	5.18; 5.25; 6.16	1	Since 5.18; continental	1
1984	5.19–20; 5.27	1	5.18–19; 5.26	1	Since 5.18	1
1985	5.30–6.01; 6.21	1	5.10; 07–6.09; 6.13-19	1 3	Since 5.10	1
1986	**6.13; 6.20–21**	**1**	**5.10; 6.07–08; 6.14-15; 6.21-22; 6.28-29**	**1-3**	**Since 5.10**	**1-3**
1987	-	-	-	-	-	-
1988	**6.01; 6.06-07**	**1**	**5.24-25; 5.30–6.01; 6.11; 6.24; 6.28; 6.30**	**1–3**	**Since 5.24**	**1–3**
1989	5.27; 6.29–30	1	6.04–07; 6.24–25; 6.29–30	1–2	Since 5.27	1–2
1990	6.28	-	6.29	-	-	-
1991	-	-	6.25–27	1	Since 6.25 continental	1
1992	6.13–16; 6.29–30	1	6.13–17; 6.22; 6.29–30	1–2	Since 6.13	1–2
1993	5.08; 5.16	1	5.09	1	Since 5.08	1
1994	-	-	-	-	-	-
1995	**6.01–05; 6.13–17**	**3**	**6.04–11; 6.15–18**	**4**	**Since 6.01**	**3–4**
1996	6.13	-	5.15; 6.04; 6.10; 6.14	1–2	Since 5.15	1
1997	6.13		6.09–16	1–2	Since 6.09	1–2
1998	6.11–13	1	5.20**; 6.08–17**	1; 3	Since 5.20; **6.08**	1–**3**
1999	**6.16–17; 6.23–24**	**3**	**6.06-10; 6.18–29**	**3**	**Since 6.06**	**3**
2000	6.24–25	1	5.21; 6.12; 6.24–26	1	Since 5.21	1

Table 5. Risk of infection and number of risky days.

Year	Primary infection				Active infection			
	Lääne-Nigula		Võru		Lääne-Nigula		Võru	
	Days	Level	Days	Level	Days	Level	Days	Level
1966	3	1	9	3	12	3	21	4
1967	2	1	2	1	19	3	21	2
1968	3	1	7	4	13	4	19	4
1969	-	-	-	-	6	2	10	2
1970	2	1	7	2	11	3	17	3
1971	-	-	5	2	4	2	20	4
1972	4	1	4	3	16	3	21	4
1973	5	1	-	-	14	3	9	1
1974	3	1	-	-	10	3	5	1
1975	8	1	-	-	15	4	15	1
1976	-	-	-	-	2	1	1	1
1977	2	1	2	2	20	4	16	2
1978	2	1	14	3	10	3	22	4
1979	5	1	7	2	16	3	10	4
1980	5	2	5	4	16	4	10	4
1981	9	2	19	1	18	3	21	3
1982	2	1	3	2	13	4	10	4
1983	-	-	3	1	20	2	28	3
1984	3	1	3	1	16	3	22	4
1985	4	1	11	3	14	4	26	4
1986	3	1	10	3	16	4	24	4
1987	-	-	-	-	18	1	23	2
1988	3	1	9	3	17	4	26	4
1989	3	1	8	2	13	3	26	4
1990	1	1	1	-	8	2	12	2
1991	-	-	3	1	9	1	25	2
1992	6	1	8	2	12	4	13	4
1993	2	1	1	1	11	3	18	2
1994	-	-	-	-	7	1	12	1
1995	10	3	12	4	26	4	20	4
1996	1	-	4	2	12	2	12	3
1997	1	-	8	2	13	3	17	4
1998	3	1	11	3	22	3	30	4
1999	4	3	17	3	13	4	23	4
2000	2	1	4	1	14	3	21	3

In Lääne-Nigula an extreme risk of infection occurred in eleven years (32%) and in Võru in eighteen years (52%) out of the thirty-five years. In both the areas the simultaneous risk of infection was extreme in nine years. A high risk of infection occurred in Lääne-Nigula in fifteen years (43%), in Võru in five years (14%); a moderate risk of infection in Lääne-Nigula in five years (14%), in Võru in seven years (20%); and a low risk of infection in Lääne-Nigula in four years (11%) and in Võru in five years (14%).

In Table 5 comparative numbers of risky days and the risk of primary and active infection is demonstrated.

In the Fig. 5 the days of high risk of infection on the basis of primary infection (four-day degree hour total over 110 and precipitation at least 0.25 mm, or at least 2.5 mm on the previous day) and occurrence of hibernate active cankers (four-day degree hour total over 0 and precipitation at least 0.25 mm, or at least 2.5 mm on the previous day) are compared. The 61 days in May and June allow us to calculate the average of primary infection: in Lääne-Nigula on three days, in Võru on six days and appearance of active cankers in Lääne-Nigula on fourteen days, and in Võru on eighteen days. The maximum of risky days in 1998 is near thirty.

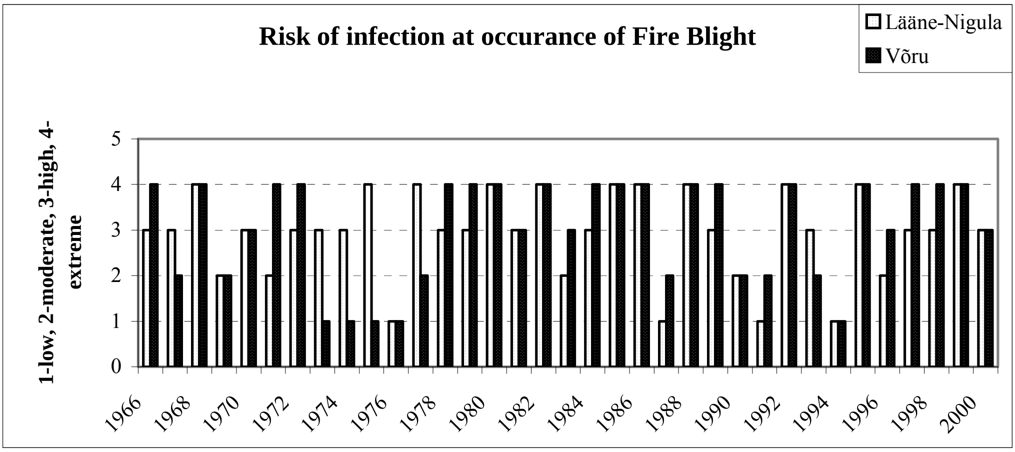

Fig. 4. Risk of active infection of fire blight on the basis of temperature and precipitation.

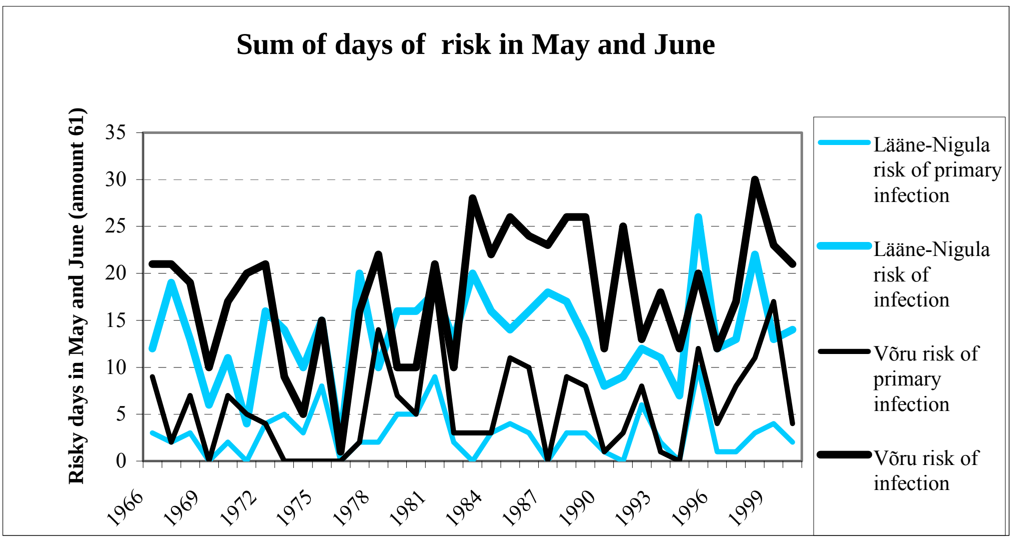

Fig. 5. Days of infection risk on the basis of primary infection and occurrence of active cankers.

In 1968 the risky period occurred at the end of June, when most of the host plants ceased blossoming (Fig. 6). A primary risk of infection can therefore be excluded. A risk of infection cannot still be excluded because some host plants (*Crataegus, Cotoneaster*) bloom in June (Table 2). Infection could result, but epidemics cannot be forecasted as the host plants blooming in the second half of June are not growing in large quantities. Spread of the bacteria on the flowers of host plants and on young shoots by means of wind, rain, sucking and pollinating insects and human activities can therefore be limited.

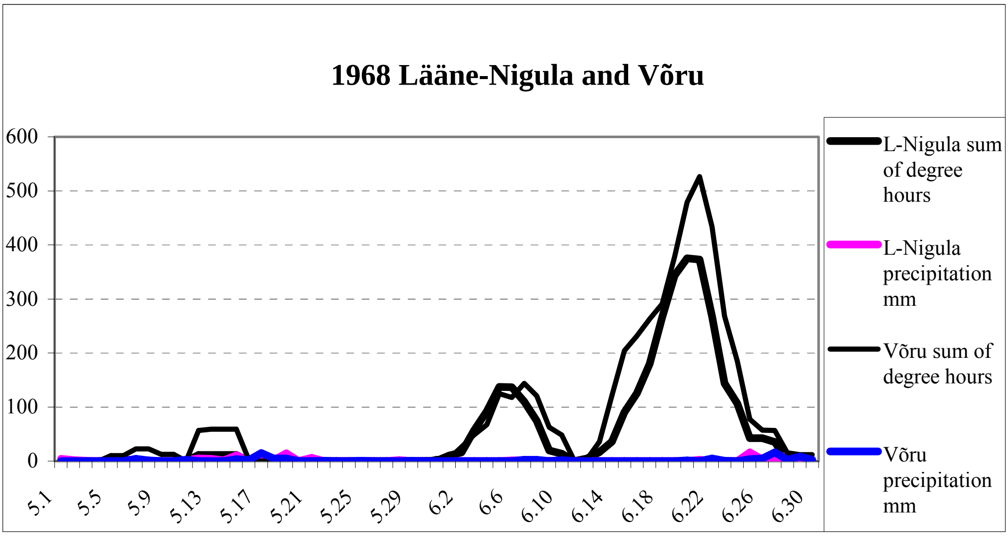

Fig. 6. Comparison of temperatures and precipitation in Lääne-Nigula and Võru in 1968.

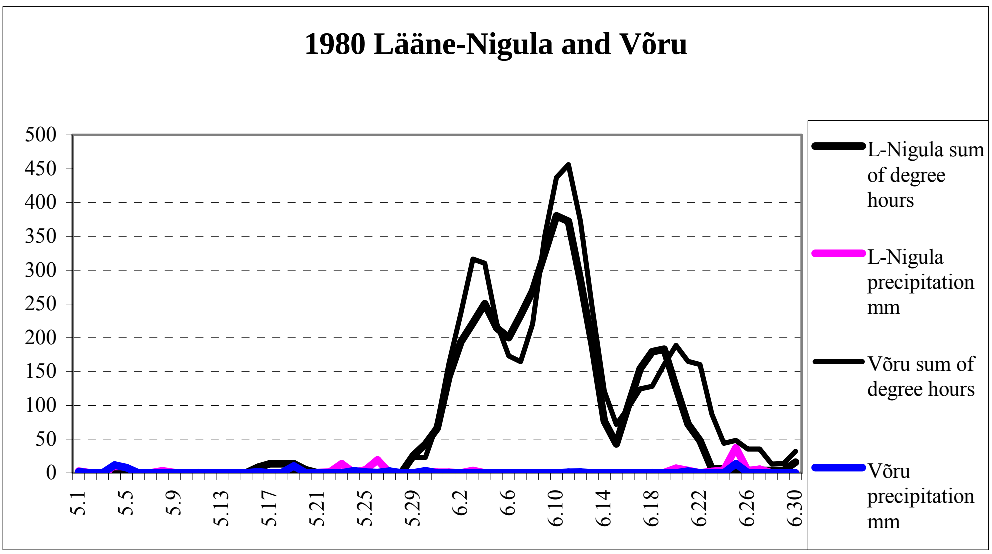

Fig. 7. Comparison of temperatures and precipitation in Lääne-Nigula and Võru in 1980.

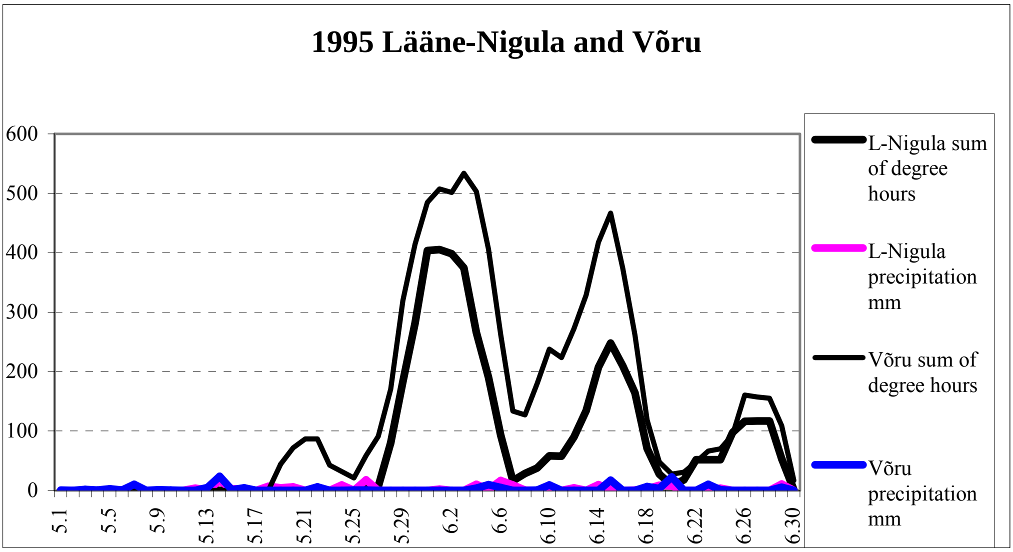

Fig. 8. Comparison of temperatures and precipitation in Lääne-Nigula and Võru in 1995.

In 1980 and 1995 (Figures 7, 8) risky periods occurred at the end of May and in the first half of June, in the blooming period of most of the host plants of fire blight, including widely-spread apple trees and rowan-trees. The risky period with interim rainfalls and a few cooler days was long, lasting for 2–3 weeks.

How does the bacteria behave in such conditions? In those years an epidemic could be forecasted on the basis of temperature, precipitation and the blooming period of host plants. The bacteria, carried on the host plant flowers by means of rain, wind and insects multiply epiphytically in flowers and are carried onto other flowers by means of honeybees and miscellaneous pollinating insects. At the beginning of June the bacteria become pathogenic because of favourable meteorological conditions and can multiply in flowers and enter a plant. Sucking insects on the new host plants, developing young shoots, fruits and twigs, carry the bacteria.

Possibility of an epidemic is very probable in both the years.

DISCUSSION AND CONCLUSIONS

Spread of the harmful bacterial disease fire blight in Estonia is possible. The following conditions appear:

- fire blight host plants grow naturally and are cultivated in the area;
- the transfer of the bacteria to the territory is possible;
- the conditions making the blooming period infection and development of the bacteria possible are available in most years.

If the bacteria appears in the territory of Estonia and primary infection will not be discovered, it may result in a situation, where a primary infection can develop epidemic in the year favourable for the bacteria and spread over the territory. In this case the risk of further infection is high. Since fire blight host plants are spread in

Estonia, the infection of host plants and herewith spread of bacteria is possible practically every year. Spread of the disease and the accompanying destruction of fruit trees leads to economical losses in production. Inspection of host plants, preventive control of fire blight and liquidation of infection focuses – cutting diseased shoots and branches, rooting out and burning infected trees, requires additional resources.

Primary prevention of fire blight are legislative restrictions. Fire blight is included in the list of harmful organisms, verified with the regulation No. 300 of September 13, 2000, of the Government of the Republic of Estonia (Ohtlike…, 2000). Estonian legislation regulates import of fire blight host plants (Piiril asuvas…, 2000; Sisseveo keeld…, 2000; Taimede, taimsete…, 2000; Taimetervise…, 2000), production and marketing (Tootmise…, 2000) and, in the case of fire blight occurrence, its control (Ohtliku…, 2001).

Protection of the Estonian territory from fire blight is possible with establishment of restricted protection treatments. On the basis of monitoring results conducted by the Plant Production Inspectorate and further supervision of fire blight it is possible to apply for a status of pest free area for the entire Estonian territory. As stated by the Food and Agricultural Organisation (FAO), a pest free area is an area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained (Determination of…, 1998). According to surveys officiated in Estonia and samples collected and tested, the absence of this harmful organism has been proved. This condition will be preserved by further surveys. A pest free area, accepted by other countries allows fire blight host plants export.

Hitherto the European and Mediterranean Plant Protection Organisation (EPPO) describes the fire blight situation in Estonia as follows: absent, confirmed by surveys (Survey on…, 2001; 2002 surveys…, 2003).

The concept of the European Union of a pest free area is a protected zone. Creation of protected zones is regulated by general Plant Health directive, Council Directive 2000/29/EC (Council …, 2000). Creation of a protected zone makes it possible to apply more restrictive regulations for host plant inspection, import and production and marketing of host plant propagating material.

In Finland, a member country of the European Union, a protected zone has been created. Estonian neighbouring countries Latvia and Lithuania will apply for the status of fire blight protected zone after joining the European Union.

To protect the territory and local market from fire blight, it is necessary to apply for the protected zone status after joining the European Union. Groundwork for this has been done.

REFERENCES

Aasa, A. 2001. Eesti agrofenoloogiline kalender. *Eesti looduse kalender,* Publicationes Instituti Geographici Universitatis Tartuensis 90, Tartu Ülikool, Geograafia Instituut, Tartu 139–163 (in Estonian).

Ahas, E-G. 2001. Eesti Põllumajandusülikooli Järvselja õppe- ja katsemetskonna dendrofenoloogiliste vaatluste programm ja looduse kalendrid. *Eesti looduse kalender*, Publicationes Instituti Geographici Universitatis Tartuensis 90, Tartu Ülikool, Geograafia Instituut, Tartu 111–118 (in Estonian).

Council Directive 2000/29/EEC of 8 May 2000 on protective measures against the introduction into the Community of organisms harmful to plants or plant products and against their spread within the Community. *Official Journal of the European Communities L* 169/1, 10.7.2000. p. 169.

Crop Protection Compendium. 2002 Edition. Database, CD. CAB International (CABI) of Wallingford, Oxon, UK.

Järelevalve ohtlike taimekahjustajate leviku üle 2002. aastal. 2003.*Taimetoodangu Inspektsiooni Teataja*, **4**, 3–8 (in Estonian).

2001. a ohtlike taimekahjustajate järelevalve tulemused. 2002.*Taimetoodangu Inspektsiooni Teataja*, **2**, 3-5(in Estonian).

Determination of Pest status in an Area. 1998. In *International Standards for Phytosanitary Measures*, FAO, Rome 15 p.

Ohtlike taimekahjustajate nimekiri. *Vabariigi Valitsuse 13. septembri 2000. a määrus* nr 300. - RT I 2000, 74, 465 (in Estonian).

Ohtliku taimekahjustajaga saastunud, saastumisohus või saastumiskahtlasel taimel, taimsel saadusel või muul objektil leiduva ohtliku taimekahjustaja liigile kohased tõrjeabinõud. *Vabariigi Valitsuse 17. jaanuari 2001. a määrus* nr 26. - RT I 2001, 10, 45 (in Estonian).

Piiril asuvas tollipunktis kontrollitavate taimede, taimsete saaduste ja muude objektide loetelu. *Vabariigi Valitsuse 20. septembri 2000. a määrus* nr 315. - RT I 2000, 77, 485 (in Estonian).

Sisseveo keeld välisriigist või selle piirkonnast taimede, taimsete saaduste või muude objektide suhtes, millega taimekahjustaja võib levida. Vabariigi Valitsuse 25. juuli 2000. a määrus nr 249. - RT I 2000, 64, 409 (in Estonian).

Situation of quarantine pests in Latvia in 2001. 2002. *EPPO Reporting Service* 2002, No 5, 2002/075.

Smith, I.M., McNamara, D.G., Scott, P.R. & Holderness, M. (Editorial Commitee) 1997. Quarantine Pests for Europe. Second Edition. CAB International, EPPO, Cambridge University Press, Cambridge pp. 1001-1007.

Smith, T.J. 2000. Cougarblight 2002 Fire Blight Risk Assessment Model. //www.ncw.wsu.edu/FB2000f.htm (05.03.03).

Smith, T.J. 2002. Fire Blight Daily Risk Estimation Model: Version 2002C (Celsius). //www.ncw.wsu.edu/fbmd198c.htm (05.05.03).

Spina, F., Bendini, L., Bazzi, C. & Tagliati, M.E. 1993. Migratory Birds: Assessment of their origin as potential vectors of *Erwinia amylovora* in Italy. **-** ISHS Acta Horticulturae 338: VI International Workshop on Fireblight. //www.actahort.org/books/338/338_24.htm (14.12.02).

Survey on *Erwinia amylovora* in Estonia. 2001. - EPPO Reporting Service 2001, No 10, 2001/175.

2002 surveys on *Erwinia amylovora*, Tomato spotted wilt tospovirus and several glasshouse pests in Estonia. 2003. *EPPO Reporting Service* 2003, No. 02, 2003/022.

Taimede, taimsete saaduste ja muude objektide sisseveo kord ning lihtsustatud korras sisseveoks lubatud taimede, taimsete saaduste ja muude objektide loetelu, lubatud kogused ja nende sisseveo lihtsustatud kord. Vabariigi Valitsuse 29.septembri 2000. a määrus nr 316. RT I 2000, 77, 486 (in Estonian).

Taimetervise erinõuded. *Vabariigi Valitsuse 29. septembri 2000. a määrus* nr 318. - RT I 2000, 77, 488 (in Estonian).

Tootmise asukohas kontrollitavate ja taimepassiga varustatavate taimede, taimsete saaduste ja muude objektide nimekiri; taimepassi ja fütosanitaarsertifikaadi sisu- ja vorminõuded ning nimetatud dokumentide väljastamise, asendamise ja säilitamise kord. Vabariigi Valitsuse 29. septembri 2000. a määrus nr 317. - RT I 2000, 77, 487 (in Estonian).

Turechek, W.W., Biggs, A.R., Lightner, G.W., Aldwinckle, H.S., Breth, D.I. & Glenn. D.M. 2001. Reduced Antibiotic Use on Apples with Revised MARYBLYT Forecasting. Northeast Region IPM Grants. //northeastipm.org/fundedProj/ripm/01/turechek.htm (02.12.02).

van der Zwet, T. & Beer, S.V. 1991. Fire Blight – Its Nature, Prevention, and Control: A Practical Guide to Integrated Disease Management. U.S. Department of Agriculture, Agriculture Information Bulletin No 631, p.57.

Методические указания по диагностике ожога плодовых культур, вызываемого *Erwinia amylovora* (Burrill) Winslow et al. //www.aris.ru/VTO/PER_MAT/document/16.html (27.02.01) (in Russian).