OCCURRENCE OF FRUIT AND LEAF DISEASES ON JAPANESE QUINCE (*CHAENOMELES JAPONICA*) IN LATVIA

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Abstract
Japanese quince (*Chaenomeles japonica*) is a minor but prospective fruit crop due to the value of fruits and suitability for processing. Research aimed to clarify the incidence of quince leaf and fruit diseases depending on the year and plantation and determine the critical periods of diseases. The study was conducted from 2017 to 2019 in eight commercial Japanese quince plantations across different regions of Latvia. The incidence (%) of leaf and fruit spots and fruit rot was assessed several times during vegetation period. Considerable rot development was observed in only the first year of the study. The incidence of fruit rot in the middle of 2017 ranged from 0.7 to 11.7% depending on the plantation, while in 2018–2019 did not exceed 2% in any of the plantations. The critical period of fruit rot development was determined in the middle of fruit development and time closer to ripeness. Development of fruit spots increased closer to ripeness. In 2017, the incidence of fruit spots fluctuated from 0.7 to 44.0%, in 2018 – 7.7 to 46.0%, and in 2019 – 0.7 to 24.0%, depending on the plantation. The incidence of leaf spots reached high levels at the end of the vegetation periods (21–100% depending on year and plantation). The most critical periods of leaf spot development were the end of fruit development and full ripening of fruits. Determination of the critical periods of quince disease development could be used to create an effective and environmentally friendly disease control system.
Key words: incidence, critical period, fruit rot, spots.

Introduction

Japanese quince (*Chaenomeles japonica*) is taxonomically classified within the *Rosaceae* family, *Maloidae* subfamily. Japanese quince (hereinafter – quince) has been grown in Latvia for fruit production since the fifties of the last century (Kaufmane *et al*., 2013). Quince fruits are of high value and suitable for processing (Mierina *et al*., 2011; Nahorska, Dzwoniarska, & Thiem, 2014). Therefore, interest in their cultivation has increased in recent years, and quinces are regarded as a prospective crop in Latvia.

Although there are no reports about economically significant quince diseases, as the area of quince plantations increases, it is expected that the importance of diseases could also increase, similar to other crops of the *Rosacea* family.

Quince's diseases have been poorly researched, and only a few studies have been conducted. The occurrence of diseases in Northern Europe was studied more than 20 years ago (Norin & Rumpunen, 2003) and 12 years ago in the Nacional Botanical Garden of Lithuania (Grigaliūnaitė, Žilinskaitė, & Radaitienė, 2012). The latest results on the identified quince diseases and their causal agents are shown in two studies conducted in Russia (Firsova & Rusinov, 2013; Fedulova *et al*., 2020).

Fruit rots and leaves and fruit spots are described as quince's most essential diseases (Norin & Rumpunen, 2003). Previous studies in Latvia and other countries showed that fruit and leaf spots and fruit rot are caused by different fungi (Grigaliūnaitė, Žilinskaitė, & Radaitienė, 2012; Fedulova *et al*., 2020; Jakobija *et al*., 2022). Systematic observations of quince diseases have not been conducted previously in Latvia. The results of the first year of this study on the incidence of fruit rot have been previously reported by Jakobija *et al*. (2018). The results of all three years of the study, including data on the incidence of fruit rot in 2018 and 2019 and the development of leaf and fruit spots in quince plantations are analysed in current article.

The presented study aims to determine the incidence of quince leaf and fruit diseases depending on the year and plantation and clarify the critical periods of diseases.

Materials and Methods

Monitoring sites and assessment of diseases

Quince diseases were assessed in Latvia's eight commercially growing farms covering all regions of Latvia between 2017 till 2019. Disease assessments in plantations of three Japanese quince cultivars ('Rondo', 'Rasa', and 'Darius') were performed at the Institute of Horticulture, Latvia University of Life Sciences and Technologies (IH); in the rest of the plantations, quince is grown by seedlings. A more detailed description of the quince plantations including a map is given in the publication of Gailis *et al*. (2023). Diseases were assessed twice a month in three plantations – IH (56°36'28.7"N, 23°17'57.7"E), Lubeco Ltd. (57°25'16.5"N, 22°38'50.5"E), and Cooperative Ltd. (57°25'44.8"N,25°16'31.4"E) –, and once a month in other farms: Mežvidi (56° 49'57.8"N, 21°38'15.3"E), Buliņi (57°28'00.1"N, 25°50'02.7"E), Lejaskārkli (57°24'04.6"N, 25° 22'52.3"E), Elianda (57°01'45.2"N, 24°58'03.1"E), and Rāmkalni Nordeco Ltd. (57°08'37.7"N, 24° 35'44.9"E) during each growing season.

Going diagonally through the field, 20 randomly selected quince plants were examined for leaf and fruit damage associated with fungi. Five fully developed leaf rosettes (300 in each plantation) on three randomly selected shoots of each plant were chosen for assessment. Symptoms of the fungal disease were registered on 15 fruits from each plant intended for accounting (for 300 in each plantation).

The phenological growth stage (GS) of quince was

recorded at each assessment according to the BBCH scale for pome fruits (Meier, 2001) that have been adapted for quince. Data of disease incidence were ranged based on GS of quince. The incidence (%) of fruit and leaf spots and fruit rot was calculated as a formula used by Jakobija & Bankina (2018).

Meteorological conditions

Meteorological conditions in the vegetation season 2017 were characterised by long periods of rain. Meanwhile, the season of 2018 was hot and dry. Only at the beginning of August, close to harvest time, the amount of precipitation increased. The vegetation period in 2019 started with high air temperatures and drought. The beginning of May was cool, precipitation slightly exceeded the long-term level. The second ten-day period of May was hot, and the humidity was low. The end of May was hot, with a high precipitation level. June is characterized by high air temperatures and relatively low precipitation. There is cool and very wet weather in July and at the beginning of August. The middle of August was hot with low amount of precipitation. Still, high air temperatures and precipitation were recognised in the next ten days. Gailis *et al*. (2023) have described meteorological conditions during these observations in more detail.

Statistical processing of data

The incidence data were assessed for normal distribution using Bartlett's and the Shapiro-Wilk normality tests. These tests confirmed that the data do not follow a normal distribution. Subsequent data analysis was conducted using nonparametric methods, specifically the Kruskal-Wallis test and Dunn's test with Bonferroni correction (with a significance level of $\alpha<0.05$). All statistical analyses were performed in R (version 4.1.1) and RStudio.

Results and Discussion

Various symptoms of diseases in quince have been previously detected and described (Jakobija *et al*., 2022).

Fruit rot

Botrytis cinerea and *Monilinia* species are considered important causal agents of quince fruit rot in Sweden and Russia (Norin & Rumpunen, 2003; Fedulova *et al*., 2020). Also, fungi from the genera *Botrytis* and *Monilinia* have been isolated from rotted quince fruits in Latvia (Jakobija *et al*., 2022).

The first symptoms of fruit rot appeared at the beginning of fruit development. In 2017, the highest incidence of disease was observed when fruits reached 40–80% of final size (GS 74–78), fluctuating from 0.7 to 11.7% depending on the plantation. Closer to harvest, fruit rot incidence decreased, by around 1%, because previously rotted fruits had fallen off. However, a week later, in plantation Lubeco, where the last harvest was due, fruit rot incidence extended to 12.3%. Based on this, it can be hypothesized – timely and random harvesting is an important measure to decrease fruit rot development. Differences in fruit rot incidence among the plantations in this season were not statistically significant (Jakobija & Bankina, 2018).

Due to drought at the beginning of 2018, fruit rot occurred late and only in some plantations. Close to the harvest period, when humidity rapidly increased, cracking of fruits was observed in IH. Cracks promoted the development of fruit rot and resulted in the highest incidence in comparison with the rest of the plantations, however, it did not exceed 2%.

The first rot symptoms on young fruits were detected early in season 2019 – at the beginning of June when quince fruits reached 40–50% of final size (GS 74–75). Nevertheless, due to hot and dry weather conditions, there was no observed increase in fruit rot incidence. The overall incidence of fruit rot before harvesting fluctuated within 1–2%, depending on the plantation.

Considering these results, it can be concluded that the most critical periods of fruit rot development were the middle of fruit development (GS 75) and the time closer to harvest (GS 85–89).

Fruit spots

Several genera of fungi (most frequently – *Alternaria, Fusarium, Monilinia*, and *Neofabraea*) have been found in fruit spots of quince in Latvia (Jakobija, Bankina, & Klūga, 2022). In Sweden, the *Cladosporium*, *Alternaria*, *Penicillium*, *Neofabraea*, *Phoma*, and *Septoria* species are isolated from fruit spots (Norin & Rumpunen, 2003).

Spots associated with fungal damage appeared on fruits when they reached final size (GS 79) and started to ripen (GS 81) at the beginning of August of 2017. Development of fruit spots increased closer to ripeness (GS 87–89), and the incidence of disease fluctuated from 0.7–44% depending on the plantation (Table 1).

In plantations Buliņi and Elianda, the first signs of fruit spots in the vegetation period 2018 were detected earlier than in the previous season – during the fruit's second fall (GS 73). However, the increase in spot incidence did not continue for the whole of June due to dry weather. In addition, a drop of infected fruits was detected. Fruit spot development resumed in IH in the middle of July when fruits started to ripen (GS 81), and in the middle of August, they were detected in all plantations. Changes in the development of the disease could be explained by the increase in precipitation level at the beginning of August. The incidence of fruit spots closer to harvest time reached 7.7–46.0%, depending on the plantation (Table 1).

Despite the early disease appearance in 2019, the incidence of fruit spots increased slowly during the 2019 season because the weather was dry. Closer to harvest time the incidence of fruit spots grew, in IH and Lubeco reached 13.0–24.0%, and was lower in the rest of the plantations (0.7–6.0%) (Table1).

No significant differences in average fruit spot incidence were found among farms ($p=0.91$) and vegetation periods ($p=0.16$).

The results obtained confirmed the critical period for the development of fruit spots, which occurs during the stage of fruit ripening (GS 81–89).

Table 1

Incidence of fruit spots (%) in vegetation periods 2017–2019 during fruit ripening depending on plantation

Plantation	2017			2018			2019		
	The growth stage of quince								
	77–80	81	85–87	81–83	85	87–89	79–80	81–85	87–89
Institute of Horticulture 'Darius'	0.0	16.3	16.7	1.3	23.7	43.0	0.0	7.3	22.0
Institute of Horticulture 'Rasa'	0.0	15.0	12.7	2.0	13.0	46.0	3.0	16.0	24.0
Institute of Horticulture 'Rondo'	0.0	2.0	0.7	2.7	17.3	39.0	1.7	3.7	22.3
Farm Mežvidi	0.0	N/A	10.7	1.0	N/A	7.7	0.0	N/A	2.7
Lubeco Ltd.	1.7	18.0	40.3	0	10.7	16.0	3.3	5.0	13.0
Cooperative Ltd.	1.3	13.0	25.7	0	1.3	14.7	0.3	4.3	2.7
Farm Buliņi	0.0	N/A	40.0	0.3	N/A	12.3	0.0	N/A	0.7
Farm Elianda Ltd.	0.3	N/A	44.0	0.7	N/A	12.3	0.0	N/A	7.3
Rāmkalni Nordeco Ltd.	0.0	N/A	70.0	0	5.0	7.7	0.3	N/A	1.3
Farm Lejaskārkli	2.3	N/A	0.0	0	N/A	10.3	0.0	N/A	6.0

N/A – not assessed.

Leaf spots

Several fungi were detected in leaf spots of quince – mainly *Alternaria*, *Diplocarpon*, *Phyllosticta*, *Cladosporium*, and *Epicoccum* – in Russia and Sweden (Norin & Rumpunen, 2003; Fedulova *et al.*, 2020). Also, fungi from genera *Alternaria* and *Sarocladium* were recognized as most specific on quince leaves in Latvia (Jakobija *et al*., 2022). The first symptoms of leaf spots in 2017 in some plantations appeared at the end of May during flowering (GS 61–69). In the middle of June at the beginning of fruit development (GS 71), leaf spots appeared in all sites of observation; the incidence fluctuated from 4 to 9% depending on the plantation. It was observed that leaf spots cause premature leaf drop during the onset of fruit development. In the middle of vegetation season, leaf spot incidence was lower in IH (1.7–6.7% depending on cultivar) compared with other survey sites (8.7–30.0% depending on plantation). At the end of the season, leaf spotting reached a similar level in all quince plantations, and the incidence of disease fluctuated from 22 to 62% (Table 2).

Table 2

Incidence of leaf spots (%) in vegetation periods 2017–2019 during end of fruit development and fruit ripening depending on plantation

Plantation	2017		2018		2019	
	The growth stage of quince					
	75–81	83–89	76–81	87	78–80	89
Institute of Horticulture 'Darius'	17.0	53.7	10.33	44.67	15.3	25.0
Institute of Horticulture 'Rasa'	19.7	31.3	5.67	62.33	3.0	24.0
Institute of Horticulture 'Rondo'	29.0	22	3.33	11.00	7.7	35.7
Farm Mežvidi	42.3	37.7	61.33	81.67	27.3	54.7
Lubeco Ltd.	43.7	49.7	16.00	38.33	28.3	34.0
Cooperative Ltd.	29.3	36.3	6.00	9.33	17.0	50.0
Farm Buliņi	13.3	43.7	13.00	14.67	22.3	20.3
Farm Elianda Ltd.	36.7	40.7	4.33	2.00	9.7	29.7
Rāmkalni Ltd.	25.7	31.7	28.67	45.33	28.7	58.0
Farm Lejaskārkli	69.7	62.7	35.67	59.33	28.7	66.7

The first symptoms of leaf spots in the season 2018 appeared at the beginning of June in time of fruit development (GS 71–74) in most observed plantations, a little later than in the previous year. However, increasing in leaf spot development was observed only at the beginning of August when fruits were about to finish the development and started to ripen (GS 76–81) (Table 2). The high amounts of precipitation promoted the spread of disease; incidence reached high levels (21–100% depending on the plantation) close to harvest. These findings align with results obtained by Norin & Rumpunen (2003) that severity of leaf spots depends on weather conditions of the year.

The first spots on quince leaves were detected when fruits started to develop (GS 71) in 2019. The following increase in disease coincided with a rainy period in June. At the end of June (GS 75–76) and the beginning of July, when fruits reached about 80% of final size (GS 78), in several plantations incidence of leaf spots reached agronomically significant levels (about 20% and higher). Infected leaves turned yellow and fell off prematurely. This process co-occurred with fruit development and could be assumed to damage yield formation. Similar observations, when leaf spots initiate leaf drop in the middle of vegetation, were described in Russia in the Tambov region (Fedulova, Kuklina, & Kaštanova, 2017) and Sweden (Norin & Rumpunen, 2003). At the end of the vegetation period incidence of leaf spots reached high levels (20–66%) in all plantations (Table 2). There were no significant differences in average leaf spot incidence among years ($p=0.332$) and among plantations ($p=0.069$).

However, during the research, it was proved that average leaf spot incidence significantly differed among quince growth stages ($p=0.001$) 'Figure 1'. During flowering, the first spots on leaves were detected only in 2017. Therefore, the average incidence over seasons was low 'Figure 1'. The incidence of leaf spots was significantly lower at the beginning of fruit development (GS 71–74) compared to results at the end of fruit development (GS 75–79) and the beginning of fruit ripening (GS 81–85). The significantly highest incidence was observed at the end of ripening (GS 87–89) 'Figure 1'.

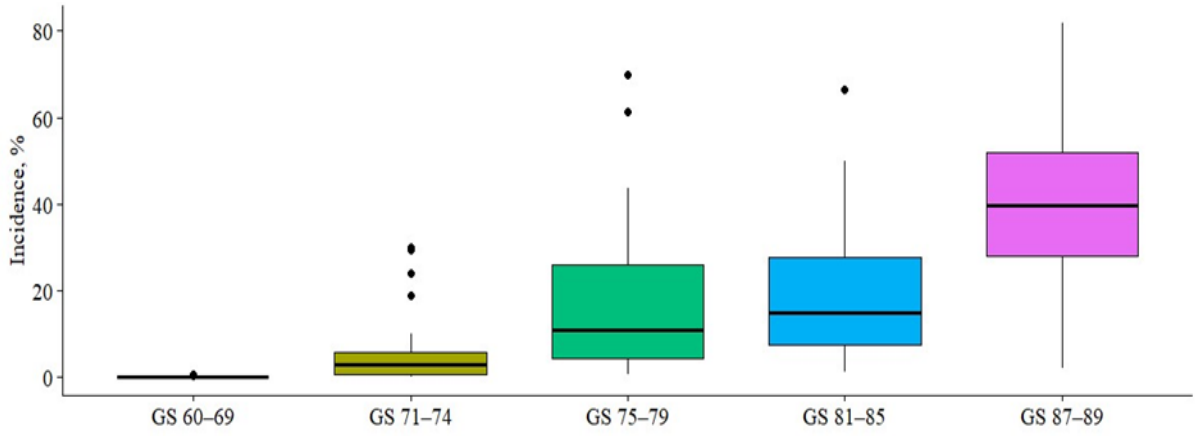

Figure 1. Average quince leaf spot incidence depending on growth stage (GS) in vegetation periods 2017–2019 in all plantations.

It can be determined that critical periods of the spread of leaf spots were the end of fruit development and close to fruit maturity.

Conclusions

1. Considerable fruit rot incidence was detected only in one studied vegetation period. In the middle of 2017, the incidence of fruit rot ranged from 0.7 to 11.7% depending on the plantation, while in 2018–2019 it did not exceed 2% in any of the plantations.
2. The critical periods for spread of fruit rot were the middle of fruit development (GS 75) and the end of ripening (GS 85–89).
3. The critical period of fruit spot development is time closer to harvesting (GS 85–89). Fruit spot incidence was not influenced by the conditions of vegetation period and farms.
4. The leaf spot level differed among quince growth stages. At the end of vegetation periods, the incidence of leaf spots reached 21–100%, depending on the year and plantation.
5. The end of fruit development (GS 75–79) and the period of full ripening of fruits (85–89) were the most critical periods of leaf spot development.

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