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EFFECT OF VIRUS INFECTION ON FUNCTIONAL TRAITS OF *PRUNUS AVIUM* AND *PRUNUS CERASUS* PLANTS IN NURSERIES

Liliia PAVLIUK[1,2*], Iryna RIABA[2], Viktoriia KRYVOSHAPKO[2], Mykola BUBLYK[2], Pavlo BONDARENKO[3], Kateryna UDOVYCHENKO[2]

[1]Research and Breeding Institute of Pomology Holovousy, Czech Republic
[2]Institute of Horticulture of the National Academy of Agrarian Sciences of Ukraine
[3]M.F. Sydorenko Melitopol Fruit Growing Research Station, Ukraine

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ABSTRACT

Understanding the effect of viral diseases on plant health is crucial to the successful cultivation of planting material and intensive horticulture of any crop. Our study aimed to investigate the effects of Prunus necrotic ringspot virus (PNRSV) and prune dwarf virus (PDV) on the physiological condition of cherry seedlings. The research subjects were young trees of sweet cherry (*Prunus avium* L.) 'Nizhnist' and sour cherry (*Prunus cerasus* L.) 'Bohuslavka' and 'Ksenia'. Three types of virus-free rootstocks were budded with virus-free and virus-infected buds of these cultivars and then physiological and biometric parameters were evaluated. Due to virus-induced incompatibility, 100% of virus-infected buds on Krymsk-5 and Krymsk-6 rootstocks were found dead during spring inspection. The survival rate of infected buds on the VC-13 rootstock ranged from 50% to 76.6%, depending on the cultivar. Viral infection negatively affected the physiological parameters of plants, leading to a decrease in chlorophyll *a* content by 20.9–38.0%, chlorophyll *b* content by 31.0–43.9%, and a decrease in leaf blade area by 7.6–31.0%, depending on the pathogen and cultivar.

Key words: budding, rootstocks, cherry, gum formation, mortality, Prunus necrotic ringspot virus, PNRSV, prune dwarf virus, PDV

INTRODUCTION

In Ukraine, sweet and sour cherry orchards occupy 48.3% of the area under stone fruit cultivation (ukrstat.gov.ua). Therefore, the demand for high-quality planting material is growing. Viral pathogens are one of the limiting factors in obtaining planting material and stable, high yields. It is known that 25 viral pathogens can infect sweet and sour cherries (Myrta et al. 2003). However, according to European legislation, mainly EPPO standard PM 4/29(1) (2001), only 15 are economically significant and can be controlled by planting certified material. The effect of many of the viruses on this list on individual sour and sweet cherry cultivars remains unknown. In nurseries, Prunus necrotic ringspot virus (PNRSV) reduces the survival rate of grafted buds (Pscheidt & Ocamb 2024) and the rooting success of cuttings (Golino et al. 2007). In some cases it can even lead to the complete death of plants (Lang 2000). PDV can reduce the yield of maiden trees by up to 54% (Németh 1986). Calculations showed that the nursery and fruit and berry growing sector in Ukraine lost UAH 1.5 billion (about EUR 40 million) in 2010–2013, due to a decline in product quality caused by viral diseases (Triapitsyna 2016).

*Corresponding author
e-mail: pavliukl.92@ukr.net

One of the major challenges in nursery tree cultivation is the incompatibility of rootstock and scion combinations, which reduces the yield of marketable plants (Dogra et al. 2018). The compatibility of components depends significantly on several factors (physiological and biochemical reactions, air temperature, method used, and others), and sometimes even closely related species may be incompatible. Considering this, there is a need to assess compatibility before grafting a specific rootstock and cultivar (Reig et al. 2019; Rasool et al. 2020). Incompatibility can also be observed with regard to viral pathogens. Since some rootstocks are tolerant to viral infection, this can lead to the accumulation of pathogens in the planting material and their further spread. In Ukraine, several authors reported incompatibility of sweet and sour cherries with rootstock components (Mezhens'ky & Brusentsov 2006; Tsviliov 2009). Additionally, viral pathogens can affect the pigment content of infected plants. PNRSV alone and its combination with cherry virus A (CVA) have been shown to reduce the anthocyanin content in 'Łutówka' sour cherry fruit (Paduch-Cichal et al. 2024).

Considering that incompatibility depends on the type of rootstock, cultivar, and characteristics of the virus isolate, our aim was to study the effect of viral pathogens on the growth and development of several sour and sweet cherry cultivars budded on three types of rootstock.

MATERIALS AND METHODS

The field experiment was conducted in 2020–2021 near Kyiv (50°21'N, 30°27'E), in the fruit nursery of the Institute of Horticulture of the National Academy of Agrarian Sciences of Ukraine. The soil of the experimental site is podzolic and loamy, formed on loess loam. The climate of the region is moderately continental, the average annual air temperature is 7.4 ± 1.1 °C. Nursery management included regular cultivation of the soil between the rows and irrigation of the plants. Plant protection was carried out in accordance with the recommendations for the cultivation of sweet and sour cherry planting material. The planting scheme in the nursery was 1.20 × 0.15 m.

Rootstock and scion combinations were studied under conditions of viral infection of the scion, compared with virus-free control. Graft material for budding was collected from trees and tested for viral infection using the RT-PCR method.

PNRSV and PDV were identified using RT-PCR with specific primer pairs targeting a fragment of the CP gene. For PNRSV, the primers used were PNRSV–10F (5'-TTC TTG AAG GAC CAA CCG AG AGG-3') and PNRSV–10R (5'-GCT AAC GCA GGT AAG ATT TCC AAG C-3'), with an expected fragment of 348 bp. PDV identification was carried out using primers PDV–17F (5'-CGA AGT CTA TTT CCG AGT GGA TGC-3') and PDV–12R (5'-CAC TGG CTT GTT TCG CTG TGA AC-3'), producing the expected fragment of 303 bp (Massart et al. 2008). An internal control was included using nad5-f/nad5-r primers to ensure successful RNA amplification, generating a 181 bp fragment (Menzel et al. 2002). RT-PCR was performed using the commercial Verso 1-Step RT-PCR Kit ReddyMix (Thermo Scientific, USA) according to the manufacturer's instructions. The reaction mixture had a total volume of 20 µl and contained 10 µl of 2X 1-Step PCR ReddyMix, 0.4 µl of Verso Enzyme Mix, 1 µl of RT Enhancer, 0.4 µl of forward primer (10 mmol), 0.4 µl of reverse primer (10 mmol), 6.6 µl of H_2O, and 50 ng of RNA per reaction. To assess RNA quality, the same reaction conditions were applied using nad5-f/nad5-r primers.

Experimental design

The field experiment included two sour cherry cultivars – 'Bohuslavka' and 'Ksenia', and one sweet cherry cultivar – 'Nizhnist', in combination with the clonal rootstocks – Krymsk-5, Krymsk-6, and VC-13. In total, the experimental design included 18 variants (9 combinations of rootstocks and scions infected with viruses and the same 9 combinations using virus-free scions that served as a control):
1 – Krymsk-5/'Nizhnist' infected by PDV + PNRSV,
2 – Krymsk-5/'Bohuslavka' infected by PDV,
3 – Krymsk-5/'Ksenia' infected by PNRSV,
4 – Krymsk-6/'Nizhnist' infected by PDV + PNRSV,
5 – Krymsk-6/'Bohuslavka' infected by PDV,
6 – Krymsk-6/'Ksenia' infected by PNRSV,
7 – VC-13/'Nizhnist' infected by PDV + PNRSV,
8 – VC-13/'Bohuslavka' infected by PDV,
9 – VC-13/'Ksenia' infected by PNRSV.

The experiment was conducted in a randomized block design with three repetitions, 10 plants in each replicate. Budding was carried out in mid-August.

Due to the death of plants budded on susceptible rootstocks, further research was carried out on plants of the following sets: VC-13/'Nizhnist' (PDV + PNRSV), VC-13/'Bohuslavka' (PDV), VC-13/'Ksenia' (PNRSV) + control for each cultivar.

The pigment content under viral infection conditions was determined in the nursery. Leaves for analysis were sampled from the same side and at the same height on each plant in early July. Chlorophyll *a* and *b* were determined using a KFK-3 spectrophotometer with wavelengths of 649 nm and 665 nm. 96% ethanol was used for extraction. The calculations were performed according to the following formulas: $C_{Chl.\ a} = 13.70\ A_{665} - 5.76\ A_{649}$; $C_{Chl.\ b} = 25.80\ A_{649} - 7.60\ A_{665}$; where A_{644} – optical density of the solution at a wavelength of 649 nm, A_{662} – optical density of the solution at 662 nm.

After determining the concentration of pigments, their quantitative content (X, in mg per g) was calculated according to the formula:

$$X = \frac{V\ C}{m\ 1000},$$

where V – volume of ethanol extract (ml), C – chlorophyll concentration in the extract ($mg \cdot l^{-1}$), m – mass of raw material (g). The manifestation of anthocyanin coloration was assessed visually.

Plant biometric parameters were measured in mid-October, plant height was determined using a ruler, and the stem diameter 10 cm above the grafting point was measured using a caliper.

Experimental data were analyzed using one-way ANOVA with Tukey's post hoc test at $p \leq 0.05$ using Minitab 16 software (Minitab, State College, USA). The analysis compared virus-infected plants with healthy plants in each combination. No comparisons were made between cultivars or rootstocks since the plants were infected with different viruses.

RESULTS AND DISCUSSION

Effect of rootstock and scion combinations and scion infection on budding results

Three weeks after budding the first signs of incompatibility were observed. They were manifested by the presence of gum at the budding site and variable intensity of anthocyanin coloration of the rootstock leaves (Figs. 1 & 2). The most intense coloration was observed on Krymsk-5 rootstock in combinations with all cultivars and slightly less on Krymsk-6 rootstock (Table 1).

Table 1. Effect of viral infection of scions on the incompatibility of rootstock and scion combinations (%) of sweet and sour cherry in the nursery

Cultivar	'Nizhnist'		'Bohuslavka'		'Ksenia'	
Rootstock	infected by PDV + PNRSV	healthy	infected by PDV	healthy	infected by PNRSV	healthy
Gummosis						
Krymsk-5	100±0 a	0±0 b	90±5.7 a	0±0 b	100±0 a	0±0 b
Krymsk-6	96.6±3.3 a	0±0 b	93.3±3.3 a	0±0 b	90±5.7 a	0±0 b
VC-13	0±0 a	0±0 a	0±0 a	0±0 a	0±0 a	0±0 a
Anthocyanin coloration of leaves						
Krymsk-5	100±0 a	0±0 b	83.3±3.3 a	0±0 b	100±0 a	0±0 b
Krymsk-6	90±5.7 a	0±0 b	86.6±3.3 a	0±0 b	100±0 a	0±0 b
VC-13	0±0 a	0±0 a	0±0 a	0±0 a	0±0 a	0±0 a

Data are presented as mean ± SE; Different letters indicate significant differences between infected and healthy material within each combination at $p < 0.05$ (Tukey's range test)

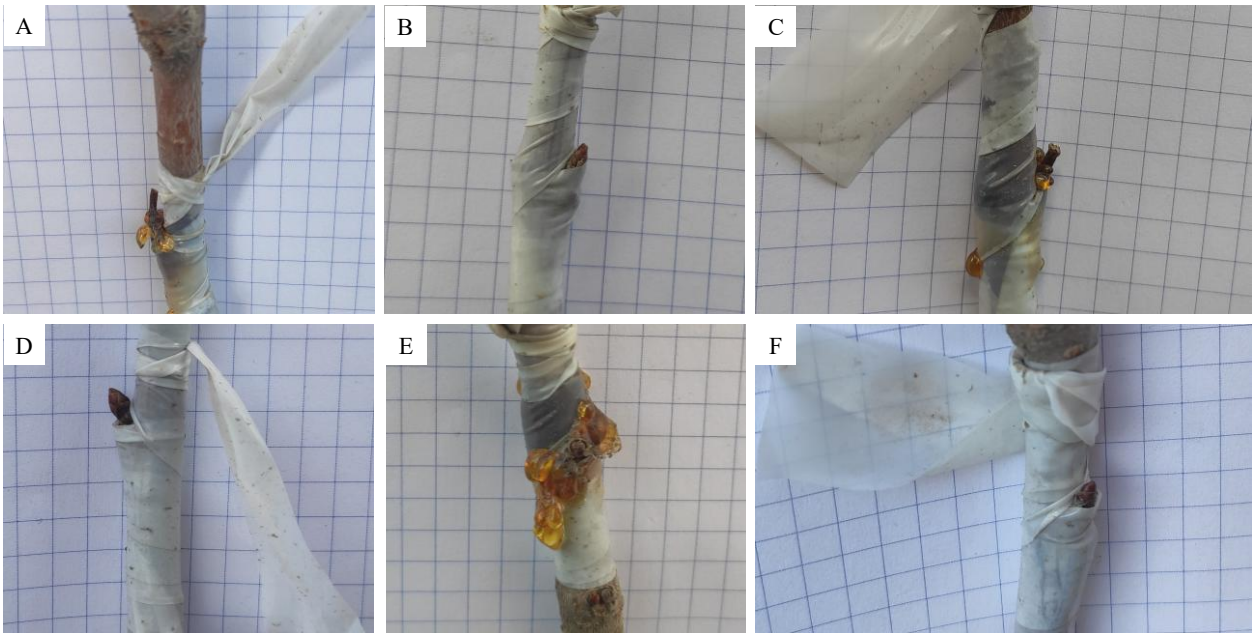

Figure 1. Manifestation of incompatibility of grafting components of sweet and sour cherry cultivars with Krymsk-5 rootstock: 'Nizhnist' (PDV + PNRSV) (A), 'Nizhnist' (virus-free) (B), 'Bohuslavka' (PDV) (C), 'Bohuslavka' (virus-free) (D), 'Ksenia' (PNRSV) (E), 'Ksenia' (virus-free) (F). Each cell measures 5 × 5 mm

Figure 2. Reaction of Krymsk-5 rootstock to PNRSV infection: buds from trees infected with the virus (visible anthocyanin coloration of leaves) (A), buds from trees free from the virus (B)

Gummosis, as one of the symptoms of incompatibility, was observed in 90–100% of plants, depending on the rootstock and cultivar, and its intensity was almost the same in all combinations (Fig. 1A). At the same time, no manifestation of the described symptoms was recorded on the virus-free control objects. Gummosis is considered to be one of the symptoms of rootstock hypersensitivity to a viral infection (Lang et al. 1996). It was reported that gummosis on Krymsk-5 rootstock is usually observed in 70–80% of cases (Drozd 2011), but never on virus-free material. Other authors assumed that rootstocks with steppe cherry (*Prunus fruticosa*) as one of the parents have a genetically determined sensitivity to viral infection (Mezhens'ky & Brusentsov 2006).

In contrast to gummosis, the anthocyanin coloration of the rootstock leaves was more pronounced in Krymsk-5 (Fig. 2), whereas the color intensity was weaker in Krymsk-6 samples. This symptom was observed overall in 83.3–100% of plants. Pscheidt and Ocamb (2024) and Purnell (2024) described yellowing and browning of the leaf blade as the main symptoms of PNRSV infection.

VC-13 rootstock was tolerant to infection. No signs of incompatibility were found in all combinations studied.

During autumn examination of grafted plants, it was found that budding success was relatively low on rootstocks susceptible to viral infection (Table 2). On Krymsk-5 rootstock, none of the buds survived in 'Nizhnist' and 'Ksenia', and only 6.6% in 'Bohuslavka'. However, during the spring inspection, no buds remained viable in 'Bohuslavka', while the survival rate of uninfected scions was 90%. For Krymsk-6 in combination with 'Nizhnist', autumn survival was 3.3%, whereas for the other cultivars no successful budding occurred. No spring buds survived on this rootstock, except for virus-free control plants. The best results were achieved on VC-13 rootstock, with grafting success rates in autumn reaching 73.3% for 'Nizhnist', 83.3% for 'Bohuslavka', and 90% for 'Ksenia'. After overwintering, 50% of the buds remained viable in combinations with 'Nizhnist' and 76.6% with 'Bohuslavka' and 'Ksenia'.

The hypersensitivity of Krymsk-5 and Krymsk-6 can be both an advantage and a limitation. On the one hand, their rapid response to viral infections allows for early detection and elimination of infected clones of sour and sweet cherry cultivars, making them valuable markers nursery certification. It also helps prevent the introduction of viruses into industrial orchards and reduces long-term economic losses. On the other hand, their susceptibility may limit their use in commercial production in regions with a high risk of viral infections.

Table 2. Effect of virus infection of scions on the survival of buds (%) of sweet and sour cherry cultivars

Cultivar	'Nizhnist'		'Bohuslavka'		'Ksenia'	
Rootstock	infected by PDV + PNRSV	healthy	infected by PDV	healthy	infected by PNRSV	healthy
			Autumn			
Krymsk-5	0±0 b	100±0 a	6.6±0.3 b	90±5.7 a	0±0 b	90±5.7 a
Krymsk-6	3.3±1.4 b	100±0 a	0±0 b	80±0 a	0±0 b	90±0 a
VC-13	73.3±8.8 a	90±0 a	83.3±3.3 a	90±0 a	90±5.7 a	90±0 a
			Spring			
Krymsk-5	0±0 b	90±5.7 a	0±0 b	90±0 a	0±0 b	90±0 a
Krymsk-6	0±0 b	90±0 a	0±0 b	70±5.7 a	0±0 b	90±0 a
VC-13	50±2.8 b	90±0 a	76.6±6.6 a	90±5.7 a	76.6±1.6 a	90±5.7 a

Data are presented as mean ± SE; Different letters indicate significant differences between infected and healthy plants within each combination at $p < 0.05$ (Tukey's range test)

Effect of scion viruses on the growth of sweet and sour cherry maiden trees in the nursery

Since Krymsk-5 and Krymsk-6 rootstocks were hypersusceptible to infection, which led to the death of grafted buds in infected variants, further growth and development of maiden trees were evaluated only on plants grafted onto VC-13 rootstock.

Bud development started in early May, but infected variants had slightly delayed bud growth. Therefore, the first measurements were taken when the newly grown shoots were 3–9 cm long.

The growth of 'Ksenia' grafts was significantly affected by PNRSV. More uniform growth of virus-free plants was observed. At the end of the vegetation period the difference in growth between infected and healthy plants was 13%. According to our results, PDV-infected plants were 16% smaller than the control at the beginning of vegetative bud regrowth. During the growing season, no significant delay in the growth of PDV-infected 'Bohuslavka' was observed. Thus, by the end of September, infected plants reached a height of 102.5 cm, while healthy plants were 3.1% higher. During the observation period, the difference between variants was 1.8–21.9%.

We found that PNRSV caused a significant reduction in vigor, whereas PDV had less effect on plant growth in the nursery. Other studies have shown that PDV reduced growth to a greater extent than PNRSV, causing a 2–16.9% reduction in the height of cherry maiden trees (Borisova 2018) and 38–42% in orchard cherry trees (Andersone et al. 2002). This effect of the PDV on growth processes is probably caused by the individual reaction of the rootstock and cultivar, as it has been shown that sour cherry is more susceptible to the negative effect of the virus than sweet cherry (Andersone et al. 2002).

In case of simultaneous infection with several viruses, their interaction may manifest itself in the form of synergy or interference. The synergistic effect of two viruses increases the negative effect on the tree growth and leads to reduced productivity. In such conditions, the level of manifestation depends on the interacting pathogen isolates. A feature of the interaction between PDV and PNRSV in coinfections is interference, where PNRSV can reduce the concentration of PDV up to 17-fold, depending on the combination of plant inoculation components. This phenomenon was studied on peach plants. At the same time, PDV does not affect the concentration of PNRSV RNA (Scott et al. 2001).

In our study, infected (PDV + PNRSV) and healthy 'Nizhnist' plants showed almost the same growth dynamics until mid-June. The infected plants then began to retard their growth, and by the end of the growing season their height was 36.2% lower compared to healthy plants.

Viral infection can affect the growth and development of young plants in various ways. In our study, PNRSV monoinfection and the PNRSV + PDV complex had a greater effect on plants, while PDV hardly hindered the growth processes. Such latent transmission of the virus can cause problems in orchards because infected trees are a source of virus spread, leading to reduced yields and disease resistance in the future.

Effect of viral infection on the content of photosynthetic pigments in sweet and sour cherry leaves

Chlorophyll content decreased when sour and sweet cherry plants were infected with PDV and PNRSV (Table 3). The results indicate a decrease in chlorophyll *a* in infected plants. No visible chlorotic changes were observed on the leaves during sampling for analysis. In the case of chlorophyll *a*, the largest difference compared to the virus-free control was observed for 'Ksenia' (PNRSV) – 38.4%, while in the infected samples of 'Bohuslavka' (PDV) and 'Nizhnist' (PDV + PNRSV) this decrease was 22.5% and 20.9%, respectively. Chlorophyll *b* values showed a more marked decrease. In infected samples of 'Nizhnist' and 'Bohuslavka' this indicator decreased by 31%, and in case of 'Ksenia' by 43.9%.

Table 3. Effect of viral infection of scions on the chlorophyll content (mg g^{-1}) in leaves of sour and sweet cherry cultivars grafted onto the VC-13 rootstock

Cultivar	Virus-infected plants	Healthy plants	P value
	Chlorophyll *a*		
'Nizhnist'	1.40±0.01 b	1.77±0.01 a	0.001
'Bohuslavka'	1.17±0.04 b	1.51±0.05 a	0.027
'Ksenia'	0.93±0.02 b	1.51±0.05 a	0.006
	Chlorophyll *b*		
'Nizhnist'	0.32±0.04 a	0.47±0.02 a	0.061 (NS)
'Bohuslavka'	0.26±0.01 b	0.38±0.01 a	0.002
'Ksenia'	0.23±0.01 b	0.41±0.03 a	0.019

Data are presented as mean ± SE; Different letters indicate significant differences between infected and healthy plants within each combination at $p < 0.05$ (Tukey's range test); NS – not significant

Our results are consistent with studies conducted on raspberries – raspberry yellow spot virus reduced the chlorophyll content by 22.7–30.2%, and on currants – blackcurrant reversion virus reduced the sum of chlorophyll *a* + *b* content by 23.4–27.6% (Taranukho 2012). Cucumber mosaic virus reduced chlorophyll *b* content of in jimson weed plants by 33% (Takács et al. 2014) and significantly reduced the level of total chlorophyll in cucumber plants (Shakeel et al. 2016), whereas potato virus M had less effect on the photosynthetic apparatus of potatoes – total chlorophyll content was 12% lower than the control (Budzanivska et al. 2014).

In this study, coinfection with PDV and PNRSV had the least effect on the green pigment content, which may be explained by the specific interaction of the viruses and the 'Nizhnist' cultivar, as other studies reported the opposite effect in case of viral coinfection. For example, coinfection with TMV, PMMoV, and ToMV in tomato plants reduced the content of green pigments more than monoinfection (Huseynova et al. 2018). Similar results were also observed in plum trees coinfected with PPV and PBNSPaV (*Ampelovirus*), which reduced the total chlorophyll content by 25% (Pedrelli et al. 2023). Moreover, in this study as well as those conducted by Huseynova et al. (2014) and Christov et al. (2005) a greater effect of virus infection on chlorophyll *b* was observed, which changed the chlorophyll *a* to *b* ratio.

Effect of viral infection on the quality of one-year-old sour and sweet cherry plants

The leaf is one of the main assimilation organs of the plant, and its formation depends on a complex of factors. Therefore, the leaf blade area is one of the indicators of plant condition (Polunina et al. 2018). Our results suggest that viral pathogens directly affect leaf blade size. Leaf surface area decreased by 7.6–31% depending on the pathogen (Table 4). Leaf area was more affected by PNRSV (31%) than by PDV (10.3%), while coinfection had the least effect on this indicator – 7.6%. Another study showed similar results examining the effect of BYDV on oats, where a reduction leaf blade was also observed in infected plants (Persson et al. 2007).

Leaf mass per area (LMA) was higher in PDV-infected variants than in control plants. 'Nizhnist' showed a 39.9% increase in LMA, while 'Bohuslavka' showed a slight increase of 5.5% in infected samples. Conversely, the LMA of PNRSV-infected plants was 27.4% lower than that of healthy plants.

Leaf water content was 20% lower in infected 'Nizhnist' samples compared to the healthy control. At the same time, in the case of 'Bohuslavka' and 'Ksenia' the water content in infected samples was higher by 1.4% and 5.7%, respectively, but this difference was statistically insignificant.

Viral infections of plants often cause comprehensive physiological changes in them, including altered tissue water content and modified synthesis and translocation of metabolites. These changes can disrupt normal plant functions by affecting overall growth and water regulation, resulting in lower or higher water content (Xu et al. 2008; Ertunç 2020). In this study, cellular water content did not always depend on the increase in LMA, so this issue requires further study.

In addition to affecting the general condition of plants, pathogens also negatively affected specific biometric indicators of planting material. In most cases, an adverse effect on plant vigor was observed (Table 5). The greatest effect was observed with simultaneous infection of 'Nizhnist' with PDV and PNRSV. A study on the effect of ilarviruses on the growth and development of five sweet cherry cultivars in Bulgaria revealed that PNRSV caused a reduction in the diameter of the scion by 32.5%, PDV by 21.4%, and their mixed infection by 30.4% (Borisova 2018).

Table 4. Effect of viral infection of scions on biometric indicators of leaves of sweet and sour cherry cultivars grafted onto the VC-13 rootstock

Cultivar	Virus-infected plants	Healthy plants	P value
Leaf blade area (cm^2)			
'Nizhnist'	62.9±0.1 b	68.1±1.2 a	0.049
'Bohuslavka'	64.3±0 a	71.7±3.4 a	0.161 (NS)
'Ksenia'	54.1±0.9 b	78.5±0.2 a	0.001
Leaf mass per area (mg per cm^2)			
'Nizhnist'	8.2±0.3 a	5.8±0.3 b	0.030
'Bohuslavka'	7.4±1.1 a	7.0±1.5 a	0.952
'Ksenia'	8.2±0.3 a	11.3±1.9 a	0.248 (NS)
Water content (%)			
'Nizhnist'	58.0±2.0 b	72.7±2.3 a	0.040
'Bohuslavka'	72.1±7.7 a	71.1±7.6 a	0.938
'Ksenia'	63.1±2.4 a	59.7±6.9 a	0.687

Note: see Table 3

Table 5. Effect of viral infection of scions on the growth of maiden trees (2021)

Cultivar	Virus-infected plants	Healthy plants	P value
Stem diameter (mm)			
'Nizhnist'	13.6±0.7	16.0±0.3	0.012
'Bohuslavka'	13.0±0.5	15.4±0.5	0.011
'Ksenia'	13.0±0.6	13.0±0.1	1.000 (NS)
Plant height (cm)			
'Nizhnist'	94.2±0.5	149.0±0.8	<0.001
'Bohuslavka'	102.6±0.5	105.8±2.2	0.198 (NS)
'Ksenia'	74.4±1.0	86.0±0.9	<0.001

Note: see Table 3

Table 6. Effect of viral infection of scions on yield of sour and sweet cherry planting material

Plant condition	Yield of standard nursery plants (thousand pcs. per ha)	Share of plants (%)		
		commercial class 1	commercial class 2	nonstandard
		'Nizhnist'		
Virus-infected	4.4	20	20	60
Healthy	40.7	63	18	18
		'Bohuslavka'		
Virus-infected	4.4	25	25	49
Healthy	25.0	25	16	58
		'Ksenia'		
Virus-infected	11.2	25	16	58
Healthy	25.9	25	25	48

In our study, PNRSV did not affect the stem diameter. However, plant height decreased by 13%. PDV infection had no significant effect on the height of 'Bohuslavka' plants, and the stem diameter was reduced by 13%. The rootstock effect may explain the differences between the results of this study and those of other research. Since the *Prunus mahaleb* seedling rootstock was used (Borisova 2018), it can be assumed that they are more susceptible to delayed growth and development under the influence of viral pathogens. In general, the effect of a virus infection on a maiden tree may vary in intensity, depending to the individual characteristics of the cultivar and rootstock. Vegetative growth and development of plants affected by pathogens additionally negatively influenced the yield of commercially quality maiden trees (Table 6).

According to the State Standard of Ukraine DSTU 4938:2008 (2009), only 20–25% of infected planting material can be classified as the first commercial class and 16–25% as the second class. At the same time, in the control this indicator was 18–63%. Therefore, the use of infected material significantly reduces the overall yield of maiden trees. In addition, viral infection significantly reduced the yield of nursery plants of all cultivars, most noticeably for 'Nizhnist' (a decrease of 36.3 thousand pieces per ha). 'Bohuslavka' and 'Ksenia' are less susceptible to the virus (a decrease of 20.6 and 14.7 thousand pcs. per ha, respectively).

CONCLUSIONS

Rootstocks responded differently to buds from scions infected with Prunus necrotic ringspot virus and prune dwarf virus. The susceptible rootstocks Krymsk-5 and Krymsk-6 showed high incompatibility, which was manifested by gummosis at the budding site, discoloration of the rootstock leaves, and finally necrosis and death of 50–100% of the budded rootstock in autumn or spring. The resistant rootstock VC-13 budded with virus-infected buds survived 70–90%, depending on the type of virus. Trees obtained with virus-containing buds were smaller, had a smaller stem diameter and smaller leaf area, as well as less chlorophyll, which resulted in reduced quality of young trees. These factors confirmed the mandatory need to use virus-free nursery material.

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