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Production of four apple cultivars on rootstock P 22

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The aim of this investigation was to study the production and growth of commercial cultivars grown in Latvia on rootstock P 22. The rootstock P 22 is a low vigour (dwarfing) rootstock originated in Poland. The trial was established at the Latvia State Institute of Fruit-Growing in the southern part of Latvia in the spring of 1998. Four apple cultivars of different origin – ‘Auksis’ (Lithuania), ‘Zarya Alatau’ (Kazakhstan), ‘Lobo’ (Canada), ‘Sinap Orlovskii’ (Russia) – were planted as one-year-old trees on rootstock P 22 at the distances of 1.5 × 4 m. Sawdust, wood chips and pine bark were used as mulch. The soil was leached sod-calcareous with pH 7.4, 1.9 % organic matter and plant-available K₂O and P₂O₅, respectively 149 mg kg⁻¹ and 113 mg kg⁻¹. The trees were trained as slender spindles. No visible incompatibility was found between rootstock P 22 and the investigated cultivars. In the first five years of growth, the yield of cultivars ‘Auksis’ and ‘Zarya Alatau’ increased most rapidly, while the largest total yield was obtained from cultivars ‘Sinap Orlovskii’ and ‘Auksis’. Although cultivar ‘Sinap Orlovskii’ is characterized by very vigorous growth, it had the smallest trunk cross-sectional area on this rootstock, which resulted in the highest yield efficiency. Besides the largest yield and highest yield efficiency, this cultivar had also the biggest fruits. Cultivar ‘Lobo’ had the smallest total yield, possibly because of insufficient effect of plant protection against scab. All cultivars had a relatively small index of biennial yielding. Data obtained in the trial show that different kinds of mulch – sawdust, woodchips or pine bark – may significantly positively influence growth and productivity of cultivars on P 22. Average fruit weight was significantly influenced both by the cultivar and the type of mulch. The interaction between cultivars and types of mulch also was significant. Trees mulched with wood chips had significantly thicker trunks and higher total yield in kg per tree than trees mulched with sawdust. They also had larger canopy volume.

Key words: canopy volume, fruit size, growth, yield efficiency, Malus, mulch.

Introduction. The aim of this investigation was to study the yielding and growth of commercial cultivars grown today in Latvia on rootstock P 22. ‘Auksis’ (8 %), ‘Sinap Orlovskii’ (5 %) and ‘Zarya Alatau’ (2 %) are among the ten most popular cultivars (Skrivele et al., 2008).

The compatibility of cultivars ‘Sinap Orlovskii’ and ‘Lobo’ with different rootstocks, along with some other cultivars, was investigated earlier (Skrivele, Dimza, 1997; Skrivele et al., 2000). First results for cultivars ‘Auksis’ and ‘Zarya Alatau’ on
different dwarf rootstocks have also been obtained (Rubauskis, Skrivele, 2007).

Rootstock P 22 (M.9 × ‘Antonovka’) was among the first rootstocks of P series, and is described as dwarfing, very hardy and highly productive (Jadczuk, 1997; Kviklys, Kviklienė, 2000; Kviklys, Petronis, 2001).

Various studies with this rootstock have been performed in Lithuania. In 1994–1998 the trial of apple rootstocks P 14, M.26, P 60, P 2, M.9 and P 22 and two apple varieties ‘Jonagold’ and ‘Melrose’ was conducted at the Lithuanian Institute of Horticulture. P 22 was the most dwarfing in this trial (Kviklys, Petronis, 2001). The rootstock had negative effect on ‘Jonagold’ fruit size, but the biggest content of soluble solids were found in fruits from trees on rootstocks M.9 and P 22 (Kviklienė, Kviklys, 2001). P 22 stimulated earlier ripening for ‘Jonagold’, while fruits of ‘Melrose’ on P 22 were firmer at harvesting and retained higher firmness during storage (Kviklys, Kviklienė, 2000).

In trials with different planting density, the first blossoming of cultivar ‘Auksis’ on rootstock P 22 was registered in the second year after planting, but high intensity of flowering only in the fifth year. The rootstock was also included in trials where, in the frame of the Baltic fruit rootstock studies program, apple trees of cultivar ‘Auksis’ grown on 12 dwarf rootstocks were planted in Estonia, Latvia, Lithuania and Byelorussia in 2001. In all locations P 22 produced the smallest trees and the lowest cumulative yield. In Estonia P 22 was similar in yield efficiency to Pure 1 and York 9 (Kviklys et al., 2006).

The root system of P 22 is shallower than of other rootstocks, which increases the need of moisture regulation. An option could be a mulching system in the orchard (Rubauskis et al., 2004).

Studies of compatibility of cultivar ‘Auksis’ with different rootstock types showed that a tissue bulge might form in the graft union, which has bigger diameter than the trunk formed by the cultivar, and which hinders the functioning of conducting tissue (Leibus, 1999). It has been noted that some cultivar-rootstock combinations develop a bigger bulge if the tree is planted less deeply (graft union higher above the ground). Larger bulges are formed especially by cultivars with the highest vigour (Marini et al., 2003).

Object, methods and conditions. In this paper we have used data of a trial, which was established at the Latvia State Institute of Fruit-Growing (LSIFG) in Dobele, the southern part of Latvia. One-year-old trees on the rootstock P 22 were planted in the spring of 1998. Planting distances were 1.5 × 4 m. The trees were trained as free slender spindles. There was one tree per plot. Total number of trees in the trial was 60.

The influence of two factors – cultivar and type of mulch – was studied. The base plots included types of mulch. In 1999 the tree rows were covered with sawdust, pine bark or woodchip mulch. After two years the mulch was renewed.

Four apple cultivars were included in the trial (‘Auksis’, ‘Zarya Alatau’, ‘Lobo’ and ‘Sinap Orlovskii’), which are among the most widely grown cultivars in Latvia.

‘Auksis’ is a cultivar originated in Lithuania. Trees are of medium to strong vigour, spreading. Harvest time is midseason, drops rather easily. Has rather good resistance to all diseases.
‘Z a r y a  A l a t a u’ is a cultivar originated in Kazahstan. Young trees develop an upright canopy with narrow angles of branches, lateral branches of abundantly bearing trees bend down. Trees have good winter hardiness. The cultivar has rather good resistance to diseases. The harvest time in Latvia is late.

‘S i n a p  O r l o v s k i i’ is a cultivar of Russian origin. Fruits are of late season, large. They drop rather easily. The cultivar develops vigorous trees with broad irregular canopy and good, wide angles of branches. Has rather good to average resistance to diseases.

‘L o b o’ is of Canadian origin. It is known as a scab susceptible cultivar with high quality fruits and easy training of canopy. It is no more planted in new orchards.

The soil in the trial was leached sod-calcareous soil with pH 7.4, organic matter 1.9 % and plant available K₂O and P₂O₅, respectively 151 mg kg⁻¹ and 111 mg kg⁻¹. For fertilizing mineral fertilizers containing N, K₂O and P₂O₅ were used – the norm of them calculated as 12 g m⁻² for each and applied in 1 m wide strips.

The meteorological data were collected at the Dobele Point of Meteorology till 2007 and after 2007 by a “Luft” meteo-station placed at LSIFG. The weather conditions were very changeable from year to year, particularly the sum of precipitation in the period May – September: the average was 309 mm, but in 1999 only 184 mm, in 2010 – 520 mm. The average (1998–2010) annual precipitation was 584 mm. The active growth season was 135–145 days. The average (1998–2010) annual temperature was 6.9 ºC (by 1.1 ºC higher than the long-term average).

The following measurements and calculations were used:
• trunk cross-section area (TCSA) above the graft union at 20 cm height and at the place of the bulge (cm²);
• yield (kg) per tree;
• yield efficiency – total yield per trunk cross-sectional area in 2010 (kg cm⁻²);
• average fruit weight (g);
• index of biennial yielding (Skrivele et al., 2000);
• volume of canopy – equation created by I. Dimza:

\[ V = 0.5235 \cdot d_1 \cdot d_2 \cdot (H_1 - H_0) \left( \frac{f_1 + f_2}{2} \right)^{1.2} \text{ (m³)}, \]

where

\[ V \] canopy volume (m³);
\[ d_1 \text{ and } d_2 \] diameter of canopy in the direction of row and across the row (m);
\[ H_0 \] distance from soil surface to the lowest point of canopy (m);
\[ H_1 \] tree height – distance from soil surface to the highest point of canopy (m);
\[ f_1 \text{ and } f_2 \] coefficient of figurality, which characterizes how large a part of the tree canopy projection ellipse is covered by branches and leaves, estimating visually in the direction of row and across the row.

The significance of results was computed using ANOVA, the least significant difference or the Tukey test, with MS Excel and SPSS for Windows.

Results. T r e e  g r o w t h. The thickest trunks had cultivar ‘Auksis’, while the smallest trunk cross-section area had ‘Sinap Orlovskii’ (Table 1). Yet significance of differences among cultivars could not be proven mathematically. On the other side, the effect of mulch type on trunk growth could be proved with high probability. With pine bark in tree strips the trunk cross-section area was significantly larger than with the sawdust mulch treatment and just slightly less than with the woodchip treatment.
Table 1. Influence of mulch types and cultivars on trunk cross-sectional area (cm²)

<table>
<thead>
<tr>
<th>Mulch Mulčias</th>
<th>Cultivars Veislės</th>
<th>average vidurkis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>‘Auksis’</td>
<td>‘Zarya Alatau’</td>
</tr>
<tr>
<td>Pjuvenos</td>
<td>21.8</td>
<td>23.7</td>
</tr>
<tr>
<td>Woodchips</td>
<td>42.9</td>
<td>55.9</td>
</tr>
<tr>
<td>Pine bark</td>
<td>42.5</td>
<td>41.1</td>
</tr>
<tr>
<td>Average Vidurkis</td>
<td>36.4</td>
<td>35.9</td>
</tr>
</tbody>
</table>

p-value of / p vertė mulch / mulčio 0; cultivars / veislių 0.36; interaction / sąveikos 0.87

A bulge (overgrowth) of the budded cultivar trunk was visible above soil level. The cross-section area of this bulge was significantly affected by the type of mulch and also cultivar (Table 2). It was the largest for more vigorous cultivars ‘Auksis’ and ‘Sinap Orlovskii’. Woodchip and pine bark mulch, along with trunk diameter increased significantly, stimulated also the growth of the bulge, if compared with sawdust mulch.

Table 2. Trunk cross-sectional area at the place of the trunk bulge (overgrowth) of the grafted cultivar (cm²)

<table>
<thead>
<tr>
<th>Mulch Mulčias</th>
<th>Cultivars Veislės</th>
<th>average vidurkis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>‘Auksis’</td>
<td>‘Zarya Alatau’</td>
</tr>
<tr>
<td>Pjuvenos</td>
<td>86.8</td>
<td>63.4</td>
</tr>
<tr>
<td>Woodchips</td>
<td>119.4</td>
<td>82.4</td>
</tr>
<tr>
<td>Pine bark</td>
<td>130.9</td>
<td>84.2</td>
</tr>
<tr>
<td>Average Vidurkis</td>
<td>113.1 a</td>
<td>75.5 b</td>
</tr>
</tbody>
</table>

p-value of / p vertė mulch / mulčio 0; cultivars / veislių 0.01; interaction / sąveikos 0.88

For the canopy volume, influence was statistically proved only for the types of mulch (Table 3). It was significantly larger in treatments with woodchips and pine bark mulch as compared to sawdust.
Table 3. Influence of mulch types and cultivars on tree canopy volume in 2009 (m³)

<table>
<thead>
<tr>
<th>Mulch</th>
<th>Cultivars</th>
<th>Veislės</th>
<th>'Auksis'</th>
<th>'Zarya Alatau'</th>
<th>'Lobo'</th>
<th>'Sinap Orlovskii'</th>
<th>average vidurkis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sawdust</td>
<td>'Auksis'</td>
<td>1.77</td>
<td>1.08</td>
<td>1.46</td>
<td>2.13</td>
<td>1.53 b</td>
<td></td>
</tr>
<tr>
<td>Pjuvenos</td>
<td>'Zarya Alatau'</td>
<td>1.80</td>
<td>3.75</td>
<td>2.95</td>
<td>1.96</td>
<td>2.42 a</td>
<td></td>
</tr>
<tr>
<td>Woodchips</td>
<td>'Lobo'</td>
<td>2.27</td>
<td>2.53</td>
<td>2.53</td>
<td>1.83</td>
<td>2.27 ab</td>
<td></td>
</tr>
<tr>
<td>Medžio drožlės</td>
<td>'Sinap Orlovskii'</td>
<td>2.27</td>
<td>2.53</td>
<td>2.53</td>
<td>1.83</td>
<td>2.27 ab</td>
<td></td>
</tr>
<tr>
<td>Pine bark</td>
<td>average</td>
<td>1.93</td>
<td>2.09</td>
<td>2.23</td>
<td>1.96</td>
<td>2.06</td>
<td></td>
</tr>
<tr>
<td>Pušų žievės</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

p-value of / p vertė mulch / mulčio 0.02; cultivars / veislų 0.55; interaction / sąveikos 0.15

Yielding. The summary yield of the first two years was the highest for the cultivar ‘Zarya Alatau’ – 7.4 kg per tree (Fig.), while for the other cultivars it was only 2.4–2.6 kg. In the following years ‘Auksis’ had the fastest yield increase, therefore it had the highest summary yield of the first 5 years – 7.6 kg per tree, followed by ‘Zarya Alatau’ with 6.6 kg.

![Graph showing yield of different cultivars over years](image)

**Fig.** Yielding of cultivars on rootstock P 22

**Pav.** Veislų su P 22 poskiepiu derėjimas
Analyzing the effect of both factors – cultivars and mulch types – on the total yield of the whole trial period (Table 4), it can be seen that the cultivar effect on this parameter also could not be statistically proved, while the effect of mulch type was considerable and mathematically proven. The biggest increase of summary yield was obtained by woodchip mulch, but the lowest total yield was in the sawdust treatment.

**Table 4. Influence of mulch types and cultivars on the total (cumulative) yield in 1999–2010 (kg per tree)**

<table>
<thead>
<tr>
<th>Mulch Mulčias</th>
<th>Cultivars Veislės</th>
<th>‘Auksis’</th>
<th>Zarja Alatau</th>
<th>‘Lobo’</th>
<th>‘Sinap Orlovskii’</th>
<th>average vidurkis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sawdust</td>
<td>74.4</td>
<td>84.2</td>
<td>77.5</td>
<td>100.8</td>
<td>84.4 b</td>
<td></td>
</tr>
<tr>
<td>Pjuventos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Woodchips Medžio drožlės</td>
<td>145.4</td>
<td>142.4</td>
<td>113.1</td>
<td>137.5</td>
<td>133.8 a</td>
<td></td>
</tr>
<tr>
<td>Pine bark Pušų žievės</td>
<td>127.3</td>
<td>127.3</td>
<td>105.7</td>
<td>120.2</td>
<td>120.7 ab</td>
<td></td>
</tr>
<tr>
<td>Average Vidurkis</td>
<td>118.7</td>
<td>110.5</td>
<td>96.4</td>
<td>120.9</td>
<td>111.5 ab</td>
<td></td>
</tr>
</tbody>
</table>

p-value of / p vertė mulch / mulčio 0.01; cultivars / veislių 0.68; interaction / sąveikos 0.99

All cultivars had a relatively small index of biennial yielding, 0.33–0.68 (Table 5). A tendency for biennial cropping was more expressed in cultivar ‘Zarya Alatau’, while ‘Sinap Orlovskii’ had the most regular yields.

**Table 5. The index of alternance of four apple cultivars**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Auksis’</td>
<td>0.38</td>
<td>0.46</td>
<td>0.61</td>
<td>0.48</td>
<td></td>
</tr>
<tr>
<td>‘Zarya Alatau’</td>
<td>0.58</td>
<td>0.60</td>
<td>0.87</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>‘Lobo’</td>
<td>0.38</td>
<td>0.60</td>
<td>0.33</td>
<td>0.43</td>
<td></td>
</tr>
<tr>
<td>‘Sinap Orlovskii’</td>
<td>0.26</td>
<td>0.30</td>
<td>0.43</td>
<td>0.33</td>
<td></td>
</tr>
<tr>
<td>Average Vidurkis</td>
<td>0.39 b</td>
<td>0.48 ab</td>
<td>0.54 a</td>
<td>0.47</td>
<td></td>
</tr>
</tbody>
</table>

p-value of / p vertė cultivar / veislių 0.06; period / laikotarpio 0.03; interaction / sąveikos 0.06

In the period of full yielding the differences among cultivars were rather large in particular years, but the years of larger and smaller yields were not the same for all cultivars, so the differences between the average yields of the cultivars were not so big.
It was not possible to prove the effect of either cultivar or mulch type on yield efficiency, although the obtained data show that there is some tendency of differences both between cultivars and mulch types (Table 6).

**Table 6.** Influence of mulch types and cultivars on yield efficiency (cumulative yield per TCSA) (kg cm\(^{-2}\))

<table>
<thead>
<tr>
<th>Mulch</th>
<th>Cultivars</th>
<th>average vidurkis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mulčias</td>
<td>Veislės</td>
<td>'Auksis'</td>
</tr>
<tr>
<td>Sawdust</td>
<td>'Auksis'</td>
<td>1.61</td>
</tr>
<tr>
<td>Pjuvenos</td>
<td>'Zarya Alatau'</td>
<td>1.93</td>
</tr>
<tr>
<td>Woodchips</td>
<td>'Lobo'</td>
<td>1.82</td>
</tr>
<tr>
<td>Medžio drožlės</td>
<td>'Sinap Orlovskii'</td>
<td>1.80</td>
</tr>
<tr>
<td>Pine bark</td>
<td>average</td>
<td>1.80</td>
</tr>
<tr>
<td>Pušų žievės</td>
<td>p-value of mulčio</td>
<td>0.30; cultivars</td>
</tr>
</tbody>
</table>

The relatively high correlation between trunk cross sectional area and total yield (r = 0.68) shows that the highest yield was obtained from trees, in which one of the factors – cultivar or mulch type – stimulated trunk growth.

**Average fruit weight.** Both cultivars and mulch types had significant effect on the average fruit weight in the tree full yield period (Table 7).

**Table 7.** Influence of mulch types, cultivars and vegetation period on the average fruit weight (g) in the full yield period (2005–2010)

<table>
<thead>
<tr>
<th>Mulch</th>
<th>Cultivars</th>
<th>average vidurkis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mulčias</td>
<td>Veislės</td>
<td>'Auksis'</td>
</tr>
<tr>
<td>Sawdust</td>
<td>'Auksis'</td>
<td>153</td>
</tr>
<tr>
<td>Pjuvenos</td>
<td>'Zarya Alatau'</td>
<td>145</td>
</tr>
<tr>
<td>Woodchips</td>
<td>'Lobo'</td>
<td>126</td>
</tr>
<tr>
<td>Medžio drožlės</td>
<td>'Sinap Orlovskii'</td>
<td>142 c</td>
</tr>
<tr>
<td>Pine bark</td>
<td>average</td>
<td>142 c</td>
</tr>
<tr>
<td>Pušų žievės</td>
<td>p-value of</td>
<td>mulčio</td>
</tr>
</tbody>
</table>
The interaction between cultivars and mulch types also was significant. The largest fruits were obtained from ‘Sinap Orlovskii’, notwithstanding the highest yield and cropping efficiency indices, in all plots independent of mulch type. The largest fruits were in the treatment with woodchip mulch. The largest average fruit weight of all cultivars also was in plots with this mulch type, only ‘Auksis’ had the largest fruits in the sawdust treatment where the yield was the lowest.

Evidently the fruit weight of cultivar ‘Auksis’ is more influenced by yield volume than in the other cultivars. On the other side, for ‘Zarya Alatau’ yield amount considerably differed in dependence of mulch type, but the variation of average fruit weight was insignificant.

**Discussion.** No visible incompatibility (leaf discoloration or premature leaf fall, termination of growth, etc.) was found between rootstock P 22 and all the investigated cultivars. As the height of budding in nursery was low, the bud union of planted trees after mulching was at soil level. However, a bulge (overgrowth) of the budded cultivar trunk was the largest for more vigorous cultivars, but the growth of the bulge was stimulated by woodchip and pine bark mulch also, if compared with sawdust mulch. The scion overgrowth at the graft union, however, is not a reliable indicator of incompatibility (Leibus, 1999). It is more related to a genetic tendency for growth than to incompatibility. Other researchers (Marini et al., 2003) also have discovered that a larger overgrowth develops especially in vigorous cultivars. The correlation between tree vigour and size of the bulge was confirmed by the positive correlation between trunk cross-section area and bulge diameter ($r = 0.54$).

There were found differences between the mulch types. Although the layer of pine bark in tree strips was relatively thin, with this treatment trunk cross-section area was significantly larger than with sawdust mulch treatment and just slightly less than with woodchip treatment. Interaction of both trial factors could not be established, so it must be concluded that the effect of mulch type was the same for all cultivars. Evidently, the lowest summary yield in sawdust treatment can be explained both by the consuming of nitrogen by microorganisms during sawdust decay process, as well as by sawdust compression, which in periods of low precipitation hinders the access of water to tree roots. The more coarse structure of woodchip mulch must be preferred from this aspect. It was shown by previous studies about the importance of mulching for moisture regulation in fruit tree plantings, especially in heavier soils (Rubauskis et al., 2004).

In part the difference index of biennial yielding of cultivars may be explained by different types of dominant fruiting wood, as ‘Sinap Orlovskii’ has various types in more equal proportions, which provide for more regular yields (Kozlovskaya, 2003). Also in previous investigations with semi-dwarf rootstocks somewhat less pronounced alternance was exhibited by ‘Sinap Orlovskii’, but for ‘Lobo’ the alternance of bearing was one of the highest (Skrivele et al., 2000). ‘Lobo’ is known as a spur-bearing cultivar, and in ‘Zarya Alatau’ the largest part of fruiting wood also are short spurs. Cultivars with this type of dominant fruiting wood have a tendency for biennial yields.

It was not possible to prove the effect of either cultivar or mulch type on the yield
efficiency. Correlation shows that the highest yield was obtained from trees in which one of the factors – cultivar or mulch type – stimulated trunk growth. Although ‘Sinap Orlovskii’ is characterized by vigorous growth (Skrivele, Dimza, 1997; Kozlovskaya, 2003), on rootstock P 22 trunk cross-section area was the smallest, which resulted in higher calculated indices of cropping efficiency.

The highest yield efficiency was in the plots where trunk cross-section area of ‘Sinap Orlovskii’ was one of the smallest as the effect of sawdust mulch, although the summary yield per tree was comparatively lower. It is hard to explain why cultivar ‘Sinap Orlovskii’ in sawdust treatment had the thinnest trunks compared with the other cultivars, while the canopy volume of this cultivar, unlike the others, in this treatment was larger than with woodchip or pine bark mulch. Possibly it is linked with the growth peculiarities of the cultivar, which has a tendency to form long shoots.

The obtained data show that rootstock P 22 strongly reacts to growth environment factors, and even changes of mulch type may essentially influence cultivar growth and yield. The negative effect of rootstock P 22 on fruit weight was already established in trials in Poland (Jadczuk, 1997). In Lithuania on rootstock P 22, depending of tree density, the average fruit weight of cultivar ‘Auksis’ was 119–137 g (Uselis et al., 2006). Negative effect on fruit size in P 22 and cultivar ‘Jonagold’ combination was observed comparing different rootstocks (Kviklienė, Kviklys, 2001).

In our experiment such negative effect was not established. Fruit weight, for example, of cultivar ‘Auksis’ was 142 g (121–178 g) in the full yielding period (Table 7), which is similar to data obtained in trials with other rootstocks (Rubauskis, Skrivele, 2007). So the positive effect of mulch appears to have reduced the possible negative effect of the rootstock. The planting depth also could have some influence. In our trial the graft union was under the mulch layer, yet, as shown by the location of the graft union bulge slightly above the mulch, no rooting of the top cultivar had occurred.

**Conclusions.** No visible incompatibility was found between rootstock P 22 and the investigated cultivars.

In the first five years of growth the most rapid increase of yield had cultivars ‘Auksis’ and ‘Zarya Alatau’, while the largest total yield was obtained from cultivars ‘Sinap Orlovskii’ and ‘Auksis’.

Although cultivar ‘Sinap Orlovskii’ is characterized by vigorous growth, it had the smallest trunk cross-sectional area on this rootstock, which resulted in the highest yield efficiency.

All cultivars had a relatively small index of biennial yielding.

Significant effect on the average fruit weight in the full yield period was shown both by the cultivar and by the mulch type. The interaction of cultivars and mulch types also was significant.

Types of mulch – sawdust, woodchips or pine bark – may significantly influence the growth and yielding of cultivars on rootstock P 22. Trees mulched with woodchips had significantly bigger trunk sectional area and higher total yield per tree if compared with sawdust mulch treatment. No effect of cultivar and mulch type interaction was established.
Acknowledgements. This study was supported in part by ERAF project Nr. 2010/0192/2DP/2.1.1.2.0/10/APIA/VIAA/007 “Facilitating of the international recognizability and competitiveness of Latvian fruit science”, State Research Program “Sustainable use of local resources (soil, forest, food and transport) – new products and technologies” (NatRes) Project Nr. 2 “Solutions for improved apple quality, storage and processing possibilities”, for the project funded by LR Ministry of Agriculture “Development of sustainable fruit growing, using integrated growing technologies friendly to environment and water resources and preserving the countryside landscape, for reducing climate change and providing for biological diversity”.

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Parengta spausdinti 2011 07 01

References


SODININKYSTĖ IR DARŽININKYSTĖ. MOKSLO DARBAI. 2011. 30(2).

**Keturių obelų veislų su P 22 poskiepiu derėjimas**

E. Rubauskis, M. Skrivele, Z. Rezgale, L. Ikase

**Santrauka**

veislių su P 22 poskėpiu augimą ir derlingumą. Ir veislė, ir mulčio rūšis darė patikimą įtaką vidutinei vaisiaus masei. Sąveika tarp veislių ir mulčio rūšių taip pat buvo patikima. Vaismedžiai, mulčiuoti medžio drožlėmis, buvo patikimai storesnio kamieno ir davė didesnę suminį derlių (kg / vaismedis) nei vaismedžiai, mulčiuoti drožlėmis. Didesnis buvo ir jų vainikas.

Reikšminiai žodžiai: augimas, derliaus efektyvumas, lapios dydis, Malus, mulčias, vaisių dydis.
Influence of mulch on rainfall interception in apple orchard

Krzysztof Klamkowski, Waldemar Treder, Anna Tryngiel-Gać

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The study was performed in apple orchard in 2010. The analysis of temporal distribution, intensity and quantity of rainfall along with measurements of soil water content were done to assess the impact of precipitation on moisture changes of soil covered with mulch (wood chips) or maintained as a chemical fallow. Total rainfalls in 2010 were higher than the multi-year average. The amount of rainfall collected during the vegetative period (May-September) constituted more than 50 % of the total yearly precipitation. The efficiency of precipitation depended on the orchard floor management system. The highest efficiency of precipitation (for both soil surface management systems) was recorded for heavy rains (5–10 mm h\(^{-1}\)). Low and medium intensity rains (below 5 mm h\(^{-1}\)) were less efficient for soil covered with mulch. In case of stormy rains (> 10 mm h\(^{-1}\)), which contribution to the total amount of precipitation during vegetative period was approx. 7 %, a higher increase in moisture was recorded in plots with mulched soil surface compared to the control ones (without mulching).

Key words: orchard floor management, precipitation efficiency, soil moisture.

Introduction. The climate of Poland is characterized by high temporal and spatial variation. The total amount and seasonal distribution of precipitation show significant variability. A quarter of the country is subject to a low water balance, with a deficit of more than 100 mm (Bac, 1980).

Precipitation is the major input to the soil water balance in temperate zones. Its amount, intensity and seasonal distribution have an indubitable impact on soil moisture. According to Drupka (1993), the most useful rainfalls for plants are those with low intensity (2–3 mm h\(^{-1}\)) and small drops. In case of excessive amount or intensity of rain, part of water percolates below the root system level or runs off the soil surface (Ballif, 1995).

Insufficient precipitation reduces fruit yield and quality (Treder, 1996). Soil moisture can be controlled by irrigation or mulching, which reduces evaporation and allows more economical use of water. The main aims of orchard floor management are to conserve and increase retention of soil moisture, increase rainfall infiltration, and
prevent runoff on sloping ground (Mustaffa, 1988; Glenn, Welker, 1989). Natural methods of orchard floor management, such as mulching with organic matter, are widely employed in integrated fruit production (Mika et al., 1998; Autio, Greene, 1991; Neilsen et al., 2003). Recycled biomass mulches, such as wood chips, straw, grass clippings, municipal composts and shredded newspaper, have been used to improve the soil fertility, increase water availability and control weeds without the use of herbicides (Merwin et al., 1995).

In the study, the analysis of temporal distribution, intensity and quantity of rainfall along with measurements of soil water content were done to assess the impact of precipitation on moisture changes of soil covered with mulch or maintained as a chemical fallow.

Objects, methods and conditions. The study was performed in an experimental apple orchard in 2010. 8 years-old ‘Gala’/M.9 trees were grown at a row and tree spacing of 4 × 1.2 m. Soil surface in the orchard was maintained as a chemical fallow (control) or it was covered with mulch (wood chips) applied in a 20 cm thick layer. The treated strip along the tree rows was 1.5 m wide.

Amount and intensity of precipitation were measured using an automatic weather station (iMETOS, Pessl Instruments, Austria). Efficiency of rainfall of different intensity was estimated by recording changes in soil water content (expressed in mm in 0–40 cm profile) within 24 h after the rainfall onset. Precipitation intensity was classified according to Radomski (1979): heavy rain – intensity 5–10 mm h⁻¹, rainstorm – intensity over 10 mm h⁻¹.

Continuous measurements of soil moisture were done using four EC-5 capacitance probes (Decagon Devices, USA) placed every 10 cm in soil profile. The probes were integrated with the meteorological station and data were transmitted via Internet network. Additionally, weekly measurements of soil water content (from May to September) using Diviner 2000 moisture meter (Sentek Sensor Technologies, Australia) were performed. This system enables the measurement of water content at the selected depth in soil profile by swiping down the probe through an access tube (PVC tube 50 mm in diameter) installed in soil. The changes of soil water balance (mm week⁻¹) were calculated as a difference between the final soil water content (after weekly period) and the initial soil water content (Treder and Konopacki, 1999).

The experiment was prepared in three replicates (3 fields with the probes and access tubes installed in soil covered with mulch or maintained as a chemical fallow). The experimental data were statistically elaborated using analysis of variance (ANOVA), followed by means separation using Duncan’s multiple-range t-test at P < 0.05.

Results and discussions. The temporal distribution of precipitation for the year examined is presented in Table 1. Total rainfalls for 2010 was higher by approx. 12 % as compared to multi-year average. The amount of rainfall collected during the vegetative period (May–September) constituted more than 50 % of the total yearly precipitation.
Table 1. Distribution of precipitation (mm) in the experimental orchard in Skierniewice

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>2010</td>
<td>0</td>
<td>14.6</td>
</tr>
<tr>
<td>1979–2005*</td>
<td>26.7</td>
<td>24.1</td>
</tr>
</tbody>
</table>

* – on the basis of data obtained from meteorological station located approx. 5 km from the study area.

Total changes in soil water balance as influenced by amount of precipitation (weekly periods) are presented in Figure. The graph shows that for both soil surface management systems (with or without the mulch) the characteristics of the regression lines are similar, with the change of soil water content equal to zero for weekly total precipitation of approximately 12–13 mm. Similar values were reported by Treder and Konopacki (1999) who performed the study in the same orchard.

![Graph showing soil water balance in response to precipitation]

Fig. Influence of precipitation amount on change in water balance of soil maintained in chemical fallow or mulched with wood chips

Pav. Kritulių kiekio įtaka dirvožemiai, palikto cheminiams pūdymui arba mulčiuoto medžio drožliams, vandens pusiausvyros pokyčiui
According to the authors, the average weekly amount of precipitation necessary to maintain the soil moisture at the constant level during the vegetative period had to reach 18 mm.

As it was stated above, changes in water balance were similar for the soil maintained as the chemical fallow or covered with wood chips (mulched). According to Treder and Konopacki (1999), efficiency of rainfall strongly depends on the initial soil moisture. Due to a large amount of precipitation recorded in 2010, the level of soil moisture in the experimental orchard (especially in the mulched plots) was high during the larger part of the vegetative period. Study conducted by Treder and coauthors (2004) showed that the efficiency of mulches in diminishing water evaporative losses was the highest in the initial phase of drought period. In their experiment the water content in soil covered with mulch (wood chips) was higher up to 30 % compared to non-mulched one. Beneficial effect of mulching in preventing drastic changes in soil moisture level was showed also by Choi and coauthors (2003) in peach orchard, and by Locascio and Thompson (1960) in strawberry plantation.

Efficiency of precipitation depended on the rainfall intensity and soil surface management system. In 2010 the contribution of heavy rains (5–10 mm h⁻¹) constituted approx. 10 % of total rainfall during the vegetative period (May–September) with the amount reaching 43 mm. The contribution of rainstorms during the analyzed period of time reached 7 %.

The highest efficiency of precipitation (in both combinations) was showed for heavy rains (5–10 mm h⁻¹) (Table 2). In case of bare (non-mulched) soil it was similar to the one observed for medium intensity rains (2–5 mm h⁻¹). The lowest precipitation efficiency was recorded for rains of very low intensity (< 2 mm h⁻¹). It was especially visible in case of soil covered with the mulch. Short-lasting rains of low intensity in a hot sunny day affect soil water content in a minimal measure. A large part of rain water is intercepted by above-ground parts of plants. Kędziora (1995) claims that interception capability (i. e. keeping water on the leaf surface) after rainfall event can reach even 2 mm.

**Table 2.** Efficiency of precipitation (%) as influenced by its intensity for soil maintained in chemical fallow or mulched with wood chips

<table>
<thead>
<tr>
<th>Surface management system</th>
<th>Intensity of precipitation Kritulių intensyvumas (mm h⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paviršiaus tvarkymo sistema</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>Chemical fallow</td>
<td>29.7 b</td>
</tr>
<tr>
<td>Cheminis pūdymas</td>
<td>11.3 a</td>
</tr>
</tbody>
</table>

Means marked with the same letter are not significantly different according to Duncan’s multiple range test at P ≤ 0.05 / Reikšmės, pažymėtos ta pačia raide patikimai nesiskiria pagal Dunkano kriterijų, kai P ≤ 0.05.
For bare soil, the efficiency of rainstorms (> 10 mm h\(^{-1}\)) was lower by approx. 13% compared to heavy rains (Table 2). It means that a large part of water ran off of the surface. This confirms observations made by Święcicki (1981), who stated that a surface runoff is caused mainly by rains of intensity larger than 10 mm h\(^{-1}\) in Polish orchards. Low efficiency of rainstorms was also presented by Treder and Konopacki (1999).

A different situation was observed in case of soil covered with wood chip mulch. Efficiency of rains of intensity below 5 mm h\(^{-1}\) was considerably lower compared to the control plots (maintained as the chemical fallow) (Table 2). This phenomenon supports a hypothesis that in case of low intensity rains, some part of water can be intercepted by the mulch layer before it reaches the topsoil. Rainfall-storage capacity of mulch depends on its thickness and composition (Xiaoyan et al., 2000; Cook et al., 2006). Relatively high efficiency of rainstorms is worth noticing. It proves the effectiveness of mulching in conserving soil moisture and preventing surface runoff.

**Conclusions.** The study confirmed high variation in the amount and distribution of precipitation during vegetative season. Both the total rainfall and its distribution in 2010 differed from that observed in multi-year time period. Heavy rains (5–10 mm h\(^{-1}\)) and rainstorms (> 10 mm h\(^{-1}\)) contributed significantly the total precipitation during the analyzed period. It was showed that efficiency of precipitation strongly depended on the soil surface management system. Rainfall of low to medium intensity (below 5 mm h\(^{-1}\)) was less efficient in mulched soil. However, in case of stormy rains (> 10 mm h\(^{-1}\)) mulch improved soil water retention compared with no mulch preventing surface runoff event.

**References**


Mulčio įtaka lietaus vandens sulaikymui obelų sode

K. Klamkowski, W. Treder, A. Trygiel-Gać

Santrauka

Tyrimas atliktas obelų sode 2010 metais. Siekiant įvertinti kritulių įtaką mulčiu (medžio drožlėmis) padengto arba cheminiame pūdyme laikomo dirvožemio drėgmės pokyčiams, buvo atliktas lietaus vandens laikino pasiskirstymo, intensyvumo ir kiekio analizė bei išmatuotas vandens kiekis dirvožemyje. 2010 metais lijo daugiau nei daugiametis vidurkis. Vegetacijos laikotarpiu (gegužė–rugsėjis) iškrito daugiau kaip 50 % viso metų kritulių kiekio. Kritulių veiksmingumas priklausė nuo sodo dirvožemio paviršiaus tvarkymo sistemos. Veiksmingiausi krituliai (abiem dirvožemio paviršiaus tvarkymo sistemoms) buvo, kai lijo stipriai (5–10 mm h⁻¹). Silpni ir vidutinio intensyvumo lietūs (mažiau kaip 5 mm h⁻¹) mulčiu padengtam dirvožemiui buvo ne tokie veiksmingi. Audrų įnašas į bendrą kritulių kiekį vegetacijos laikotarpiu buvo maždaug 7 %, drėgmės padidėjimas buvo užregistruotas sklypuose su mulčiutu dirvožemio paviršiumi, lyginant su kontroliniais (nemulčiuotais).

Reikšminiai žodžiai: dirvožemio drėgmė, dirvožemio drėgmės matuoklis, kritulių veiksmingumas, sodo dirvožemio paviršiaus tvarkymas.
Stability of some quality characteristics of new plum cultivars in Latvia

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The aim of the study was to evaluate variability of some quality characteristics of plum fruits and their changes in different years under different meteorological conditions – air temperature, solar intensity and precipitation. The study was done at Latvia State Institute of Fruit-Growing. The soil in the trial field was sod-podzolic and carbonate with sandy clay loam, with organic matter content 2.7 %. Soil reaction was slightly acidic (pHKCl 6.1). The trial was carried out with four perspective cultivars ‘Ance’, ‘Adele’, ‘Sonora’ and ‘Lotte’. Three trees per each cultivar grafted on seedlings of P. cerasifera were planted at distances of 3 × 5 m.

Evaluation trial was established in 1998–1999. Analysis included: total content of acids (%), flesh firmness (kg cm⁻²), and soluble solid content (Brix %) of fresh fruits. Each measurement was carried out in 20 replications. Significance of interaction was shown among cultivars, years, years and cultivars.

In total, weather conditions significantly correlated with the qualitative characteristics, but the correlation within years was different. In 2008 all three climatic factors had significant effect on the content of soluble solids (r = -0.98; -0.97; -0.89) and the average yield per tree (r = -0.68; -0.69; -0.84). In 2009 all weather factors had significant impact on soluble solid content, total content of acids and flesh firmness. In 2010, air temperature and solar intensity significantly correlated with the average yield per tree (r = -0.70; -0.78). This year rainfall significantly affected the soluble solid content (r = -0.53) and average fruit weight (r = -0.66).

Key words: climatic conditions, flesh firmness, Prunus domestica L., soluble solid content, total content of acids.

Introduction. Biochemical composition is variable and differs between cultivars grown in different climate zones. The aim of the study was to determine variation of the soluble solid content and total content of acids depending on the year and weather conditions during vegetation in four home plum varieties submitted for registration in Latvia, in 2010. Weather conditions during the study (2008–2010) were extremely different, ant this significantly affected the results of biochemical parameters.

As wrote W. Hartman and M. Neumüller (2009), plum blooming time depends not only on species but also on variety and region. Blooming time of the individual flower
depends on the position of flower bud on tree. Flower buds flower in different times because they develop on short or long shoots. Fruits, which develop from flowers on long shoots, ripen a bit later than the other ones. Cultivar productivity is low, if weather conditions during flowering is subtropical (Hartman, Neumüller, 2009). In warmer regions, the time span between the full bloom of early and late blooming genotypes is more prolonged than in cooler or in continental climate. The length of flowering period is genetically determined but largely modified by the environment as well (Szabo, 1989). Influence of precipitation on fruit quality was studied in Skierniewice (Poland), when dry and very wet years occurred periodically (Treder et al., 1998)

Object, methods and conditions. The study was carried out at Latvia State Institute of Fruit-Growing (LSIFG) in Dobele. Plum trial was established in 1998–1999. Three trees per each cultivar grafted on seedlings of Prunus cerasifera were planted at distances of 3 × 5 m. The soil in the trial is sod-podzolic and carbonate with sandy clay loam, with organic matter content 2.7 %. Soil reaction is slightly acidic (pH_KCl 6.1), with an average to low P labeled (221 mg kg⁻¹), average K labeled (335 mg kg⁻¹), low Mg content (274 mg kg⁻¹).

Performed biochemical analysis in fruits:

(1) total content of acids (%) (TA). The TA was determined by titration with 0.1N NaOH (Khan et al., 2008);
(2) fruit firmness (kg cm⁻²) of fruit with a digital penetrometer (instrument error ± 0.01 g cm⁻²) following the standard BS EN 12143 (July, 2001);
(3) soluble solid content (Brix %) of fresh fruits (SSC) (ISO 2173: 2003) at 20 °C with a digital refractometer ATAGO N20 (instrument error ± 0.01 %) standard BS EN 12147 (July, 2001).

Meteorological data were collected at Dobele Point of Meteorology and by a “Lufft” meteo-station placed at LSIFG. Data analyzed from the beginning of flowering to the harvesting of fruits was precipitation (mm⁻²), solar radiation (W m⁻²), and the average air temperature (° C).

(1) Cultivar ‘Ance’ is early ripening – 1 month before ‘Victoria’. Fruit skin is thin, yellow with reddish blush. Suture line is inconspicuous. Stone is easily separated from flesh. The average yield from 2008 to 2010 was 43 kg per tree.
(2) Cultivar ‘Adele’ is medium ripening – 1 week before ‘Victoria’. Fruit skin is thin, yellow with reddish over-colour on part of fruit. Stone separation from flesh is good. Over colour is well pronounced, if the tree is trained to provide sunlight access into the canopy. The average yield from 2008 to 2010 was 20 kg per tree.
(3) Cultivar ‘Sonora’ is medium ripening – 1 week after ‘Victoria’ – and self-fertile. Fruitlets are self-thinning. The fruit skin is rather thin, with reddish ground colour and purple bloom. The suture line is semi-pronounced. Flavour is good. Stone separation from flesh at full maturity is good. The fruits are very attractive. The average yield from 2008 to 2010 was 25 kg per tree.
(4) Cultivar ‘Lotte’ is medium-late ripening – two weeks later than ‘Victoria’. It is partially self-fertile. Flavour is very good and notably sweet. Fruit skin is rather thin, purplish blue with greyish blue bloom. Stone separation from flesh is semi good. The average yield from 2008 to 2010 was 18 kg per tree.
Results. Years analyzed in our study according to meteorological data were significantly different (Table 1). In 2008 there was a lot of precipitation, solar intensity and the average air temperature was a little higher than in 2009, whereas in 2009 there was significantly less rainfall and lower average air temperature. In 2010 from the beginning of the growing season until middle of August it was hot and humid. Although the beginning of flowering in this year was delayed for 2 weeks, but uncharacteristic higher temperature and abundant humidity shortened the period from flowering to fruit ripening for all tested cultivars.

Table 1. Period from flowering to the harvest of tested plum cultivars and respective meteorological parameters

<table>
<thead>
<tr>
<th>Cultivars</th>
<th>Years</th>
<th>Period from flowering to ripening (days)</th>
<th>Precipitation (mm m⁻²)</th>
<th>Solar radiation (Saulės radiacija)</th>
<th>Average air temperature (Vidutinė oro temperatūra)</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Ance’</td>
<td>2008</td>
<td>102</td>
<td>456</td>
<td>2663</td>
<td>175</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>104</td>
<td>236</td>
<td>2575</td>
<td>171</td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td>94</td>
<td>449</td>
<td>3463</td>
<td>238</td>
</tr>
<tr>
<td>‘Adele’</td>
<td>2008</td>
<td>119</td>
<td>758</td>
<td>2808</td>
<td>191</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>119</td>
<td>244</td>
<td>2759</td>
<td>187</td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td>112</td>
<td>461</td>
<td>3612</td>
<td>249</td>
</tr>
<tr>
<td>‘Sonora’</td>
<td>2008</td>
<td>124</td>
<td>832</td>
<td>2897</td>
<td>203</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>124</td>
<td>259</td>
<td>2937</td>
<td>203</td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td>114</td>
<td>461</td>
<td>3612</td>
<td>249</td>
</tr>
<tr>
<td>‘Lotte’</td>
<td>2008</td>
<td>129</td>
<td>842</td>
<td>3002</td>
<td>211</td>
</tr>
<tr>
<td></td>
<td>2009</td>
<td>129</td>
<td>244</td>
<td>2759</td>
<td>187</td>
</tr>
<tr>
<td></td>
<td>2010</td>
<td>123</td>
<td>545</td>
<td>3725</td>
<td>263</td>
</tr>
</tbody>
</table>

Fruit firmness. Analysis of data using Descriptive Statistics showed significant differences in fruit firmness among years, cultivars, as well as significant interaction between cultivars and year (p < 0). The lowest fruit firmness in three years of the study for tested cultivars was found in 2009. Significantly firmer fruits for all cultivars were observed in 2010, when precipitations were significantly higher; higher solar intensity and average of air temperature occur (Fig. 1). Therefore, the significant difference in firmness measurement between 2009 and 2010 was stated for all cultivars.

The most stable cultivar with the least amount of data scatter for all tree years of testing was ‘Adele’ (Fig. 2). Analysis of data about the other cultivars marked out significantly the year 2010, where data from some trial replications were out of sampled population. The widest data distribution was for cultivar ‘Ance’.
Soluble solid content. SSC over the study years differed significantly from 10.14–14.96 Brix % (Fig. 3). For all cultivars, except ‘Ance’, SSC in 2008 was significantly lower than in other years. In very dry 2009, SSC for cultivars ‘Ance’ and ‘Adele’ was significantly higher than for other cultivars, and significantly differed from the others measurements of that year. 2010 was hot and humid. However, it has not a
positive effect on SSC increases, except for a cultivar ‘Sonora’. Weather conditions had significant effects on evaluation of separate cultivars.

Fig. 3. Changes of soluble solid content of plum cultivars in different years
3 pav. Tirpių sausųjų medžiagų pokyčiai slyvų veislėse skirtingais metais

There were not found significant differences among cultivars (p > 0.005) in SSC content (Fig. 4) in the analyses of separate cultivar sampling populations. Average parameters of cultivars ‘Ance’ and ‘Adele’ were relatively stable. SSC fluctuations of cultivar ‘Sonora’ were on large-scale, besides, meteorological conditions of 2010 led to higher results in some replications. The significant of distinctness of cultivar ‘Lotte’ was found in 2008.

Fig. 4. Soluble solid content in plum cultivars
4 pav. Tirpios sausosios medžiągos slyvų veislėse
Total content of acids. The TA of the cultivars ‘Ance’ and ‘Adele’ did not changed significantly in study years (Fig. 5). Significant changes were found for cultivar ‘Sonora’, which in 2008 had the highest acidity (1.42 %), which is significantly different from data in 2009 (1.12 %). This parameter differed significantly between 2009 and 2010 also for the cultivar ‘Lotte’.

![Fig. 5. Changes of total content of acids of plum cultivars in different years](image)

Evaluating characteristics of average cultivar samples, mathematically significant differences among the cultivars were not detected. Cultivar ‘Ance’ showed significantly higher data distribution, as well as higher acid content for some replicates collected in 2008 (Fig. 6).

Response of cultivars to climatic factors is very different, which could be explained by differences in leaf morphological characteristics of various plant genotypes. Heat tolerant cultivars have more rapid transpiration, which helps them to diminish the temperature of the leaves and the plant does not overheat. Different intensity of transpiration of cultivar leaves is determined by differences of cuticle, stoma size and quantity, etc. (unpublished data).

In Table 2 there is shown differences in the response of cultivars to meteorological conditions.
Fig. 6. Total content of acids in plum cultivars

6 pav. Bendras rūgščių kiekis slyvų veislėse

Table 2. Coefficient of correlation between precipitations and fruit parameters

2 lentelė. Koreliacijos koeficientas tarp kritulių ir vaisių parametrų

<table>
<thead>
<tr>
<th>Cultivar Veislė</th>
<th>Precipitations Krituliai</th>
<th>Fruit firmness Vaisių kietumas</th>
<th>Soluble solid content Tirpios sausosios medžiagos</th>
<th>Total content of acids Bendras rūgščių kiekis</th>
<th>Average yield Vidutinis derlius</th>
<th>Average fruit weight Vidutinė vaisiaus masė</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Ance'</td>
<td>Rainfall Lietus</td>
<td>0.07</td>
<td>-0.15</td>
<td>0.99</td>
<td>-0.69</td>
<td>-0.92</td>
</tr>
<tr>
<td>'Adele'</td>
<td>Solar radiation Saulės radiacija</td>
<td>-0.85</td>
<td>0.90</td>
<td>-0.66</td>
<td>-0.19</td>
<td>0.20</td>
</tr>
<tr>
<td>'Sonora'</td>
<td>Average air temperature Vidutinė oro temperatūra</td>
<td>-0.53</td>
<td>0.45</td>
<td>0.75</td>
<td>-0.98</td>
<td>-0.98</td>
</tr>
<tr>
<td>'Lotte'</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</table>
Table 2 continued
2 lentelės tęsinys

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<th>5</th>
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<tbody>
<tr>
<td>‘Adele’</td>
<td>Rainfall Lietus</td>
<td>0.06</td>
<td>-0.78</td>
<td>-0.82</td>
<td>0.04</td>
<td>-0.88</td>
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<tr>
<td></td>
<td>Solar radiation Saulės radiacija</td>
<td>-0.85</td>
<td>0.96</td>
<td>0.94</td>
<td>0.79</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>Average air temperature Vidutinė oro temperatūra</td>
<td>-0.54</td>
<td>-0.27</td>
<td>-0.33</td>
<td>0.61</td>
<td>-0.99</td>
</tr>
<tr>
<td>‘Sonora’</td>
<td>Rainfall Lietus</td>
<td>-0.32</td>
<td>-0.47</td>
<td>0.88</td>
<td>-0.81</td>
<td>-0.94</td>
</tr>
<tr>
<td></td>
<td>Solar radiation Saulės radiacija</td>
<td>-0.59</td>
<td>-0.45</td>
<td>-0.89</td>
<td>0.00</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>Average air temperature Vidutinė oro temperatūra</td>
<td>-0.81</td>
<td>-0.90</td>
<td>0.44</td>
<td>-1.00</td>
<td>-0.96</td>
</tr>
<tr>
<td>‘Lotte’</td>
<td>Rainfall Lietus</td>
<td>-0.07</td>
<td>-0.98</td>
<td>0.22</td>
<td>0.74</td>
<td>-0.98</td>
</tr>
<tr>
<td></td>
<td>Solar radiation Saulės radiacija</td>
<td>-0.78</td>
<td>0.72</td>
<td>0.67</td>
<td>-0.98</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>Average air temperature Vidutinė oro temperatūra</td>
<td>-0.64</td>
<td>-0.69</td>
<td>0.75</td>
<td>0.21</td>
<td>-0.66</td>
</tr>
</tbody>
</table>

Summarizing the fruit firmness, SSC and TA interaction trend over the years (Fig. 7), it is possible to say that cultivars showed a significant mutual influence ($p < 0.005$).

**Fruit firmness** for all cultivars had significant negative correlation with solar radiation and average air temperature.

**Soluble solid content** had a significant negative correlation with precipitation for all cultivars; but significant correlations had cultivars ‘Adele’ and ‘Lotte’.

SSC for cultivars ‘Ance’, ‘Adele’ and ‘Lotte’ had a significant positive correlation with the intensity of sun – in sunny years fruits were much sweeter; whereas SSC in cultivars ‘Sonora’ and ‘Lotte’ had a significant negative correlation with average air temperature.

**The total acid content** had a significant positive correlation with precipitation for cultivars ‘Ance’ and ‘Sonora’, but a significant negative correlation for cultivar ‘Adele’. The solar intensity had a significant positive correlation for cultivars ‘Adele’ and ‘Lotte’, but a significant negative correlation for cultivars ‘Ance’ and ‘Sonora’. The average air temperature had a significant positive correlation for cultivars ‘Ance’ and ‘Lotte’.
Average yield for cultivars ‘Ance’ and ‘Sonora’ had a significant negative correlation with precipitation and average air temperature; whereas cultivar ‘Adele’ had significant positive correlation with the solar intensity and the average air temperature. Yield for cultivar ‘Lotte’ had significant positive correlation with precipitation, but significant negative correlation with solar intensity.

Average fruit weight for all cultivars significantly negatively correlated with precipitation and average air temperature; cultivar ‘Lotte’ had a significant positive correlation with solar intensity.

Data procession showed the significance of interaction effects among all three analyzed parameters (Fig. 7).

**Discussion.** This study showed variability of cultivar response to rainfall, solar intensity and average air temperature. Increasing of solar intensity and average air temperature decreased fruit firmness in all tested cultivars. Some cultivars had a large data scattering due to difficulties to define precisely the degree of ripeness for all replications. Scientist V. Baltess described the process of fruit ripening – how the enzymes react with their substrates: starch is split down to glucose, its partially isomerisation into fructose, cellulose and pectin partially pull down, and fruit becomes soft; chlorophyllases pull down chlorophyll, and carotene and xanthophylls form the yellow ground colour. Later develop anthocyanins, which make fruit red colour (Baltess, 1998). Sometimes it was difficult to define the most suitable colour intensity for some cultivars, because cover colour intensity over the years was different. In the LSIFG in 1996–2006 the study was carried out with 13 cultivars for analysis of fruit
firmness, SSC and TA. Parameters analyzed in this study also showed significant
differences between years, (Kaufmane et al., 2010).

Fruit firmness is one of the quality characteristic parameters that determine strength
of fruit transportability and shelf-life (Sekse, Wermund, 2010). As noted by scientists
from California (Crisoto et al., 2000), plum fruits with flesh firmness of 1 kg cm\(^{-2}\) were
considered by consumers “ready to eat”.

Average fruit firmness of cultivars in our experiment in 2009 ranged from 0.52
to 0.94 kg cm\(^{-2}\). In other years the firmness was up to 2.8 kg cm\(^{-2}\).

Fruit firmness of cultivars ‘Adele’ and ‘Sonora’ did not changed significantly
after 2 weeks in cool storage, while fruits of the cultivars ‘Ance’ and ‘Lotte’ firmness
decreased significantly after one week storage. Similar studies were conducted in
Norway, in which different firmness stability of cultivars during storage was studied
(Vangdal et al., 2007 b).

Soluble solid content is one of the most important determinants of fruit flavour
and shelf-life (Sekse et al., 2010).

Russian scientists have described the decline in photosynthesis at the leaf cells
during maximum moisture saturation and the elevation of temperature above 30 °C.
Photosynthesis activity is the main process which results give a dry matter of the plant.
By contrast, low humidity and lower average air temperature in the cells of leaves are
promoting activation of photosynthesis and therefore plant development is not impeded
(Jakushkina, 1980). In 2010 SSC was decreased in cultivars ‘Ance’ and ‘Adele’ due
to elevated humidity or temperature. It is difficult to explain negative correlation SSC
with average air temperature of cultivars ‘Sonora’ and ‘Lotte’.

Norwegian scientist E.Vangdal found that the SSC is higher, if the average
monthly temperature is higher in April and June, but lower in February and July, as
well as a lot of rainfall in May. It corresponds to sweeter plums. The TA increases by
higher amount of precipitation in time of the end of crop formation (Vangdal et al.,
2007a). Studies of A. Døving in Norway showed that increase of average temperature
in January increase the yield, but reduce SSC. TA is most affected by precipitation. As
the researcher showed, it is more closely correlated with precipitation in August – in
the years, when the end of harvest time is wet and content of acids in fruits is higher.
The abundant precipitation in May ensure a sweeter fruit (Døving et al., 2005).

The influence of weather conditions on biochemical content of fruits as well as
interaction of different biochemical characters was found in our trial. In Russia also
were carried out studies, which demonstrated a possible relationship between mete-
orological conditions and SSC and AT (Bogdanov, 2003). The Serbian researchers
also found that fruit quality is mainly affected by the particular growing conditions of
cultivar (including weather) (Rakičevič et at., 2008).

Conclusions. 1. Significant changes in fruit firmness were found in 2009 and
2010 due to high differences in precipitation level between years.

2. SSC for cultivars ‘Ance’, ‘Sonora’ and ‘Lotte’ was significantly higher in dry
2009 than in 2008 and 2010. Sweeter fruits of these cultivars could be acquired in
plantations established on well-permeable soils, where the accumulation of excess
moisture does not occur. Cultivar ‘Lotte’ formed sweeter fruits at higher solar intensity.
3. TA for cultivars ‘Ance’ and ‘Adele’ had not changed in the study years significantly, but the cultivar ‘Sonora’ showed significant differences in 2008 and 2009. Significant differences were found for the cultivar ‘Lotte’ in 2009 and 2010. TA indicators for cultivars ‘Ance’ and ‘Sonora’ increased by the influence of abundant rainfall. High solar intensity decreased TA. Total acid content of cultivars ‘Ance’ and ‘Lotte’ was increased by higher air temperature.

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References


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Naujų slyvų veisių kai kurių kokybės charakteristikų stabilumas Latvijoje

I. Grāvīte, E. Kaufmane

Summary


Tirta: bendras rūgščių kiekis (%), minkštimo tvirtumas (kg cm\text{-2}) ir šviežių vaisių tirpių sausųjų medžiagų kiekis (Brix %). Kiekvienas matavimas kartotas 20 kartų. Atskleistas sąveikos tarp veisių, metų, metų ir veislių patikimumas.

Oro sąlygos patikimai sąveikavo su kokybės charakteristikomis, bet toji sąveika skirtingais metais buvo skirtinga. 2008 metais visi trys klimato veiksmai turėjo patikimą poveikį tirpių sausųjų medžiagų kiekiai (r = -0,98; -0,97; -0,89) ir vidutiniu vaismedžio derliu (r = -0,68; -0,69; -0,84). 2009 metais visi klimato veiksmai darė patikimą įtaką tirpių sausųjų medžiagų kiekiai, bandram rūgščių kiekiai ir minkštimo tvirtumu. 2010 oro temperatūra ir saulės intensyvumas patikimai sąveikavo su vidutiniu vaismedžio derliu (r = -0,70; -0,78). Tais metais lietus turėjo patikimą įtaką tirpių sausųjų medžiagų kiekiai (r = -0,53) ir vidutinei vaisių masei (r = -0,66).

Reikšminiai žodžiai: bendras rūgščių kiekis, minkštimo tvirtumas, oro sąlygos, Prunus domestica L., tirpio sausosios medžiagos.
Influence of rootstock on wintering and health status of plum cultivar ‘Kubanskaya Kometa’

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The choice of rootstock is the main precondition for the establishment of high yield and sustainable plum orchards. Therefore, influence of rootstock on wintering of plum cultivars under Latvian climatic conditions becomes more and more actual. Research was carried out with the aim to clarify the influence of rootstock on wintering and health status of plum cultivar ‘Kubanskaya Kometa’. Research was carried out at the Pure Horticultural Research Center during wintering seasons of 2009–2010 and 2010–2011, in an orchard planted in 2001. The winter of 2008–2009 had sharp temperature fluctuations, but the winter of 2009–2010 and 2010–2011 was snowy with stable low temperatures. 16 rootstocks broadly used in Europe were included in the investigation. Plum tree health status and the number of dead trees were evaluated in the research. Statistically significant differences among rootstocks were noted according to the evaluation of tree health status. Differences in wintering ability of the rootstocks were recorded between the first and the second year of the research. Trees grafted on Brompton cuttings had the best health status. Two dead trees were registered on this rootstock. After the severe winter of 2009–2010 the rootstock St. Julien A was less suitable for Pure requirements. The largest amount of dead trees was registered on this rootstock.

Key words: Prunus cerasifera, Prunus domestica, rootstock, winter hardiness.

Introduction. The choice of rootstock is the main precondition for the establishment of high yielding and sustainable orchard. The lack of appropriate rootstocks is one of the main reasons limiting the development of intensive plum orchards in Latvia. Compatibility of the rootstock and cultivar is the main condition influencing tree productivity and yield comprising parameters. Therefore, tree life, resistance to unfavourable weather conditions, crown size, precocity and yield intensity depends not only on the rootstock or cultivar, but also on their interaction (Wertheim, 1998).

The Caucasus plum (Prunus cerasifera Ehrk.) has been the most used rootstock in Latvia during the last several decades (Lepsis et al., 2004). However, it does not
meet intensive orchard needs because its vigorous habit (Grzyb et al., 1998). It is also not well suited for hobby gardens if they are located in moist areas. As an additional drawback, the incompatibility of this rootstock with some cultivars should be mentioned. In the Pūre Horticultural Research Center insufficient health evaluation of trees grafted on Caucasian plum as rootstock was observed (Lepsis et al., 2008).

Myrobolana and dwarfing Wangenheim’s Zwetche as rootstocks are used in other European countries ( Rozpara, Grzyb, 2007). Pixy is investigated as a dwarfing rootstock in intensive orchards in Europe (Sosna, 2002). Also several other plum rootstocks have been included in European research projects, but research in these rootstocks have not been carried out in Latvia until recently.

In Latvia the cultivars of the hybrid plum (2n = 16) are popular and very widely grown. Therefore, popular cultivar ‘Kometa Kubanskaya’ belonging to this group was included in the investigation of the different rootstocks. The aim of the research was to clarify the influence of the different rootstocks on wintering and health status of cultivar ‘Kometa Kubanskaya’ under Latvian conditions. The data obtained during two vegetation seasons (2009 and 2010) and consequently after two wintering seasons of 2009–2010 and 2010–2011 are examined.

**Object, methods and conditions.** A plum orchard was established in 2001 at the Pūre Horticultural Research Center, Latvia. Cultivar ‘Kometa Kubanskaya’ was used in the research, grafted on 16 different rootstocks well known in Europe. Eight vegetative propagated rootstocks were included in the research:

- St. Julien A, Brompton, Ackermann, Pixy, GF8/1, G5/22, GF655/2, Hamyra; as well as eight generative propagated rootstocks: St. Julien INRA2, St. Julien d Orleans, St. Julien Noir, Brompton, Wangenheim’s Zwetche, St. Julien Wädenswill, Myrobolana, _P. cerasifera_ var. _divaricata_.

Plants were planted at a spacing of 3 × 5 m, in four replications, three trees per plot. The soil was sandy loam, of _pH_ _KCl_ 7.2. Irrigation in the orchard was not available. Weed in spaces between the rows was removed and herbicide strips were applied to control weeds around the trees.

The general health status of the trees was scored in 2009, 2010 and 2011 by the following scale: 0 – tree completely dead, 1 – tree has lost the ability to grow, 2 – the above ground part was completely damaged, but new shoots were developed, 3 – two and three-year-old branches and trunks were damaged, 4 – one-year-old shoots were damaged, 5 – tree in excellent condition. The average yield per tree (kg) was analysed in 2008 and 2009, but in 2010 the yield was insignificant. Dead trees were evaluated at the end of 2010 and in the beginning of 2011.

A mathematical analysis of the results was performed using ANOVA.

Meteorological data was obtained from the automatic meteorological station “Lufft” registering meteorological conditions every 10 minutes. Recent meteorological data was compared to long-term data. The average air temperature in 2009–2011 and long-term temperatures are summarized in Fig. 1.

During the wintering period of January 2009, a rapid decrease of air temperature was observed, down to -21.8 °C. Such low temperatures could negatively influence tree wintering. Average precipitation in the form of snow was 21 mm. Also in February there was cold weather during the 2nd decade. It was -15.6 °C and precipitation was only 4 mm. However, in March precipitation reached 54 mm and the average air temperature fluctuated between -11 °C and +5 °C.
Fig. 1. Average twenty four hour temperatures of 2009, 2010, 2011 and long-term observations (°C)

Such meteorological conditions negatively influenced cultivars, which have an early growth cycle. The minimal air temperature in April fluctuated from -2.4 °C (1st decade) to -5 °C (3rd decade); precipitation was 7.9 mm. During the 1st decade of May the average air temperature dropped to -1.4 °C, but did not influence plum flowering. Maximal temperatures in May fluctuated between +20.8 °C and 25.0 °C. June had high precipitation – up to 81.4 mm (Fig. 2). Air temperatures were not high – only during the 3rd decade temperature reached +17.6 °C. July also had a plenty of precipitation (107 mm), an amount that significantly exceeded long-term observations.

Fig. 2. Precipitation sums of 2009, 2010, 2011 and long-term observations (mm)

2 pav. 2009, 2010, 2011 metų ir ilgalaikių stebėjimų kritulių sumos, mm
The maximal air temperature in August was +26.6 °C in the 1st decade and +22.7 °C in the 3rd. In September the minimal air temperature started to decrease and reached +2.2 °C in the 3rd decade. Total precipitation in September was 39.7 mm. The minimal air temperature in October dropped down to -4.4 °C. Total precipitation was 82.7 mm. Plum vegetation in this period ends. In November precipitation was relatively low if compared with long-term observations, 20.4 mm. Rapid decrease of temperature was observed in December (-22.7 °C in the 2nd decade); that could influence plum wintering processes negatively. Temperatures under 0 °C were until the end of the December.

January of 2010 was cold – the 3rd decade was the coldest, when temperatures dropped to -28.6 °C. Also February was relatively cold, with minimal temperature -21.6 °C, but at the 3rd decade temperatures increased to +3.5 °C. These are very sharp temperature fluctuations, which can cause tree damage. March had changeable weather, which can injure trees. In the 1st decade of May the minimal air temperature dropped down to -3.2 °C. July and August of 2010 was hot, when in the 2nd decade of August air temperature reached +32.3 °C. August had the most precipitation – 143.7 mm. Autumn was warm and only in the 3rd decade of November minimal air temperature rapidly dropped down to -15.2 °C. December was relatively cold.

A very low temperature was registered during February of 2011, when the temperature dropped to -28.5 °C.

Results. In 2008, the highest yield was obtained from trees grafted on Brompton cuttings (36.6 kg per tree), Wangenheims Zwetche (34.8 kg) and Julien A (33.6 kg per tree) (Fig. 3).

![Fig. 3. Average yield (kg per tree)](image)

3 pav. Vidutinis derlius, kg / vaismedis
The lowest yield was harvested on trees grafted on Ackermann (9.1 kg per tree). In 2009 the obtained yields were lower than the yields of 2008. Trees grafted on GF655/2 and Myrobolana gave the best yields. Whereas the lowest yields were harvested from trees on Ackermann and St. Julien Wädenswill. The yield of trees on Wangenheims Zwetche in 2009 was significantly lower than in 2008.

Meteorological conditions of the most recent wintering periods had a significant influence on health status of trees grafted on all rootstocks and showed significant differences between rootstocks (Table). In 2010, the general tree health status was the best for trees on St. Julien d’Orleans and Brompton cuttings (3.0 points). Trees on rootstocks *P. cerasifera* and St. Julien A had the lowest evaluation of general health status (1.1 points). After winter of 2010/2011 there was a sharp decrease in the health status of trees grafted on Ackermann, Myrobolana, St. Julien d’Orleans and Brompton cuttings.

**Table.** Tree health status of cultivar ‘Kometa Kubanskaya’ (points)

<table>
<thead>
<tr>
<th>Rootstock</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ackermann</td>
<td>2.3</td>
<td>1.9</td>
<td>1.1</td>
</tr>
<tr>
<td>St. Julien INRA2</td>
<td>1.5</td>
<td>1.4</td>
<td>1.2</td>
</tr>
<tr>
<td>Brompton seedlings</td>
<td>3.0</td>
<td>2.8</td>
<td>1.6</td>
</tr>
<tr>
<td>Myrobolana</td>
<td>2.1</td>
<td>1.8</td>
<td>1.0</td>
</tr>
<tr>
<td>GF8/1</td>
<td>2.8</td>
<td>2.4</td>
<td>1.4</td>
</tr>
<tr>
<td>G5/22</td>
<td>3.4</td>
<td>3.4</td>
<td>2.0</td>
</tr>
<tr>
<td>St. Julien d’Orleans</td>
<td>3.2</td>
<td>3.0</td>
<td>1.7</td>
</tr>
<tr>
<td>Brompton cuttings</td>
<td>3.5</td>
<td>3.0</td>
<td>1.7</td>
</tr>
<tr>
<td>St. Julien Noir</td>
<td>2.5</td>
<td>2.3</td>
<td>1.8</td>
</tr>
<tr>
<td>St. Julien Wädenswill</td>
<td>2.2</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>Wangenheims Zwetche</td>
<td>1.9</td>
<td>1.8</td>
<td>1.7</td>
</tr>
<tr>
<td>St. Julien A</td>
<td>1.3</td>
<td>1.1</td>
<td>0.8</td>
</tr>
<tr>
<td>Pixy</td>
<td>1.6</td>
<td>1.5</td>
<td>1.3</td>
</tr>
<tr>
<td>Hamyra</td>
<td>2.1</td>
<td>2.2</td>
<td>1.3</td>
</tr>
<tr>
<td><em>P. cerasifera</em> var. <em>divaricata</em></td>
<td>1.3</td>
<td>1.1</td>
<td>0.6</td>
</tr>
<tr>
<td>GF655/2</td>
<td>2.8</td>
<td>2.6</td>
<td>2.0</td>
</tr>
<tr>
<td>LSD&lt;sub&gt;0.05&lt;/sub&gt; / R&lt;sub&gt;0.05&lt;/sub&gt;</td>
<td>1.40</td>
<td>1.25</td>
<td>1.07</td>
</tr>
</tbody>
</table>
The highest amount of dead trees was registered on St. Julien A and *P. cerasifera*. The less number of dead trees was observed for plum trees on Brompton cuttings and G5/22. After the wintering of 2010/2011 there well additional dead trees registered on GF 8/1, St. Julien d’Orleans, Myrobolana and St. Julien INRA 2 (Fig. 4).

**Discussion.** It should be taken into account that abundant yields have a direct influence on the yield of the coming year and proper pruning. During the spring of 2009 strong pruning was used for plum trees, therefore the yield of cultivar ‘Kometa Kubanskaya’ in 2009 was lower than in 2008. It does not allow detecting the best rootstock in this year. If we compare the results obtained in our investigation with results obtained in other European countries some differences are observed. It was observed in Poland that under good soil conditions higher yields are obtained from trees on Wangenheims Zwetche and GF655/2 than from trees on Myrobolana (Grzyb et al., 1998), but on average the yield on Myrobolana seedlings is higher. In our investigation relatively low yields are obtained from trees grafted on *Prunus cerasi-fera*. This differs from other investigations (Клакоцкий, 2009).

The general health status of the diploid plum ‘Kometa Kubanskaya’ on rootstock St. Julien A became worse during the latter years of the research (Dēkena et al., 2009; Lepsis et al., 2008). During the spring of 2011 an unsatisfactory health status was observed also for trees on *P. cerasifera*, Myrobolana and Ackermann. Meteorological conditions over the most recent years have created over-wintering conditions that have influenced the trees negatively. Wintering and survival of the trees have been investigated under our conditions; tendency of the decreasing of health status has been noted.
Diploid plum ‘Kometa Kubanskaya’ has very good regeneration ability; therefore, tree can recover after light wintering injuries. The plum ‘Kometa Kubanskaya’ is characterized as a mid winterhardy cultivar (4.8 points of 9) in Estonia where weather conditions are more severe (Jänes, Kahu, 2008).

According to current results, the less suitable plum rootstock for Pūre conditions is St. Julien A, which produced the highest amount of dead trees. Winter of 2010–2011 negatively influenced trees on rootstock St. Julien d’Orleans, which till now yielded satisfactory. Three dead trees were observed for this rootstock, which can be also be attributed to the previous severe winter. Better viability is observed for trees on Brompton cuttings.

Conclusions. 1. The best wintering and health status for the cultivar ‘Kometa Kubanskaya’ until 2010 was observed on the rootstocks of St. Julien d’Orleans and Brompton cuttings. Health status of all trees decreased in the spring of 2011, which were negatively influenced by the meteorological conditions of the previous winter.

2. Trees on St. Julien A have unsatisfactory health status. The highest amount of dead trees is observed on this rootstock.

3. The highest yields were obtained from trees grafted on Brompton cuttings rootstock.

References


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Slyvų veislės ‘Kubanskaya Kometa’ poskiepio įtaka žiemojimui ir sveikatos būklei
D. Dēķena, I. Alsiņa
Santrauka

Reikšminiai žodžiai: ištvermingumas žiemą, poskiepis, Prunus cerasifera, Prunus domestica.
The severity of European pear rust depending on pear cultivars

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Pear (Pyrus communis L.) is the second most common pome fruit crop in Latvia. A critical situation with the severity of disease – European pear rust (caused by Gymnosporangium sabinae) – has been observed in the home gardens in Latvia, where plant protection products are not used at all or used in very limited amounts. Therefore, the disease becomes more and more common. The agent of pear rust is an obligatory parasite with incomplete development cycle, which requires both pear and juniper. In case of strong infection disease features could be found not only on pear leaves, but also on branches and fruits. The disease can cause significant crop losses, as well as gradual destruction of trees. Therefore, the aim of this study was to evaluate the differences of pear rust spreading among pear cultivars. The study was performed at the Latvia State Institute of Fruit-Growing on cultivars ‘Belorusskaya Pozdnyaya’, ‘Mlievskaya Rannaya’, ‘Mramornaya’, ‘Vizhnica’ and ‘Zemgale’ grafted on rootstock Pyrodwarf and planted in 2004. Tree planting distances were 4 × 1.5 m. The prevalence of pear rust infection on leaves among cultivars was evaluated for three years (2008–2010) in points, 0–5. European pear rust severity results showed significant difference over the years of evaluation. The incidence and spread of the disease increased during more humid growth periods. There were no resistant cultivars among the tested ones, only there was observed variability of susceptibility. Results showed that high severity of European pear rust infection has significant influence on pear yield.

Key words: cultivars, Gymnosporangium sabinae, junipers, pear.

Introduction. Pear (Pyrus L.) is the second most common pome fruit crop in Latvia – total pear growing area is about 200 ha (CSB, 2011). The yield of pears directly or indirectly can be influenced by different diseases, which damage leaves, branches as well as fruits, like pear–juniper rust. Strong pear leaf infection by European pear rust rapidly decreases assimilating surface, which interferes with photosynthesis, assimilation and metabolism in normal plant tissue. As a result weakened tree, defective fruit development and leave fall could be observed. In some cases, infection can be found in branches. Consequently, the disease can cause significant crop losses, as well as destruction of trees.

European pear rust is caused by Gymnosporangium sabinae (Dicks) G. Winter,
which is an obligatory parasite with incomplete development cycle requiring both pear and juniper, because it does not constitute uredospores or summer spores (Juhasova, Praslieka, 2002; Aime, 2006). Otherwise, European pear rust, like other rusts, has a complex development cycle, which forms spores of four different types (Hilber, Siegfried, 1989). Geographical distribution of European pear rust is closely related with the dissemination of junipers. In such way the pathogen was introduced into North America by infected junipers imported from Europe (Ormrod et al., 1984). During the last decades various species of junipers have become very popular and widespread also in Latvian gardens, which resulted in spreading of the European pear rust in pear orchards.

Relatively few studies have been done on the pathogen *G. sabinae* development cycle. It is stated that the development starts in early spring on the junipers, where basidiospores are developed, which infect the pear leaves using wind as carrier. The first symptoms of pear infection occur in early June. At the top of the leaves it appears as reddish-orange spots, which gradually become larger (5–10 mm). Whereas in August the mature aeciospores develop on pears and by wind return to the juniper, where they hibernate (Hilber, Siegfried, 1989). In some cases fungus can survive the winter in the pear branches for a few years (Hunt, O’Reilly, 1978). Stages of disease development are dependent on weather conditions. High relative humidity and water drops on the leaves encourage formation of basidiospores in telia (Hilber, Siegfried, 1989). The spore germination occurs at the temperature range from 5 to 20 °C, but the optimal temperature for infection is 15 °C (Hilber et al., 1990).

Selection of appropriate resistant or tolerant cultivars could limit the impact of disease to the pear production. Investigations of the European pear rust severity among pear species has been performed and species *P. korzhinskyi*, *P. betulifolia*, *P. cordata* and *P. salicifolia* as less susceptible were stated (Fitzner, Fischer, 2005). Therefore, these species are recommended for use in pear breeding (Fischer, 2005). Unfortunately, there are no wide investigations on the severity of European pear rust among widely grown pear cultivars.

There have been no scientific studies on European pear rust severity in Latvia. For the first time disease was mentioned in 1938 by M. Eglītis (Eglītis, 1938), where it was characterized as widespread and damaging disease only for Western Europe, but not found in Latvia. Later, M. Seržāne (Seržāne, 1962) did not note this disease for pears at all. Some sporadic information about European pear rust appeared only in popular publications and online resources.

Although the distribution of European pear rust can be limited by application of pesticides containing active substance fungicides (Ormrod et al., 1984), its use in home gardens and organic orchards could be problematic. It may be sold by selection and introduction of resistant or tolerant cultivars in pear growing. Therefore, the aim of this investigation was to evaluate the European pear rust severity depending on cultivars under field conditions.

**Object, methods and conditions.** The study was performed at the Latvia State Institute of Fruit-Growing (LSIFG) on cultivars ‘Belorusskaya Pozdnaya’, ‘Mlievskaya Rannaya’, ‘Mramornaya’, ‘Vizhnica’ and ‘Zemgale’ grafted on rootstock Pyrodwarf and planted in 2004. The cultivars ‘Belorusskaya Pozdnjaya’, ‘Mlievskaya
Rannaya’ and ‘Mramornaya’ are recommended for growing in commercial plantations, whereas ‘Vizhnica’ and ‘Zemgale’ – for growing in home gardens.

Tree planting distances were 4 × 1.5 m, ten trees per plot. Soil management consisted of frequently mowed grass in the alleyways, while 1 m wide strips were treated with herbicides.

The severity of European pear rust infection on leaves for each tree among cultivars was evaluated for three years (2008–2010). Adapted scale for scab spreading evaluation in points (0–5) was used (Percival et al., 2009):

- 0 – a tree has no infected leaves;
- 1 – less than 5 % infected leaves;
- 2 – 5–20 % of infected leaves;
- 3 – 21–50 % infected leaves;
- 4 – 51–80 % infected leaves;
- 5 – 81–100 % infected leaves.

Spreading of pear-juniper rust was evaluated using an adapted scale for scab spreading evaluation (Percival et al., 2009).

Yield was estimated for each tree of the cultivar.

Environmental information was collected at the meteorological station “Lufft” at LSIFG, selecting data from the first and second decades of May. Moisture of leaf surface was measured in range from 255 to 0, where 255 – dry leaves, 0 – wet leaves.

Data analysis was performed using analysis of variance, MS Excel software. The significance of differences between cultivars and years was estimated at the 0.05 level.

**Results.** Three years of investigation showed significant differences in European pear rust severity depending on cultivars (p < 0.05). None of the tested pear cultivars showed distinct resistance. In general, the highest severity of disease occurred on cultivars ‘Vizhnica’ and ‘Zemgale’, whereas cultivars ‘Belorusskaya Pozdnyaya’, ‘Mlievskaya Rannaya’ and ‘Mramornaya’ were less sensitive to the rust than the other tested cultivars (Fig. 1).

---

**Fig. 1.** Average infection rate of *G. sabinae* on different pear cultivars

1 pav. Vidutinis *G. sabinae* infekcijos intensyvumas skirtingoje kriaušių veislėse
Statistically significant differences were observed among cv. ‘Zemgale’ and all other tested pear cultivars (p < 0.05). The lowest sensitivity to the European pear rust was stated for ‘Belorusskaya Pozdnjaya’ and ‘Mramornaya’ (1.5 and 1.6 points, respectively).

The severity of European pear rust on the tested pear cultivars varied significantly among years and there some association with wet climate conditions was found (Table 1). In 2008 only cultivar ‘Vizhnica’ was infected – 0.1 points on average (Fig. 2).

Table 1. Severity of European pear rust infection on the pear trees depending on climatic conditions during infection

<table>
<thead>
<tr>
<th>Year</th>
<th>Average level of rust severity (scores, 0–5)</th>
<th>Characterization of climatic conditions</th>
<th>Moisture of leaf surface*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vidutinis rūdžių intensyvumas (balais, 0–5)</td>
<td>Klimato charakteristikos</td>
<td>lapų paviršiaus drėgnumas*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>average air temperature</td>
<td>precipitation</td>
</tr>
<tr>
<td>2008</td>
<td>0.02</td>
<td>11.3</td>
<td>6</td>
</tr>
<tr>
<td>2009</td>
<td>1.00</td>
<td>11.1</td>
<td>4.5</td>
</tr>
<tr>
<td>2010</td>
<td>4.00</td>
<td>12.5</td>
<td>30.5</td>
</tr>
</tbody>
</table>

* moisture of leaf surface was measured in range from 255 to 0, where 255 – dry leaves, 0 – wet leaves / lapų paviršiaus drėgnumas buvo išmatuotas nuo 255 iki 0, kur 255 – sausai lapai, 0 – drėgni lapai

Whereas in 2009 all tested varieties were infected at low level (1 point on average) without differences among cultivars. The highest rust severity on all tested pear cultivars was observed in 2010 (3.6–4.7 points). Significant differences were observed also in the distribution of disease on parts of plant. In 2008 and 2009 symptoms of disease were observed only on leaves, whereas in 2010 they were found also on fruits and branches. The correspondence between the severity of European pear rust and environmental conditions was found. The climate conditions in 2008 and 2009 were similar (Table 1), whereas in 2010 significantly higher measurements of precipitation, relative air humidity and moisture of leaf surface were detected.

The average yield per tree was evaluated to detect the impact of European pear rust infection on the fruit production. The association between severity of disease and average yield for tree was found (Fig. 3). Low level of European pear rust severity has no impact on fruit production. The average yield per tree has statistically significant growth between years 2008 and 2009 for the most of tested cultivars (‘Belorusskaya Pozdnjaya’, ‘Mlievskaya Rannaya’, ‘Vizhnica’ and ‘Zemgale’) (Fig. 3). Drastic yield reduction was observed in 2010, when despite good flowering intensity and fruit set, yield was absent. Due to high severity of European pear rust infection, the fruit development was stopped; they dried out and fell down.
Fig. 2. Severity of European pear rust depending on cultivars and years

2 pav. Europinių kriaušių rūdžių intensyvumo priklausomybė nuo veisių ir metų

Fig. 3. The average yield per tree of pear cultivars during three-year period (2008–2010)

3 pav. Vidutinis derlius nuo kriaušių veisių vaismedžio trejų metų laikotarpiu (2008–2010 m.)
Discussion. European pear rust severity evaluation showed that none of the tested pear cultivars has resistance to this pathogen, but significant differences in susceptibility level among the cultivars have been observed. Cultivars ‘Belorusskaya Pozdniyaya’ and ‘Mramornaya’ were recognized as the most tolerant. Similar results were shown also by Fischer and Weber (2005). The most important factors affecting European pear rust severity were environmental conditions, mainly humidity and temperature on host surface. In 2010 the environmental conditions were very favourable for disease development, because mature telial horns germinate when free water from rain is available and produce basidiospores, which infect young pear leaves (Hilber et al., 1990). The infection of pear leaves by basidiospores depends also on the duration of humid periods and temperature during them (Hilber et al., 1990). This period of time in spring is essential for plant susceptibility and pear rust infectivity, as stated also by other authors (Agrios, 1997). Especially favourable climate conditions in the spring of 2010 for European pear rust increased the severity of disease to a very high level: 3–5 points (Fig. 2), that corresponds to 20–100 % infected leaves, besides due to high infection level of cultivars the symptoms of disease were observed also on fruits and branches.

It has been already stated that growth and fruit set of heavily infected pear trees is inhibited and leaves tend to drop early in the season (Gill, 1992; Gebauer et al., 2001). This investigation also showed that high severity of European pear rust may lead to yield reduction or complete loss. In 2010 the strong infection by rust completely destroyed the yield despite normal development of flowers and flowering as well as fruit set. The disease has negative impact on pear fruit yield only when a large proportion of the leaves (fruits or branches) were infected. Low severity of disease with up to 5 % of infected leaves had no impact on yield, regardless the tested cultivar.

Conclusions. The results of the three-year field experiment demonstrated the natural infection level of the European pear rust at the Latvia State Institute of Fruit-Growing (LSIFG). During the experiment it was found that none of the tested pear cultivars has distinct resistance to European pear rust. The climatic conditions of the particular year have significant influence on the development of European pear rust. The incidence and spread of European pear rust is increasing during more humid growth periods. High severity of European pear rust infection has significant influence on pear yield, up to complete loss of annual harvest.

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References

Santrauka


Reikšminiai žodžiai: Gymnosporangium sabinae, kadagiai, kriaušės, veislės.
Currant breeding in Western Siberia

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Breeding of black currant from the beginning of the decade 1930s of 20\textsuperscript{th} century to the present is shown. Eighteen cultivars have been developed since 1990. A scheme to reduce the length of breeding process, system of estimate, use and improvement of primary currant stocks has been developed. The necessity to involve genetically heterogeneous stocks in the breeding process has been determined. The sources and donors of productivity components combining disease and pest resistance, high self-fertility and earliness were identified during the research. Highly disease resistant and productive cultivars ‘Zonalnaya’, ‘Aleandr’, ‘Berdchanka’, ‘Ranniya Potapenko’, ‘Karachinskaya’, ‘Obskaya Chernaya’, ‘Berdskaya Chernaya’, ‘Rakhil’, ‘Mariushka’ and ‘Glarioza’ are recommended for agricultural industry in Siberia. Cultivars with the large berries are recommended for agricultural industry and amateur gardeners: ‘Pamiati Potapenko’, ‘Shadrikha’, ‘Kalinovka’, ‘Degtiarevskaya’ and ‘Podarok Kuminovu’.

Key words: breeding, cultivars, currant.

Introduction. Black currant has the leading position in the bulk production as the basic berry crop of Russia. It occupies an area of 44 860 ha in the industrial and amateur gardens of Russia. The area occupied by black currant was 11 600 ha (Kuminov, 1983) in Siberia. At present, there are 1 170 ha in the Novosibirsk region planted with this crop.

The preference for black currant growing can be explained with not a complicated technology of the crop, its high winter hardiness, frost resistance and berry-forming potential being up to 5 t/ha (Volodina, Naumova 1980), easy vegetative reproduction, transportability, large amount of active biological agents and minerals in berries, useful for human health. Black currants are rich in organic acids, sugars, tanning agents and vitamins C, P, B, B1, B2, B9, PP. Only the berries of actinidia and dog-rose hips (Samorodova-Bianki, 1969) accede them in the content of ascorbic acid. The positive qualities of black currant mentioned above are the reasons why currant breeding was initiated in Siberia.

Currant breeding was started by N. I. Davidovich and agrotechnician A. I. Skakova in 1935. The first experimental currants were planted and 8 overseas varieties and those
of Michurin’s breeding. Two clones were selected in wild berry study in 1936 and 9 more varieties were included into the second trial. The beginning of regular work at currant breeding is connected with D. A. Andreichenko. It was mostly analytical work involving European cultivar ‘Goliath’. The scientific-research institute (Michurinsk) conducted detailed investigations of the Siberian and Far Eastern berry areas in the 1930s. The expedition headed by D. A. Andreichenko (1952) was one of the most memorable.

The aim of the work is to present the results of currant breeding in Siberia at the Novosibirsk Michurin Zonal Fruit-berry Experimental Station from the beginning of 1930s of 20th century to the present.

Results. The basic outcome of black currant breeding for 60 years is presented in Table 1.

<table>
<thead>
<tr>
<th>Table 1. Achievements of currant breeding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 lentelė. Serbentų selekcijos rezultatai</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Years</th>
<th>Cross-combination number</th>
<th>Seed number</th>
<th>Seedling number</th>
<th>Studied in the garden</th>
<th>Selected Atrinkta</th>
<th>Regionalized cultivars number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metai</td>
<td>Kryžminimo kombinacijų skaičius</td>
<td>Sėklų skaičius</td>
<td>Sėjinukų skaičius</td>
<td>Tirta sode</td>
<td>perspektyvių</td>
<td>Rajonuotų vaislių skaičius</td>
</tr>
<tr>
<td>1935–1955</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1963–1969</td>
<td>57</td>
<td>74 276</td>
<td>22 287</td>
<td>18 107</td>
<td>119</td>
<td>10</td>
</tr>
<tr>
<td>1970–1979</td>
<td>114</td>
<td>245 496</td>
<td>33 513</td>
<td>188</td>
<td>82</td>
<td>6</td>
</tr>
<tr>
<td>1980–1989</td>
<td>139</td>
<td>267 980</td>
<td>43 067</td>
<td>12 033</td>
<td>63</td>
<td>14</td>
</tr>
<tr>
<td>1990–1994</td>
<td>274</td>
<td>132 625</td>
<td>18 162</td>
<td>11 301</td>
<td>103</td>
<td>12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Black currant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Juodieji serbentai</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>1935–1955</td>
<td>1 323</td>
</tr>
<tr>
<td>1963–1969</td>
<td>56</td>
</tr>
<tr>
<td>1970–1979</td>
<td>23</td>
</tr>
<tr>
<td>1980–1989</td>
<td>6</td>
</tr>
<tr>
<td>1990–1994</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>Iš viso (1935–1994)</td>
</tr>
<tr>
<td></td>
<td>594</td>
</tr>
<tr>
<td></td>
<td>720 377</td>
</tr>
<tr>
<td></td>
<td>109 029</td>
</tr>
<tr>
<td></td>
<td>59 312</td>
</tr>
<tr>
<td></td>
<td>367</td>
</tr>
<tr>
<td></td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>

|                | Ribelaria                 |
|                | Agrastiniai serbentai     |
|                |                           |
|                | 1 350                     |
|                | 13                        |

The breeding data are fragmental (till 1963) and were almost not mentioned in the reports. Other documents have not been preserved. 13231 seedlings had been studied for 20 years, 56 were chosen for the prospect, 26 as elite and further 6 cultivars were developed according the report of 1995. Those were ‘Berdskaya’, ‘Rus’, ‘Danko’, ‘Kolkhoznitsa’, ‘Zarnitsa’ and ‘Obskaya’. Origin of these cultivars is shown in Table 2.
<table>
<thead>
<tr>
<th>Cultivar Veislė</th>
<th>Origin of cultivar Veislės kilmė</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Genotype* Genotipas</td>
</tr>
<tr>
<td>'Berdskaya'</td>
<td>ES 'Chernaya local' × ‘Goliath’</td>
</tr>
<tr>
<td>'Zarnitsa'</td>
<td>ES 'Chernaya local' × ‘Goliath’</td>
</tr>
<tr>
<td>'Rus'</td>
<td>ES 'Chernaya local' × ‘Goliath’</td>
</tr>
<tr>
<td>'Kolkhoznaya'</td>
<td>ES 'Chernaya local' № 18 × ‘Goliath’</td>
</tr>
<tr>
<td>'Danko'</td>
<td>ES 'Chernaya local' × ‘Goliath’</td>
</tr>
<tr>
<td>'Obskaya'</td>
<td>S 'Chernaya local № 1'</td>
</tr>
<tr>
<td>'Agrolesovskaya'</td>
<td>ESD 'Druzhnaya’ × ‘Altaiskaya Dessertnaya’</td>
</tr>
<tr>
<td>'Iskitimskaya'</td>
<td>ESD 'Druzhnaya’ × ‘Altaiskaya Dessertnaya’</td>
</tr>
<tr>
<td>'Berdchanka'</td>
<td>ESD 'Druzhnaya’ × ‘Altaiskaya Dessertnaya’</td>
</tr>
<tr>
<td>'Ranniya Potapenko'</td>
<td>HESD ‘Kanadskaya’ № 5 × 21-1-65 (‘Nadezhda’ × ‘Primorskij Champion’ 1 + ‘Zoya’ + ‘Golubka’ + ‘Druzhnaya’)</td>
</tr>
<tr>
<td>'Zapozdalaya'</td>
<td>ESD 'Druzhnaya’ × ‘Altaiskaya Dessertnaya’</td>
</tr>
<tr>
<td>'Kalinovka'</td>
<td>ScESD 'Agrolesovskaya’ × ‘Brödtorp’</td>
</tr>
<tr>
<td>'Shadrikha'</td>
<td>ScESD 'Agrolesovskaya’ × ‘Brödtorp’</td>
</tr>
<tr>
<td>'Aleandrp'</td>
<td>ScESD 'Agrolesovskaya’ × ‘Brödtorp’</td>
</tr>
<tr>
<td>'Zonalnaya'</td>
<td>ScESD 'Agrolesovskaya’ × ‘Brödtorp’</td>
</tr>
<tr>
<td>'Parni Potapenko'</td>
<td>ScESD 'Agrolesovskaya’ × ‘Brödtorp’</td>
</tr>
<tr>
<td>'Karachinskaya'</td>
<td>ScESD 23-29-66 (‘Druzhnaya’ × ‘Altaiskaya Dessertnaya’) × 'Brödtorp’</td>
</tr>
<tr>
<td>'Obskaya Chernaya'</td>
<td>ScESD 'Agrolesovskaya’ × ‘Brödtorp’</td>
</tr>
<tr>
<td>'Berdskaya Chernaya’</td>
<td>ScESD 'Agrolesovskaya’ × ‘Brödtorp’</td>
</tr>
<tr>
<td>'Degtiarevskaya'</td>
<td>ESD 'Seyanets Golubki’ × ‘Berdchanka’</td>
</tr>
<tr>
<td>'Podarok Kuminovu'</td>
<td>ESD ‘Berdchanka’ × ‘Seyanets Golubki’</td>
</tr>
<tr>
<td>'Rakhil'</td>
<td>HScESD 125-1-75 (‘Agrolesovskaya’ × ‘Kanadskaya 2’) × ‘Ojebin’</td>
</tr>
<tr>
<td>'Glarioza'</td>
<td>ScESD 'Iskitimskaya’ × ‘Ojebin’</td>
</tr>
<tr>
<td>'Mariushka'</td>
<td>HScESD 125-1-75 (‘Agrolesovskaya’ × ‘Kanadskaya 2’) × ‘Ojebin’</td>
</tr>
</tbody>
</table>

*D – Ribes dikuscha; E – Ribes nigrum ssp. Europeum; S – Ribes nigrum ssp. Sibiricum

Locally selected currant forms and European ‘Goliath’ were used in creation of new cultivars. The first varieties were quite winter-hardy with high yield performance. Potapenko established that industrial monovarietal plantations had either weak berry-forming capabilities or no harvest at all. Therefore, they were not spread in plant industry (Potapenko, 1969).

From the beginning of the 1950s till early 1960s breeding of currant weakened. Research was basically focused on the studies of wild selected plant forms and those
developed in breeding. Breeding of currants intensified when Potapenko began working at the experimental station in 1962. Three hundred ten cross-combinations were made by him during 1963–1987: 30 elite forms were studied, out of which 17 were sent to State cultivar testing (SCT). It equaled to 0.002 % of the seed number obtained with crosses and 0.02 % out of seedlings studied in the breeding garden.

As a result, cultivars ‘Agrolesovskaya’, ‘Iskitimskaya’, ‘Berdchanka’, ‘Zapozdalaya’ were created in a family ‘Druzhnaya’ × ‘Altaiskaya Dessertnaya’ and ‘Ranniaya Potapenko’ was selected in a family ‘Canadian’ No 5 × elite seedling 21-1-65. Cultivar ‘Ranniaya Potapenko’ was the first cultivar developed in Russia using Canadian currant. The cultivars mentioned above have a number of economic traits and high yield potential (Table 3). Cultivar ‘Berdchanka’ demonstrated resistance to gall mite and American powdery mildew during observations, just as ‘Ranniaya Potapenko’ and ‘Zapozdalaya’. Cultivars ‘Agrolesovskaya’ and ‘Ikitimskaya’ can be affected by powdery mildew and gall mite, but are still highly tolerant and have high yield performance (Potapenko, 1985).

Cultivars ‘Berdchanka’ (1987), ‘Ranniaya Potapenko’ (1991), ‘Agrolesovskaya’ (1995), ‘Shadrikha’ (1997), ‘Pamati Potapenko’ (2000) and ‘Glarioza’ (2001) were included into the regionalized set of cultivars. Many efforts were put in interspecific hybridization of currant and gooseberry during the 1940s–1950s. Thirteen forms were selected for the prospect (Table 1) out of 1 350 plants in the experimental garden. Breeding Ribelaria stopped after the retirement of Andreichenko. At present, many breeders think that a resistant cultivar can be only parasite resistant under unfavourable environments. New fungus races often develop and follow each other under intensive agricultural production; a resistant cultivar can soon become sensitive (Torlina, 1978; 1981). In this connection, a search for resistance sources on the genetic background is necessary among currant species and cultivars. Thus, cultivars with balanced disease resistance over various geographical regions of the country are of primary importance both in production and as donors. Hybridization was initiated in 1990 involving the donors of powdery mildew resistance carrying M1, M, M2, Ms, Sph2 and R genes.

Earlier investigations on American powdery mildew resistance by Potapenko (1981; 1987) and us (Sorokopudov, 1991) showed that the chosen way of developing cultivars resistant to the pathogen is reasonable.

A collection of currant species from South-Eastern Asia and the European part of Russia has been established in recent years and is being studied. Some seedlings were selected from free pollinated seeds of cultivars ‘Ben Alder’ and ‘Stor Class’, received from V. Traikovsky (Sweden). Two hundred seventy-four cross-combinations have been made since 1990; 132 655 seeds have been obtained and 18 162 seedlings have been grown in the experimental field; 11 301 seedlings have been studied in the breeding field. One hundred three seedlings have been focused on for the prospect including those from the hybrid stock of Potapenko (Table 1).

A search for the ways to shorten the breeding process has been made on black currant. Earlier the term of developing a new cultivar was 14–24 years. The novelties introduced by means of rapid reproduction, selection on pathogen resistance and cultivar tests allow creating new cultivar in 10–12 years.

Eighteen black currant cultivars have been sent to SCT since 1991. They have
high yield performance, winter hardiness, pest and disease resistance and a high tasting score (Table 3). Cultivars ‘Glarioza’ and ‘Pamiati Potapenko’ have become prospective according to the results of SCT in the Novosibirsk region. Cultivars ‘Shadrikha’ and ‘Kalinovka’ have been regionalized in the Novosibirsk region and cultivar ‘Agrolesovskaya’ in the Irkutsk region.

Alongside with high yield performance, easy transportability, resistance to extreme environments, new cultivars have complex disease and pest resistance and it is very important for dietetic production (Sorokopudov, 1993, Sorokopudov at al., 1994, Sorokopudov, 2007).

**Table 3.** Length of breeding process of black currant at the Novosibirsk Michurin Zonal Fruit-berry Experimental Station

<table>
<thead>
<tr>
<th>Cultivar Veislė</th>
<th>Years Metai obtaining seeds sėklų gavimas</th>
<th>selection atrinkimas</th>
<th>sending to SCT perdavimo valstybiniais veislų tyrimais</th>
<th>Length of breeding process (year) Selekcijos proceso trukmė, metai</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Agrolesovskaya’</td>
<td>1966 1979 1982</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Iskitimskaya’</td>
<td>1966 1979 1982</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Berdchanka’</td>
<td>1966 1979 1982</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Rakhil’*</td>
<td>1986 1990 1994</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Glarioza’*</td>
<td>1985 1990 1994</td>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Mariushka’*</td>
<td>1986 1990 1999</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Augusta’*</td>
<td>1979 1990 2001</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Chernysh’*</td>
<td>1979 1990 2001</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Solomon’*</td>
<td>1979 1990 2001</td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>‘Irmen’*</td>
<td>1979 1991 2001</td>
<td>21</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* cultivars developed with our assistance / veislės, išvestos su mūsų pagalba
Earlier the breeding process of black currant lasted for 14–24 years. We suggest the following scheme of shortening the breeding process based on the carried out experimental work:

- **1st year** – developing seeds;
- **2nd year** – growing seedlings, selection at early stages of growth and development on resistance to powdery mildew and septoriosis under on the provocative background, establishing a breeding plot;
- **3rd–5th year** – studying of seedlings in the experimental plot on the expression degree of economic traits (disease and pest resistance, winter hardiness, yield performance), detecting prospective seedlings;
- **5th–6th year** – establishing a plot of primary cultivar studies;
- **6th–10th year** – estimation of the selected seedlings on a complex of economic traits and detection of the elite with their parallel reproduction.

Ten–twelve years are considered a real term to develop a new black currant cultivar under Siberian environment based on the gained experience and the scheme suggested. Eight–nine years could be considered a real term to study breeding stocks for the possible shortest time.

It is necessary to select prospective seedlings with the least number of stomata on leaf surface and the closest location of the longest internode on a shoot to the ground for a quicker estimate of breeding stock at early ontogenetic stages, as age powdery mildew resistance is typical to black currant cultivars. Higher ascending of internode curve length on shoots show early aging and bigger resistance to powdery mildew – the fungus evolutionarily adapted to young plant tissues. Dividing the primary shrub into 15–20 parts was used for a quicker set up of the primary cultivar studies plot; propagation by cutting was carried out simultaneously to set up initial plots. Besides, some shoots of interest were being studied in the breeding garden for 2, but not 3 years. All these undertakings considerably affected the reduction of breeding terms. Moreover, we used the techniques recommended by Potapenko (1970, 1974).

The stocks dealt with also influence the acceleration of the breeding process. Naturally, it proceeds quicker when using donors and sources of economic traits. Based on the research performed, we believe that it is quite real to produce a new black currant cultivar in Siberia in 10–12 years or even more quickly.

Table 4. Description of new currant cultivars under dry-farming land of the breeding at the Novosibirsk Zonal Experimental Station (1990–2001)


<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Veislė</th>
<th>Yield (kg/shrub)</th>
<th>Berry weight Uogų masė (g)</th>
<th>Content of AA Askorbo rūgštis kiekis (mg/100 g)</th>
<th>Maximal affection (score) Maksimalus pažeidimo balas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>average vidutiniškai</td>
<td>max. maksimalus</td>
<td>average vidutiniškai</td>
<td>max. maksimalus</td>
</tr>
<tr>
<td>‘Berdchanka’ (c)</td>
<td>1.5</td>
<td>1.7</td>
<td>1.1</td>
<td>1.6</td>
<td>132.1</td>
</tr>
<tr>
<td>‘Avgusta’</td>
<td>1.9</td>
<td>2.2</td>
<td>1.6</td>
<td>3.0</td>
<td>174.2</td>
</tr>
<tr>
<td>‘Aleandr’</td>
<td>1.9</td>
<td>3.48</td>
<td>1.6</td>
<td>2.3</td>
<td>143.5</td>
</tr>
<tr>
<td>‘Berdskaya Chernaya’</td>
<td>2.2</td>
<td>2.4</td>
<td>1.1</td>
<td>1.6</td>
<td>132.4</td>
</tr>
<tr>
<td>‘Glarioza’</td>
<td>2.7</td>
<td>3.1</td>
<td>1.7</td>
<td>2.7</td>
<td>98.1</td>
</tr>
<tr>
<td>‘Degtiarevkaya’</td>
<td>3.3</td>
<td>3.7</td>
<td>2.2</td>
<td>5.0</td>
<td>100.5</td>
</tr>
<tr>
<td>‘Zonalnaya’</td>
<td>2.2</td>
<td>2.6</td>
<td>1.3</td>
<td>1.7</td>
<td>170.8</td>
</tr>
<tr>
<td>‘Irmen’</td>
<td>2.0</td>
<td>2.4</td>
<td>1.6</td>
<td>3.5</td>
<td>187.8</td>
</tr>
<tr>
<td>‘Kalinovka’</td>
<td>2.3</td>
<td>2.9</td>
<td>1.5</td>
<td>1.9</td>
<td>132.8</td>
</tr>
<tr>
<td>‘Karachinskaya’</td>
<td>2.3</td>
<td>2.7</td>
<td>1.2</td>
<td>1.7</td>
<td>150.7</td>
</tr>
<tr>
<td>‘Mariushka’</td>
<td>2.2</td>
<td>2.4</td>
<td>1.6</td>
<td>3.2</td>
<td>184.4</td>
</tr>
<tr>
<td>‘Obskaya Chernaya’</td>
<td>2.2</td>
<td>2.7</td>
<td>1.2</td>
<td>1.6</td>
<td>96.1</td>
</tr>
<tr>
<td>‘Pamiati Potapenko’</td>
<td>2.8</td>
<td>4.1</td>
<td>1.85</td>
<td>6.0</td>
<td>141.9</td>
</tr>
<tr>
<td>‘Perepel’</td>
<td>2.1</td>
<td>2.3</td>
<td>1.7</td>
<td>4.5</td>
<td>147.2</td>
</tr>
<tr>
<td>‘Podarok Kuminovu’</td>
<td>3.2</td>
<td>3.6</td>
<td>2.3</td>
<td>5.0</td>
<td>95.8</td>
</tr>
<tr>
<td>‘Rakhil’</td>
<td>2.9</td>
<td>3.3</td>
<td>1.4</td>
<td>2.2</td>
<td>60.4</td>
</tr>
<tr>
<td>‘Solomon’</td>
<td>2.3</td>
<td>2.5</td>
<td>1.2</td>
<td>1.7</td>
<td>189.8</td>
</tr>
<tr>
<td>‘Chernysh’</td>
<td>1.8</td>
<td>1.9</td>
<td>1.8</td>
<td>4.2</td>
<td>139.4</td>
</tr>
<tr>
<td>‘Shadrikha’</td>
<td>2.1</td>
<td>2.8</td>
<td>1.6</td>
<td>4.3</td>
<td>133.2</td>
</tr>
</tbody>
</table>

LSD_{01} on cultivars / R_{01} veisles – 0.30 years / metai – 0.21

Note / Pastaba: AA – ascorbic acid / askorbo rūgštis; (c) – control / kontrolė

All the above-mentioned characteristics of black currants are interesting for breeding under Siberian conditions. New currant cultivars are economically efficient when cultivated under dry-farming land and are highly prospective compared to control.

Conclusions. 1. The regionalized assortment of black currant cultivars has been increased and improved in the Novosibirsk region as a result of 65-year research; 29 new cultivars have been developed. Eighteen cultivars having been developed since 1990 are distinct in their high productivity, berry-forming stability, large berries and tolerance to pests and diseases compared to earlier regionalized cultivars.
‘Primorsky Champion’, ‘Seyanets Golubki’ and ‘Berdchanka’.

2. The necessity to involve genetically heterogeneous stocks in the breeding process has been determined. The sources and donors of productivity components combining disease and pest resistance, high self-fertility and earliness were detected.


References

Serbentų selekcija Vakarų Sibire
V. Sorokopudov, O. Sorokopudova

Santrauka


Reikšminiai žodžiai: selekcija, serbentai, veislės.
Influence of meteorological conditions on strawberry production season in Latvia

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Strawberry production season can be influenced by different factors including genotype, meteorological and growing conditions, etc. Influence of meteorological conditions on strawberry production season was evaluated in this investigation. Meteorological data and strawberry production period observed in the Pure Horticultural Research Station during 1990–2008 were used in the analysis. In Latvia two widely grown strawberry cultivars ‘Zefyr’ and ‘Senga Sengana’ with different production season were included in the investigation. Strawberry production season varied between years and cultivars. Meteorological conditions significantly influenced strawberry production time for both of tested cultivars. The highest influence was observed for air temperature and amount of precipitation. The closest correlation was found between the beginning of production and effective heat summations from the beginning of year to the beginning of production; the beginning of production and active heat summations in May, and the beginning of production and amount of precipitation in May. The end of production was mostly influenced by effective and active heat summations in June.

Slight tendency for increase of average air temperature was observed during the period of 1990–2008. It influenced strawberry production season. There was observed some slight trend for earlier production time for both of tested cultivars.

Key words: cultivar, *Fragaria × ananassa*, precipitation, production season, temperature.

Introduction. The variation of strawberry production season between years and influence of climate has been emphasized by many investigations (Døving, 2004; Døving, 2009; Esitken et al., 2009; Shokaeva, 2006). Genotype, meteorological conditions and growing conditions are mentioned as the main factors influencing production season. It was confirmed also in our previous investigations that strawberry productions time strongly vary between years with different meteorological conditions (Laugale, 1996; Laugale et al., 1999; Laugale, 2004). However, there is less information on long term influence of changing climatic factors on production season. Several investigations had been done in Norway (Ljones, 1978; Døving, Måge, 2001 a; Døving, Måge, 2001 b; Døving, 2004) and Germany (Rudolph, 1985). Hor-tyński et al. (1994) had been studied influence of some atmospheric factors on yield.
and fruit weight. Our study was conducted to obtain information how the strawberry production time changes during long term period in Pūre, Tukums region, Latvia, and what are the main meteorological factors influencing it.

**Object, methods and conditions.** Data on strawberry production season were collected from Pure Horticultural Research Station (Pure HRS) strawberry fields from 1990 to 2009. Pure HRS is situated at 57°02` N and 22°52` E, 50 m above see level. Main soil type is brown soil with residual carbonates. Strawberries were grown in open field in matted rows without using any mulch. Plants were planted at a spacing 0.3 m between plants and 1.0 m between rows. Two in Latvia widespread and permanently grown short day strawberry cultivars ‘Zefyr’ and ‘Senga Sengana’ were used in investigations. The meteorological data were collected from local meteorological station. 1990–2005 the data were collected manually, but from 2006 the automatical meteorological station “Lufft OPUS” was used.

The beginning of production has been fixed as the day when first yield was harvested and the end of production – as the day when the last fruits were harvested. The meteorological data: mean, maximal, minimal temperatures, effective (> 5 °C) and active (> 10 °C) heat summations, number of days with temperature > 5 °C and > 10 °C, sum of precipitations were used in analysis. For statistical calculations software Excel 2003 has been used.

**Results.** The beginning and the end of strawberry production season significantly varied between years for both tested cultivars (Fig. 1, 2).

![Graph showing the beginning and end of strawberry production season for 'Zefyr' cultivar from 1990 to 2008.](image)

Fig. 1. The beginning and the end of production season for cultivar ‘Zefyr’ in 1990–2008 and tendency curves

1 pav. Veislės ‘Zefyr’ derėjimo sezono pradžia ir pabaiga 1990–2008 metais ir tendencijos kreives
In 19 observation years the average beginning of production season for cultivar ‘Zefyr’ was day of year 171 ± 2 when the sum of effective temperatures reached 959 ± 26 °C and sum of active temperatures reached 772 ± 28 °C. The beginning of production varied between years in 30 days amplitude. The earliest beginning of production season was observed in 2002 when it was on June 8 (159th day of year). The latest beginning of production season was observed in 1991 when it was on July 8 (189th day of year).

The end of production season for cultivar ‘Zefyr’ on the average was 200 ± 2 day of year. The average production period was 30 ± 1 days. The end of production varied between years in 33 days amplitude. The earliest end of production season was observed in 2007 when it was on July 2 (183rd day of year). The latest end of production season was observed in 2004 when it was on August 4 (216th day of year) (Fig. 1).

The average beginning of production season for cultivar ‘Senga Sengana’ was 176 ± 2 day of year when the sum of effective temperatures reached 1023 ± 17 °C and sum of active temperatures reached 843 ± 21 °C. The beginning of production varied between years in 25 days amplitude (Fig. 2). The earliest beginning of production season was observed in 2000 and 2002 when it was on June 14 (165th day of year). The latest beginning of production season was observed in 1994 when it was on July 5 (186th day of year).

**Fig. 2.** The beginning and the end of production season for cultivar ‘Senga Sengana’ in 1990–2008 and tendency curves

2 pav. Veislės ‘Senga Sengana’ derėjimo sezono pradžia ir pabaiga 1990–2008 metais ir tendencijos kreivės
The end of production season for cultivar ‘Senga Sengana’ on the average was 203 ± 2 day of year (Fig. 2). The average production period was 27 ± 1 days. The end of production varied between years in 33 days amplitude. The earliest end of production season was observed in 2007 when it was on July 2 (183rd day of year). The latest end of production season was observed in 2004 when it was on August 4 (216th day of year).

In Figures 1 and 2 the tendency curves show that there is some slight trend for shifting of strawberry production season earlier for both tested cultivars. More marked tendency was observed for beginning of production for cultivar ‘Senga Sengana’.

The significant ($p < 0.05$) correlation between the beginning of production season and mean air temperature in May, minimal air temperature in June, maximal air temperature in February, March, May and June, effective (> 5 °C) and active (> 10 °C) heat summations in May, June and from the beginning of year to the beginning of production, days with temperature > 10 °C in June and sum of precipitations in May and from the beginning of year to the beginning of production for cultivar ‘Zefyr’ was stated (Table). The beginning of production season for cultivar ‘Senga Sengana’ was significantly ($p < 0.05$) influenced by mean air temperature in May, minimal air temperature in June, maximal air temperature in February, March, May and June, effective (> 5 °C) and active (> 10 °C) heat summations in May and from the beginning of year to the beginning of production and sum of precipitations in May and from the beginning of year to the beginning of production.

**Table.** Effects (correlation coefficients) of meteorological factors on strawberry production season. Only the most significant effects are shown

**Lentelė.** Meteorologinių veiksnių poveikiai (koreliacijos koeficientai) braškių derėjimo sezonui. Pateikti tik patikimiausi poveikiai

<table>
<thead>
<tr>
<th>Meteorological factor</th>
<th>Time</th>
<th>Beginning of production season (day of year)</th>
<th>End of production season (day of year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean air temperature</td>
<td>May</td>
<td>‘Zefyr’ -0.51</td>
<td>‘Senga Sengana’ -0.50</td>
</tr>
<tr>
<td></td>
<td>Gėg.</td>
<td>‘Zefyr’ -0.16</td>
<td>‘Senga Sengana’ -0.25</td>
</tr>
<tr>
<td>Minimal temperature</td>
<td>June</td>
<td>‘Zefyr’ -0.59</td>
<td>‘Senga Sengana’ -0.54</td>
</tr>
<tr>
<td></td>
<td>Birž.</td>
<td>‘Zefyr’ -0.52</td>
<td>‘Senga Sengana’ -0.43</td>
</tr>
<tr>
<td>Maximal temperature</td>
<td>Feb.</td>
<td>‘Zefyr’ -0.54</td>
<td>‘Senga Sengana’ -0.49</td>
</tr>
<tr>
<td></td>
<td>Vas.</td>
<td>‘Zefyr’ -0.42</td>
<td>‘Senga Sengana’ -0.42</td>
</tr>
<tr>
<td></td>
<td>Mėn.</td>
<td>‘Zefyr’ -0.53</td>
<td>‘Senga Sengana’ -0.53</td>
</tr>
<tr>
<td></td>
<td>Gėg.</td>
<td>‘Zefyr’ -0.54</td>
<td>‘Senga Sengana’ -0.53</td>
</tr>
<tr>
<td></td>
<td>Birž.</td>
<td>‘Zefyr’ -0.55</td>
<td>‘Senga Sengana’ -0.56</td>
</tr>
<tr>
<td></td>
<td>June</td>
<td>‘Zefyr’ -0.48</td>
<td>‘Senga Sengana’ -0.47</td>
</tr>
<tr>
<td></td>
<td>Birž.</td>
<td>‘Zefyr’ -0.25</td>
<td>‘Senga Sengana’ -0.30</td>
</tr>
</tbody>
</table>
The significant \( p < 0.05 \) correlation between the end of production season and minimal air temperature in June, maximal air temperature in March and May, effective and active heat summations in June, active heat summation from the beginning of year to the beginning of production and sum of precipitations in May for cultivar ‘Zefyr’ was stated (Table). The end of production season for cultivar ‘Senga Sengana’ was significantly \( p < 0.05 \) influenced by maximal air temperature in May and effective and active heat summations in June.

**Discussion.** The strawberry production season was influenced by genotype and year. ‘Zefyr’ was earlier than ‘Senga Sengana’ and it was expected, because ‘Zefyr’ is well known as cultivar with early ripening time, but ‘Senga Sengana’ – with later ripening time. The beginning of production for cultivar ‘Senga Sengana’ varied between years less than for cultivar ‘Zefyr’, but the variation with the end of production season was similar for both cultivars. The flowering and production time for early

<table>
<thead>
<tr>
<th></th>
<th>May</th>
<th>June</th>
<th>Birželis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Effective heat summation</strong></td>
<td></td>
<td>-0.59</td>
<td>-0.54</td>
</tr>
<tr>
<td>Efektyvių temperatūrų sumos (&gt; 5 °C)</td>
<td>Gegužė</td>
<td>-0.47</td>
<td>-0.36</td>
</tr>
<tr>
<td>From the beginning of year to the beginning of production</td>
<td>0.64</td>
<td>0.58</td>
<td>0.44</td>
</tr>
<tr>
<td><strong>Active heat summation</strong></td>
<td></td>
<td>-0.60</td>
<td>-0.56</td>
</tr>
<tr>
<td>Aktyvių temperatūrų sumos (&gt; 10 °C)</td>
<td>Gegužė</td>
<td>-0.52</td>
<td>-0.39</td>
</tr>
<tr>
<td>From the beginning of year to the beginning of production</td>
<td>0.56</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td><strong>Days with temperature &gt; 10 °C</strong></td>
<td></td>
<td>-0.49</td>
<td>-0.40</td>
</tr>
<tr>
<td>Dienos, kai temperatūra buvo &gt; 10 °C</td>
<td>June</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Birželis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sum of precipitations</strong></td>
<td>May</td>
<td>0.59</td>
<td>0.65</td>
</tr>
<tr>
<td>Kritulių suma (mm )</td>
<td>Gegužė</td>
<td></td>
<td></td>
</tr>
<tr>
<td>From the beginning of year to the beginning of production</td>
<td>0.47</td>
<td>0.49</td>
<td>0.28</td>
</tr>
</tbody>
</table>

\( N = 19; r_{0.05} = 0.456; r_{0.01} = 0.575 \)
Cultivars can be more affected by spring frosts, which sometimes can change the beginning of production, because first flowers are lost.

The slight tendency for earlier production season during long term observations for both cultivars can be explained by global climate changing. Probably analysis of longer observation period could show more marked tendency. Due to climatic changes annual mean temperatures in Europe are likely to increase more than the global mean (IPCC, 2007). According to observations in Finland in 2000ies, the heat summations in every growing season have been higher than the mean values in 1961–1990, daily mean temperatures have been higher especially in spring and late summer, and the growing seasons have extended by several weeks (Tuovinen, 2009). The earlier and shorter strawberry production season has been predicted also in investigations in Norway (Døving, 2009). Analysis of historical meteorological data for the UK confirms a trend towards warmer winters and also changes in woody plant phenology, particularly flowering traits (Jones, Brennan, 2009).

Average air temperature in May, minimal air temperature in June, maximal air temperature in February, March, May and June, sum of active temperatures from the beginning of year to the beginning of production and sum of precipitations in May and from the beginning of May to the beginning of production significantly influenced the beginning of production season for both tested cultivars. Strong negative correlation between May and June temperatures and the beginning of season is found also in investigations in Norway (Døving, 2004). Ambient temperature determines the intensity of all physiological processes, and thus, the fact that environmental conditions influence strawberry growth and development (Palencia et al., 2009).

There was less number of factors influencing the end of production season. Only maximal air temperature in May and effective and active heat summations in June influenced the end of production season for both cultivars.

Conclusions. Strawberry production season significantly varies between years and cultivars. A slight trend for earlier strawberry production season in Latvia is observed.

Temperature and the amount of precipitations significantly influence the beginning of production season. The closest correlation is stated between the beginning of production and effective heat summations from the beginning of year to the beginning of production; the beginning of production and active heat summations in May; and the beginning of production and the amount of precipitation in May. The end of production season is mostly influenced by effective and active heat summations in June.

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Parengta spausdinti 2011 07 01

References

Meteorologinių sąlygų įtaka braškių derėjimo sezonui Latvijoje

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Santrauka


Impact of pollination on cranberry yield

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This study, which took place in 2010, contains analysis and evaluation of the productiveness of large cranberries and berry mass under the influence of different pollinators. Large cranberries were pollinated using bees and bumblebees in open fields and under covering. The study was carried out in eight steps with three cranberry cultivars: ‘Stevens’, ‘Lemynion’ and ‘Bergman’. During each test the experimental fields were sprayed with an initiator – sugar syrup (1 kg sugar and 1 l water) – and not sprayed. At the end of the season berry yield and its quality was evaluated. Cranberry productiveness depends on berry cultivars and the pollinator. Cultivar ‘Stevens’ showed the highest results producing 0.747 g/m², while cultivar ‘Lemynion’ produced 0.630 g/m² and cultivar ‘Bergman’ – 0.435 g/m².

**Key words:** bees, bumblebees, cranberry, initiator, yield, pollination.

**Introduction.** Due to good growth conditions in Latvia and wide areas of oligotrophic marshes, large cranberries cover an area of 130 ha in this country, but there is a plan to enlarge this area to 300 ha. Considering the good conditions for cranberry cultivation in Latvia, it is important to look for new effective methods for improving yield amounts. One of these methods is using additional pollinators and it has not been widely studied under the conditions of Latvia.

It is known that bees are rarely found in large amounts in cranberry plantations. A variety of bee species in cranberry plantations can only be found in the state of Massachusetts in USA, where mostly honeybees and bumblebees, _B. Impatiens_ and _B. Bimaculatus_, inhabit the plantations (MacKenzie un Averill).

Bumblebees typically inhabit abandoned and natural marshes while honeybees are only found in cultivated marshes where hives have been taken. Abandoned and natural marshes are also populated by a much larger number of solitary bees than in cultivated fields. Honeybees and bumblebees _B. mixtus, B. occidentalis_ and _B. sitkensis_ act as cranberry pollinators in Washington, USA. Approximately 25 insect species visit cranberry plantations in marshes in Ontario, Canada (Kevan et al., 1983).

Honeybees are not effective cranberry pollinators. Bumblebees are more active in flowers and their pollen baskets are less polluted with pollen from other flowers than in honeybees. Honeybee hives were taken into cranberry plantations in Ontario marshes
but the amount of honeybees in cranberry flowers was small regardless of the distance between hives and plantations. Several honeybee colonies fed from nettles – a competing plant – more than 220 feet (200 m) away (Kevan et al., 1983). A study shows that the amount of yield and seeds does not depend on the distance between a plantation and a honeybee hive. Honeybees got attracted by several competing nectar sources, and the authors of this study point out that the activity of honeybees can be effective in very large marshes where the number of competing nectar plants is relatively low.

Honeybees are widely used for pollination of commercially grown cranberries regardless of their relative inefficiency. The density of honeybees in Washington State is one hive per acre (2.5 ha). Research shows that this increases cranberry crop by 25–43 % (MacKenzie un Vinstons). Although local bees and bumblebees are good pollinators, their number in plantations is not always sufficient. We arrived at a conclusion that using honeybees is the best method for cranberry pollination.

Honeybee hives, which are stationed in cranberry marshes for acclimatization, are taken there right before the pollination season, unlike the model for pollination of other cultivation plants. The Caucasica honeybee (Apis mellifera caucasica) functions within cranberry plants more effectively under cool weather than the Italian bee (Apis mellifera ligustica) does. Bees can pollinate most cranberry flowers in approximately 4 days under good weather conditions. It usually takes about a week under optimum climate conditions but the actual time for pollination is three weeks, considering weather conditions.

Therefore, beekeepers should give about a week for the beehive to pollinate under good weather conditions. It can take up to three weeks of actual time if there has been a week of good conditions.

<table>
<thead>
<tr>
<th>Table 1. Suggested density of bees in cranberry plantations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 lentelė. Siūlomas bičių tankumas spanguolių plantacijose</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of honeybee hives / acres (ha)</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bičių avilių skaiciaus / akrai, ha</td>
<td>Pastabos</td>
</tr>
<tr>
<td>0.2–10 (0.5–25)</td>
<td></td>
</tr>
<tr>
<td>3–4 (7.4–10)</td>
<td>Luwin</td>
</tr>
<tr>
<td>1 (2.5)</td>
<td>Kevan</td>
</tr>
<tr>
<td>2 (5)</td>
<td>Macfarlane et al.</td>
</tr>
<tr>
<td>1 (2.5)</td>
<td></td>
</tr>
<tr>
<td>3 (7.6)</td>
<td></td>
</tr>
<tr>
<td>Other insects</td>
<td></td>
</tr>
<tr>
<td>Kiti vabdziai</td>
<td></td>
</tr>
<tr>
<td>443 bumblebees / acres (1 100 ha)</td>
<td>Hutson</td>
</tr>
<tr>
<td>443 kamanių / akrai, 1 100 ha</td>
<td></td>
</tr>
</tbody>
</table>

Cranberries are an insignificant source of pollen and an insufficient source of nectar. Nectar is crucial in the process of pollination and the process of bees visiting older flowers as well. For example, in New Jersey cultivar ‘Stevens’ produces 25–35 %
more nectar sugar per flower than ‘Ben Lear’ or ‘Early Black’. In conclusion we can state that using honeybees is the most efficient method for pollination of cranberries.

**Object, methods and conditions.** The studies were conducted in the Station of gardening and apiology for education and scientific research of Latvia University of Agriculture, Institute of Agrobiotechnology in Jelgava, Strazdu street 1, and in the farm “Strēlnieki” in 2010.

During the study tests were carried out in which bumblebees and bee colonies pollinated cranberry plantations in both open fields and under covering. The study was carried out in eight steps formed in four groups (open field, covered field, bumblebees and honeybees) with three cranberry cultivars: ‘Stevens’, ‘Lemynion’ and ‘Bergman’. During every test additional studies were carried out in experimental fields where an initiator – sugar syrup (1 kg sugar and 1 l water) – was either used or not. The syrup was used to attract pollinators and was sprayed on cranberry sprouts at 10 AM each morning once in every two days.

Bee colonies of the Carpatica race (*Apis mellifera carpatica*) and earth bumblebee colonies (*Bombus terrestris*) within Tripol hives were used in this study. Bees of the Carpatica race have inherited their qualities from Carniolan bees (*Apis mellifera carnica*) and Caucasian bees (*Apis mellifera carpatica*), which are successfully being used for pollinating cultivated plants. In Latvia bees of the Romanian race are the most popular. Tripol hives are optimal for pollinating strawberries, cherries, blueberries, raspberries, apricots, apples, pears, kiwis, etc. The Tripol is specially developed for outdoor use, but also fit for pollination of these crops when grown under protection of plastic or netting.

In 2010 the florescence of cranberries began in the middle of June, on 23rd June 25 % of all cranberries were florescent, on 29th June – 50 %, but on 4th July 75–100 % of cranberries were florescent. During the period of florescence the minimal air temperature was 5.7 °C, maximum air temperature was 36.8 °C, average air temperature was 24.1 °C.

**Results.** Analysis of yield data obtained in this study (Table 2) leads to a conclusion that the use of an initiator can attract additional pollinators and produce larger cranberry yields.

A comparison of the tests “Bees + Initiator” and “Bees + no initiator” shows significant differences between cultivars and the use of initiators. Interpretation of the data (Anova: Two-factor without replication) cultivars (‘Stevens’, ‘Lemynion’ and ‘Bergman’), compared p = 95 %, P-value = 0.019, F = 49.34, F crit = 19, df = 2, but pollinator groups – P-value = 0.016, F = 58.96, F crit = 18.51, df = 1.

A comparison of the tests “Bumblebees + initiator” and “Bumblebees + no initiator” was also made (cultivars p = 95 %, P-value = 0.463, F = 1.15, F crit = 19, df = 2, pollinator – p = 95 %, P-value = 0.111, F = 7.49, F crit = 18.51, df = 1). A data analysis shows that after one year of testing the results show no significant difference between cultivars and the use of initiators. Still, the results show a tendency of a positive impact of an initiator on the process of pollination and yield.
Table 2. Yield of large cranberry cultivars depending on the pollinator (kg/m²)

<table>
<thead>
<tr>
<th>Pollinators</th>
<th>Cultivars</th>
<th>'Stevens'</th>
<th>'Lemynion'</th>
<th>'Bergman'</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open field + initiator</td>
<td></td>
<td>0.747</td>
<td>0.520</td>
<td>0.275</td>
</tr>
<tr>
<td>Atviras laukas + iniciatorius</td>
<td></td>
<td>0.658</td>
<td>0.150</td>
<td>0.070</td>
</tr>
<tr>
<td>Open field + no initiator</td>
<td></td>
<td>0.700</td>
<td>0.630</td>
<td>0.440</td>
</tr>
<tr>
<td>Atviras laukas + be iniciatoriaus</td>
<td></td>
<td>0.420</td>
<td>0.180</td>
<td>0.340</td>
</tr>
<tr>
<td>Bumblebees + initiator</td>
<td></td>
<td>0.710</td>
<td>0.540</td>
<td>0.435</td>
</tr>
<tr>
<td>Kamanės + iniciatorius</td>
<td></td>
<td>0.526</td>
<td>0.390</td>
<td>0.200</td>
</tr>
<tr>
<td>Bumblebees + no initiator</td>
<td></td>
<td>0.420</td>
<td>0.180</td>
<td>0.340</td>
</tr>
<tr>
<td>Kamanės + be iniciatoriaus</td>
<td></td>
<td>0.710</td>
<td>0.540</td>
<td>0.435</td>
</tr>
<tr>
<td>Bees + initiator</td>
<td></td>
<td>0.710</td>
<td>0.540</td>
<td>0.435</td>
</tr>
<tr>
<td>Bitės + iniciatorius</td>
<td></td>
<td>0.526</td>
<td>0.390</td>
<td>0.200</td>
</tr>
<tr>
<td>Bees + no initiator</td>
<td></td>
<td>0.526</td>
<td>0.390</td>
<td>0.200</td>
</tr>
</tbody>
</table>

An analysis of the tests “Open field + initiator”, “Bees + initiator” and “Bumblebees + initiator” shows that there is a significant difference between cranberry cultivars, but there is no significant difference between pollinators. This means that all pollinators are able to pollinate cranberries if an initiator is used.

A comparison of the tests “Open field + no initiator”, “Bees + no initiator” and “Bumblebees + no initiator” shows that there are no significant differences between the pollinators with and without initiators (cultivars p = 95 %, P-value = 0.008, F = 20.08, F crit = 6.94, df = 2, pollinator – p = 95 %, P-value = 0.429, F = 1.05, F crit = 6.94, df = 2), but there is a difference between cranberry cultivars (90 % reliability). This shows that the effectiveness of a pollinator depends on cranberry cultivar.

The increase in yield for every cranberry cultivar depends on the use of pollinators. In this test cultivar ‘Stevens’ showed the highest results producing 0.747 g/m², while cultivar ‘Lemynion’ produced 0.630 g/m², ‘Bergman’ – 0.435 g/m².

The process of pollination has a significant influence on the change of mass of 100 cranberries. A change in berry mass indicates an increase in berry size. The mass of 100 berries ranges from 20 to 55 grams in test types and from 20 to 96 in test groups. The data obtained confirm the important role of using an initiator. It can be concluded that an increase in mass can be observed in all groups and tests, and this increase depends on the peculiarities of the group. The highest increase in the mass of 100 berries for the cultivars ‘Stevens’ and ‘Lemynion’ can be observed in the group “bumblebees + initiator” – 0.0602 and 0.0669 kg. Cultivar ‘Bergman’ shows the highest results in the group “bees + initiator”. The study showed congruence in the groups “open field + initiator” and “open field + no initiator” for the cultivar ‘Bergman’. Usually berry mass increases if an initiator is used, but for ‘Bergman’ the opposite can be observed. Berry mass is larger when no initiator has been used (0.1523 kg/m²) compared to berry mass when an initiator has been used in order to stimulate pollination. A similar
situation can be observed in the groups “bumblebees + initiator” and “bumblebees + no initiator” (0.1789 and 0.1796 kg/m², cultivars p = 95 %, P-value = 0.062, F = 15.09, F crit = 19, df = 2). The group “open field + no initiator” mirrors a real-life cranberry plantation where the process of pollination occurs naturally. An analysis of data for each cultivar shows the efficiency of the naturally occurring pollination (P-value = 0.037, F = 25.68, F crit = 19, df = 2). A comparison of groups show the highest results for ‘Steven’ when pollination occurred in the group “bumblebees + initiator” (0.280 kg/m²); ‘Lemynion’ – “bumblebees + initiator” (0.227 kg/m²), ‘Bergmann’ – “bees + initiator” (0.1965 kg/m²).

**Fig.** Comparison of the mass of 100 large cranberries (kg/m²)

**Pav.** 100 didžiųjų spanguolių masės palyginimas, kg/m²

Figure shows that berry mass changes significantly among groups and different pollination methods. This indicates that the increase in production is due to increase in berry size and number per unit of area. However, it is necessary to do additional analysis of the chemical composition of berries and the changes in it. This would help indicate the importance of pollination in cultivation of cranberries.

**Discussion.** Pollinators are key to global sustainable terrestrial productivity. Certainly, agriculture cannot function efficiently without honeybees and the potential for diversifying stocks within the genus is great. There is increasing recognition of the importance of non-honeybees as crop pollinators (Bohart, Kevan, Parker et al.,
Torchio, Kevan et al., Richards, Roubik, Matheson et al.). Comparing the property with honeybees and the property with no honeybees in 2000, a higher percentage of flowers received the required number of pollen grains for optimum fertilization during mid-bloom and late bloom with honeybee presence. Thus, honeybees may not be as critical during early bloom. Our results support the prediction that when no honeybees are brought in, any honeybees or other native bees that are present in the surrounding area reach the edges of the cranberry beds, but they may not be present in sufficient numbers to forage throughout the interior areas of the cranberry beds.

In 2000 when no honeybees were introduced also shows that honeybee presence provided more uniform levels of pollination across the entire cranberry bed than wild native bee pollinators. Although not always statistically sufficient, the higher percentage of bumblebees carrying pollen loads compared with honeybees on most cranberry beds corroborates the superiority of bumblebees as cranberry pollinators on an individual bee-by-bee basis (Macfarlane). Although bumblebees more consistently collected pollen, their numbers were not great enough to provide reliable pollination. In summary, honeybees are effective pollinators of cranberries when sufficient numbers are brought into an area, particularly during mid and late bloom. The number of honeybee colonies needed will be greater if the beds are surrounded by disturbed areas because of both the attractiveness of these areas to foraging honeybees and the decrease in the number of wild native pollinators.

The research results have confirmed that the Latvian honeybees play a role in big cranberry harvest efficiency and fruit quality (size) improvement. However, pollinating agent (sugar syrup) use has been little studied. Such an approach contributes to cranberry pollination, and is reflected in Table 2 and Figure – higher yield and berry weight of 100 obtained using the agent. The method requires additional studies to clarify.

The process of pollination has not been studied in Latvia during the past fifty years. Cranberry planters gather information from various sources – publications, the Internet and advice from foreign colleagues. It can be concluded that the development of pollination methods in cranberry plantations might significantly improve cranberry yield and contribute greatly to the development of Latvian national economy.

**Conclusions.** 1. The calculations of production and the mass of 100 berries after these tests prove the significance of using additional pollinators in large cranberry plantations.

2. Different methods of pollination need to be used for every cranberry cultivar in order to obtain maximum production. For cultivar ‘Steven’ it is an open field and the use of an initiator, for ‘Lemynion’ – bumblebees and an initiator, for ‘Bergman’ – bees and an initiator.

3. It is necessary to do additional analysis of the chemical composition of berries. Changes in the chemical composition of berries can have a significant influence on the conditions of pollination in the cultivation of cranberries.
References


SODININKYSTĖ IR DARŽININKYSTĖ. MOKSLO DARAI. 2011. 30(2).

Apdulkinimo įtaka spanguolių derliui

B. Tikuma, M. Liepniece

Santrauka


Reikšminiai žodziai: apdulkinimas, bitės, derlius, iniciatorius, kamanės, spanguolės.
Influence of temperature on the productivity of highbush blueberry cultivars

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Latvia University of Agriculture, Institute of Agrobiotechnology, Liela iela 2, Jelgava, Latvia, LV 3001, E-mail dace.sterne@llu.lv

Success in the cultivation of highbush blueberry has been achieved in Latvia. The objective of the experiment was to evaluate the influence of temperature on highbush blueberry winter hardiness and productivity. The field trial with 11 highbush blueberry cultivars was established in South Latvia in 2002. The trial was carried out in an experimental plot on sandy soil; the plants were planted in the furrow filled with peat. To select cultivars for experiment we took into consideration the winter hardiness of plants and harvest season of berries. Experiment was done in 2007–2010. Highbush blueberry cultivars were affected by frost in the winter of 2006/2007 and 2009/2010. Winter of 2007/2008 and 2008/2009 was more suitable for growing highbush blueberries and more typical for Latvia. During the experiment the highest winter hardiness was observed for ‘Chippewa’, ‘Polaris’, ‘Northblue’, ‘Blueray’ and ‘Patriot’. The medium hardy cultivars were ‘Northland’, ‘Spartan’, ‘Jersey’ and ‘Bluejay’, and the least hardy cultivar was ‘Duke’. The yields of highbush blueberries ‘Patriot’, ‘Northland’ and ‘Chippewa’ were highest. The berry weight ranged from 1.1 to 2.5 g. ‘Northblue’, ‘Bluecrop’ and ‘Spartan’ had the largest berries. The cultivars ‘Chippewa’, ‘Northblue’, ‘Blueray’ and ‘Patriot’ grew good under Latvian conditions and showed the greatest yield stability.

Key words: air temperature, fruit weight, yield, V. corymbosum × V. angustifolium, Vaccinium corymbosum L., winter damage.

Introduction. There are now three types of highbush blueberry varieties grown – Northern, Southern and Intermediate. These vary in the number of chilling hours they require for normal floral development and their level of tolerance to winter cold. Northern highbush blueberry varieties are adapted to quite cold mid-winter temperatures below – 20 °C, but grow well anywhere there are 800–1 000 hours of chilling. These are grown primarily in Germany, France, Michigan, New Jersey, Poland and Chile. Southern highbush blueberry varieties do not tolerate winter temperatures much below freezing and require chilling about 350 hours. They are grown primarily in Australia, Argentina, California, Florida, Chile and southern Spain. Intermediate highbush blueberry varieties have a wide range in chilling requirements from 400–800 hours. They generally fail in the colder climates, because they
bloom too early and are too slow to harden in the fall, resulting in freeze damage to the flower buds. These highbush blueberry types are grown primarily in Arkansas, Chile, North Carolina and the Pacific Northwest (Gough, 1994; Trehane, 2004; Rieger, 2006; Hancock, 2009).

Blueberry growing is expanding in North America (USA, Canada), Europe (Belgium, the Netherlands, Germany, Poland, Italy, Denmark, Slovenia), and likewise Japan, Chile, New Zealand and Australia. In North European countries such as Norway, Finland and Sweden, the cultivation of blueberries is also being considered. Climate conditions of North Europe are suitable for the half-highbush (Vaccinium corymbosum × Vaccinium angustifolium) blueberry cultivation (Bläsing, 1989; Haffner and Vestrheim, 1994; Strik, 2005). Air temperature is one of the limitation factors for blueberry growth. Blueberry plants have been hardened to withstand –40 °C in deep rest (Quamme et al., 1972); however, since winter temperatures often rise about –2.2 °C, resulting in some potential for dehardening, blueberries should not be planted where winter temperatures regularly fall below -29 °C (Kender and Brightwell, 1966).

Highbush blueberry under field conditions may yield at least 4.5 to 5.5 tons of berries per hectare. The berry weight of highbush blueberries may reach 3 to 4 g in the U. S. A. (Hancock and Draper, 1989) or 1.0 to 3.4 g in Europe (Bal et al., 2006; Giongo et al., 2006; Bădescu et al., 2009; Starast et al., 2009).

The objective of the experiment was to evaluate the influence of air temperature on highbush and half-highbush blueberry (V. corymbosum L. and V. corymbosum × V. angustifolium) cultivars winter hardiness and productivity.

Object, methods and conditions. The experiment was situated in South Latvia at the Institute of Agrobiotechnology of the Latvia University of Agriculture (LLU) in Jelgava. Soil in the experimental area was sandy; the plants were planted in the furrow (0.5 m depth) filled with peat (pH$_{KCl}$ 4.5). The experimental plantation was established in the autumn of 2002 and in the spring of 2003 (two-year-old plants were used). Plant to plant spacing was 1.0 m and space between rows was 3 m. 11 cultivars were used in the experiment. Each plant was considered an experimental unit. Three to five single plant replications were selected from each cultivar. The plants were fertilized using complex fertilizer (N : P$_2$O$_5$ : K$_2$O 8 : 7 : 21 + micronutrients). Fertilizer was given 2 times per season: the first time at the beginning of vegetation, the second time at the end of flowering. In spring, peat was used as mulch. No regular irrigation system was used in the trial.

Winter damage was estimated at the beginning of the blooming. A ten-point scale was used (0 point – a plant is dead, 1 point – very low hardiness, all branches damaged up to the soil level, 9 – very high winter hardiness, branches not damaged). Yield from each plant was harvested separately. Plants were harvested in 2008 – six times, in 2009 – five times and in 2010 – three times (from the middle of July to the middle to end of August). To find the berry weight (g), 100 fruits from each replication were picked, weighed, and the average calculated. The ripening period of cultivars was established in days (from first harvest time to last harvest time).

The air temperature was determined using data of the Latvian Environment, geology and meteorology agency Jelgava station and portable MicroLite USB data logger for external temperature. The temperature was registered after 30 minutes and average temperature of day was calculated.
Experiment data were collected from 2007 to 2010.

The mean air temperature in the experimental area in 2007 was 7.4 °C with precipitation of 641 mm; in 2008 it was 7.9 °C with precipitation of 744 mm. It was relatively warm in 2009 and sufficient wet. The mean temperature was 6.9 °C with precipitation of 753 mm. In 2010 average temperature was 6.8 °C with precipitation of 798 mm. The temperatures during 2010 could be characterized as very variable. The mean air temperature in winter period was: in 2007 – 0.3 °C, in 2008 – 1.3 °C, in 2009 – 0.5 °C and in 2010 – -3.9 °C. Taking into account the climatic conditions of 2006/2007 it was impossible to correctly register the blueberry yields in 2007.

The data were statistically processed using analysis of variance (ANOVA). In order to find correlations between different parameters, correlation coefficient (r) was calculated.

Results. In 2007 and 2008 it was determined the significant differences between the mean air temperature of month (P\sub{0.05} = 0.015 and P\sub{0.05} = 0.019). In 2009 and 2010 they had no significant differences (P > 0.05). Winter damage was detected in all cultivars in 2007 and 2010 (Table 1), in 2008 and 2009 climatic conditions were suitable for cultivation of blueberry. The results of the experiment with highbush and half-highbush blueberry cultivars in 2007 showed that ‘Bluecrop’, ‘Bluejay’, ‘Blueray’, ‘Chippewa’, ‘Jersey’, ‘Patriot’, ‘Polaris’, ‘Spartan’ and ‘Northblue’ had the most winter hardiness than ‘Duke’ and ‘Northland’. In 2008 only single highbush blueberry branches were damaged by frost, but in 2009 the winter damage was not detected in all cultivars. In 2010 the hardest cultivars were ‘Chippewa’, ‘Northblue’ and ‘Northland’. The results showed that air temperature of all experimental years significantly (P < 0.05) affected winter damage of blueberry cultivars (Table 1).

Table 1. Winter damage of 11 highbush blueberry cultivars (1–9 points), 2007–2010

<table>
<thead>
<tr>
<th>Genus Rūsis</th>
<th>Cultivars Veislės</th>
<th>Year Metai</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2007</td>
</tr>
<tr>
<td>V. corymbosum</td>
<td>‘Bluecrop’</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>‘Bluejay’</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td>‘Blueray’</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>‘Duke’</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>‘Jersey’</td>
<td>5.8</td>
</tr>
<tr>
<td></td>
<td>‘Patriot’</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>‘Spartan’</td>
<td>3.0</td>
</tr>
<tr>
<td>V. corymbosum × V. angustifolium</td>
<td>‘Chippewa’</td>
<td>5.8</td>
</tr>
<tr>
<td></td>
<td>‘Northblue’</td>
<td>4.2</td>
</tr>
<tr>
<td></td>
<td>‘Northland’</td>
<td>2.8</td>
</tr>
<tr>
<td></td>
<td>‘Polaris’</td>
<td>4.8</td>
</tr>
</tbody>
</table>

P – value / P – vertė 0
In 2007 blueberry plants were injured by winter frosts, therefore the yield, ripening period and berry weight was not recorded. Ripening period in all experimental years ranged from 5 to 30 days (Table 2). There were significant differences between cultivars (P = 0.04) and years (P = 0.01). This shows that metrological conditions were significant factor for blueberry growth. In 2008 and 2009 the mean temperature of vegetation period was 12.4 and 12.3 °C (Table 2). The longest ripening period in 2008 and 2009 had ‘Polaris’, ‘Patriot’, Northland’, ‘Northblue’ and ‘Chippewa’ (30 and 21 days, respectively), while ‘Bluejay’ showed very short ripening period (5 to 6 days). In 2010 the mean temperature of vegetation period was 2.4 degrees higher than in two prior years. That factor affected the ripening period and picking times (Table 2). In 2010 ripening period ranged from 8 to 18 days. Cultivar ‘Spartan’ had shorter ripening period than other highbush blueberry cultivars. Part of cultivars was harvested in one time (‘Bluecrop’, ‘Blueray’ and ‘Jersey’). Correlation analysis showed that the ripening period and picking times had significant negative correlation with average air temperature in vegetation period (r = -0.52 and r=-0.59, respectively).

Table 2. Ripening period, picking times and average air temperature in vegetation period (°C)

<table>
<thead>
<tr>
<th>Genus Rūšis</th>
<th>Cultivars Veislės</th>
<th>Year Metai</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ripening period (days) nokimo laikotarpis, dienos</td>
<td>picking times skynimo metas</td>
<td>ripening period (days ) nokimo laikotarpis, dienos</td>
<td>picking times skynimo metas</td>
<td>ripening period (days) nokimo laikotarpis, dienos</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V. corymbosum</td>
<td>‘Bluecrop’</td>
<td>30</td>
<td>5</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>‘Bluejay’</td>
<td>6</td>
<td>3</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>‘Blueray’</td>
<td>26</td>
<td>3</td>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>‘Duke’</td>
<td>n. a.</td>
<td>n. a.</td>
<td>21</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>‘Jersey’</td>
<td>21</td>
<td>4</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>‘Patriot’</td>
<td>30</td>
<td>5</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>‘Spartan’</td>
<td>21</td>
<td>4</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td>V. corymbosum × V. angustifolium</td>
<td>‘Chippewa’</td>
<td>30</td>
<td>6</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>‘Northblue’</td>
<td>30</td>
<td>5</td>
<td>23</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>‘Northland’</td>
<td>30</td>
<td>5</td>
<td>23</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>‘Polaris’</td>
<td>30</td>
<td>5</td>
<td>23</td>
<td>4</td>
</tr>
<tr>
<td>Average air temperature in vegetation period</td>
<td>12.4</td>
<td>12.3</td>
<td>14.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

n. a. – data not available / nėra duomenų
The yield per plant ranged from 0.22 to 6.00 kg, and berry weight ranged from 1.1 to 2.5 g (Table 3). In 2009 cultivars yielded better than in 2008 and 2010. The highest yield in all year was harvested from cultivars ‘Chippewa’ and ‘Patriot’, but cultivars ‘Northblue’ showed greater stability of yield over year than other cultivars. Metrological conditions affected yield of cultivars ‘Bluecrop’ and ‘Bluejay’. In 2010 the berries of eight cultivars were heavier than in other years. The results show a significant weather effect on blueberry yield (P = 0.0005) and berry weight (P = 0.0077).

**Table 3.** Yield and berry weight of blueberry cultivars

<table>
<thead>
<tr>
<th>Year</th>
<th>Genus Rūšis</th>
<th>Cultivars Veislės</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>yield (kg per bush)</td>
<td>berry weight (g)</td>
<td>yield (kg per bush)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>derlius, kg/krtm</td>
<td>uogų masė</td>
<td>derlius, kg/krtm</td>
</tr>
<tr>
<td>2008</td>
<td>V. corymbosum</td>
<td>‘Bluecrop’</td>
<td>1.58</td>
<td>1.9</td>
<td>3.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td>‘Bluejay’</td>
<td>0.70</td>
<td>1.3</td>
<td>2.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td>‘Blueray’</td>
<td>0.70</td>
<td>1.4</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>‘Duke’</td>
<td>0</td>
<td>0</td>
<td>1.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>‘Jersey’</td>
<td>1.34</td>
<td>1.1</td>
<td>0.94</td>
</tr>
<tr>
<td></td>
<td></td>
<td>‘Patriot’</td>
<td>4.08</td>
<td>2.2</td>
<td>6.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>‘Spartan’</td>
<td>1.21</td>
<td>2.0</td>
<td>4.31</td>
</tr>
<tr>
<td>2009</td>
<td>V. corymbosum × V. angustifolium</td>
<td>‘Chippewa’</td>
<td>3.68</td>
<td>1.6</td>
<td>4.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>‘Northblue’</td>
<td>1.44</td>
<td>2.2</td>
<td>1.48</td>
</tr>
<tr>
<td></td>
<td></td>
<td>‘Northland’</td>
<td>4.12</td>
<td>1.6</td>
<td>5.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>‘Polaris’</td>
<td>2.44</td>
<td>1.8</td>
<td>2.35</td>
</tr>
</tbody>
</table>

P – value, yield / p – vertė, derlius 0.0005
P – value, berry weigh / p – vertė, uogų masė 0.0077

‘Chippewa’, ‘Northblue’, ‘Polaris’, ‘Jersey’ and ‘Northland’ were more winter hardy than other cultivars, while ‘Duke’ suffered serious damage. Average ripening period ranged from 7 to 24 days. The shorter ripening period showed cultivar ‘Bluejay’ (7 days). Cultivars ‘Patriot’, ‘Northland’ and ‘Chippewa’ produced higher yield, cultivars ‘Patriot’, ‘Northblue’ and ‘Bluecrop’ had heavier berries (Table 4). Correlation analysis showed that the yield of the plant had significant correlation with winter hardiness (r = 0.52), picking times (r = 0.68) and ripening period (r = 0.47). We find significant negative correlation between berry weight and winter hardiness (r = -0.46).

<table>
<thead>
<tr>
<th>Genus Rūšis</th>
<th>Cultivars Veislės</th>
<th>Winter hardiness (points)</th>
<th>Ripening period (days)</th>
<th>Yield (kg per bush)</th>
<th>Berry weight (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>V. corymbosum</em></td>
<td>‘Bluecrop’</td>
<td>6.9 a</td>
<td>18 a</td>
<td>1.76 a</td>
<td>1.9 a</td>
</tr>
<tr>
<td></td>
<td>‘Bluejay’</td>
<td>6.8 a</td>
<td>7 b</td>
<td>1.19 a</td>
<td>1.5 b</td>
</tr>
<tr>
<td></td>
<td>‘Blueray’</td>
<td>6.9 a</td>
<td>17 a</td>
<td>0.55 ab</td>
<td>1.7 ab</td>
</tr>
<tr>
<td></td>
<td>‘Duke’</td>
<td>6.0 ac</td>
<td>13 d</td>
<td>0.91 ab</td>
<td>1.3 bc</td>
</tr>
<tr>
<td></td>
<td>‘Jersey’</td>
<td>7.1 abc</td>
<td>12 d</td>
<td>0.91 ab</td>
<td>1.4 bc</td>
</tr>
<tr>
<td></td>
<td>‘Patriot’</td>
<td>6.9 abc</td>
<td>23 c</td>
<td>4.21 c</td>
<td>2.0 a</td>
</tr>
<tr>
<td></td>
<td>‘Spartan’</td>
<td>6.9 abc</td>
<td>17 a</td>
<td>1.99 a</td>
<td>1.7 ab</td>
</tr>
<tr>
<td><em>V. corymbosum × V. angustifolium</em></td>
<td>‘Chippewa’</td>
<td>7.8 ab</td>
<td>23 c</td>
<td>3.59 c</td>
<td>1.5 b</td>
</tr>
<tr>
<td></td>
<td>‘Northblue’</td>
<td>7.4 abc</td>
<td>24 c</td>
<td>1.60 a</td>
<td>1.9 a</td>
</tr>
<tr>
<td></td>
<td>‘Northland’</td>
<td>7.0 abc</td>
<td>24 c</td>
<td>3.49 c</td>
<td>1.5 b</td>
</tr>
<tr>
<td></td>
<td>‘Polaris’</td>
<td>7.2 abc</td>
<td>24 c</td>
<td>1.92 a</td>
<td>1.7 ab</td>
</tr>
</tbody>
</table>

Means followed by the same letter in the column are not significantly at α = 0.05
Skirtumai tarp reikšmių, pažymėtų ta pačia raide, yra statistiškai nepatikimi, kai α = 0.05

Correlation analysis showed that the berry weight had poor significant correlation with meteorological conditions (r = 0.38). There was significant negative correlation of meteorological conditions with winter hardiness (r = -0.69), ripening period (r = -0.59) and picking times (r = -0.51).

**Discussion.** The results of this experiment with highbush and half-highbush blueberry cultivars in four-year period (2007–2010) showed that ‘Chippewa’, ‘Northblue’, ‘Polaris’, ‘Jersey’ and ‘Northland’ were the most winterhardy. ‘Duke’ and ‘Northland’ suffered the most winter damage. In the experimental years weather condition were very different, the winter of 2007/2008 and 2008/2009 were favourable for blueberries. Despite the high incidence of winter damage for cultivars, they formed substantial yield potential for following year. ‘Patriot’ has also gown well in Norway (Vestrheim et al., 1997). ‘Northland’ was the poorest winterhardy under Estonia conditions. However, cultivar ‘Northblue’ showed better winter hardiness under Latvian conditions than under Estonian ones (Starast et al., 2009).

The first harvest was produced in the middle of July, which is the same time when first highbush blueberry fruit ripen in Poland and Estonia (Smolarz, 2006; Starast et al., 2009).

The average yield in our experimental plantation was 6.6 t per hectare. The average yields of ‘Patriot’ plants were 13.9 t per ha. In Estonia, the average yield was 2.5 tons per hectare. Cultivars with high yield and large berries are more suitable for
commercial production. Scientists in Estonia had found that ‘Bluecrop’ and ‘Northland’ has higher yield than ‘Northblue’ (Starast et al., 2009). Similar conclusions can also be made basing on our results; but in average, ‘Patriot’ had biggest berries followed by ‘Northblue’ and ‘Bluecrop’. In Italy, fruit weight of ‘Bluecrop’, ‘Jersey’, ‘Northland’, ‘Polaris’ and ‘Spartan’ has been 1.2 to 2.0 g (Giongo et al., 2006). Under suitable climatic conditions blueberry cultivars in Latvia can reach similar or higher fruit weight than in Italy. In Netherlands, berry weight of ‘Bluecrop’ was 1.7 g (Bal et al., 2006). In our experiment ‘Bluecrop’ had a heavier berry (1.9 g).

Conclusions. Results showed that northern highbush and half-highbush blueberry cultivars grew satisfactorily or well under Latvia conditions. Cultivars ‘Chippewa’, ‘Northblue’, ‘Blueray’ and ‘Patriot’ were more winterhardy under Latvian conditions and showed the greatest yield stability.

Also research results showed that temperature is an important limiting abiotic factor of blueberry production.

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References


SODININKYSTĖ IR DARŽININKYSTĖ. MOKSLO DARBAI. 2011. 30(2).

Temperatūros įtaka aukštųjų šilauogių veislių derlingumui
D. Šterne, M. Liepniece, R. Sauserde, M. Āboliņš

Santrauka


Reikšminiai žodžiai: derlius, oro temperatūra, pažeidimai žiema, V. corymbosum × V. angustifolium, Vaccinium corymbosum L., vaisių masė.
Kompleksinis temperatūros ir drėgmės poveikis sėjamojo žirnio ($Pisum sativum$ L.) fiziologiniams rodikliams

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Temperatūros ir drėgmės kompleksinis poveikio sėjamojo žirnio fiziologiniams rodikliams tyrimai atlikti 2010 metais Lietuvos agrarinių ir miškų mokslų centro filialo Sodininkystės ir daržininkystės instituto Augalų fiziologijos laboratorijos fitotroniniame komplekse.

Tirtas sėjamasis žirnis ‘Pinochio’ ($Pisum sativum$ L.). Žirniai auginti skirtingos temperatūros (+21/14 °C ir +25/18 °C dieną/naktį) ir skirtingo substrato drėgnio (normalus (~ 40 %), vidutinis (~ 25 %) ir sausas (< 10 %)) sąlygomis.


Reikšminiai žodžiai: drėgmės trūkumas, sausa masė, sėjamasis žirnis, temperatūra, žalia masė.

pagrindinių veiksnių, darančių įtaką augalų augimui, vystymuisi ir produktyvumui (Šlapakauskas, Duchovskis, 2008).


Sėjamasis žirnis priklauso pupinių (Fabaceae L.) šeimai. Šios šeimos augalai vertinami, nes sukaupia daug vertingų baltymų. Žirniai nėra reikšmingi temperatūrai, tačiau ekstremali temperatūra ir netinkamas drėgmės režimas gali neigiamai paveikti jų fiziologinius procesus bei derlių (Bourion ir kt., 2003).

Darbo tikslas – nustatyti skirtingų temperatūros ir drėgmės režimų kompleksinį poveikį sėjamojo žirnio fiziologiniams rodikliams.


Sėjamieji žirniai auginti nevienodas temperatūros (+21/14 °C ir +25/18 °C dieną/naktį) ir substrato drėgmę (~ 40 %, ~ 25 % ir ~ 10 %) sąlygomis. Žirniai auginti trimis poveikio sąlygomis: +21/14 °C ir +25/18 °C temperatūroje, palaikant normalų (~ 40 %) substrato drėgnį; +21/14 °C ir +25/18 °C temperatūroje, palaikant vidutinį (~ 25 %) substrato drėgnį; +21/14 °C ir +25/18 °C temperatūroje sausame (~ 10 %) substrato drėgnė – B veiksny. Poveikio trukmė – 10 dienų.

Tyrimo duomenys apdoroti dispersinės analizės metodu, naudojant kompiuterinę programą ANOVA iš paketo SELEKCIJA, apskaičiuotas mažiausias esminis skirtumas \( R_{05} \) (Tarakanovas, Raudonius, 2003).

Rezultatai. Atlikti tyrimai parodė, kad skirtingi temperatūros ir drėgmės režimai turėjo reikšmingos įtakos sėjamųjų žirnių antžeminės dalies aukštui (1 pav.).

1 pav. Sėjamųjų žirnių antžeminės dalies aukštis (cm), esant skirtingos temperatūros ir drėgmės režimams. Substrato drėgnis: normalus – ~ 40 %, vidutinis – ~ 25 %, sausas – ~ 10 %.

Fig. 1. The height (cm) of pea shoots above-ground in different combinations of humidity and temperature regimes. Substrate humidity: normal – ~ 40 %, moderate – ~ 25 %, dry – ~ 10 %.

2 pav. Sėjamųjų žirnių žalia masė (g), esant skirtingos temperatūros ir drėgmės režimams. Substrato drėgnis: normalus – ~ 40 %, vidutinis – ~ 25 %, sausas – ~ 10 %.

Fig. 2. Fresh weight (g) in different combinations of humidity and temperature regimes of pea. Substrate humidity: normal – ~ 40 %, moderate – ~ 25 %, dry – ~ 10 %.

Tyrimo duomenys rodo žirnių aukščio didėjimo tendenciją esant +21/14 °C temperatūrai, nepriklausomai nuo substrato drėgnio. Iš esmės didžiausias (58,40 cm)
sėjamųjų žirnių antžeminės dalies aukštis nustatytas esant +21/14 °C temperatūrai ir vidutinių substrato drėgnio. Žirnių antžeminės dalies aukščio sumažėjimui esminės įtakos turėjo (+25/18 °C) temperatūra, nepriklausomai nuo substrato drėgnio. Iš esmės mažiausias (38,20 cm) sėjamųjų žirnių antžeminės dalies aukštis nustatytas esant substrato drėgnio trūkumui ir aukštai (+25/18 °C) temperatūrai (1 pav.).

Sėjamųjų žirnių žalia masė padidėjo esant vidutiniu drėgnio substratui ir +21/14 °C temperatūrai (2 pav.). Iš esmės didžiausia (7,05 g) sėjamųjų žirnių žalia masė nustatytas esant +21/14 °C temperatūrai ir vidutiniu substrato drėgniu. Dėl sausros ir aukštos temperatūros poveikio sausųjų medžiagų sukaupta mažiau. Žalios masės augimui neigiamos įtakos turėjo substrato drėgmės deficitas. Iš esmės mažiausia (3,53 g) sėjamųjų žirnių žalia masė nustatytas esant aukštai (+25/18 °C) temperatūrai ir substrato drėgmės trūkumui. Išanalizavus tyrimo duomenis galima daryti prielaidą, kad aukšta temperatūra ir drėgmės trūkumas mažina žalios masės augimą (2 pav.).

Žirnių sausos masės kiekio padidėjimas nustatytas esant vidutiniu drėgnio substratui ir +21/14 °C temperatūrai (3 pav.). +21/14 °C temperatūra, nepriklausomai substrato drėgnio, skatino augimo procesus. Iš esmės didžiausia (0,74 g) sėjamųjų žirnių sausos masės kiekis nustatytas esant +21/14 °C temperatūrai ir vidutiniu substrato drėgniu.

**3 pav.** Sėjamųjų žirnių sausa masė (g), esant skirtingos temperatūros ir drėgmės režimams. Substrato drėgnis: normalus – ~ 40 %, vidutinis – ~ 25 %, sausas – < 10 %.

![Image](image-url)

**4 pav.** Chlorofilių a/b santykis žirniuose, esant skirtingos temperatūros ir drėgmės režimams. Substrato drėgnis: normalus ~ 40 %, vidutinis ~ 25 %, sausas – < 10 %.

![Image](image-url)
Drėgmės trūkumas slopino sausos masės kaupimąsi. Sausame substrate, esant +21/14 °C temperatūrai, augintų žirnių sausos masės kiekis buvo mažiausias (0,57 g), palyginti su normaliu ir vidutinio drėgnio substratu. Aukšta (+25/18 °C) temperatūra, nepriklausomai nuo substrato drėgnio, slopino sausos masės kiekia kaupimąsi (3 pav.).

Kintant aplinkos sąlygoms, žirnių lapuose keičiasi chlorofilų a/b santykis ir karotenoidų kiekis (4, 5 pav.). Esant abiem temperatūros režimams sausame substrate chlorofilų a/b santykis buvo iš esmės didžiausias. Iš esmės didžiausias (1,55) chlorofilų a/b koncentracijos santykis gaudiet augant aukštos temperatūros ir substrato drėgnio trūkumui. Iš esmės mažiausias (1,20) chlorofilų a/b santykis nustatytas žirniuose, augusiuose normalaus drėgnio substrate, esant +25/18 °C temperatūrai (4 pav.).

5 pav. Karotenoidų kiekis žirniuose (mg g⁻¹), esant skirtingos temperatūros ir drėgmės režimams. Substrato drėgnis: normalus – ~ 40 %, vidutinis – ~ 25 %, sausas – < 10 %.

Gaišumo paklaida ± Sx, n = 3.

Fig. 5. Carotenoid content (mg g⁻¹) in pea under different combinations of humidity and temperature regimes. Substrate humidity: normal – ~ 40 %, moderate – ~ 25 %, dry – < 10 %.

6 pav. Sėjamųjų žirnių asimiliacinis lapų plotas (cm²), esant skirtingos temperatūros ir drėgmės režimams. Substrato drėgnis: normalus – ~ 40 %, vidutinis – ~ 25 %, sausas – < 10 %.

Gaišumo paklaida ± Sx, n = 3.

Fig. 6. Leaf assimilation area of pea (cm²) in different combinations of humidity and temperature regimes. Substrate humidity: normal – ~ 40 %, moderate – ~ 25 %, dry – < 10 %.

Sėjamieji žirniai, auginti +21/14 °C temperatūroje, nepriklausomai nuo substrato drėgnio, lapuose sukaupe didesnį karotenoidų kiekį. Tyrimo duomenys rodo karotenoidų kiekio didėjimą žirniuose, esant +21/14 °C temperatūrai ir sausam substrate. Iš esmės daugiausia (0,77 mg g⁻¹) karotenoidų nustatyta žirniuose, augusiuose +21/14 °C temperatūroje, kai substrate trūko drėgmės. Iš esmės mažiausias karotenoidų kiekis (0,42 mg g⁻¹) nustatyta normalaus drėgnio substrate augusiuose žirniuose, esant +25/18 °C temperatūrai. Aukšta aplinkos temperatūra, nepriklausomai nuo substrato drėgnio, mažino karotenoidų kiekį sėjamųjų žirnių lapuose. Iš esmės mažiausias
karotenidų kiekis (0,42 mg g⁻¹) nustatytas normalaus drėgnio substrate augusiuose sėjamuosiuose žirniuose, esant aukštai (+25/18 °C) temperatūrai (5 pav.).

Drėgmės trūkumas substrate ir +21/14 °C temperatūra darė neigiamą įtaką žirnių asimiliaciniam lapų plotui (6 pav.). Mažiausias (48,94 cm²) buvo +25/18 °C temperatūroje augusių žirnių asimiliacinis lapų plotas, kai substrate trūko drėgmės. Esant abiem temperatūros režimams normalaus ir vidutinio drėgnio substrate augusių žirnių asimiliaciniam lapų plotui esminio poveikio nenustatyta. Didžiausias – 87,84 cm² – sėjamųjų žirnių lapų asimiliacinis plotas gautas esant +21/14 °C temperatūrai ir vidutinio drėgnio substratui. Išanalizavus tyrimo duomenis matyti, kad substrato drėgnio trūkumas padarė neigiamą įtaką sėjamųjų žirnių asimiliaciniam lapų plotui (6 pav.).

**Aptarimas.** Augalų fiziologiniai procesai labai priklauso nuo klimato ir aplinkos sąlygų. (Šlapakauskas, Duchovskis, 2008). Vieni iš dažniausiai augalų produktyvumą ribojančių aplinkos veiksnų yra sausra ir ekstremalai temperatūra (Chaves ir kt., 2003).

Mūsų gauti rezultatai rodo, kad sėjamųjų žirnių antžeminės dalies aukštį labiausiai paveikė sausra, esant +25/18 °C temperatūrai. Šliogerytės ir kt. atlikti tyrimai taip pat rodo, kad vandens deficitas daro neigiamą įtaką augalų fiziologiniams rodikliams (Šliogerytė ir kt., 2009).


tyrimo rezultatų matyti, kad +25/18 °C temperatūra ir sausas substratas skatina chlorofilų $a/b$ santykio padidėjimą.


Išvados. +21/14 °C temperatūra, esant vidutinio drėgnio substratui, skatino žirnių antžeminės dalies bei sausos ir žalių masės augimą, o aukšta (+25/18 °C) temperatūra, nepriklausomai nuo substrato drėgnio, slopino žirnių antžeminės dalies bei žalios ir sausos masės augimą. Žirnių asimilacinį lapų plotą mažėjo +21/14 °C temperatūra ir substrato drėgnio trūkumas. Aukšta (+25/18 °C) temperatūra ir substrato drėgnio trūkumas skatino chlorofilų $a/b$ santykio padidėjimą žirnių lapuose. Nepriklausomai nuo substrato drėgnio, aukšta (+25/18 °C) temperatūra mažino karotenoidų kiekį sėjamų žirnių lapuose. Apibendrinant tyrimo duomenis galima daryti išvadą, kad geriausios augimo sąlygos sėjamui ‘Pinochio’ yra +21/14 °C temperatūra ir vidutinio drėgnio substratatas.

Literatūra


Gauta 2011 06 17
Parengta spausdinti 2011 07 19


The complex influence of temperature and humidity on pea
(*Pisum sativum* L.) physiological indices

N. Rasiukevičiūtė, S. Sakalauskienė, A. Brazaitytė, P. Duchovskis

Summary

The experiments of complex influence of temperature and humidity on pea (*Pisum sativum* L.) physiological rates were performed at the Lithuanian Research Center of Agriculture and Forestry at the Institute of Horticulture Plant Physiology laboratory, phytotronic complex in 2010.

The aim of this study was to investigate pea cultivar ‘Pinochio’. Peas were grown under conditions of different temperature (+21/14 °C and +25/18 °C day/night) and humidity (normal (~ 40 %), moderate (~ 25 %) and dry (< 10 %)) regime.

Moderate moisture substrate and +21/14 °C temperature stimulated the growth of above-ground parts and high (+25/18 °C) temperature it inhibited, irrespective of the amount of moisture. Moderate moisture substrate and +21/14 °C temperature stimulated the accumulation of fresh and dry weight on the peas. High (+25/18 °C) temperature had adverse effect on a fresh and dry weight accumulation. High (+25/18 °C) temperature and the lack of humidity increased chlorophyll *a/b* ratio in pea leaves. Irrespective of the amount of moisture, at +21/14 °C temperature peas accumulated significantly more carotenoids. The deficit of moisture and +21/14 °C temperature essentially reduced pea leaf assimilation area. Summarizing the survey data, we conclude that the best growth conditions for pea ‘Pinochio’ are +21/14 °C temperature and moderate humidity substrate.

Key words: dry weight, fresh weight, moisture deficit, pea, temperature.
GUIDELINES FOR THE PREPARATION AND SUBMISSION OF ARTICLES TO THE VOLUMES OF SCIENTIFIC WORKS “SODININKYSTĖ IR DARŽININKYSTĖ“

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The author must return the corrected manuscript to the Editorial Board in ten days by e-mail or by mail in a diskette or CD.

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  – Institution(s), address, email address
  Should be written in small letters in Italic (Institute of Horticulture Lithuanian Research Centre for Agriculture and Forestry).

The main text

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  Should contain the statement of the aims, methods and main results in short.
– Key words (should not exceed 10 words)
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  Should present the investigated subject, results of earlier related research, reasons of the study, innovation. Should indicate the aim of the investigation.
– Object, methods and conditions
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    Should present concisely the collected data during investigation, documentation (tables, figures).
– Discussion
    Should not repeat results presented in “Results” but should interpret them with reference to the results obtained by other authors, explain the reasons of the investigated phenomena and raise new ideas, hypotheses.
– Conclusions
– Acknowledgements (optional)
– References
    Should be kept to a minimum of 10 latest references on this theme.
– Summary in Lithuanian and English (600–1 400 characters)
    Articles written based on non-traditional trial data and the obtained results may have other than traditional structural parts of a paper.
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In bold there are written the title of the paper in all languages, headings and all main structural elements (introduction, object, methods and conditions, results, discussion, conclusions, acknowledgements, references, abstract). In italic there are written Latin names of species, genera, diseases, pests micro-organisms and other biological objects. Names of plant cultivars should be placed within single quotation marks (for example, ‘Auksis’).

The quoted reference in the text is indicated in round brackets (author’s surname, year).

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description of first table (figure).

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It is desirable to describe in detail the applied research methods and indicate their original references. The information on the scheme (design) of field, vegetative and other trials and motivation of their choice is very important. Data presented in tables and figures must be statistically processed. Abbreviations of parameters should be explained if they do not correspond to the international standard abbreviations (ISO).

**Figures**

All illustrations – drawings, graphs, diagrams, photographs, pictures, etc. are considered as figures. The text in them is written in Lithuanian and English.

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**Examples of quotation:**

**Book of one author:**


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ATMINTINĖ AUTORIAMS, RAŠANTIEMS Į MOKSLO DARBUS „SODININKYSTĖ IR DARŽININKYSTĖ“

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Labai glaudai pateikiamos raiškios, sąlygos, svarbiausi rezultatai.

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