

Incidence of fruit rot on strawberries in Latvia, resistance of cultivars and impact of cultural systems

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In 2007 and 2008 strawberry plantations in different regions of Latvia were inspected looking for fruit rots. Causal agents of fruit rot were detected at the laboratory of Latvian Plant Protection Research Center. 28 strawberry plantations were inspected in 2007. In this year weather conditions during strawberry flowering and harvest time were not favorable for the development of the diseases. On the damaged fruits and flowers mostly fungus *Botrytis cinerea* was detected at laboratory. On some fruits rots caused by *Hainesia lynthri*, *Muccor* spp. and *Penicillium* spp. were found. Next year 26 strawberry plantations were inspected. *Botrytis cinerea* was detected on samples with damages like pale brown fruit rot, dead flowers and ovaries and dark brown spots on pedicles. Causal agents *Hainesia lynthri*, *Phomopsis obscurans*, *Coniella castaneicola*, *Fusarium* spp., *Muccor* spp., *Rhizopus* spp., *Penicillium* spp. on rotted fruits also were found at laboratory.

Susceptibility to *Botrytis* rot of 16 strawberry cultivars was evaluated at the Pure HRC in 2006–2008. On the average during three production years, cultivars ‘Honeoye’ and ‘Tenira’ had the lowest *Botrytis* incidence, but ‘Venta’ and ‘Bounty’ were the most susceptible among the tested cultivars. In 2008, experiments on extending of strawberry production season using different plant covers, plastic soil mulches, cultivars, and “frigo” plants were started at the Pure HRC. The first results showed the significant effect of plastic soil mulches and plant covers on reduction of *Botrytis* incidence.

Key words: cultivar susceptibility, cultural practices, *Fragaria* × *ananassa*, grey mold, incidence.

Introduction. Strawberry is one of the most popular commercial berry crops in Latvia. In 2007 the area of strawberries was about 500 ha. Most of production is used for fresh local markets. The yield is quite low in comparison with other European countries, on the average 3–5 t ha⁻¹. There are several reasons for it. Mostly yield losses can be caused both by unfavourable environment conditions and due to damage by different pathogenic organisms. The efficiency of plant protection is low in many farms. Grey mould, leaf spots, mildew, root diseases and nematodes are mentioned as the most widespread on strawberries under Latvia conditions (Moročko, 2003;

Laugale et al., 2004). Especially high yield losses can be caused by fruit rots. The implementation of Integrated Plant Protection system demands to reduce the using of chemical plant protection products and to look for alternative methods like more resistant cultivars and proper agriculture (Meszka and Bielenin, 2004). Studies described here were started with aim to determine the main causal agents for strawberry fruit rots in Latvia and to evaluate the susceptibility of widely grown cultivars. The first investigation results revealing the influence of cultural practice on fruit rot reduction in strawberry fields also are presented.

Object, methods and conditions. 28 strawberry plantations in 2007 and 26 plantations in 2008 were inspected for fruit rot detection in different Latvia regions (Fig. 1). In 2007 the amount of fruit rot samples was lower than in 2008 because weather conditions during strawberry flowering and harvest time were optimal for fruit formation, but not favourable for rot development. During the harvest time samples of rotted fruits, died off flowers, ovaries and dark brown pedicles were collected for causal agent detection. Causal agents of strawberry rot were isolated in pure culture, used PDA (potato-dextrose agar). Discovered fungi were identified at the laboratory of Latvian Plant Protection Research Center.



Fig. 1. Inspected strawberry plantations in Latvia, 2008
1 pav. Tikrintos braškių plantacijos Latvijoje, 2008 m.

16 widely grown in Latvia strawberry cultivars were evaluated on susceptibility to *Botrytis* rot at the Pure Horticultural Research Station in 2006–2008. Plants were planted in biologically certified field in single rows at spacing of 30 × 100 cm in the autumn of 2005. A completely randomized block design with four replicates and thirty plants per plot was used. The following cultivars were tested: ‘Bogota’, ‘Bounty’,

'Dukat', 'Feierverk', 'Honeoye', 'Induka', 'Jonsok', 'Rubinovij Kulon', 'Pandora', 'Polka', 'Senga Sengana', 'Symphony', 'Siurprise Olimpiadi', 'Tenira', 'Venta' and 'Zefyr'. Only in organic farming permitted plant protection and nutrition products were used.

In 2008 at the Pure Horticultural Research Center the damage by fruit rots were evaluated in following trials: 1) 3 cultivars grown on soil mulched with black plastic and no soil mulch; in spring till the beginning of production plants were covered with transparent film (polyethylene) or agronet (Agryl 17) and without cover as control; 2) "frigo" plants (3 cultivars) in two planting densities (3.3 and 6.6 plants m⁻²) grown on soil mulched with white plastic (black lower side) and no mulch; 3) two plant types M₀ and M₁ generation from micropropagation of everbearer cultivar 'Brighton' grown on soil mulched with white plastic (black lower side) and no mulch. In all trials plants were spaced 40 cm apart within rows (except one variant in trial with "frigo" plants where 20 cm distance between plants also was used), and 30 cm apart between rows. The beds were 150 cm apart, center-to-center. Split-split block design with four replicates was used. No fungicides were applied.

In all trials rotted berries were harvested and weighted at each picking time separately, and the percentage of damaged berries from total yield was calculated. The data were analyzed using descriptive statistics and ANOVA (probability 95 %). Duncan's multiple range test was applied to compare the means.

Results. Incidence of fruit rot in strawberry plantations. In 2007 from 28 inspected strawberry plantations 51 samples of damaged fruits were collected. Pale brown rot spots were the most widespread damages on unripe and ripe fruits. Some flowers were died off as well. *Botrytis cinerea* was detected on damaged fruits and flowers in 57 % of inspected strawberry farms. Only in four plantations in West and one in South region of Latvia ripe fruit rot caused by *Mucor* spp. was detected. In few plantations rot caused by *Hainesia lynthri*, *Fusarium* spp., *Rhizopus* spp. and *Penicillium* spp. (Maas, 1998) also were found.

In 2008 from 26 strawberry plantations 127 samples of rotted strawberry were collected. The pale brown fruit rot, died off flowers, ovaries and dark brown spots on pedicles were the main damages in strawberry plantations. *Botrytis cinerea* was detected in all inspected plantations (Fig. 2). Infection level of *Botrytis cinerea* was very high, because weather conditions were optimal for fungus progression.

Powdery mildew (*Sphaerotheca macularis*) on fruits was observed only in Kurzeme region in 44 % of the inspected fields. *Fusarium* spp. developed at laboratory from samples with fruits, dead flowers, ovaries and dark brown pedicles. The fungus usually causes the rot of root; in this case probably infection level was very high and conidia by splash got from soil to flowers, and fruits. *Fusarium* spp. was detected in 44 % of the plantations in Kurzeme and in 25 % in Vidzeme (Fig. 3). In samples with ripe fruit rot *Mucor* spp. and *Rhizopus* spp. were found (Smith et al., 1979).

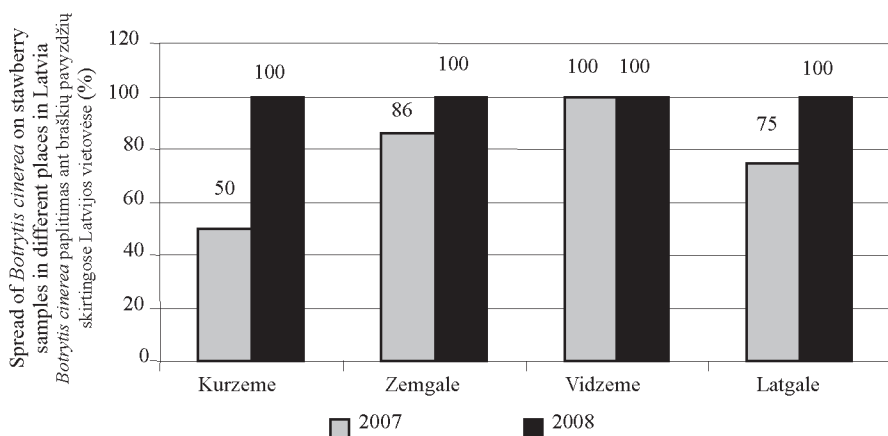


Fig. 2. Spread of *Botrytis cinerea* on strawberry samples taken from different places in Latvia, in 2007 and 2008 (%)

2 pav. *Botrytis cinerea* paplitimas brašķiņ pavyzdziuose, paimtuose skirtingose Latvijos vietovėse 2007 ir 2008 metais, %

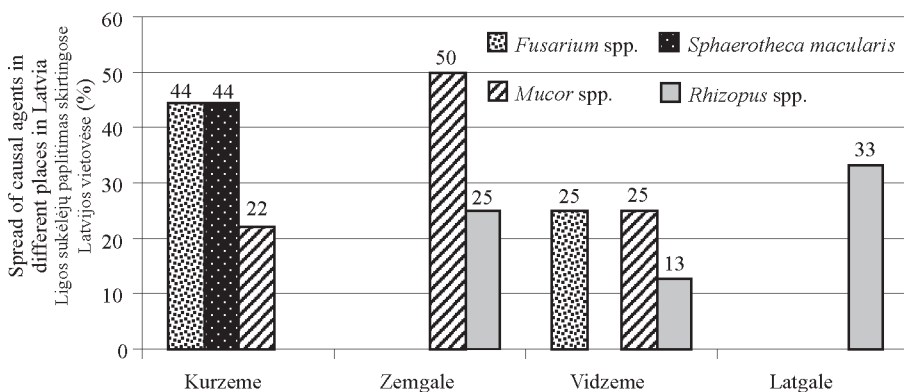


Fig. 3. Spread of causal agents on strawberry samples taken from different places in Latvia, in 2008 (%)

3 pav. Ligos sukėlėjų paplitimas brašķiņ pavyzdziuose, paimtuose skirtingose Latvijos vietovėse 2008 metais, %

Causal agents *Hainesia lynthri*, *Phomopsis obscurans*, *Coniella castaneicola* and *Penicillium* spp. were detected only in few plantations in Kurzeme. The detection of the fruit rot causal agents will be continued.

Susceptibility of cultivars. In strawberry cultivar trial the spreading of fruit rots was very low in 2006. In 2007, the percentage of damaged fruits increased, but did not exceed 7 % from total yield. Late ripening cultivars were more damaged than early ripening, because there was increased amount of precipitation at the end of

season. The lowest percentage of damaged berries had cultivars ‘Honeoye’, ‘Zefyr’ and ‘Rubinovii Kulon’ (data not shown). Cultivar ‘Bounty’ had the highest percentage of damaged fruits. In 2008, the amount of rotted fruits on the average was significantly higher than in 2006 and 2007. It varied from 1.1 to 7.2 % from total yield depending on cultivar (data not shown). Cultivars ‘Honeoye’ and ‘Tenira’ had the lowest percentage of damaged berries, but ‘Venta’ was the most susceptible between tested cultivars.

On the average of three production years, cultivar ‘Honeoye’ had the lowest fruit rot incidence (Fig. 4). Cultivars ‘Tenira’, ‘Jonsok’, ‘Rubinovij Kulon’ and ‘Zefyr’ also showed low susceptibility.

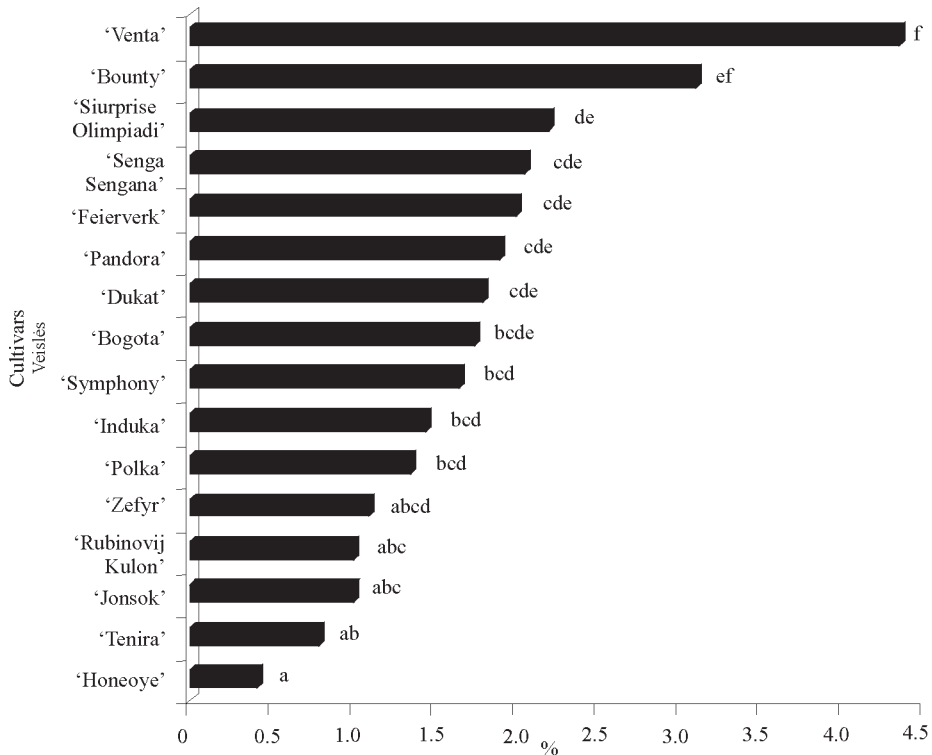


Fig. 4. The amount of rotted fruits (%) from total yield on the average of three production seasons in strawberry cultivar trial.

Values in columns followed by the same letter do not differ significantly according to Duncan’s multiple range test ($p = 0.05$)

4 pav. Vidutinis supuvusių vaisių kiekis (%) nuo bendro derliaus braškių veislių bandyme per trejus derėjimo metus.

Stulpeliai, pažymėti vienodomis raidėmis, patikimai nesiskiria pagal Dunkano kriterijų ($p = 0,05$)

‘Venta’ and ‘Bounty’ had the highest percentage of rotted fruits on the average of three investigation years between tested cultivars.

Impact of cultural practices. In the trial for early production using black plastic soil mulch and different plant covers the significant differences in the percentage of rotted fruits was stated, while the amount of damaged berries was low in 2008 (0–2.4 % from total yield depending on treatment). The percentage of rotted fruits was significantly lower ($p = 0.007$) than this of plants grown on black plastic mulch comparing to non-mulched soil (Fig. 5).

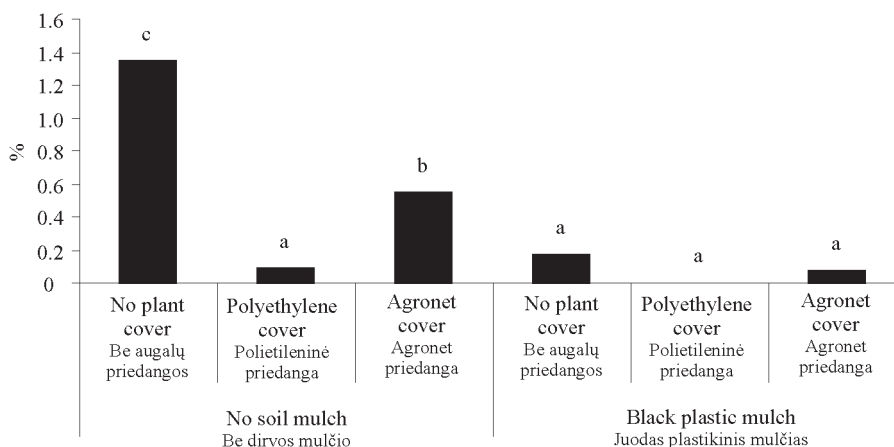


Fig. 5. The amount of rotted fruits (%) from total yield in 2008 trial using black plastic soil mulch and different plant covers for early production.

Columns assigned by different letters are significantly different, when $p \leq 0.05$

5 pav. Supuvusių vaisių kiekis (%) nuo bendro derliaus 2008 metų bandyme, panaudojant juodą plastikinį dirvos mulčią ir skirtingas augalų priedangas ankstyvai produkcijai. Stulpeliai, pažymėti skirtingomis raidėmis, patikimai skiriasi, kai $p \leq 0,05$

Notably low amount of rotted fruits was obtained from plants grown with polyethylene cover. Agronet cover also significantly reduced the percentage of rotted fruits comparing to control (without any plant cover) (Fig. 5). The highest percentage of rotted fruits was observed on plants grown without any soil mulch and plant covering, but the lowest one – on plants grown on beds with black plastic soil mulch and polyethylene cover.

In the trial where “frigo” plants in two planting densities and white with black lower side plastic soil mulch were used, significantly lower percentage of rotted fruits was obtained from plants grown on plastic mulch ($p = 0.03$) comparing to non-mulched treatment (Fig. 6).

Significant difference in the percentage of rotted fruits between two planting densities was not stated in this year (Fig. 6). There was observed tendency for increasing of *Botrytis* damage in higher plant density for plants grown on beds with plastic mulch.

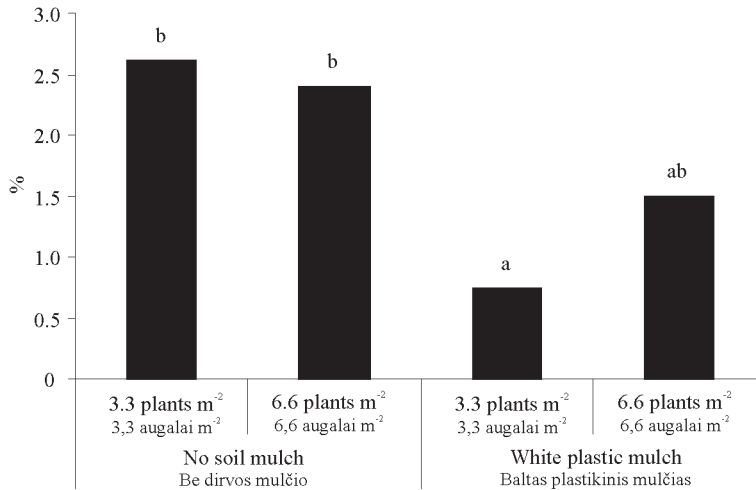


Fig. 6. The amount of rotted fruits (%) from total yield in trial 2008 with “frigo“ plants in two planting densities and white with black lower side plastic soil mulch for late production. Columns assigned by different letters are significantly different, when $p \leq 0.05$

6 pav. Supuvusių vaisių kiekis (%) nuo bendro derliaus 2008 metų bandyme su “frigo” augalais, pasodintais dvejopu tankumu, ir panaudojant baltą su juoda apatine puse plastikinį dirvos mulčią vėlyvai produkcijai. Stulpeliai, pažymėti skirtingomis raidėmis, patikimai skiriasi, kai $p \leq 0,05$

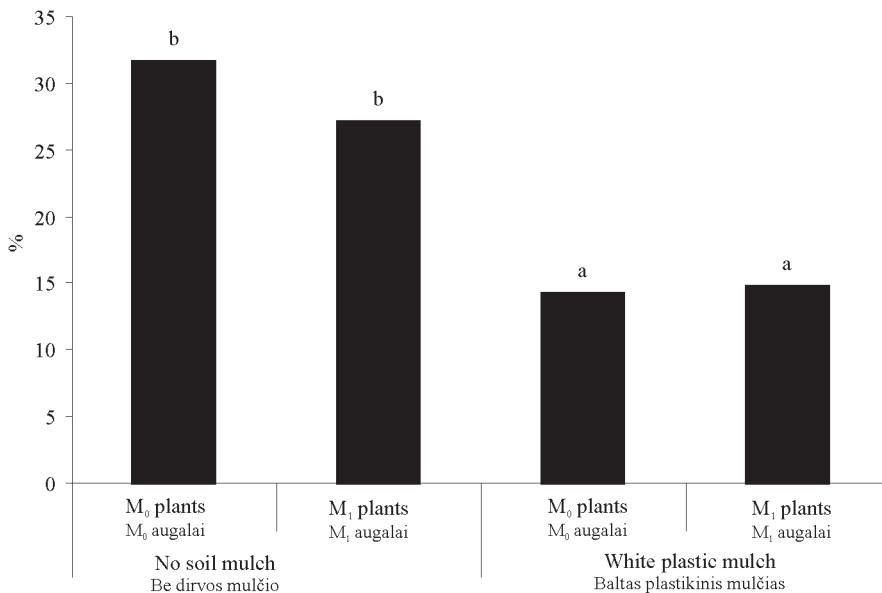


Fig. 7. The amount of rotted fruits (%) from total yield in 2008 trial with everbearer strawberry cultivar ‘Brighton’ using two plant types and white with black lower side plastic soil mulch. Columns assigned by different letters are significantly different, when $p \leq 0.05$

7 pav. Supuvusių vaisių kiekis (%) nuo bendro derliaus 2008 metų bandyme su nuolat derančia braškių veisle ‘Brighton’ panaudojant du augalų tipus ir baltą su juoda apatine puse plastikinį dirvos mulčią. Stulpeliai, pažymėti skirtingomis raidėmis, patikimai skiriasi, kai $p \leq 0,05$

In the trial with everbearer cultivar 'Brighton' using two plant types and white with black lower side plastic soil mulch, significantly lower percentage of rotted fruits was obtained from plants grown on plastic mulch ($p = 0.03$) comparing to non-mulched treatment (Fig. 7).

Significant difference in the percentage of rotted fruits between two plant types M_0 and M_1 was not stated (Fig. 7).

Discussion. In our investigations *Botrytis cinerea* was determined as the main casual agent of strawberry fruit rotting. It conform to the previous investigations carried out in Latvia (Dūks, 1976; Moročko, 2003; Laugale et al., 2004). *Botrytis* rot is also one of the most important diseases of strawberry, reducing yield and quality pre- and post-harvest in all strawberry production areas (Berrie et al., 2000; Legard et al., 2002; Rigotti, Viret, 2004). It is important to remove rotted fruits from the field during the harvest time to reduce infection level in strawberry plantations.

In the evaluation of strawberry cultivars significant difference in susceptibility to grey mould between cultivars was stated. Only cultivar 'Venta' had significantly higher percentage of damaged fruits than 'Senga Sengana', which is characterized as susceptible to grey mold (Zurawicz, Daubeny, 1995). Several cultivars like 'Bounty', 'Siurprise Olimpiadi', 'Feierverk', 'Pandora', 'Dukat' and 'Bogota' showed susceptibility similar to this of 'Senga Sengana'. In previous investigations in Pure cultivars 'Dukat' and 'Bogota' showed good resistance to *Botrytis* rot (Laugale et al., 2004; Laugale, Lepse, 2007). Also in this trial they had lower percentage of rotted fruits than 'Senga Sengana', but the difference was not significant. It can be explained by overall low spreading of the rots during test years 2006–2008. 'Honeoye' was the most resistant to grey mould between tested cultivars. It showed also good resistance to *Botrytis* rot in Finland (Matala, 2002), Poland (Cieśliński et al., 1993) and Estonia (Libek, 1997).

In all trials where different cultural practices were applied the significant impact of plastic soil mulches both black, and white with black lower side on the reduction of fruit rot incidence was stated. The positive effect of black plastic soil much on reducing of grey mold damage on strawberries is reported also by Lille et al. (2003), Plekhanova and Petrova (2002). Using plant covers, especially polyethylene film, till the beginning of harvesting also reduced the percentage of rotted fruits. According to Xiao et al. (2001), shorter periods of leaf wetness and higher temperatures in plastic tunnels may have contribute to a lower incidence of *Botrytis* rot on fruit in comparison to the open field. According to the investigations in Finland, Agronet plant cover reduced different disease spreading, and succeeded to stop the spreading of grey mold on late cultivar 'Hiku' (Dalman, 1993). The increase of planting density did not cause significant increase of *Botrytis* rot damage in our trial. Probably because the fruit rot incidence was low in this year and in the first cropping year plants were not fully-grown. According to the investigations of Daugaard (2003), climatic factors may play more important role in the control of *Botrytis* than differences in plant density.

Conclusions. The main causal agent of strawberry fruit rotting in Latvia strawberry plantations is *Botrytis cinerea* Pers. It causes pale brown fruit rot, death of flowers and ovaries and dark brown spots on pedicles. *Mucor* spp. and *Rhizopus* spp. were the main casual agents for ripe (post-harvest) rot.

Strawberry cultivars grown in Latvia have significantly different resistance level to *Botrytis* rot. Cultivars 'Honeoye' and 'Tenira' showed the highest resistance, but 'Venta' and 'Bounty' were the most susceptible among the tested cultivars.

According to the first obtained results, plastic soil mulches and plant covers can significantly reduce fruit rot incidence.

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Vaišu puvinio paplitimas ant braškiu Latvijoje, veislu atsparumas ir kultūrinu sistemu itaka

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Santrauka

2007 ir 2008 metais įvairiuose Latvijos regionuose patikrintos braškių plantacijos ieškant vaišu puvinu. Vaišu puvinio sukėlėjai nustatyti Latvijos augalų apsaugos tyrimų centro laboratorijoje. 2007 metais patikrintos 28 braškių plantacijos. Tais metais oro sąlygos braškių žydėjimo ir derliaus metu nebuvo palankios ligų vystymuisi. Ant pažeistų vaišu ir žiedų laboratorijoje daugiausia aptiktas *Botrytis cinerea* grybas. Ant kai kurių vaišu rasta *Hainesia lythri*, *Muccor* spp. ir *Penicillium* spp. sukeliamų puvinu. Kitais metais patikrintos 26 braškių plantacijos. *Botrytis cinerea* buvo aptiktas ant pavyzdžių su tokiais pažeidimais, kaip šviesiai rudas vaišu puvinys, negyvi žiedlapiai bei mezginės ir tamsiai rudos dėmės ant žiedkočių. Be to, ant puvinio pažeistų vaišu laboratorijoje rasti šie ligos sukėlėjai – *Hainesia lythri*, *Phomopsis obscurans*, *Coniella castaneicola*, *Fusarium* spp., *Muccor* spp., *Rhizopus* spp., *Penicillium* spp.

16 braškių veislu jautrumas *Botrytis* puvinui buvo įvertintas Pure LTC 2006–2008. Per trejus derėjimo metus veislės 'Honeoye' ir 'Tenira' buvo mažiausiai užsikrėtusios *Botrytis*, o 'Venta' ir 'Bounty' – iš visų tirtų veislu labiausiai. 2008 metais Pure LTC pradėti tyrimai, kaip pratęsti braškių derėjimo sezoną, panaudojant įvairias augalų priedangas, plastikinius dirvos mulčius, veisles ir "frigo" augalus. Pirmieji rezultatai parodė reikšmingą plastikiniu dirvos mulčiu ir augalų priedangų poveikį *Botrytis* paplitimo sumažinimui.

Reikšminiai žodžiai: agrotechninės priemonės, *Fragaria* × *ananassa*, kekerinis puvinys, paplitimas, veislės jautrumas.