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EVALUAREA UNOR SOIURI ROMÂNEȘTI DE MĂR ÎN LETONIA
EVALUATION OF ROMANIAN APPLE CULTIVARS IN LATVIA

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Abstract

Commercial apple growing in Latvia feels some lack of climate adapted modern cultivars. Development of fruits and trees is limited by active growth period (temperatures over 10 °C) of 135-150 days and active temperature sum of 1700-2100 °C. Winter hardiness also is essential, as temperatures below −30°C occur each 10 years, and winter thaws are frequent. Annual precipitation 692 mm favours development of fungal diseases. In 2016, a trial of four Romanian apple cultivars resistant to scab - 'Aura', 'Ciprian', 'Jonaprim' and 'Romus 3' was established in Latvia. Trees were grafted on dwarfing rootstock B.396 and planted as 1-year old whips in 3 replications with 2-3 trees in each replication, and trained as slender spindle. Commercial cultivars 'Auksis' (midseason) and 'Ligol' (late) were used as controls. Most trees of all cultivars in the 2nd year (2017) developed a well branched frame, from 37.5% trees of 'Ciprian' to 90% trees of 'Jonaprim'. The first fruits were harvested in 2017, and commercially significant yield was achieved in 2018, except 'Jonaprim', which had the slowest yield increase. By the sum of yield in 2017-2021 'Aura' and 'Jonaprim' surpassed commercial cultivar 'Auksis', but were less productive than 'Ligol'. Only slightly lower summary yield was obtained from 'Ciprian', while 'Romus 3' showed the lowest productivity and strong premature fruit drop. Very good taste panel results were obtained for 'Aura' and 'Ciprian', 7 to 8 points in average. Their fruits also kept well, to 5 months in common storage at 2 ±1°C. Fruits of the other two cultivars were too small and had mediocre or poor taste. The weather conditions in the trial years allowed to test susceptibility to spring frosts and drought. All cultivars showed good tree health after over-wintering. 'Jonaprim' and 'Auksis' in 2019 had the highest spring frost injury, 60-70% of fruits, while least injured were 'Aura' (21.5%) and 'Ciprian' (27.7%). Extreme drought in summer of 2021 led to low average fruit mass of all cultivars including the normally large fruited 'Ligol' (120-130 g), while in other years 'Aura' had fruits over 180 g, very attractive yellow with red stripes. Fruits of 'Ciprian' also had good size, but in some years too dark over-colour. 'Aura' and 'Ciprian' showed good adaptation to the climate of Latvia and can be recommended for wider trials at farms.

Cuvinte cheie: *Malus domestica,* adaptare climatică, productivitate, calitate fruct.
Key words: *Malus domestica*, climate adaptation, productivity, fruit quality.

1. Introduction

Commercial apple growing in Latvia feels some lack of climate adapted modern cultivars. Development of fruits and trees is limited by active growth period (temperatures over 10°C) of 135 to 150 days and active temperature sum of 1700 to 2100°C (Kļaviņš, 2016). The average annual air temperature is 6.4°C, in February −3.7°C, in July 17.4°C. Winter hardiness also is essential, as temperatures below −30°C occur each 10 years, and winter thaws are frequent. Annual precipitation 692 mm favours development of fungal diseases. Such climate makes the choice of cultivars for commercial growing challenging, as they must be adapted to the complex of these factors. For this reason, the commercial apple variety assortment in Latvia does not include cultivars most widely grown in Europe (Kaufmane et al., 2017).

No Romanian apple cultivars have been tested in Latvia before. The geographical location difference in south-north direction may have both positive and negative effect on productivity and fruit quality parameters like size, colour and biochemical composition (Kviklys et al., 2013; Viškelis et al., 2019). However, with climate change cultivars from South-eastern Europe may prove more suitable.

The aim of this study was to evaluate the suitability of four Romanian apple cultivars to the climate in Latvia and their promise for commercial growing.

2. Material and methods

In 2016, a trial of four Romanian apple cultivars resistant to scab - 'Aura', 'Ciprian', 'Jonaprim' and 'Romus 3' was established in Latvia. Commercial cultivars 'Auksis' (midseason) and 'Ligol' (late) were used as controls.

Trees were grafted on dwarfing rootstock B.396 and planted as 1-year old whips in 3 replications with 3 or 2 trees in each replication, and trained as slender spindle. Grass was sown in alleyways and regularly mown, keeping tree strips clean with herbicides, applied once in season. Standard spraying (fungicides and insecticides) and fertilizing were used, according to the standard of integrated growing (MK regulations Nr. 1056, 2009). The fruits were thinned by hand. The trial was not irrigated.

The trial site is located at the Institute of Horticulture, Dobele, southern Latvia (56°37´N 23°16´E). The soil of the orchard site is sandy loam, sod carbonate gleyic, with organic matter 2.3%. Soil pH_{KCl} is 6.7, content of phosphorus (P_2O_5) 207 mg kg^{-1}, potassium (K_2O) 255 mg kg^{-1}, magnesium (Mg) 230 mg kg^{-1}.

The climate of the trial site is milder than average in Latvia, with sum of temperatures over 10 °C 2000 to 2100 °C. Apple flowering is from beginning to end of May (depending on year), apple harvest from end of July to 1st or 2nd decade of October (first autumn frosts).

The weather conditions in the trial years allowed to test susceptibility to winter cold, spring frosts and drought. During the trial period, extreme summer droughts were observed in 2018 (194.6 mm April to September) and 2021 (214.7 mm April to July), which had negative influence on non-irrigated trees. Both these years summer temperatures exceeded 33°C. No extreme winter colds were observed; the longest period with temperatures below -20°C was in January-February, 2021. In 2019 frost to -3 °C caused significant flower and fruit damages. The same year, hail damaged the crop.

The following parameters were evaluated in the second stage trials annually:

- Tree general health in spring and summer (points 0-9, where 0 – tree perished, 9 – excellent tree health),
- Flowering and yielding intensity (points 0-9, where 0 – none, 9 - abundant),
- Scab and mildew damages (points 0-9, where 0 – no visible infection, 9 – > 90% infection, almost all tree damaged),
- Full bloom and harvest dates,
- Yield amount from each tree (kg),
- At harvest for a 5-6 kg sample from each tree: average fruit mass (g), amount on non-standard fruits – undersize or damaged (%), describing type of damage.
- In storage (common storage at 2 ± 1 °C) for a sample of 30-50 fruits, every 2 weeks: amount of damaged fruits (%), type of damage (disease, physiological), date of latest storage (end of storage - over 25% damaged or overripe fruits).

Harvest maturity of fruits was determined by starch-iodine test.

As the trees were planted as 1-year old whips, their branching intensity was evaluated in the spring of 2nd year, counting the percentage of well-branched trees (with at least 2 side shoots).

Frost damages of flowers in 2019 were rated from 1 to 9 points, where: 1 - no visible damage, 5 - 50% damage, 9 - all flowers damaged.

Taste panels were carried out for 3 years and included 10-12 tasters, evaluating the following parameters: fruit appearance, taste, sweetness, acidity, aroma, juiciness, firmness, crispness. For each tasting 5-6 fruits of about 10 cultivars were taken at eating maturity. Whole fruits were evaluated visually then cut into slices for tasting (unpeeled). A 5-point scale was applied, where: 1 - very poor, 2 – poor, 3 - medium, 4 – good, 5 - very good. To make data comparable, recalculation was made to a 9-point scale, where: 1 - very poor, 3 - poor, 5 - medium, 7 - good, 9 - very good. Taste panel data were processed mathematically, finding averages and standard error *(Sx)* for each tasting.

Data were processed mathematically using variance analysis of general linear model by IBM SPSS (Statistics 25), and multiple comparisons by Tukey HSD and LSD_{05} criteria. Differences were considered to be significant for *p-value* < 0.05.

3. Results and discussions

Tree development

In the Latvian climate tree plants rarely develop side shoots in nursery in the 1st year. When planted as whips, they may not grow enough branches in the planting year, either. However, trees of most Romanian cultivars in the spring of 2nd year (2017) had a well branched frame: 37.5% trees of ‘Ciprian’, 57% of ‘Romus 3’, 71% of ‘Aura’ and 90% trees of ‘Jonaprim’. Control cultivar ‘Ligol’ had 100% well-branched trees, while the poorest branching was observed for ‘Auksis’ - 18%.

During the trial period, all cultivars showed good tree health after over-wintering (Table 1).

No significant scab, mildew or canker damages were observed in the trial, although ‘Auksis’ and ‘Ligol’ (both not resistant to scab) had some weak scab injury in 2017 and 2019, not exceeding 3 points.

Flowering and harvest dates

Most tested cultivars had early to medium (most years, beginning May 9-10, full bloom May 18-19) flowering dates, only ‘Aura’ had medium flowering (beginning May 16, full bloom May 19). This is more

than a month later than in Romania (Preda et al., 2020). However, the vegetation period of all cultivars in the trial allowed good fruit ripening and tree vegetative part maturing for winter.

The earliest harvest time had cultivar 'Romus 3', most years in mid-August. It needed several pickings, as the fruits drop very easily. 'Jonaprim' was harvested from end of August to mid-September, which ranges it with mid-season cultivars, like control 'Auksis'. Medium to late harvest dates had 'Aura' and 'Ciprian', from end of September to beginning of October, which is earlier than the control cultivar 'Ligol'.

Productivity

All cultivars bore some fruits in 2nd year, but only 'Ligol' had notable yield, 1.9 kg per tree. Commercially significant yield was achieved in 2018, except 'Jonaprim', which had the slowest yield increase. In 2018 it had good flowering, but poor fruit set due to extreme drought, which shows its susceptibility to water deficiency. Only in 2019 it gave noteworthy yield, 7.8 kg per tree. However, in the following years its productivity reached the level of other cultivars (Table 1).

Statistically significant differences were found between cultivars for yield amount ($p < 0.01$). By the sum of yield in 2017-2021 'Aura' and 'Jonaprim' surpassed commercial cultivar 'Auksis', but were less productive than 'Ligol'. Only slightly lower summary yield was obtained from 'Ciprian', while 'Romus 3' showed the lowest productivity. On the contrary, in a trial in Bucharest area 'Aura' had been the least productive and 'Romus 3' the most productive of the four cultivars (Preda et al., 2020). These differences may show different climate adaptation potential of the two cultivars.

In 2021 'Aura' and 'Ligol' showed the highest yield per tree, 18.0 and 22.1 kg per tree, respectively ($p<0.01$). This suggests that in the period of full production 'Aura' can compete by yield amount with the highly productive commercial cultivar 'Ligol', if grown in the conditions of southern Latvia.

Spring frost and hail damages

In 2019 the cultivars had frost damages of flowers at -3 °C. Cultivars 'Aura' and 'Ciprian' has significantly lower damages (1 point of 9) than control cultivars 'Auksis' and 'Ligol' (3 points). However, damages of fruits were observed for all cultivars, and made more severe by hail in summer (Table 1). Differences between cultivars were significant ($p < 0.05$). The lowest damages of fruits had 'Aura' (21.5%), the highest 'Jonaprim' and control cultivar 'Auksis' (62.5 and 74.1%, respectively). Cultivars 'Ciprian' and 'Romus 3' had medium damages, slightly below 30%, which are lower than control cultivar 'Ligol'. In total, 'Aura' had the lowest frost damages of flowers and fruits.

Fruit quality

Significant differences ($p < 0.01$) were found between cultivars and years for average fruit mass (Table 1). Cultivars 'Aura' and 'Ciprian' showed the best fruit market quality, comparable to the control cultivars. Most years, 'Aura' had fruits over 180 g, very attractive yellow with red stripes. Fruits of 'Ciprian' also had good size and uniformity, but in some years too dark over-colour. The average fruit size of 'Jonaprim' and 'Romus 3' was below 120 g, which makes then unsuitable for supermarket sales. They also had mediocre or poor taste (Table 2), and were excluded from further taste panels.

Extreme drought in summer of 2021 led to low average fruit mass of all cultivars including the normally large fruited 'Ligol' (only 127 g). Average fruit mass of 'Auksis', 'Ciprian', 'Romus 3' and 'Jonaprim' was significantly lower than for other cultivars ($p < 0.01$), and for 'Romus 3' and 'Jonaprim' it was below 100 g. In 2018 only 'Romus 3' and 'Jonaprim' had significantly lower fruit mass, 109 and 123 g ($p < 0.01$). The less expressed negative effect of drought in 2018 is explained by a lower fruit number per tree (Table 1).

Taste panel results showed that Romanian cultivars 'Aura' and 'Ciprian' by their organoleptic characteristics were close to standard cultivars 'Auksis' and 'Ligol' (Table 2, Figure 1). The appearance rating was about 8 points on 9-point scale, slightly higher for 'Ligol' (8.4). Taste rating varied very little, from 7.2 to 7.4. The sweetest apples had 'Ciprian' (7.2), slightly less sweet were 'Aura' and 'Ligol' (6.6), 'Aura' was evaluated also as more acid (6.8), while 'Ligol' had the lowest acidity (5.8). Aroma of the cultivars was evaluated similarly (6.6), except 'Ligol' (6.2). However, 'Ligol' had the highest firmness (7.2), juiciness (7.4) and crispness (7.4), while the standard cultivar 'Auksis' was rated the least juicy (6.6) and least crisp (6.4). The least firm was 'Aura' (6.6). In total, 'Aura' and 'Ciprian' were inferior to 'Ligol' by several parameters but had equal taste rating and stronger aroma, and were equal or surpassed 'Auksis' by most parameters.

In Romania, cultivars 'Aura' and 'Ciprian' also are rated as medium firm (Branişte et al., 2008). The taste of 'Ciprian' in Romania is evaluated as balanced, while in Latvia it is sweet with some acidity. These may prove desirable traits, as consumer polls show that to Latvian consumers sweetness is preferable and medium firmness is more acceptable than high firmness (Ikase, Segliņa, 2008).

Fruit storage

The fruits of 'Aura' and 'Ciprian' kept well, to 5 months in common storage at 2±1^{o}C (till February). They had low fruit rot damages, 7.4% of fruits for 'Ciprian' and 2.6% for 'Aura'. Fruits of 'Jonaprim' and 'Romus 3' had relatively short storage, less than 3 months.

Characteristics of the evaluated scab-resistant Romanian cultivars

The characteristics of cultivars tested in Latvia can be summarized as follows:

'Aura' – early production, good annual yields. Tree frame easy for training, branching good. Fruits over medium size, attractive, bicolor, flavour good, balanced, aromatic, juicy, flesh medium firm, crisp. Harvest time medium to late, storage to 5 months. Flowering time medium. Tolerant to spring frosts.

'Ciprian' - early production, good productivity, slight tendency to become biennial. Tree frame easy for training, but plants may be slow to develop side branches. Fruits medium size, attractive, dark purplish red, flavour good, sweet with some acidity, aromatic, juicy, flesh medium firm. Harvest time medium to late, storage to 5 months. Flowering early to medium. Relatively tolerant to spring frosts.

'Jonaprim' – slow increase of production, later productive. Trees branching easily, but with sparse crown. Fruits below medium size, bright red or brownish, flesh medium firm, aromatic, juicy, subacid, flavour poor. Harvest early to medium, consumption time medium. Stores less than 3 months. Flowering early to medium. Susceptible to drought and spring frosts.

'Ţomus 3' – early production, but relatively low yields. Tree crown drooping, branching good. Fruits below medium size, may have irregular shape, medium or dark red, flesh medium firm, juicy, subacid, flavour medium to poor. Harvest time early, tends to drop easily and needs several pickings. Storage short, 2 months. Flowering early to medium. Susceptible to drought.

4. Conclusions

By their growth and phenology characteristics, Romanian apple cultivars showed good adaptation to the climate of Southern Latvia.

Cultivars 'Aura' and 'Ciprian' have some potential for commercial growing in Latvia and can be recommended for wider trials at farms.

Cultivars 'Romus 3' and 'Jonaprim' do not show promise in Latvian conditions, having unsatisfactory fruit quality and productivity in some or all years.

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Tables and Figures

Table 1. Evaluation of Romanian apple cultivars in 2017-2021 (rootstock B.396, planted 2016)

Cultivar	Year	Tree health (0-9)	Flowering (0-9)	Harvest date	Fruit number, pcs.	Yield, kg/tree	Average fruit mass, g	Non-standard fruits, %
Romus 3	2021	8.9	6.7	20.08.	51.9	5.3	106.9	21.4
	2020	8.9	7.1	15.08.	54.7	9.9	118.6	4.5
	2019	8.9	6.9	13.08.	24.3	3.2	132.4	25.1[1]
	2018	9.0	6.7	06.08.	22.3	4.8	109.1	4.0
	2017	8.7	4.3	22.08.	3.1	0.4	122.2	0.0
	average	8.9[abc]	6.3[a]		31.3[b]	4.6[c]	117.7[c]	11.3[ab]
	sum				156.3	23.6		
Jonaprim	2021	9.0	7.2	14.09	116.3	11.5	99.3	2.2
	2020	8.9	5.5	24.09.	73.3	9.9	137.4	0.9
	2019	9.0	8.6	03.09.	65.6	7.8	111.9	62.5[1]
	2018	9.0	7.1	22.08.	9.9	1.1	117.6	0.4
	2017	9.0	2.7	01.09.	1.1	0.1	122.8	0.0
	average	9.0[a]	6.2[a]		53.2[b]	6.1[bc]	117.4[c]	14.2[ab]
	sum				266.2	28.6		
Auksis	2021	8.7	7.0	01.09.	115.1	12.0	106.3	5.5
	2020	9.0	6.8	09.09.	81.3	13.3	166.1	0.0
	2019	9.0	4.8	03.09.	20.0	3.2	164.7	74.1[1]
	2018	9.0	5.7	07.09.	19.8	3.5	181.0	0.0
	2017	8.8	3.8	05.09.	0.8	0.2	200.0	0.0
	average	8.9[ab]	5.6[ab]		47.4[ab]	6.4[bc]	155.5[ab]	17.8[a]
	sum				237.0	32.2		
Aura	2021	8.6	7.6	17.09	147.3	18.0	123.8	15.0
	2020	8.9	5.0	24.09.	62.0	12.0	191.2	1.7
	2019	9.0	6.7	17.09.	43.0	7.9	183.5	21.5[1]
	2018	9.0	2.8	03.10.	4.3	0.9	210.0	1.6
	2017	9.0	0.3	09.10.	1.0	0.1	136.0	0.0
	average	8.9[ab]	4.5[b]		51.5[ab]	7.8[ab]	177.1[a]	9.1[b]
	sum				257.6	38.9		
Ciprian	2021	8.3	5.1	06.10	87.0	7.9	91.9	24.2
	2020	8.9	6.5	07.10.	79.9	12.3	181.5	3.0
	2019	8.8	7.4	17.09.	43.0	5.7	136.8	27.7[1]
	2018	8.9	4.6	03.10.	11.6	1.9	157.6	0.0
	2017	8.6	1.8	09.10.	0.8	0.3	165.0	0.0
	average	8.7[bc]	5.1[b]		44.5[ab]	6.4[bc]	143.3[b]	13.8[ab]
	sum				222.2	28.2		
Ligol	2021	8.0	7.3	01.10.	176.0	22.1	127.0	12.5
	2020	8.9	4.0	05.10.	42.0	9.8	240.4	1.5
	2019	8.7	7.2	10.10.	44.1	9.3	210.7	44.8[1]
	2018	8.9	3.7	04.10.	17.6	3.7	211.7	1.7
	2017	8.9	5.6	09.10.	7.0	1.9	256.7	8.7
	average	8.9[c]	5.6[ab]		57.3[a]	9.4[a]	207.5[a]	13.8[ab]
	sum				286.7	46.8		

Notes: For the same parameter, cultivars marked with different letters (a, b, c) differed significantly by *Tukey HSD*; [1] - Frost and hail damage in 2019

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Table 2. Taste panel evaluation of Romanian apple cultivars in 2018-2020, compared to standard cultivars 'Auksis' and 'Ligol' (points 1-9)

Cultivar	Harvest year	Appea-rance	Taste	Sweet-ness	Acidity	Aroma	Firm-ness	Juici-ness	Crisp-ness
Auksis	2020	8.2	7.2	6.4	6.4	6.2	6.8	6.4	6.4
Auksis	2019	7.8	7.0	6.6	5.4	6.2	6.4	6.2	6.2
Auksis	2018	8.2	7.6	7.6	7.6	7.4	7.2	7.6	6.8
Auksis	**average**	**8.2**	**7.4**	**6.8**	**6.4**	**6.6**	**6.8**	**6.6**	**6.4**
Aura	2020	8.6	7.8	6.4	6.6	6.6	6.8	7.2	6.8
Aura	2019	7.8	7.0	6.6	7.0	7.2	7.6	7.4	7.2
Aura	2018	7.6	7.0	7.0	7.6	7.2	5.2	5.8	5.8
Aura	**average**	**8.0**	**7.2**	**6.6**	**6.8**	**6.6**	**6.6**	**6.8**	**6.6**
Ciprian	2020	8.2	7.8	6.8	5.0	6.6	6.6	7.0	6.6
Ciprian	2019	7.6	7.0	6.8	5.6	6.4	6.8	6.6	6.6
Ciprian	2018	8.0	7.6	8.0	7.4	7.0	7.6	7.8	7.4
Ciprian	**average**	**8.0**	**7.4**	**7.2**	**6.0**	**6.6**	**7.0**	**7.0**	**6.8**
Ligol	2020	8.6	7.8	6.6	5.4	6.2	7.4	7.8	7.6
Ligol	2019	8.2	8.0	6.8	5.6	6.6	7.8	7.8	8.0
Ligol	2018	8.4	6.6	6.4	6.4	5.8	6.4	7.8	6.6
Ligol	**average**	**8.4**	**7.4**	**6.6**	**5.8**	**6.2**	**7.2**	**7.8**	**7.4**
Jonaprim	2018	7.0	5.8	5.6	5.0	7.4	7.4	7.0	7.8
Jonaprim	2019	6.6	7.4	5.4	5.4	7.0	7.4	7.4	7.4
Jonaprim	**average**	**6.8**	**6.8**	**5.5**	**5.2**	**7.2**	**7.4**	**7.2**	**7.6**
Romus 3	2017	7.0	5.8	5.0	7.0	6.2	7.6	7.0	7.0
Romus 3	2018	7.8	7.4	6.0	6.0	7.4	7.0	7.2	7.4
Romus 3	**average**	**7.4**	**6.8**	**5.5**	**6.5**	**7.7**	**7.3**	**7.1**	**7.2**

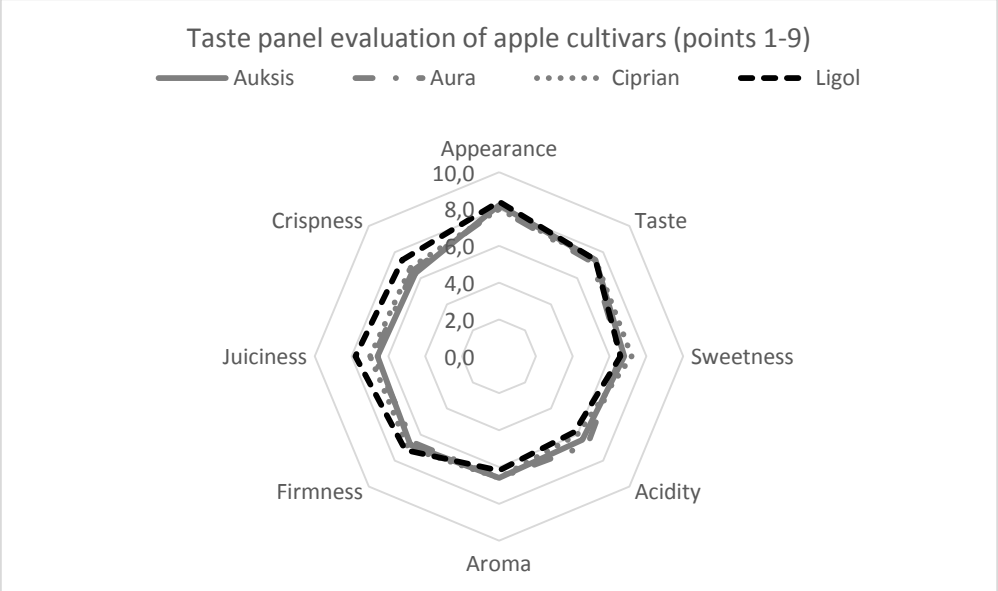

Fig. 1. Average taste panel rating of Romanian apple cultivars 'Aura' and 'Ciprian', compared to standard cultivars 'Auksis' and 'Ligol' (3-year data)