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PERFORMANCE OF DIFFERENT APPLE CULTIVARS IN A YOUNG HIGH DENSITY ORCHARD

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The aim of the study was to evaluate the suitability of rootstock and cultivar combinations for high density orchards in northern climate conditions like in Latvia. In 2009, a trial was established with rootstocks M.9 and B.396 in combination with seven cultivars. The density of trees reached 2500 trees per 1 ha. The yields and the observed yield efficiency of all cultivars during the first four production years were larger on rootstock B.396. Also, average trunk diameter was slightly larger on this rootstock. On both rootstocks cultivars, 'Gita' and 'Ligol' had larger part of total yield formed on previous year shoots. These cultivars had more vigorous trunks as well. In the orchard at the given density, on both rootstocks thinner trunks and smaller yields were observed for cultivars with poor branching, like 'White Transparent' and 'Konfetnoye'. 'Rubin' (Kazakh cv.) had low yield, this cultivar produces very large fruits on the ends of shoots. Lower average yields were also obtained for cultivars that produce fruits on spurs of older branch sections, like 'Antei' and 'Kovalenkovskoye'. Summer cultivar 'Konfetnoye' had relatively smaller fruits. Rootstock B.396 and scab resistant cultivar 'Gita' showed best performance in the high density orchard.

Key words: Malus, *rootstocks, yield, biennial bearing, trunk, yield efficiency.*

INTRODUCTION

From the economical point of view, technologies facilitating high productivity are recommended in orchards. This can be achieved by choosing cultivars with early beginning of production and high productivity, disease resistance and suitability to local conditions, and by using dwarf rootstocks in higher density orchards. Some studies have shown that high density orchards can both provide large yields at the beginning and maintain high potential of productivity at full harvest during later periods (Robinson and Hoying, 2011; Stehr, 2011). At the same time, the optimum planting density strongly depends on economical factors; in some apple production regions it is considered that the optimum density is 2500–3300 trees per ha (Robinson, 2007; Robinson and Hoying, 2011) for apple trees on dwarf rootstocks.

In order to ensure high potential production, trees with narrow canopy must be formed in high density apple orchards. The narrow canopies provide better light use efficiency, fruit quality and efficiency of plant protection means (Palmer, 2011). At the same time the tree height depends on permissible shading. It is estimated that if tree height exceeds 90% of the distance between tree rows, fruit quality decreases in the lower part of the canopy (Robinson and Hoying, 2011). In Latvia (56°N), taking into account the height of sun above the horizon (calculating optimum height by dividing distance between rows and adding one metre to the result), the tree height should not exceed 70–80% of the distance between rows, using the given technology. With distance of 4 m between rows, the least shaded tree height should not exceed 3 m (75%), taking into consideration the optimal row direction (North to South).

Dwarf apple rootstocks should be used to establish high density orchards. One of the most used dwarf apple rootstocks in Latvia is B.396, while M.9 is not recommended to farmers due to its low winter-hardiness (Skrivele *et al.*, 2011).

Suitability of cultivar and rootstock combinations in high density orchards has not been evaluated sufficiently. In Latvia, cultivars of various origin, which are suitable to local conditions, are commercially exploited. Belarusian apple cultivars occupy a significant part (about 10%) of new apple plantings in Latvia — 'Antei' and 'Kovalenkovskoye' rank 4^{th}–5^{th} place (4% area) and 7^{th} place 2% (area) among the 10 most popular cultivars (Skrivele *et al.*, 2008), and their fruits are often sold at supermarkets. Observations and questioning of fruit growers in Latvia have shown the characteristic traits and problems of these cultivars:

'Antei' is easy in training, productive and has large fruits with long storage, but the fruits may have bitter pit and insufficiently bright colour. In some locations cancer susceptibility has been observed (Skrīvele and Ikase, 2013; Kozlovskaya and Samus, 2015).

'Kovalenkovskoye' is a cultivar with high adaptability — growing well almost at any location (Skrīvele and Ikase, 2013; Kozlovskaya and Samus, 2015). The crown tends to become too dense, but the tree shape is good, with wide branching angles. Fruits are without acidity and should best be sold and consumed directly off-tree, as flavour becomes bland in storage, and the fruit look becomes poorer over time.

'Gita' is a new cultivar and it is resistant to scab (contains gene *Rvi6*), with rather good tolerance to mildew and other diseases (Ikase and Dumbravs, 2004; Skrīvele and Ikase, 2013). It is an autumn cultivar with storage till December – January in normal atmosphere cooling chambers. The tree is very productive with regular yields and forms a wide, low crown. Fruits are large, with red blush and stripes, subacid, very juicy and crisp.

These cultivars are valued for their ecological adaptability and less need for intense care, and for this reason they are increasingly planted in organic orchards.

In commercial plantations some cultivars developed in Poland have become very popular (Przybyla *et al.*, 2009; Ikase and Lācis, 2013; Skrīvele and Ikase, 2013). However, their suitability must be evaluated taking into account characteristics that are not related just to their productivity — first of all, winter-hardiness in Latvia.

The aim of this trial was to evaluate the cultivar and rootstock combination suitability in high density conditions.

MATERIALS AND METHODS

The trial was established in 2009 at the Institute of Horticulture, Dobele, Latvia (56°37′N 23°16′E). One-year whips of cultivars 'White Transparent' ('Baltais Dzidrais', 'Transparente Blanche'), 'Konfetnoye', 'Kovalenkovskoye', 'Ligol', 'Rubin' (Kazakh cv.), 'Antei', and a new Latvian cultivar 'Gita' (Ikase and Dumbravs, 2004; Skrivele *et al.*, 2008; Ikase and Lācis, 2013; Kazlouskaya, 2013; Skrīvele and Ikase, 2013; Kozlovskaya and Samus, 2015) were planted on dwarf rootstocks B.396 (winterhardy) and M.9 (less winterhardy) at distances 1 × 4 m (2500 trees per ha), using a split-plot design with four replications and arranging the cultivars randomly and rootstocks in separate rows.

The trees were trained as slender spindle. Integrated plant protection and standard cultivation methods were applied, including irrigation. In the first years tree growth, branching and rooting were promoted by tree training and removing flowers and fruitlets.

The meteorological data were collected by a "Luft" meteo station at the Institute. The weather conditions were very variable from year to year, particularly the amount of precipitation, which in 2015 was only 387 mm, but in 2010 — 793 mm. During the vegetation period (May to September) precipitation was only 226 mm in 2015, but was 648 mm in 2010. In the period of the experiment, the positive temperature sum was from 2507 ^{o}C in 2015 to 3155 ^{o}C in 2010. The lowest air temperature was noted in February 2012 (–28.3 ^{o}C), the highest in August 2013 (33.9 ^{o}C). During the dormancy period of fruit trees temperature fluctuations were observed, like in February of 2012 when low temperatures occurred along with a thaw to 6.9 ^{o}C. In that year March and April had the following temperature range: from –10.9 ^{o}C to 15.0 ^{o}C and from –9.0 ^{o}C to 20.9 ^{o}C respectively.

The following measurements were collected: yield per tree (kg), number of fruits, trunk diameter (cm) at the end of the vegetation period 20 cm above graft union. Tree growth was determined by calculating trunk cross sectional area (TCSA) and its increase (cm^2). The mean one fruit mass (g) was calculated by weighing a part of yield (a constant volume) from a tree and dividing by the number of fruits per volume (harvest bin). Yield efficiency was calculated as a relation of cumulative yield to trunk cross sectional area (kg·cm^{-2}). The index of biennial bearing (index of alternance (I)) was calculated as the difference of two yields divided by sum of two yields, in two subsequent years (Skrivele *et al.*, 2000). Productivity (t·ha^{-1}) was calculated taking into account tree density per hectare.

SPSS for Windows was used for statistical analysis of data by ANOVA and Pearson bivariate correlation.

RESULTS

At the beginning of the study, growth and canopy development of apple trees were promoted by tree training and removing flowers and fruitlets. In the fourth growing year (2012), the largest yields on rootstock B.396 were obtained for 'Ligol' (calculated yield 17.5 t·ha^{-1}), and on M.9 for 'Gita' (Table 1). The difference was significant ($p < 0.05$) when comparing 'Ligol' to other cultivars. There was no significant interaction effect between rootstock and cultivar on yield. In that year the obtained average yield on rootstock M.9 was significantly ($p < 0.05$) larger in comparison with B.396. 'Antei' and 'Rubin' had significantly smaller yields.

In 2013, yield on M.9 was slightly lower in average than before. On both rootstocks 'Gita' was more productive (Table 1). In this year significant interaction between cultivar and rootstock was found. Almost all cultivars had larger yields on rootstock B.396.

In 2014, all cultivars had higher yield than in previous seasons. Cultivars which were more productive in previous years had significant increases in production. Also 'Antei' and 'Rubin', which were less productive in previous seasons had a very pronounced increase in productivity in 2014. The summer cultivar 'Kovalenkovskoye' had a similar yield to 'Antei' and 'Rubin' (Table 1). The other summer cultivars — 'White Transparent' and 'Konfetnoye' had significantly lower yields; however, if compared to previous seasons, their yields increased.

Table 1

YIELD PERFORMANCE OF CULTIVARS AND ROOTSTOCK COMBINATIONS

Rootstock / Cultivar	Yield per tree, kg				Cumulative yield (2012–2015), kg per tree	Average yield (2012–2015), t·ha^{-1}
	2012	2013	2014	2015		
Rootstock B.396						
White Transparent	4.2^{b}	3.6^{b}	7.1^{c}	4.7^{cd}	19.6^{c}	12.3^{c}
Konfetnoye	2.1^{bc}	5.3^{b}	6.1^{c}	8.2^{bc}	21.7^{bc}	13.6^{bc}
Kovalenkovskoye	4.7^{b}	3.9^{b}	11.0^{b}	9.3^{bc}	28.9^{b}	18.1^{b}
Rubin	1.5^{c}	3.5^{b}	13.0^{b}	3.4^{d}	21.4^{c}	13.4^{c}
Gita	4.1^{ab}	5.8^{a}	20.9^{a}	15.8^{a}	46.6^{a}	29.1^{a}
Ligol	7.0^{a}	2.0^{b}	23.1^{a}	12.3^{b}	44.4^{a}	27.8^{a}
Antei	1.3^{c}	0.9^{c}	16.4^{b}	3.4^{d}	22.0^{b}	13.8^{b}
Average for rootstock	*3.6^{B}*	*3.6^{A}*	*13.9^{A}*	*8.1^{A}*	*29.2^{A}*	*18.3^{A}*
Rootstock M.9						
White Transparent	4.2^{b}	2.0^{b}	6.3^{c}	2.2^{cd}	14.7^{c}	9.2^{c}
Konfetnoye	4.6^{bc}	3.0^{a}	4.9^{c}	6.5^{b}	19.0^{bc}	11.9^{bc}
Kovalenkovskoye	5.1^{b}	1.2^{c}	11.2^{b}	0.4^{d}	17.9^{b}	11.2^{b}
Rubin	2.0^{c}	2.1^{b}	10.1^{b}	2.1^{cd}	16.3^{c}	10.2^{c}
Gita	6.4^{ab}	3.0^{a}	17.3^{a}	16.1^{a}	42.8^{a}	26.7^{a}
Ligol	6.5^{a}	2.6^{b}	18.4^{a}	2.9^{cd}	30.4^{a}	19.0^{a}
Antei	1.6^{c}	2.5^{b}	10.5^{b}	2.6^{cd}	17.2^{b}	10.7^{b}
Average for rootstock	*4.3^{A}*	*2.3^{B}*	*11.2^{B}*	*4.7^{B}*	*22.5^{B}*	*14.1^{B}*

a, b, c and d — marked statistically significant ($p < 0.05$) different groups of cultivar data within rootstock

A and B — marked statistically significant ($p < 0.05$) different groups of rootstock data

In 2015, the yield was relatively low; however, the average yield of all cultivars was almost twice larger on rootstock B.396 than on M.9 (Table 1). The most productive cultivar 'Gita' had only slightly lower yield compared to the previous season; consequently this cultivar tends to be productive every year. At the same time, 'Ligol' which had been so far the most productive cultivar, had significantly decreased production, especially on rootstock M.9. Also other cultivars indicated tendency to have a more biennial bearing on rootstock M.9 (Table 2). Statistically significant ($p < 0.05$) interaction of rootstock and cultivar combinations was also observed. On rootstock B.396 'White Transparent', 'Rubin' and 'Antei' were less productive in 2015. On rootstock M.9 'White Transparent', 'Kovalenkovskoye', 'Rubin', 'Ligol' and 'Antei' (Table 1) were less productive in 2015. 'Ligol' had the second largest yield on rootstock B.396, productivity reached 30 t·ha^{-1}.

Effect of rootstock and cultivar was detected also for index of biennial bearing (Table 2). This index was smaller on rootstock B.396. On both rootstocks 'Gita' had significantly smaller index of biennial bearing comparing with other cultivars, because it was able to develop fruits on 1-year-old shoots. On rootstock B.396 cultivars 'Rubin', 'Ligol' and 'Antei' had a very pronounced effect of biennial bearing, also on rootstock M.9 cultivar 'Kovalenkovskoye' had such effect. Yet among all summer cultivars 'Konfetnoye' had the lowest index of biennial bearing.

The rootstocks had significant ($p < 0.05$) effect on the cumulative yield of four years. The largest cumulative yield was obtained on rootstock B.396 (Table 1). On both rootstocks the highest average yields were obtained for cultivars 'Gita' and 'Ligol' (19.0 to 29.1 t·ha^{-1}). Lower yields were obtained for the summer cultivars especially 'White Transparent', and also 'Rubin'.

Fruit size was determined for all cultivars, as well as the number of fruits per tree and their correlation ($r = –0.24$ in 2013). 'Rubin' had significantly ($p < 0.05$) larger fruits compared to 'White Transparent', 'Konfetnoye' and 'Kovalenkovskoye' (Table 3). 'Konfetnoye' had the smallest fruits. During the period of canopy development and growth filling space, a slight tendency was observed to develop slightly larger fruits on trees that had stronger growth (larger TCSA). In some cases TCSA affected yield. The coefficients of correlations of average fruit weight and TCSA in 2012 and 2013 were, respectively, 0.26 and 0.33 ($p < 0.05$).

The difference of trunk cross-sectional areas (TCSA) between rootstocks was significant ($p < 0.05$). On rootstock B.396 the trees had a little stronger trunk. No significant difference between the two rootstocks was found for increase of TCSA if calculated as average of all cultivars, but differences between cultivars were significant (Table 2). It was found that the cultivars 'Gita' and 'Ligol' on both rootstocks had the largest TCSA while other cultivars had significantly lower TCSA. Cultivar 'Konfetnoye' had the thinnest trunks compared to other cultivars, and this in some conditions can influence the size of fruits. In 2015, cultivars 'Kovalenkovskoye' and 'Ligol' on rootstock B.396 had sig-

Table 2

GROWTH, YIELD EFFICIENCY AND BIENNIAL YIELDING OF APPLE CULTIVARS ON ROOTSTOCKS B.396 AND M.9

Rootstocks / cultivars	Trunk cross-sectional area (2015), cm^2	Increase of trunk cross-sectional area per 7th season (2015), cm^2	Increase of trunk cross sectional area during seven years, cm^2 (2009–2015)	Cumulative yield per trunk cross sectional area (yield efficiency), $kg \cdot cm^{-2}$ (2012–2015)	Index of biennial yielding (2014–2015)
Rootstock B.396					
White Transparent	13.5^{cd}	1.7^{b}	12.8^{cd}	1.58^{cd}	0.53^{b}
Konfetnoye	12.8^{d}	1.5^{b}	12.1^{d}	1.75^{bc}	0.43^{c}
Kovalenkovskoye	17.4^{b}	3.1^{a}	16.9^{b}	2.02^{abc}	0.50^{bc}
Rubin	16.8^{bc}	2.7^{ab}	16.1^{bc}	1.19^{d}	0.81^{a}
Gita	21.4^{a}	2.0^{ab}	20.6^{a}	2.26^{ab}	0.19^{d}
Ligol	22.7^{a}	3.1^{a}	22.0^{a}	2.35^{a}	0.72^{a}
Antei	14.2^{bcd}	2.3^{ab}	13.6^{bcd}	1.68^{cd}	0.77^{a}
Average for rootstock	*17.0^{A}*	*2.3*	*16.3*	*1.81^{A}*	*0.57^{B}*
Rootstock M.9					
White Transparent	12.6^{cd}	1.5^{b}	12.3^{cd}	1.24^{cd}	0.77^{bc}
Konfetnoye	10.7^{d}	0.9^{b}	10.4^{d}	1.84^{ab}	0.66^{c}
Kovalenkovskoye	15.8^{b}	1.8^{ab}	15.4^{b}	1.28^{cd}	0.98^{a}
Rubin	14.1^{bc}	1.9^{ab}	13.5^{bc}	1.20^{d}	0.86^{a}
Gita	19.4^{a}	3.2^{a}	18.8^{a}	2.11^{a}	0.20^{d}
Ligol	22.4^{a}	3.1^{a}	21.8^{a}	1.74^{abc}	0.93^{a}
Antei	15.8^{bcd}	2.1^{ab}	15.3^{bcd}	1.57^{bcd}	0.84^{a}
Average for rootstock	*15.8^{B}*	*2.1*	*15.3*	*1.54^{B}*	*0.75^{A}*

a, b, c and d — marked statistically significant ($p < 0.05$) different groups of cultivar data within rootstock

A and B — marked statistically significant ($p < 0.05$) different groups of rootstock data

Table 3

FRUIT MASS OF CULTIVARS ON TWO DWARF ROOTSTOCKS

Cultivar	Average fruit mass, g				
	2012	2013	2014	2015	Average (min – max)
Rootstock B.396					
White Transparent	142^{c}	194^{b}	125^{c}	132^{d}	148^{c} (85 – 270)
Konfetnoye	145^{c}	169^{b}	106^{c}	87^{e}	126^{d} (54 – 291)
Kovalenkovskoye	137^{c}	184^{b}	137^{c}	136^{cd}	149^{cd} (98 – 360)
Rubin	231^{a}	298^{a}	193^{a}	189^{a}	227^{a} (132 – 520)
Gita	210^{ab}	260^{a}	171^{ab}	178^{a}	205^{b} (122 – 440)
Ligol	197^{b}	251^{a}	181^{ab}	156^{bc}	196^{b} (76 – 368)
Antei	212^{b}	284^{a}	161^{b}	158^{b}	203^{b} (107 – 407)
Average for rootstock	*182*	*234*	*153*	*148*	*179*
Rootstock M.9					
White Transparent	150^{c}	176^{b}	111^{c}	111^{d}	137^{c} (98 – 223)
Konfetnoye	143^{c}	165^{b}	108^{c}	78^{e}	124^{d} (66 – 195)
Kovalenkovskoye	140^{c}	180^{b}	105^{c}	95^{cd}	130^{cd} (87 – 206)
Rubin	229^{a}	270^{a}	201^{a}	199^{a}	225^{a} (146 – 353)
Gita	210^{ab}	249^{a}	187^{ab}	177^{a}	205^{b} (127 – 382)
Ligol	209^{b}	258^{a}	177^{ab}	126^{bc}	193^{b} (96 – 305)
Antei	193^{b}	264^{a}	143^{b}	150^{b}	188^{b} (127 – 360)
Average for rootstock	*182*	*223*	*147*	*134*	*172*

a, b, c, d and e — marked statistically significant ($p < 0.05$) different groups of cultivar data within rootstock nificantly larger increase of TCSA compared with 'White Transparent' and 'Konfetnoye'. At the same time on rootstock M.9 'Gita' and 'Ligol' had significantly larger increase of TCSA compared with 'White Transparent' and 'Konfetnoye'.

Significant differences between the rootstocks were found regarding yield efficiency (cumulative yield of four years per TCSA). Similarly as for yield and TCSA, the highest yield efficiency was found on rootstock B.396, as an average of all cultivars (Tables 1, 2). On rootstock B.396 'White Transparent', 'Rubin' and 'Antei' had significantly lower yield efficiency compared to 'Gita' and 'Ligol'. On rootstock M.9 'White Transparent', 'Rubin' and 'Kovalenkovskoye' had significantly lower yield efficiency compared to 'Gita' (determined by lower yield amount) and 'Konfetnoye' (determined by the smallest TCSA).

After seven growing years, in this study 90% of 'Konfetnoye', 'Kovalenkovskoye' and 'Gita' trees remained alive on rootstock M.9. About 31% of the cultivar 'Ligol' trees were destroyed and damaged. In comparison, on rootstock B.396 all trees remained alive for 'Konfetnoye' and 'Rubin', 97% for 'Gita', 94% — 'White Transparent', 88%— 'Ligol' and 81% 'Antei'.

DISCUSSION

In this study apple trees on rootstocks of different origins were compared in conditions of Latvia. Rootstock M.9 is known and widely used in Western Europe and outside its borders. However, due to its unsatisfactory winter-hardiness this rootstock is not recommended for fruit growing in Latvia (Skrivele *et al.*, 2011). Still, in the more favourable regions and orchard sites of Latvia some cultivars in combination with this rootstock may be used.

In this trial the vigour (TCSA) of trees on B.396 was significantly larger than on M.9 (Table 2). However, both these rootstocks generally represent the same group of rootstocks regarding their effect on tree size in the Baltics region (Kviklys, 2006; Kviklys *et al.*, 2006; Univer *et al.*, 2010; Lepsis *et al.*, 2014). In the Baltics, rootstock B.396 may be a better alternative than M.9 taking into account its winter-hardiness. Rootstock B.396 has shown good results of winter-hardiness in Belarus (Samus *et al.*, 2006; Kazlauskaya and Samus, 2011; ; Kazlauskaya, 2013), including good performance of propagation by stoolbed rooting, even compared to M.9.

After seven growing years, with different winter conditions and possibly due to the micro relief in this study, more trees remained alive for 'Konfetnoye', 'Kovalenkovskoye' and 'Gita' on rootstock M.9. 'Ligol' had the most damaged and destroyed trees. On rootstock B.396, which is known for its higher cold resistance, all trees remained alive for 'Konfetnoye' and 'Rubin', other cultivars were less damaged, too. These observations must be taken into consideration in calculating real productivity per ha and also when establishing a new orchard.

In this trial various cultivars with different ripening times, fruiting type and resistance to apple scab were included to compare their performance in dense orchards. Although the cultivar 'Ligol' is very productive and suitable for dense orchards, it has relatively low winter-hardiness, as well as poor scab resistance (Szklarz, 2004) and has biennial bearing. This cultivar had similar productivity and tendency to biennial bearing in trials in Lithuania (Uselis, 2006).

The cultivar 'Gita' had comparably good yield and is scab resistant (Ikase and Dumbravs, 2004; Skrīvele and Ikase, 2013). Also the number of healthy trees was very large, especially on B.396. This cultivar has the least pronounced biennial bearing, and it has a wide canopy. 'Gita' has perspectives for commercial growing if the storage and consumption time can be prolonged. As observed in some seasons (not in this study) the ripening of fruits can be uneven, at a certain stage of maturity ripe fruits can easily drop while other fruits are hard to pick. The harvest time of 'Gita' is similar to another wide spread and popular cultivar in Latvia — 'Auksis' (Skrivele *et al*, 2008). The increase of the share of these cultivars on one farm can create a problem in harvesting qualitative and storable yield in conditions of limited work power, because fruits of cultivar 'Auksis' also drop easily. The fruits of the cultivar 'Auksis' become mature more equally and they are easily to pick.

'Kovalenkovskoye' had the highest yield data among summer cultivars, but it is characterised by high pronounced biennial bearing, especially on rootstock M.9. The cultivar forms a very dense canopy with short fruit spurs dominating (Skrīvele and Ikase, 2013; Kozlovskaya and Samus, 2015). 'Kovalenkovskoye' has a compact branching type, which is determined by cultivar genotype.

Potentially, the widely used summer cultivar 'Konfetnoye' could be suitable for plantations with higher tree density in order to increase yield efficiency per unit of area, which is necessary due to its week vigour, characterised by TCSA of cultivar-rootstock combinations in this trial. Yet in this trial the tree vigour was affected already by the quality and size of planting material, and there was no significant difference between rootstocks for increase of TCSA (Table 2).

Cultivar 'Rubin' develops fruits at the end of longer shoots. Its suitability for high density orchards must be investigated in regard to facilitating short spur development by methods of canopy training that decrease development of blind wood. Large yields can be reached by increasing the number of fruits per tree. Excessively large fruits are observed at low yield conditions, when fruit weight exceeds even 500 g (Table 3). Canopy training can be used to increase fruit number and decrease their size. As a result fruit damage during storage time caused by soft scald can be decreased.

In Latvian commercial orchards the widely used cultivar 'Antei' is characterised by a slow increase of yield capacity, that is predicted by the fruiting type of the cultivar, e.g. development of yield on older wood (Kozlovskaya and Samus, 2015). Biennial bearing of this cultivar was observed. Fruit size was variable and effected by the obtained yield (Tables 1 and 3). Investigation of 'Antei' in such dense planting conditions should be continued to determine the stability of yielding, necessity to renew canopy, as well as decreasing the biennial bearing. Therefore, stability of yield of this cultivar must be provided, with enough fruits each year. The fruits of 'Antei' frequently can be damaged by a bitter pit, which occurs at low yield conditions. This must be managed by decreasing the amount of fruits damaged by bitter pit by promoting large and stable yields with a large number of fruits with optimal size.

The cultivar 'White Transparent' on dwarf rootstocks has a relatively wide canopy with weak branching. It is also known for its susceptibility to apple scab, which decreases suitability for dense orchards.

It can be concluded that the yields and yield efficiencies of all cultivars during the first four production years were larger on rootstock B.396. On both rootstocks intensive type cultivars like 'Gita' and 'Ligol' the form fruits on 1-year-old shoots had larger total yield. In such dense orchard on both rootstocks thinner trunks and smaller yields were obtained for cultivars with poor branching like 'White Transparent' and 'Konfetnoye'. 'Rubin', which produces fruits at the end of shoots and forms large fruits, had small yields. Smaller yields were also obtained for cultivars that produce fruits on fruiting twigs (spurs) of older branch sections like 'Antei' and 'Kovalenkovskoye'. The study conducted in the young high density orchard showed better performance of rootstock B.396 and scab resistant cultivar 'Gita'.

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DAŽĀDU ĀBEĻU ŠĶIRŅU VĒRTĒJUMS JAUNĀ, SABIEZINĀTĀ DĀRZĀ

Pētījuma mērķis bija izvērtēt šķirņu un potcelmu × šķirņu kombināciju piemērotību augļu dārzam ar lielu koku blīvumu Latvijas apstākļos. Izmēģinājums stādīts 2009. gada pavasarī, izmantojot potcelmus M.9 un B.396, kā arī septiņas šķirnes. Koku blīvums, ievērojot stādīšanas attālumus, sasniedz 2500 uz 1 ha. Visām šķirnēm gan raža, gan ražošanas efektivitāte lielāka iegūta uz potcelma B.396 četru ražas gadu laikā. Arī vidējais stumbra šķērsgriezuma laukums uz šī potcelma bija nedaudz lielāks. Uz abiem potcelmiem kopējā raža bija lielāka intensīva tipa šķirnēm, kā 'Ligol' un 'Gita', kas to veido uz iepriekšējā gada dzinumiem. Šīm šķirnēm bija arī lielāks stumbra šķērsgriezuma laukums. Šādā blīvā dārzā uz abiem potcelmiem tievāki stumbri un mazākas ražas iegūtas šķirnēm, kas sliktāk zarojas, kā 'Baltais Dzidrais' un 'Konfetnoje'; šķirnēm, kuras ražu veido dzinumu galos, kā lieaugļainai šķirnei 'Rubīns' (Kazahija); šķirnēm, kas ražo veido uz vecākas zaru daļas, kā 'Antejs' un 'Kovaļenkovskoje'. Vasaras šķirnei 'Konfetnoje' tika iegūti salīdzinoši mazi augļi. Jaunā, sabiezinātā dārzā labākus rezultātus nodrošināja ābeles uz potcelma B.396 un kraupja izturīgā šķirne 'Gita'.