BUDAPESTI CORVINUS EGYETEM
Kertészettudományi Kar

EVALUATING APPLE ROOTSTOCKS IN TWO TRAINING SYSTEMS IN THE „NYÍRSÉG” GROWING AREA

ABSTRACT OF THE DOCTORAL THESIS

Takács Ferenc

Budapest, 2009

PhD School Name: Doctoral School of Horticultural Sciences

Field: Crop Sciences and Horticulture

Head of Ph.D. School: Prof. Dr. Magdolna Tóth
Doctor of the Hungarian Academy of Sciences
Head of Department of Fruit Sciences
CORVINUS UNIVERSITY OF BUDAPEST,
Faculty of Horticultural Sciences

Supervisor: Prof. Dr. Károly Hrotkó
Doctor of the Hungarian Academy of Sciences
CORVINUS UNIVERSITY OF BUDAPEST,
Faculty of Horticultural Sciences
Department of Floriculture and Dendrology

The applicant met the requirement of the PhD regulations of the Corvinus University of Budapest and the thesis is accepted for the defence process.

....
Head of Ph.D. School

....
Supervisor

1. PRECEDENTS AND AIMS SET

The most important fruit species of the temperate zone is the apple (*Malus Xdomestica* Borkh.). Apple production is constantly increasing both in the world and Hungary, resulting in deepened competition.

The agroecological conditions of Hungary are favourable for apple production. Apple is a major crop in our fruit growing, it represents more than 50% share of the total fruit production. However, similarly to other sectors of the Hungarian economy, it is in crisis. Production volume decreased by half during the last 10-15 years. There is only one way out of the crisis: quality fruit production in new, modern apple orchards. One of the greatest achievement of our times is the elaboration and generalization of the training systems of high density orchards. The definition of training system in the Hungarian and foreign literature is diverse. This is due to the changeability of the standard of fruit production and of the economical, political and cultivation aims typical for the different era. According to VÍG (1982) training systems are the central subject of the debate for fruit growers, and especially for apple growers. In my opinion this statement is true to a greater extent these days.

In the modern orchards rootstocks play a more and more important role in regulating the fruiting area, shoot growth, spurring and cropping of different training systems and canopy forms. However, the establishment of intensive orchards applying new production technology is greatly hindered by the lack of capital, and by the different opinion of the professional institutions on the directions of the development.

Despite these difficulties the changes in apple production during the last couple of decades had essentially changed our thinking concerning rootstock usage and training systems. To increase the yield per growing area and to enhance the effectiveness of labour, growers generally tend to increase the density of orchards. As rootstocks are one of the most important factors in the ecological adaptation of the scion cultivars, our basic task is to investigate the performance of the state licensed cultivars grafted on different rootstocks.

These days only 1-2 rootstocks of each vigour category are used in the Hungarian apple production. Of the dwarfing rootstocks the M.9, of the semi-dwarf rootstocks the M.26, and of the moderate vigour stocks the MM.106 are the dominant. The governmental subsidies starting in the mid 1990's gave the Hungarian apple production momentum. New orchards had been planted with new cultivars, utilizing new production techniques. However, the new methods were often introduced without domestic testing and adaptation, resulting in early removal of lots of orchards, and underutilization of governmental funds. The advisors had been taking a great risk when trying to show the direction to the growers willing to plant new orchards. The elaboration of training systems that suit the conditions of the region had become of primary importance. Therefore the main aims of this thesis with taking the North-East Hungarian region's agroecological conditions into consideration, were the testing of rootstocks with different vigour, getting to know their growing and cropping characteristics to provide useful help for orchards to be planted in the future concerning production technology. The wider selection of rootstocks may facilitate the elimination of adverse effects of frequent weather extremities in our region.

During the establishment of the field trials, data recording and evaluation the following were of primary importance:

1. Determining certain elements of vegetative performance an cropping for two scion cultivars ('Jonathan Csány 1' and 'Sampion') planted at different tree spacing.
2. Determining the relative order of the investigated rootstocks according to their vigour on two scion cultivars ('Jonathan Csány 1' and 'Sampion') in the "Nyírség" region.

3. Comparing the cultivar specific effects of rootstocks with different vigour to maximalize yields.
4. To provide absolute and specific indices that are effective and may serve commercial fruit production in choosing the right rootstocks for new orchards.
5. Region-specific determination of certain elements of two training systems (slender spindle and vertical axis).

2. MATERIALS AND METHODS

2.1. Trial site, geographical conditions of the area

The trial and assessments were carried out on eight consecutive years between 2001 and 2008 at the Research and Extension Centre for Fruitgrowing, Újfehértó, North-East Hungary in a cultivar-rootstock trial orchard. The site of the trial orchard is flat, situated 115 m above sea level, 20 km South-West to Nyíregyháza. It belongs to the geographical unit of "Nyírség" and is described by terrain and soil conditions typical of the "Nyírség" region.

2.2. Planting material of the orchard, trial establishment

The trial orchard was planted in September 2001. Planting material was hand-grafted in February 2001, grown in pots until August to obtain standard sized one year old whips. We evaluated the combination of 2 scion cultivars ('Jonathan Csány 1' and 'Sampion') and 8 rootstocks (M.9 T 337, M.9 Burgmer 984, Jork 9, B.9, M.26, MM.106, MM.111 and B.118), at 4 tree spacings per combination (3.6 × 0.75-1.5 m; 4.5 × 1.0-1.75) at growing area according to the vigour of the rootstocks. The orchard was treated according to integrated plant protection (IPM), irrigation and fertilization according to local conditions, dosages and timings based on commercial practices. No fruit thinning was applied. Orchard floor management under grass after planting.

Different training systems were planted to separate blocks, and within both block the rootstock-tree spacing variants in divided plots. One plot contained 4 trees, number of replications was 5. The required number of nursery trees was 5×4 trees = 20 trees per rootstock, which were investigated in 4 tree spacing, that is 80 trees. The same trees were evaluated during the 8 years of the experiment.

The trial orchard was established with two scion cultivars: 'Jonathan Csány 1' and 'Sampion'. We had chosen them, because 'Jonathan' is still an important cultivar in Hungary, it's share was 46.7% according to the statistical record of 2001 (SZABÓ, 2006), although the majority of the 'Jonathan' orchards are 30-40 years old. It's share is only 6% in the new plantations. The 'Jonathan' group of cultivars, probably due to their dominant role in the orchards, and their harmonic taste had become an etalon and are still popular in the domestic market. In our opinion, new orchards may contain 8-10% 'Jonathans'.

At the time of planning the experimental orchard 'Sampion' was a very promising variety. At that time we thought it would play a more important role in the orchards to be planted in our region, as it has excellent characteristics and taste. Moreover it's appearance suits the needs of the domestic consumers and it's production technological properties are also favourable (tolerant to apple scab).

As the domestic and foreign literature does not contain enough experience concerning the performance of these scion cultivars grafted on dwarfing rootstocks, we decided to investigate the characteristics of 'Jonathan Csány 1' and 'Sampion' grafted on different rootstocks in our region.

2.3. Data of field assessments and their calculated values

To facilitate the practical understanding of the research results we grouped the recorded data and indices calculated from them into three categories: 1) vegetative performance, 2) reproductive performance, 3) specific indices. The recording and calculation of different indices is the following.

2.3.1. Indices to describe vegetative performance

Trunk circumference (TK):

Trunk circumference was measured with a "taylors' tape" after harvest during autumn, 60 cm above ground level at 0.1 resolution, expressed in *centimetres*.

Trunk cross-sectional area (TT):

This index was calculated from the measured value of TK, using the following formula, at 0.1 resolution, expressed in cm^2.

$TT = (TK/2\pi)^2 \times \pi$ [cm^2]

Canopy width (KSz):

We recorded during the measurement of the previous two indices two variant of this index: *perpendicular to the tree row (KSz_m)* and *parallel to the tree row (KSz_i) canopy width*.

Canopy height (KM):

To calculate canopy height we measured tree height *(FM)* in the autumn after the end of shoot growth with a measure bar. The deducting trunk height *(TM)* we had canopy height. Resolution 0.01, expressed in *metres*. So the initial measured data were:

Trunk height (TM):

Measured with tape in the autumn after harvest, we measured the distance of the ground and the first lateral branch. Resolution 0.01, expressed in *metres*.

Tree height (FM):

Tree height was also measured in the autumn after the end of shoot growth with a measure bar. Resolution 0.01, expressed in *metres.*

Under-canopy area (LTr):

This index describes the occupied area of individual trees, it's value calculated using the following formula:

$LTr = ((KSz_i+KSz_m)/4)^2 \times \pi$[$cm^2$]

Canopy volume (LT):

Canopy volume was calculated for each tree using the Silberiesen-Scherr formula (SILBERIESEN and SCHERR, 1968) from *TM, FM* and *LTr* according to the following[1]:

LT=(LTr×KM)/2 [cm^3]

[1] calculating canopy volume the shape of the canopy was considered as a regular cone.

Weight of pruning wood (Ny):

The weight of pruning wood was measured during winter pruning, measuring the weight of cut branches, twigs and shoots with a digital scale at a resolution of 0.1 g.

2.3.2. Indices to describe generative performance

Crop (TMe):

Values for individual trees were measured during harvest with a digital scale at a resolution of 0.1 g.

Alternate bearing index (AI):

This index expresses the susceptibility of the given cultivar to alternate bearing. The value of the index is between 0 and 1. Value 0 means no alternance, the cultivar is producing the same crops year after year. Value 1 represents full alternance, that is high crop in one year, no apples of the trees the next year. From a practical viewpoint lower values are more favourable. The calculation of the unitless index according to RACSKÓ (2008) is done using the following formula:

$AI= 1/(n-1)\times\{|(a_2-a_1)| / (a_2+a_1) + |(a_3-a_2)| (a_3+a_2) \ldots + |(a_{(n)}-a_{(n-1)})| / a_{(n)}+a_{(n-1)})\}$

where: n = number of years

$a_1, a_2, \ldots, a_{(n-1)}, a_n$ = crop of the given year [kg/tree]

The scion-rootstock combinations' susceptibility to alternate bearing according to training systems was grouped based on the calculated value of the Alternate bearing index (AI). The intervals for each alternance groups can be found in *Table 2.1*.

Table 2.1. *Susceptibility of the rootstock-scion and training systems combinations to alternate bearing according to the calculated value of Alternate bearing index (AI)* (RACSKÓ, 2008)

Alternance groups	AI value
Not susceptible	<0.26
Medium alternance	0.26 – 0.50
Susceptible to alternance	0.51 – 0.75
High alternance	0.75<

2.3.3 Specific performance indices

Crop per trunk cross-sectional area (TKT):

This index – just like the following two – is calculated to evaluate cropping efficiency. The index is the quotient of *TMe* and *TT*. It's unit is kg/cm^2, resolution 0.1.

Crop per canopy volume (KTT):

This specific index is the quotient of *TMe* and *LT*, measurement unit is kg/m^3, resolution 0.1.

Crop per under-canopy area (KTeT):

This specific index is the quotient of *TMe* and *LTr*, measurement unit is kg/m^2, resolution 0.1.

Canopy coverage index (KBi):

The canopy coverage index is the quotient of under-canopy area and growing area (CHAIN, 1970).

2.4. Methods of data processing and evaluation

Data recordings were carried out taking into consideration reproducibleness and accuracy. Data processing and evaluation was done with computer software.

The statistical evaluation of the recorded data was carried out with SAS (version 6.12, SAS Institute, Cary, NC, USA) statistical analytical program and with SPSS 12.0 program package. The applied procedures were the ‘Mixed procedure’ (*randomized-complete-block-split-plot design*), and one-way variance analysis ad regression analysis. The investigated two scion cultivars (‘Jonathan Csány 1’ and ‘Sampion’) and two training systems were treated individually during statistical evaluation. In case of each recorded indices the significant differences between the rootstocks in each year were calculated according to Tukey’s HSD (P=0.05).

3. RESULTS

3.1. Evaluating vegetative performance

Three growth had been characterised by data connected to trunk thickening (trunk circumference (cm), trunk cross sectional area (cm^2)) for decades. Moreover some researchers complement these tree growth data with canopy dimensions, too (under-canopy area, canopy volume) (HROTKÓ, 1999). Rootstock influence on tree growth are characterized by these data (SADOWSKI et al., 1999; HROTKÓ, 1999; WEBSTER, 1997). During our investigation we described two scion cultivars (‘Jonathan Csány 1’ and ‘Sampion’) on eight rootstocks in two training systems with the above mentioned parameters.

Analyzing the increase of trunk girth we pointed out, that tree spacing in the row had no statistically proven influence on the growth of the trunk girth of the scion cultivars, but the different rootstocks had a great influence on this parameter.

Analysing Fig. 3.1. we can conclude, that there is no linear correlation between tree spacing and the increase of trunk cross-sectional area, so increasing tree spacing within the row is not followed by a linear increase of trunk cross-sectional area. It contradicts the findings of several Hungarian and foreign researchers (MIKA and KRAWIEC, 1999), however, according to HROTKÓ et al. (1995) tree spacing within the row has no influence on the growth and cropping of the trees. According to our observations, the differences in trunk girth increase are unambiguously attributed to rootstock effect. However, there were great differences between the two training systems. It was clearly visible, that the trunk girth increase on the medium vigorous rootstocks of the vertical axis training system was higher, than on the dwarfing stocks of slender spindle trees.

However, the differences between the different rootstocks are evident. There was a significant difference between the investigated rootstocks in almost every year. According to HROTKÓ (2002) the increase of trunk girth in intensive orchards is continuous, even in case of limited canopy growth due to pruning, so trunk girth is still increasing even after the canopies of the trees filled up available space, so trunk girth increase is a important index of tree vigour.

According to the results it became evident, that in case of the investigated scion cultivars (‘Jonathan Csány 1’ and ‘Sampion’), due to their different vigour, not only the classification of rootstocks, but the scion cultivars is necessary according to their vigour. Data of the two cultivars show (Fig. 3.2), that differences in vegetative growth are revealed in the early years after planting and become more pronounced each year.

According to these observations ‘Jonathan Csány 1’ can be described as a medium vigorous cultivar, while ‘Sampion’ is of weak vigour.

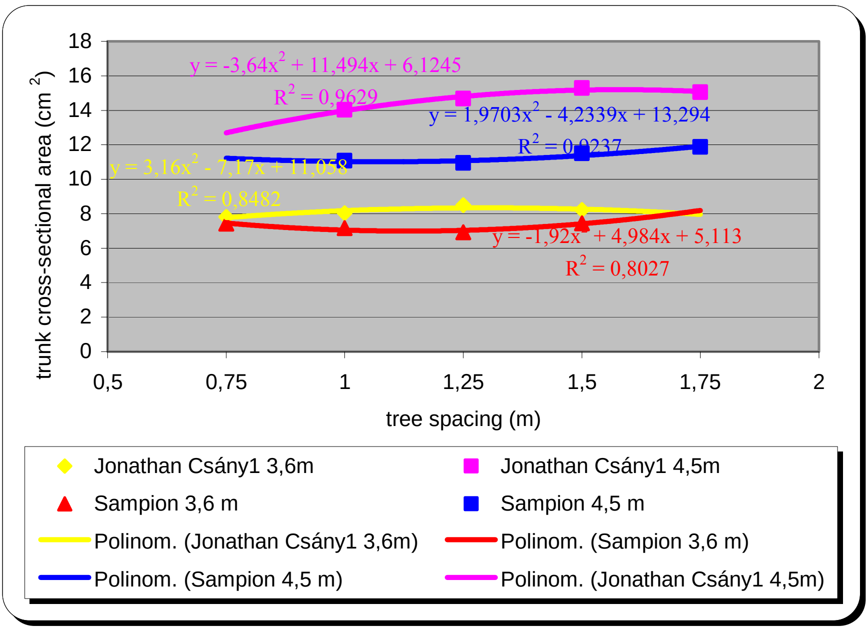

Fig. 3.1. *Increase of trunk cross-sectional area of* ‘Jonathan Csány 1’ *and* ‘Sampion’ *trees planted at different row spacing as function of tree spacing within the row (2007)*

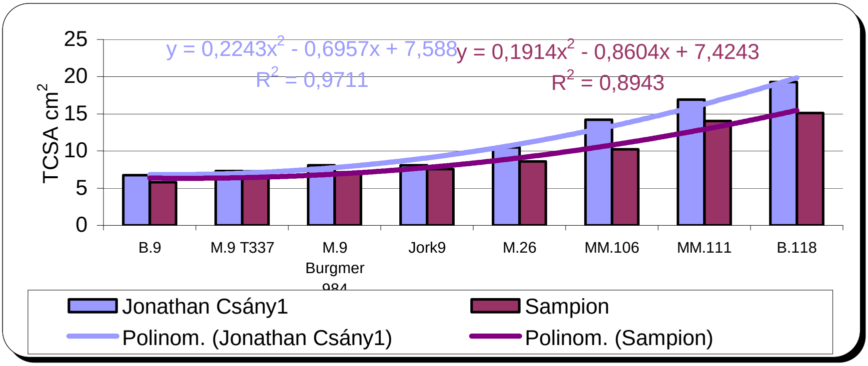

***Fig. 3.2.** Influence of different rootstocks on the trunk cross-sectional area of* 'Jonathan Csány 1' *and* 'Sampion' *trees (2007)*

According to these observations 'Jonathan Csány 1' can be described as a medium vigorous cultivar, while 'Sampion' is of weak vigour. In case of 'Jonathan Csány 1' it agrees with our knowledge of this cultivar so far (G. TÓTH, 2001; SZABÓ, 2004; SOLTÉSZ and SZABÓ, 1998), but cv. 'Sampion' was described by G. TÓTH (2001), SOLTÉSZ and SZABÓ (1998) and SZABÓ (2004) as a medium vigorous cultivar, too. The information are necessary not only for choosing the right rootstock-scion combinations, but for determining cultivar and growing site specific planting distances.

Figure 3.3. describes the relative vigour of the rootstocks. According to the recorded data the relative vigour order of the investigated rootstocks is: B.9, M.9 T 337, M.9 Burgmer 984, Jork 9, M.26, MM.106, MM.111, B.118.

Based on these findings we can group the investigated rootstocks into these significantly separable categories:

1. Weak or dwarfing rootstocks:
   - B.9
   - M.9 T 337
   - M.9 Burgmer 984
   - Jork 9

2. Semi-dwarfing rootstocks:

   – M.26

3. Medium vigorous rootstocks:

   – MM.106
   – MM.111
   – B.118

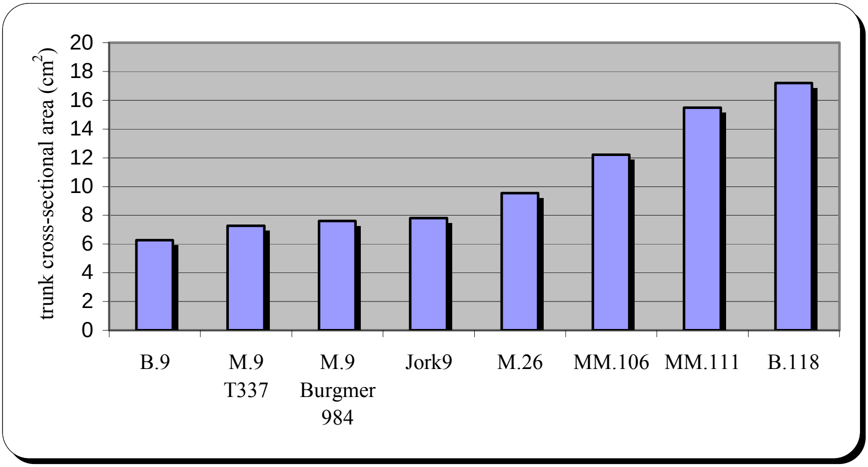

Fig. 3.3. *The relative order of rootstocks according to their vigour based on trunk cross-sectional area.*

According to literature data the weak vigour of B.9 is surprising, as WEBSTER and WERTHEIM (2003) described it having vigour between M.9 and M.26.

In our experiments canopy volume was greatly influenced by rootstock groups and by individual rootstocks in each group, but due to the young age of trees planting density had no significant influence on this parameter. In the dwarfing group of rootstocks, trees on M.26 and Jork 9 had the biggest canopy volume, irrespective of tree spacing, while in the medium vigorous group MM.111 and B.118. The order of rootstocks according to canopy volume is the same as their order based on trunk cross-sectional area. (Fig. 3.3, Fig. 3.5).

The distinct difference between the two training systems is clearly visible (Fig. 3.4). While canopy volume of the slender spindle trees is less than 1.5 m^3, this value is sometimes higher than 2.0 m^3 in case of vertical axis training system. Planting density has no considerable influence on canopy volume in case of slender spindle training system. In case of vertical axis we measured the biggest canopy volume at 4.5×1.5 m planting distance each year, other tree spacings had similar values.

In case of lower planting distances and weak rootstocks trees fill up available space by the 4th year (e.g. 'Jonathan Csány 1'), or by the 5th year (e.g. 'Sampion'), and can be maintained only by continuous sideways pruning, moreover, in the 2nd-3rd year after planting the regulation of tree height (by pruning) becomes necessary.

The sideway and height limitation influence the value of canopy volume to a great extent.

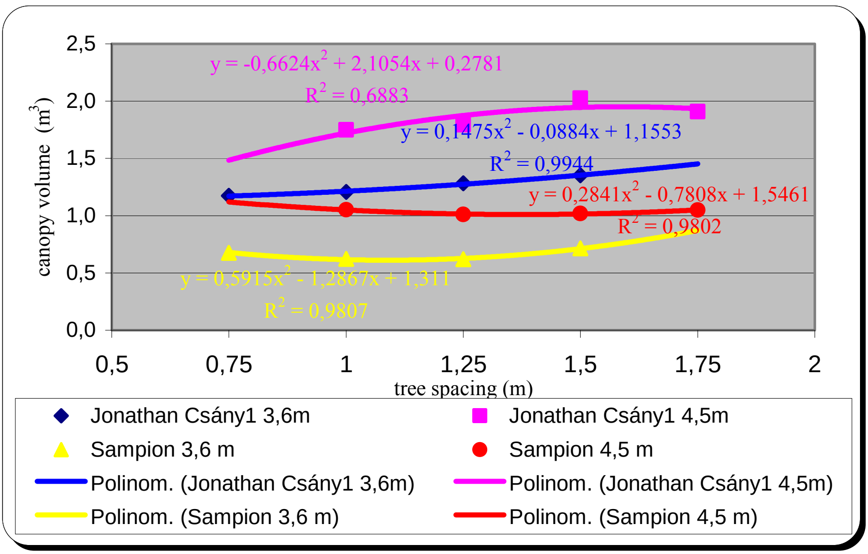

Fig. 3.4. *Influence of tree spacing within the row on the canopy volume (2007)*

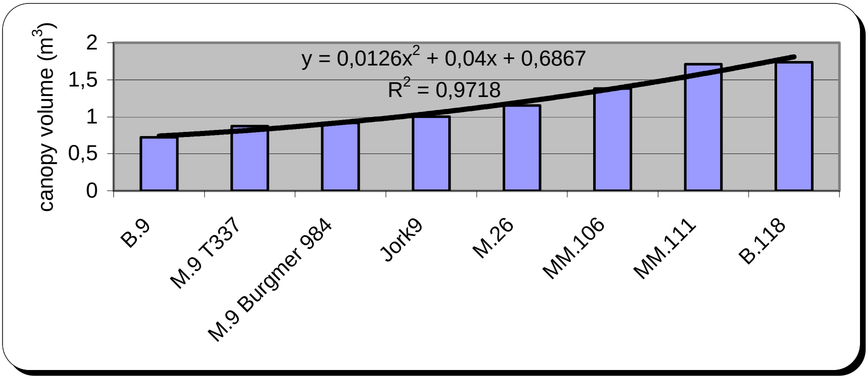

***Fig. 3.5.** Influence of the rootstocks on the canopy volume (2007)*

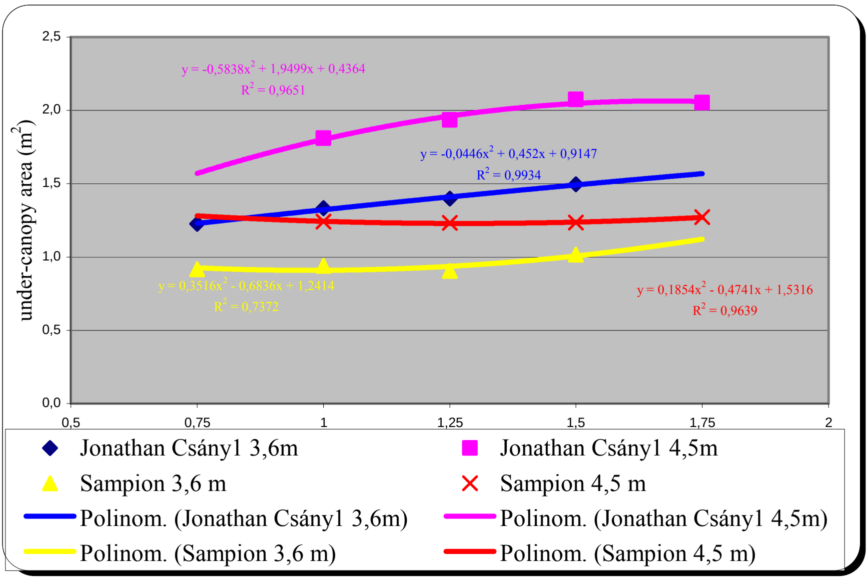

***Fig. 3.6.** Effect of tree distance within the row on under-canopy area (2007)*

The knowledge of under-canopy area describes the space requirements of each rootstock-scion combinations more detailed. In case of weak rootstocks under-canopy area reach it's final value by the 3rd-4th year after planting, namely trees fill up available space. In case of medium vigorous rootstocks this happens one year later due to the bigger planting distances (row distance, tree distance within the row). Figure 3.6 indicates that tree distance within the row has no considerable effect on the value of under-canopy area, although in case of 'Jonathan Csány 1' and row distances of 3.6 m and 4.5 m we observed increasing under-canopy area, but we could not demonstrate significant differences.

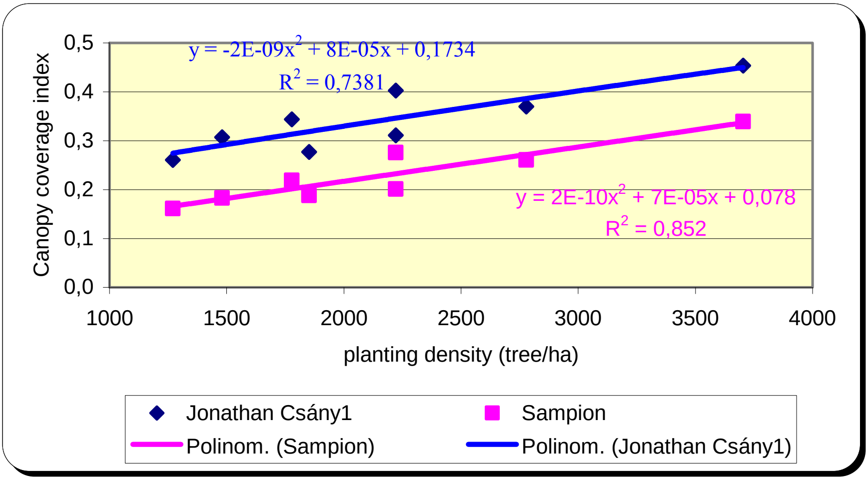

Fig. 3.7. *Canopy coverage index as function of planting density (2007)*

An important index for the optimization of tree spacing in orchards established with canopy forms of circular projection and trees planted in straight rows is the canopy coverage index, which is the quotient of under-canopy area and tree spacing (m^2). Analyzing the values of canopy coverage index we can conclude, that is was statistically significantly affected by row distance, tree distance within the row and by rootstocks. In case of both cultivars the value of canopy coverage index increased with increasing planting density. Moreover we can state, that 'Sampion' had lower values than 'Jonathan Csány 1' due to it's lower vigour.

The weight of pruning wood was dependant on rootstocks and scion cultivars to a great extent in our experiment, but due to the young age of the trees planting density had no definite effect on it. In the group of week rootstocks we can expect relatively high amounts of pruning wood and manual labour needed in case of M.26 and M.9 T 337, while in the medium vigorous group from B.118 and MM.111. For the calculation of pruning works and the amount of pruning wood it's expedient to consider the principle of decreasing ratio of pruning wood in case of these rootstocks. In case of the other rootstocks investigated we can calculate with constant amount of pruning wood.

In case of M.26, that was included in the experiment as a control rootstock, we compared the slender spindle and vertical axis training systems. Our conclusion is that we can expect more pruning work and wood during the maintenance of slender spindle trees than in vertical axis.

3.2. Evaluating the reproductive performance

The analysis of the changing of most important indices revealed the cropping potential of each rootstocks and it's maintainability over the years. The values were differentiated not only by each rootstock, but by the scion cultivars, too. We found out, that the dwarfing rootstocks are less susceptible to alternate bearing than those of medium vigour.

Moreover, in case of less vigorous scion cultivars we can rely on less alternate bearing, than in case of more vigorous cultivars. The cropping of trees on M.9 T 337 or M.26 is almost regular. From the standpoint of alternate bearing we can not recommend Jork 9 for new orchards, especially not for more vigorous scion cultivars. Of the medium vigorous rootstocks we can expect higher alternance in case of MM.106 and MM.111. In case of vertical axis we can expect reasonable crops and regular bearing on M.26.

During the early years the crop on the dwarfing rootstocks is nearly the same as on medium vigorous rootstocks. We observed higher alternance in case of 'Jonathan Csány 1' on medium vigorous rootstocks than on dwarfing ones, however in cv. 'Sampion' we could not observe significant differences between the weak and medium vigorous stocks concerning crops. This is thanks to the genetic potential of the scion cultivar.

The alternate bearing of 'Sampion' is negligible.

Possibly due to the young age of trees we could not demonstrate significant difference between the different planting densities concerning crop per tree. However, the index of cumulative yield per hectare is decreasing with increasing planting distances. (Fig. 3.8 and 3.9).

There were significant differences between the rootstocks concerning yield per tree and cumulated yield, too. Figure 3.10 demonstrates the order of rootstocks according to cumulated yield per tree.

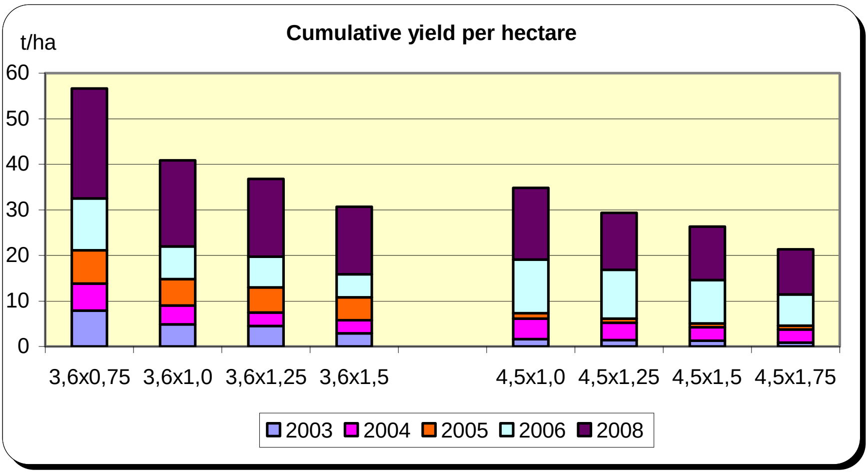

Fig. 3.8. *Cumulative yield per hectare of cv.* 'Jonathan Csány 1' *as average of the investigated rootstocks, at different tree spacings*

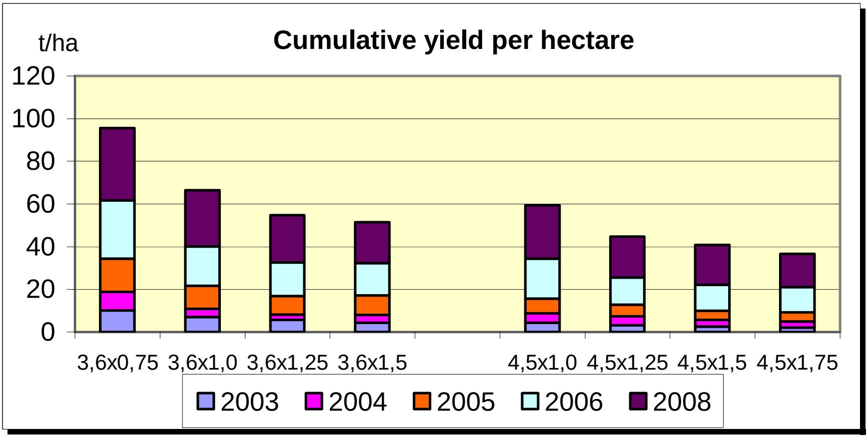

Fig. 3.9. *Cumulative yield per hectare of cv.* 'Sampion' *as average of the investigated rootstocks, at different tree spacings*

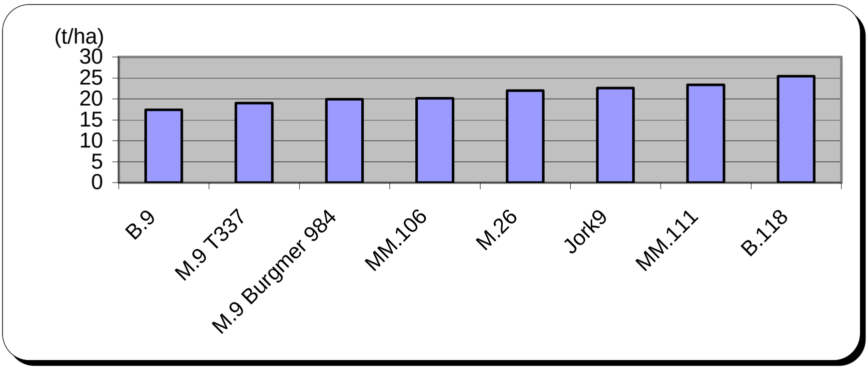

Fig. 3.10. *Cumulative yield of the rootstocks*

The order of rootstocks is almost the same as in the case of vegetative performance; B.9 having the lowest and B.118 the highest values. When analyzing the data of the two training systems separately, in case of the dwarfing rootstocks the only difference between the order according to vegetative growth and cumulative yield is, that Jork 9 precedes M.26. The order of the rest of the rootstocks is the same.

We have to remark, that we observed slight differences in the vegetative characteristics, but significant differences in the cropping habit between the two M.9 clones (M.9 Burgmer 984, M.9 T 337) and the open pollinated seedling of M.9 (Jork 9). Jork 9 has the highest cumulative yield of these three rootstocks, confirmed by the results of CSIGAI and HROTKÓ (2003), but the findings of CZYNCZYK et al. (1999) contradict our's. So the investigation of the cropping characteristics of the rootstocks needs more time to draw a correct conclusion.

The order of the medium vigorous rootstocks according to cumulative yield is the same as that of according to vegetative performance. Anyway, the performance of the most vigorous and best cropping B.118 is remarkable, so it may play an important role on the low quality soils of the 'Nyírség' region in the future.

The degree of alternate bearing is expressed by the Alternate bearing index (AI), this index with values between 0 and 1 precisely numerates the continuity or variability of cropping (Table 3.1 and 3.2).

When analysing it's values we have to take into consideration the young age of the trees and the unestablished nature of the orchard: the crops are increasing year by year (that is a positive factor in fact), but it is to be considered as a changing parameter (drawback) when calculating AI. The index was calculated between 2003 and 2006, as the low crop data of 2007 (because of almost total loss after a spring frost) would have increased alternance falsely. In the group of dwarfing rootstocks the value of this index is usually slightly increasing with increasing tree spacing (Table 3.1).

However, the differences between the average values are not significant. Alternate bearing was influenced by rootstocks to a great extent, but the different tree spacings had no considerable effect on it in our experiment. Moreover, training systems should be taken into consideration as modifying factors; e.g. the value of AI in M.26 may be one and a half times higher in vertical axis than in case of slender spindle.

Of the week rootstocks M.26 and M.9 T 337 can be recommended for new orchards because of continuous high crops. For higher planting distances M.26 or even B.118 can be considered, but the wide-spread MM.106 is not recommended.

Table 3.1. *Values of Alternate bearing index (AI) of* 'Jonathan Csány 1' *at different combinations of tree spacings and rootstocks between 2003 and 2006 in the group of weak rootstocks*

Rootstock	***3,6 × 0,75 m***	***3,6 × 1,00 m***	***3,6 × 1,25 m***	***3,6 × 1,50 m***	***Average***
M.26	0,402	0,270	0,333	0,350	*0,339*
M.9T337	0,471	0,460	0,330	0,434	*0,424*
Burgmer9	0,419	0,729	0,461	0,523	*0,533*
B.9	0,869	0,317	0,523	0,469	*0,551*
Jork 9	0,525	0,705	0,722	0,528	*0,620*
Átlag	*0,537*	*0,496*	*0,474*	*0,466*	*0,493*

Table 3.2. *Values of Alternate bearing index (AI) of* 'Jonathan Csány 1' *at different combinations of tree spacings and rootstocks between 2003 and 2006 in the group of medium vigorous rootstocks*

Rootstock	***4,5 × 1,00 m***	***4,5 × 1,25 m***	***4,5 × 1,50 m***	***4,5 × 1,75 m***	***Average***
M.26	0,526	0,469	0,514	0,518	*0,507*
B.118	0,564	0,356	0,728	0,672	*0,580*
MM.111	0,613	0,831	0,677	0,444	*0,641*
MM.106	0,882	0,870	0,946	0,846	*0,886*
Átlag	*0,646*	*0,632*	*0,716*	*0,620*	*0,654*

3.3. Evaluating specific performance indices

In the foreign scientific papers the yield per trunk cross-sectional area is frequently used to describe the cropping efficiency, so several researchers characterize tree productivity with yield per trunk cross-sectional area (kg/cm^2), as the total weight of wood above ground level is linearly correlated with trunk cross-sectional area (WESTWOOD, 1993). There is a significant difference between the cultivars investigated concerning this index, as it can be seen in Fig. 3.11. The yield per trunk cross-sectional area of 'Sampion' is almost twice as high as that of cv.

'Jonathan Csány 1'. If we take the vegetative properties into consideration we can conclude, that cv. 'Sampion' can be characterized by weaker vigour and higher productivity, so it can be recommended for high density orchards.

When analysing the variations of the yield per cross-sectional area index, we can point out, that the curve is steeply increasing in case of both cultivars, then reach the maximum, afterwards decreasing. It means, that the yield per trunk cross-sectional area index can't be increased by increasing the planting density beyond the maximum point. According to our observation this maximum point is at 3000 trees/hectare in both cultivars investigated (Fig. 3.11). STAMPAR et al. (2000) achieved similar results: the yield per trunk cross-sectional area index beyond 2500 trees/ha had been decreasing.

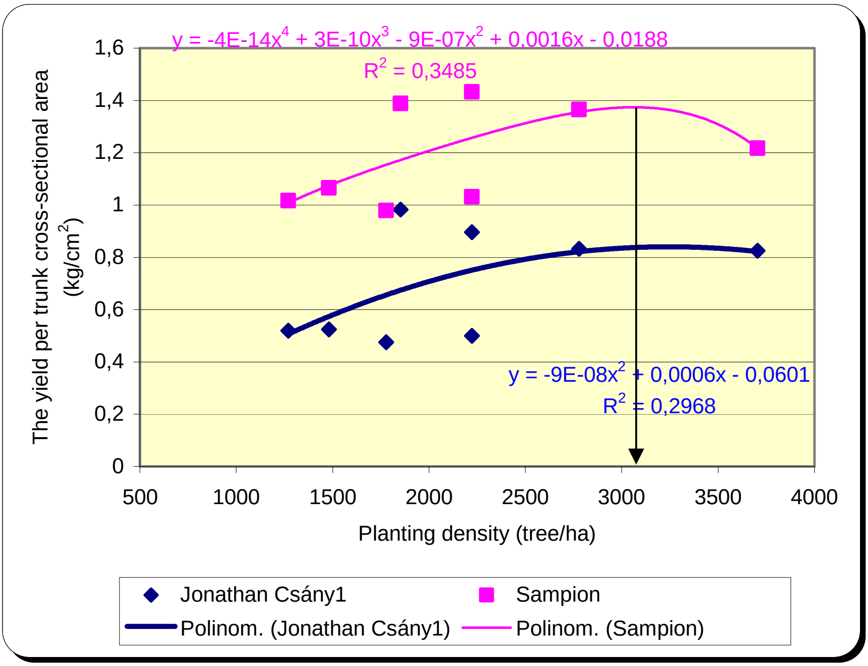

Fig. 3.11. *The yield per trunk cross-sectional area of* 'Jonathan Csány 1' *and* 'Sampion' *trees planted at different planting distances, as function of tree density (2007)*

The yield per canopy volume index is changing year by year, having low values in the initial years after planting, moreover, it may be decreasing until the trees develop canopy size typical for the scion cultivar and tree spacing. Until this point canopy volume (m^3) is increasing more rapidly than crop (kg). So the value of the index may show a decreasing trend. In case of scion cultivars with more vigour and more susceptible to alternate bearing the curves are ripple, because in off years the value of this index is greatly reduced not only by decreased crop, but by the increased vegetative performance, too.

The yield per under-canopy area index is an important one from a practical viewpoint, it is sensitive to the scion cultivars and rootstocks of different vigour. It is not heavily dependant on the individual rootstocks of each rootstock category. Of the weak rootstocks M.26 and M.9 T 337 is recommended for high density orchards. For higher planting distances, also M.26can be considered from the medium vigorous rootstocks. Generally, until the canopy growth after planting is ongoing, the value of this index is decreasing, until trees fill up available space. After this point the growing crops at constant canopy volume results in the increase of this specific index.

3.4. New scientific results

1. The two investigated scion cultivars were classified according to their vegetative vigour, so ‘Jonathan Csány 1’ can be described as a medium vigour cultivar, while ‘Sampion’ as a weak one in both training systems.

2. We determined the relative order of the eight investigated rootstocks according to their vigour in the “Nyírség” region, which is the following:
B.9, M.9 T 337, M.9 Burgmer 984, Jork 9, M.26, MM.106, MM.111, B.118

3. We determined the alternate bearing index of cv. ‘Jonathan Csány 1’ on eight rootstocks at four planting distances in the agroecological conditions of ‘Nyírség’.

4. In case of the scion cultivars investigated (‘Jonathan Csány 1’ and ‘Sampion’) the yield per trunk cross-sectional area index reach it’s maximum at 3000 trees/hectare planting density, and is decreasing beyond this point.

5. According to our results we recommend 3.6×1.25 m planting distance for orchards with slender spindle, and 4.5×1.5 m with vertical axis training system.

4. CONCLUSION, RECOMMENDATIONS

Apple is still the major crop in the Hungarian fruitgrowing, it represents more than 50% share of the total fruit production. However, similarly to other sectors of the Hungarian economy, it is in crisis from which the only way that can drive out is realising quality fruit production with newly planted, high density orchards. The deficiency of the capital, however, does hinder the planting, of new orchards applying modern production technology. Furthermore, the judgement of the different related institutions on the direction of the development holds it back, too. They are missing the consultant and advisory networks, detailed economical analyses, pointing out the expected tendencies. The uncalculable system of the latter Hungarian governmental support does not really serves the development either. The largest problems are, however, the deficiency of the basic information for orchard planting and of technological knowledge. Therefore, with this research work, we strove to enlarge the simple rootstock use in our apple growing being founded on the present, traditional cultivation systems and to suggest rootstock-scion combination for future growers that best fit their pruduction purposes. The main aims of this thesis with taking the Northeast Hungarian region's agroecological conditions into consideration, were the testing of rootstocks with different vigor, getting known their growing and yielding characteristics to provide useful help for orchards to be planted in the future concerning production technology. With this research, we would like to be able to select some from the promising foreing rootstocks that perform best in our ecological conditions and this could drive the view of our fruit tree nurseries and then the future fruit growers through this way.

To reach these aims, we set up a long-term field experiment in 2001. Our observations and data collections were made during eight consecutive years (between 2001 and 2008) in a rootstock-scion evaluation trial orchard at the Research and Extension Centre for Fruitgrowing in Újfehértó, in the North-Eastern apple growing region in Szabolcs-Szatmár-Bereg county. The combinations of two scion cultivars ('Jonathan Csány 1' and 'Sampion') and eight rootstocks (M.9 T 337, M.9 Burgmer 984, Jork 9, B.9, M.26, MM.106, MM.111 and B.118) were evaluated at four different spacings depending on the vegetative vigour of the rootstocks. In this research, we tested two main training systems; the slender spindle (on rootstocks with weak vegetative vigour at 3.6 × 0.75-1.50 m tree spacings) and the vertical axis (on rootstocks with moderate vegetative vigour at 4.5 × 1.00-1.75 m tree spacings). To make the practical understanding of the research results easier, we grouped the recorded data and their calculated parameters into three categories: 1. vegetative production; 2. reproductive production; and 3. specific parameters. To characterise the vegetative production, the following parameters were used: trunk cross-sectional area, canopy diameter, canopy height, canopy volume, under-canopy area and pruning wood weight. Reproductive production was evaluated by yield data and *Alternate bearing index*. Specific indices were the yield per trunk cross-sectional area, yield per canopy volume, and yield per under-canopy area.

An obvious increasing tendency with time, of the trunk cross-sectional area was found for both of the examined scion cultivars. The growth dynamics were strongly influenced by the vigour of the rootstocks. Doubled trunk cross-sectional area was observed on rootstocks with moderate vegetative vigour compared to those with weak vigour. Significant differences were among individual rootstocks in the group of the moderate growth inducing stocks. In case of the reference rootstock M.26, comparing the cultivation we concluded the slender spindle had larger growth of the trunk cross-sectional area. This was observed for both of the examined cultivars (’Jonathan Csány 1’ and ’Sampion’).

Canopy volume was strongly influenced by rootstock groups and by individual rootstocks, however tree spacing did not have any effect on it due to the young age of the trees. Differences were found between scion cultivars, too; a changing positive-negative-sloped function was observed for 'Jonathan Csány 1' on weak growth inducing rootstocks. On moderate vigour rootstocks, an increasing by 2005-2006, then a decrasing trend could be found in case of ’Sampion’.

Based on the increasing tendency of the canopy growth, undercanopy area was characterised with an increased trend on both the weak and moderate growth inducing rootstocks. This growth was observed by the point when canopies reached their final size for the given tree spacing. This point occured in 2005 for the vigorous 'Jonathan Csány 1' on weak rootstocks and 1-2 years later on moderate ones. For the moderate vigour 'Sampion', it was usually observed in 2006.

Pruning wood weight was higher on moderate growth inducing rootstocks at larger tree spacings. From this point of view, two stocks are necessary to be mentioned: the B.118 and the MM.111 due to their high pruning wood weight. The order among the individual rootstocks were stable with years and with tree spacings. It was also observed that the maintenance of the slender spindle training system needs higher rate of pruning work that results in more prunings compared to vertical axis. For both training systems, the weight of pruning wood was decreasing over the years.

The analysis of the changing of most important indices (yields) revealed the cropping potential of each rootstocks and it’s maintainability over the years. We observed differentiated values according to not only the individual rootstocks, but to the scion cultivars, too. Possibly due to the young age of trees we could not demonstrate significant difference between the different planting densities concerning crop per tree. The cumulative yield per hectare index was evidently decreasing with increased planting distances. However, there was a significant difference between the single rootstocks regarding crop per tree and cumulated yield, too. The order of rootstocks is almost identical to the order based on vegetative performance, B.9 having the lowest, and B.118 the highest production.

In our experiment, the weak growth inducing rootstocks did not really tend to bear biennially compared to the moderate vigorous stocks. Furthermore, lower values of the *Alternate bearing index* were found for less vigorous scion cultivars. Significant irregularity in cropping was observed on MM.106 and MM.111 in the group of the moderate growth inducing stocks. Reasonable yield and regular bearing was reached on M.26 with vertical axis training system.

We observed significant difference between the two scion cultivars concerning yield per trunk cross-sectional area index. The yield per trunk cross-sectional area of ‘Sampion’ is almost twice as high as that of cv. ‘Jonathan Csány 1’. If we take the vegetative properties into consideration we can conclude, that cv. ‘Sampion’ can be characterized by weaker vigour and higher productivity, so it can be recommended for high density orchards. The yield per cross-sectional area index is steeply increasing in case of both cultivars, then reach the maximum, afterwards decreasing. It means, that the yield per trunk cross-sectional area index can’t be increased by increasing the planting density beyond the maximum point. According to our observation this happened at 3000 trees/hectare in both cultivars investigated.

The yield per canopy volume was a changing specific parameter over the years, their values were quite low in the first couple of years after planting and even a decreasing trend was observed until the trees reached their final canopy volume for the given tree spacing. For young trees, significant differences were not observed for weak growth inducing stocks. Higher values, however, characterised the moderate rootstocks.

The yield per under-canopy area did not show strong dependence by individual rootstocks in each group. Generally, while the growth of the canopy continued, this parameter had a decreasing tendency until the canopy filled out the given tree spacing. Then, the yearly increasing yield with the constant under-canopy area resulted in the increase of this specific parameter.

REFERENCES

1. CAIN, J.C. (1970): Optimum tree density for apple orchards. Hort. Sci. 5(4):232-234. p.
2. G. TÓTH M. (2001): Gyümölcsészet. PRIMOM V.A.V.K., Nyíregyháza.
3. HROTKÓ K. (1999): A gyümölcsfajták alanyai. 407-506. p. In: HROTKÓ K. (Szerk.): Gyümölcsfaiskola. Mezőgazda Kiadó, Budapest. 550 p.
4. HROTKÓ K. (2002): Többkomponensű gyümölcsfák növekedése, produktivitása és az optimális térállás modellezése intenzív ültetvényekben. MTA Doktori értekezés. Budapest.
5. HROTKÓ K., MUKRED A., MAGYAR L. és HANUSZ B. (1995): Az alany és a tenyészterület hatása 'Idared' almafák fiatalkori növekedésére és termőre fordulására. Új Kertgazdaság 1(4):1-8. p.
6. MIKA, A. and KRAWIEC, A. (1999): Planting density of apple trees as related to rootstock. Proceedings of the International Seminar Apple Rootstocks for Intensive Orchards. Warsaw-Ursynów, Poland. 77-78. p.
7. RACSKÓ J. (2008): Különböző növekedési erélyű alanyok hatása az alma termés-önszabályozására. PhD Értekezés. Debreceni Egyetem AMTC. Kézirat.
8. SADOWSKI, A., PAJAK, T, and PÓLTORAK, W. (1999): Growth and early yield of 'Jonagold', 'Holiday' and 'Fiesta' apple trees on different rootstocks. Apple rootstocks for intensive orchards. Proceedings of the International Seminar Warsaw-Ursynów, August 18-21. 91-92. p.
9. SILBEREISEN, R. and SCHERR, F. (1968): Vergleichende Untersuchungen über Wuchs, Ertag und Fruchtqualitat auslandisher Apfelsorten. 1. Folge. Obst und Garten 87 (6):217-222. p.
10. SOLTÉSZ M. és SZABÓ T. (1998): Alma. 119-155. p. In: SOLTÉSZ, M. (Szerk.): Gyümölcsfajta-ismeret és -használat. Mezőgazdasági Kiadó, Budapest. 513 p.

11. STAMPAR, F. et. al. (2000): Influence of planting densities on vegetative and generative growth anf fruit quality of apple (*Malus domestica* Borkh). Acta Horticulturae. 513:349-356. p.
12. SZABÓ T. (2004): Tartós tárolásra alkalmas almafajták. In: INÁNTSY F. (Szerk.): Integrált növénytermesztés. Alma. Agroinform Kiadó, Budapest. 58-69. p.
13. SZABÓ T. (2006): Az almatermesztés helyzete és kilátásai Magyarországon. Őstermelő-Gazdálkodók lapja, 2006/6. szám. 38-40. p.
14. VÍG P. (1982): Almaültetvények térállása és összefüggései a termesztés-technológiával és a jövedelmezőséggel. Kertgazdaság. 14(2):1-13. p.
15. WEBSTER, A.D. (1997): A review of fruit tree rootstock research and development. Acta Horticulturae. 451. 53-73. p.
16. WEBSTER, A.D and WERTHEIM, S.J. (2003): Apple Rootstocks. In: FERREE, DC. and WARRINGTON, I.J. (Eds) Apples Botany, Production and Uses. CABI Publising. 91-124. p.
17. WESTWOOD, M.N. (1993): Temperate-zone pomology, physiology and culture. Timber press, Portland, Oregon, USA. 523. p.

MOST IMPORTANT PUBLICATIONS RELATED TO THE SUBJECT OF THESIS

Publications in journals

BUBÁN, T., **TAKÁCS, F.**, BENEDICTYNÉ RÁCZ, M. ÉS OLÁH, L. (1995): Az alma gyümölcsminőségének javítása környezetbarát hazai készítménnyel. Növényvédelem 31 (10):473-477.

TAKÁCS F. (2003): Almafajták magházpenészes betegségének vizsgálata a Nyírségi tájkörzetben. Kertgazdaság. 35. (1):58-66. p.

TAKÁCS, F. (2003): A Európai Unió almatermesztése. Gyakorlati Agrofórum. 14. (1):2-7. p.

TAKÁCS, F. (2004): Perspektívikus alanyok az almatermesztésben. Őstermelő. 6. 31-32.

TAKÁCS, F. (2006): Az agrár-környezetgazdálkodás feltételrendszerének hatása az ültetvények ápolására és művelési rendszerére. Őstermelő. 6. 31-32.

TAKÁCS, F (2007): Néhány gondolat az almatermesztésben alkalmazott művelési rendszerek változásairól. Agrofórum Extra 19. 21-23. p.

Publications in conference proceedings

TAKÁCS, F. (2003): Az almaültetvények létesítésénél számításba vehető új almaalanyokkal végzett kísérletek kezdeti eredményei. Kutatási Nap Újfehértón. (Előadás összefoglalók 15. p.)

TAKÁCS, F. (2004): Alma alany/nemes kombinációk vizsgálata művelésmód kísérletben. Kutatási Nap Újfehértón. (Előadás összefoglalók 18. p.)

TAKÁCS, F. (2005): Az alanyok hatása egyes almafajták növekedési tulajdonságaira. Kutatási Nap Újfehértón. (Előadás összefoglalók 16. p.)

TAKÁCS, F. (2005): Az alanyok és a tőtávolság hatása néhány almafajta növekedési tulajdonságaira. Lippay János – Ormos Imre – Vas Károly Tudományos Ülésszak, Budapesti Corvinus Egyetem Kertészettudományi Kar, 2005. október 19-21. Budapest, p. 244.

TAKÁCS, F. (2006): Perspektívikus almaalanyok teljesítményvizsgálata Újfehértón. Kutatási Nap Újfehértón. (Előadás összefoglalók 5. p.)

TAKÁCS, F., HROTKÓ, K. (2007): Az alanyok és a tőtávolság hatása a Jonathan Csány1 és a Sampion almafajták növekedésére és terméshozására. Versenyképes mezőgazdaság tudományos konferencia. Nyíregyházi Főiskola Műszaki és Mezőgazdasági Főiskolai Kar. 2007. november 29. Nyíregyháza. Konferencia kiadvány. 79-83. p.

CSISZÁR, L., BUBÁN, T., **TAKÁCS, F**., BENEDICTYNÉ RÁCZ, M. AND OLÁH, L. (2000): Phyl-Gold: a product o diminish russeting of 'Golden Delicious' apples. Intrernational Journal of Horticultural Science. 2000, 6, (1): 131-133. p.

TAKÁCS F. (2002): Performance of apple cultivars and rootstocks in various orchard systems in North-Eastern Hungary. Acta Horticulturae (658.) Vol.1. 301-302.

TAKÁCS, F. (2004): Testing of apple rootstocks/scion combinations in various orchard systems. Journal of Fruit and Ornamental Plant Research. Vol. XII. 173-176.

TAKÁCS, F. (2004): Preliminary results of the testing of different apple rootstocks in North-East of Hungary. Acta Horticulturae (732.) 181-184.

CSIGAI, K., HROTKÓ, K., **TAKÁCS, F.** (2004): Effect of rootstocks and in-row spacing in young intensive apple orchard. Acta Horticulturae et Regiotecturae, 121-122. SPU Nitra.

TAKÁCS, F., HROTKÓ, K. (2006): Effect of apple rootstocks on growth and productivity. International Conference of Perspectives in European Fruit Growing. Lednice. Proceeding. 161-164.

THURZÓ, S., SZABÓ, T., SOLTÉSZ, M., BALMER, M., **TAKÁCS, F.,** SZABÓ, Z., NYÉKI, J. (2007): Blüh- und Befruchtungseigenschaften von Sauerkirschsorten aus Nordost-Ungarn. 44. Gartenbauwissenschaftliche Tagung, Erfurt. Kurzfassungen der Vortrage und Poster. 62.p.

THURZÓ, S., SZABÓ, T., **TAKÁCS, F.** (2007): Eigenschaften neuer Sauerkirschsortenaus Nordost-Ungarn. 44. Gartenbauwissenschaftliche Tagung, Erfurt. Kurzfassungen der Vortrage und Poster. 147.p.

Publications in books

TAKÁCS, F. (2001): Ültetvények létesítése. In: Inántsy, F. szerk.: Almatermesztés integrált módszerekkel. Almatermesztők Szövetsége, Újfehértó, 17-20. p.

TAKÁCS, F. (2001): Terület és talajelőkészítés. In: Inántsy, F. szerk.: Almatermesztés integrált módszerekkel. Almatermesztők Szövetsége, Újfehértó, 21-25. p.

TAKÁCS, F. (2001): Az ültetvény kitűzése, ültetés. In: Inántsy, F. szerk.: Almatermesztés integrált módszerekkel. Almatermesztők Szövetsége, Újfehértó, 26-29. p.

BUBÁN, T., CSISZÁR, L, LAKATOS, T., PETHŐ, F., **TAKÁCS, F.,** ZATYKÓ, I. (2002): Meggyültetvények létesítésétől a betakarításig. In: INÁNTSY F. (Szerk.): Meggytermesztés integrált módszerekkel. Újfehértói Gyümölcstermesztési Kutató és Szaktanácsadó Kht., Újfehértó, 25-46. p.

TAKÁCS, F. (2004): Almaültetvények létesítése. In: INANTSY F., BALÁZS K. (Szerk.): Integrált növénytermesztés. Alma. Budapest: Agroinform Kiadó, 37-49. p.

TAKÁCS, F. (2004): Meggy- és cseresznyeültetvények létesítése. In: INANTSY F., BALÁZS K. (Szerk.): Integrált növénytermesztés. Meggy, cseresznye. Budapest: Agroinform Kiadó, 63-73. p
.

PETHŐ, F., **TAKÁCS, F.** (2004): A művelésmód megválasztásának szempontjai, a meggyfák metszése. In: INANTSY F., BALÁZS K. (Szerk.): Integrált növénytermesztés. Meggy, cseresznye. Budapest: Agroinform Kiadó, 74-81. p.

PETHŐ, F., **TAKÁCS, F.** (2005): Az almafa életjelenségei, a metszés időszakai. In: Pethő, F. és Takács, F. szerk.: Almafák metszése a gyakorlatban. Újfehértói Gyümölcstermesztési Kutató és Szaktanácsadó Kht., Újfehértó, 41-60. p.

TAKÁCS, F. (2005): A művelési rendszer és a metszés összefüggései. In: Pethő, F. és Takács, F. szerk.: Almafák metszése a gyakorlatban. Újfehértói Gyümölcstermesztési Kutató és Szaktanácsadó Kht., Újfehértó, 79-94. p.

TAKÁCS, F. (2005): Támberendezés. In: Pethő, F. és Takács, F. szerk.: Almafák metszése a

gyakorlatban. Újfehértói Gyümölcstermesztési Kutató és Szaktanácsadó Kht., Újfehértó, 105-109. p.
PETHŐ, F., **TAKÁCS, F.** (2005): Választható koronaformák. In: Pethő, F. és Takács, F. szerk.: Almafák metszése a gyakorlatban. Újfehértói Gyümölcstermesztési Kutató és Szaktanácsadó Kht., Újfehértó, 111-144. p.

SZABÓ,T. – **TAKÁCS, F**. (2007): Útmutató gyümölcstelepítéshez. In: Gyümölcsültetvények tervezése, fajtahasználat. Szerk.: NYÉKI, J. Inter-Claszter kiadó, Kecskemét. 60-64 p.

APÁTI, F. - **TAKÁCS, F**. (2007): A gyümölcstermő növények versenyképességének legfontosabb elemei és kockázatai. In.: Versenyképes mezőgazdasági termelés ökonómiája. (Szerk.: Szabó B.) 94-134. p. Nyíregyházi Főiskola MMFK, 2006. ROP-3.3.1.-05/1.-2005-08-0005/37.

TAKÁCS, F. (2007): Az integrált növényvédelem gyakorlata a gyümölcstermesztésben. In.: Versenyképes kertészet I.. (Szerk.: Szabó B.) 3-32. p. Nyíregyházi Főiskola MMFK, 2006. ROP-3.3.1.-05/1.-2005-08-0005/37.

TAKÁCS, F. (2007): Az ellenőrzötten környezetkímélő technológiával előállított és márkavédjeggyel ellátott garantáltan egészséges gyümölcs termesztése. In.: Versenyképes kertészet I.. (Szerk.: Szabó B.) 64-89. p. Nyíregyházi Főiskola MMFK, 2006. ROP-3.3.1.-05/1.-2005-08-0005/37.

SOLTÉSZ, M., **TAKÁCS, F**., SZABÓ, T. (2008): Meggyültetvények alanyfajtái. In.: NYÉKI, J. (Szerk.:) Meggyültetvények létesítése és termesztéstechnológiája. Debreceni Egyetem Agrár- és Műszaki Tudományok Centruma, Kutatás Fejlesztési Intézet. 21-24. p.

TAKÁCS, F. (2008): Termőhely kiválasztása, a terület és a telepítés előkészítése. In.: NYÉKI, J. (Szerk.:) Meggyültetvények létesítése és termesztéstechnológiája. Debreceni Egyetem Agrár- és Műszaki Tudományok Centruma, Kutatás Fejlesztési Intézet. 24-27. p.

TAKÁCS, F. (2008): Az ültetési anyagok eltelepítése. In.: NYÉKI, J. (Szerk.:) Meggyültetvények létesítése és termesztéstechnológiája. Debreceni Egyetem Agrár- és Műszaki Tudományok Centruma, Kutatás Fejlesztési Intézet. 27-29. p.

TAKÁCS, F., SZABÓ, T. (2008): Meggyültetvények talajművelése. In.: NYÉKI, J. (Szerk.:) Meggyültetvények létesítése és termesztéstechnológiája. Debreceni Egyetem Agrár- és Műszaki Tudományok Centruma, Kutatás Fejlesztési Intézet. 34-37. p.

SOLTÉSZ, M., **TAKÁCS, F**., CSISZÁR, L. (2008): Kézi szüret. In.: NYÉKI, J. (Szerk.:) Meggyültetvények létesítése és termesztéstechnológiája. Debreceni Egyetem Agrár- és Műszaki Tudományok Centruma, Kutatás Fejlesztési Intézet. 74-76. p.

SOLTÉSZ, M., **TAKÁCS, F**., CSISZÁR, L. (2008): Gépi és kombinált betakarítás. In.: NYÉKI, J. (Szerk.:) Meggyültetvények létesítése és termesztéstechnológiája. Debreceni Egyetem Agrár- és Műszaki Tudományok Centruma, Kutatás Fejlesztési Intézet. 76-79. p.

TAKÁCS, F. (2008): Gyümölcsök szállítása és áruvá készítése. In.: NYÉKI, J. (Szerk.:) Meggyültetvények létesítése és termesztéstechnológiája. Debreceni Egyetem Agrár- és Műszaki Tudományok Centruma, Kutatás Fejlesztési Intézet. 79. p.

SOLTÉSZ, M., **TAKÁCS, F**., SZABÓ, T. (2008): Unterlagen für Sauerkirschen. In.: NYÉKI, J., SOLTÉSZ, M., SZABÓ, T., HILSENDINGEN, P., HENSEL, G. (Szerk.:) Sauerkirschenanbau. Debreceni Egyetem Agrár- és Műszaki Tudományok Centruma, Kutatás Fejlesztési Intézet. 25-27. p.

TAKÁCS, F. (2008): Wahl des Standortes, Bodenvorbereitung. In.: NYÉKI, J., SOLTÉSZ, M., SZABÓ, T., HILSENDINGEN, P., HENSEL, G. (Szerk.:) Sauerkirschenanbau. Debreceni Egyetem

Agrár- és Műszaki Tudományok Centruma, Kutatás Fejlesztési Intézet. 27-30. p.

TAKÁCS, F., HILSENDINGEN, P. (2008): Pflanzvorbereitung, Pflanzung, Pflanzmaterial. In.: NYÉKI, J., SOLTÉSZ, M., SZABÓ, T., HILSENDINGEN, P., HENSEL, G. (Szerk.:) Sauerkirschenanbau. Debreceni Egyetem Agrár- és Műszaki Tudományok Centruma, Kutatás Fejlesztési Intézet. 30-32. p.

TAKÁCS, F., SZABÓ, T. (2008): Bodenpflege der Sauerkirschanlagen. In.: NYÉKI, J., SOLTÉSZ, M., SZABÓ, T., HILSENDINGEN, P., HENSEL, G. (Szerk.:) Sauerkirschenanbau. Debreceni Egyetem Agrár- és Műszaki Tudományok Centruma, Kutatás Fejlesztési Intézet. 35-38. p.

SOLTÉSZ, M., **TAKÁCS, F**., CSISZÁR, L. (2008): Handpflücke. In.: NYÉKI, J., SOLTÉSZ, M., SZABÓ, T., HILSENDINGEN, P., HENSEL, G. (Szerk.:) Sauerkirschenanbau. Debreceni Egyetem Agrár- és Műszaki Tudományok Centruma, Kutatás Fejlesztési Intézet. 81-83. p.

SOLTÉSZ, M., **TAKÁCS, F**., CSISZÁR, L. (2008): Mechanische und kombinierte Ernte. In.: NYÉKI, J., SOLTÉSZ, M., SZABÓ, T., HILSENDINGEN, P., HENSEL, G. (Szerk.:) Sauerkirschenanbau. Debreceni Egyetem Agrár- és Műszaki Tudományok Centruma, Kutatás Fejlesztési Intézet. 83-86. p.

TAKÁCS, F. (2008): Transzport und Aufbereitung der Frucht zur Vermarktungsware. In.: NYÉKI, J., SOLTÉSZ, M., SZABÓ, T., HILSENDINGEN, P., HENSEL, G. (Szerk.:) Sauerkirschenanbau. Debreceni Egyetem Agrár- és Műszaki Tudományok Centruma, Kutatás Fejlesztési Intézet. 86-87. p.

Books edited

PETHŐ, F., **TAKÁCS, F.** (2005): Almafák metszése a gyakorlatban. Újfehértói Gyümölcstermesztési Kutató és Szaktanácsadó Kht., Újfehértó. 149 p.