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GROWTH AND BRANCHING OF PEAR TREES (*Pyrus domestica*, *Rosaceae*) IN NURSERY

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Abstract. The study was conducted in two successive years to examine the capacity of formation of sylleptic shoots in nursery trees of 'Abbé Fétel', 'Conference' and 'Starking Delicious' pear cultivars grafted on quince MA and quince BA 29 rootstocks during the first year after bud grafting. Tree height, trunk diameter – 10 cm above the bud union and number of sylleptic shoots were measured at the end of each season. Tree height was measured from the ground level. The greatest number of sylleptic shoots was registered in 'Abbé Fétel' in both seasons, and the smallest in 'Starking Delicious'. Tree height and tree diameter were highly significantly affected by cultivar in both years and by rootstock in 2008. The interactions between them did not significantly affect the examined parameters. The study showed that the early growth and syllepsis of pear nursery trees during the first year after bud-grafting were incomparably more affected by cultivar than by rootstock.

Key words: nursery trees, pear cultivar, correlation, sylleptic shoot, rootstock

INTRODUCTION

Nursery material of high quality is the basic condition of intensive fruit growing [Baryła and Kapłan 2006]. Namely, modern pear orchards are planted at 2,000–5,000 trees · ha^{-1} or under High Density Planting (HDP), if it is grafted on dwarf or semi-dwarf quince rootstocks, yielding at least 40–50 t · ha^{-1} [Wertheim 2002]. High-density pear orchards use one-year-old or two-year old nursery trees with long sylleptic shoots [Sansavini et al. 2008]. With respect to that, nursery trees should be branched and should have a number of spirally distributed long sylleptic shoots at a suitable height above the ground. In addition, they should develop adequate length and branches at suitable angles to the primary axis, i.e. they should have „promising" tree architecture traits. However, such nursery trees are not produced by conventional growing methods

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in a nursery, due to the low natural tendency of nursery-grown fruit trees to develop sylleptic shoots during the first year after bud-grafting [Cody et al. 1985, Popenoe and Barritt 1988, Volz et al. 1994, Wertheim and Estabrooks 1994, Baryła and Kapłan 2006]. The same author suggests that rich nutrition and optimal water supply of nursery soil in early summer bring fruit trees to their optimum enabling lateral buds to grow into "sylleptic shoots" during the first year after bud-grafting [Tromp 1996]. There are striking differences between cultivars of diverse fruit species [Wertheim 1978], the differences in sylleptic shoot development over the years being due to environmental conditions [Tromp 1996].

Fruit tree architecture is defined by a number of criteria related to primary growth [Barthélémy and Caraglio 2007]. As for apples and other fruit species, there are two major factors that can affect and, consequently, alter the architecture and the overall size of fruit trees. The first one is species and/or cultivar [Lespinasse and Delort 1986, Lauri et al. 1995], the second one being the root system, studied from different standpoints, most commonly in terms of trees grafted on rootstocks [Costes et al. 2001, Baryła and Kapłan 2005, 2006, Seleznyova et al. 2008]. In addition, correlations between plant organs, including fruit ones, specifically those between their number and size are highly complex [Jacyna 2004, Lauri et al. 2006], the very essence lying in the positive correlation between the overall growth and the growth of the root and shoot systems [Fallahi et al. 2002, Costes et al. 2004].

The main objective of this study was to define the capacity to spontaneously produce sylleptic shoots, i.e. branching intensity in pear 'Abbé Fétel', 'Conference' and 'Starking Delicious' grafted on Quince MA and Quince BA 29 rootstocks in a nursery in the first year after bud-grafting during two successive years.

MATERIAL AND METHODS

The study area and environmental conditions. The trial was conducted in a commercial pear nursery in 2007 and 2008. The nursery was located at Prislonica niar Cacak (43°53′N; 20°21′E), Western Serbia. This is mainly an upland area, with an average altitude of about 320 m, characterised by temperate continental climate.

There were no significant differences between the basic climatological parameters obtained for the years of observation for the region of Cacak. In 2007, the mean temperature for the growing season (April–October) was 14.4°C. That year, seasonal precipitation totals was 364.1 mm. In 2008 the average temperature during the growing season was 17.0°C, i.e. 2.6°C higher than 2007. Total precipitation for the vegetative cycle was 305.6 mm. The weather characteristics were within the long-term averages for the Cacak region.

The nursery soil was vertisol, mildly acid (a pH of 6.39 in the topsoil), with a moderate organic matter (3.01%) and a very low N_{TOT} content (0.15%), the values thereof gradually decreasing with the depth (data not shown).

The contents of available P_2O_5 and K_2O in the 0–30 cm soil depth were 290.0 mg · kg^{-1} and 300.0 mg · kg^{-1}, respectively. The soil was kept fallow. Fertilization treatments included applications of mineral nitrogen fertilizers at the rate of 80 kg N · ha^{-1} prior to the growing season and following the cutting of the rootstock above the graft union, i.e. towards the end of March in both seasons. The drip irrigation was performed in the nursery.

Plant material and methods. The plant material used in this study included commercial pear cultivars 'Abbé Fétel', 'Conference' and 'Starking Delicious' (fig. 1) grafted on quince MA (MA) and quince BA 29 (BA 29) rootstocks.

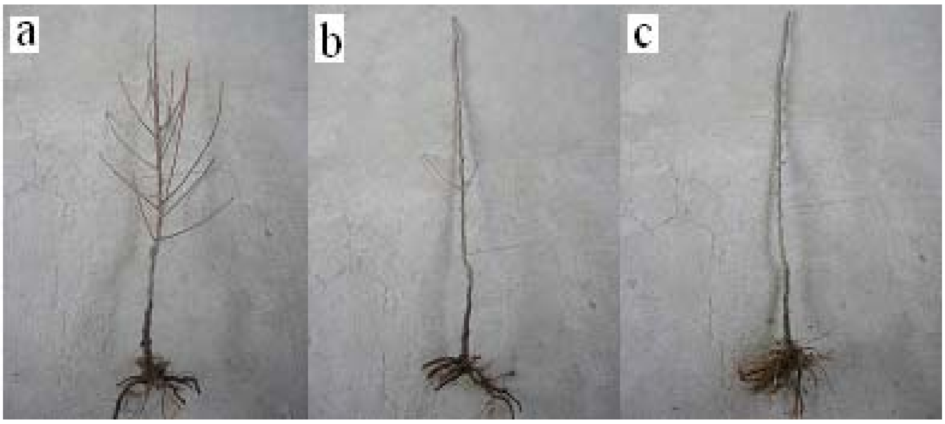

Fig. 1. One-year-old nuresery trees of pear cultivars: a) Abbé Fétel', b) 'Conference', c) 'Starking Delicious'

Rys. 1. Jednoroczne okulanty gruszy odmian: a) Abbé Fétel', b) 'Conference', c) 'Starking Delicious'

The trees were planted at a spacing of 100 × 10 cm (100,000 trees ha^{-1}) and budded 25 cm above the ground level using the T-budding technique. Grafting was conducted in mid-August 2006 and 2007. No measures were used to stimulate the development of sylleptic shoots on the nursery trees. Measurements were carried out at the end of each season and they included tree height (TH), tree diameter (TD) – 10 cm above the bud union and long shoot count (LSC). Tree height was measured from the ground level. Total lateral shoots were counted and classified as short shoots (<20 cm) (data no shown) and long sylleptic shoots (LSS) (>20 cm) according to the method described by Volz et al. [1994].

Data analysis. The grafted nursery trees were grown in a completely randomized block design for each cultivar/rootstock combination in four replications (10 trees per replication or a total of 40 per cultivar/rootstock combination). The data were subjected to ANOVA (two-way), followed by *F* test at $p \leq 0.05$ and $p \leq 0.01$. For each cultivar, the significance of differences between the rootstocks and their interactions was evaluated by LSD test at $p \leq 0.05$ and $p \leq 0.01$ and expressed as absolute values.

Correlations between TH, TD and LSC were evaluated by Pearson's Product Moment Correlation at $p \leq 0.05$ and $p \leq 0.01$. The obtained data were analyzed by MSTAT-C statistical package (M-STAT 1990).

RESULTS

Nursery tree height and tree diameter. Tree height was significantly higher in 2008 than 2007 (tab. 1). The analysis of TH values across cultivars showed that TH was lowest in 'Conference', and highest in 'Starking Delicious' in both seasons. As for rootstocks, higher TH values were recorded for BA 29 as compared to MA, in both years. The effect of cultivar on TH was found to be significant in both seasons ($p \le 0.01$), and that of rootstock only in 2008 ($p \le 0.05$). The cultivar/rootstock interactions effect on TH were not observed in either season.

Table 1. Influence of studied treatments on the height of pear nursery trees (TH), mean ±SE, n = 40
Tabela 1. Wpływ badanych czynników na wysokość okulantów gruszy (TH), średnia ±SE, n = 40

Treatment – Czynnik		Tree height – Wysokość drzewa, cm	
		2007	2008
Cultivar – Odmiana (A)			
Abbé Fétel		156.75 ± 2.05 b	156.85 ± 3.06 b
Conference		117.27 ± 7.69 c	119.70 ± 6.13 c
Starking Delicious		189.40 ± 5.49 a	195.00 ± 4.56 a
Rootstock – Podkładka (B)			
Quince – Pigwa MA		151.90 ± 3.56 a	150.75 ± 3.32 b
Quince – Pigwa BA 29		157.05 ± 4.29 a	163.62 ± 3.82 a
A × B			
Abbé Fétel	Quince – Pigwa MA	165.35 ± 2.05 a	150.00 ± 3.06 a
	Quince – Pigwa BA 29	148.15 ± 5.15 a	163.70 ± 4.96 a
Conference	Quince – Pigwa MA	108.45 ± 3.85 a	112.15 ± 2.74 a
	Quince – Pigwa BA 29	126.10 ± 3.03 a	127.25 ± 2.89 a
Starking Delicious	Quince – Pigwa MA	181.90 ± 5.49 a	190.10 ± 4.16 a
	Quince – Pigwa BA 29	196.90 ± 5.18 a	199.90 ± 4.56 a
Average over years Średnia z lat		154.47 ± 4.35 B	157.18 ± 4.31 A
ANOVA			
Cultivar – Odmiana (A)		**	**
Rootstock – Podkładka (B)		ns – ni	ns – ni
A × B		ns – ni	ns – ni

The different letter indicates significant differences between means at $p \le 0.01$ by LSD test; – Inna litera wskazuje na istotne różnice między średnimi przy $\alpha \le 0{,}01$ według testu NIR.
ns – non significant differences – ni – różnice nieistotne
* – significant differences between means at $p \le 0.01$ by LSD test – istotne różnice między średnimi przy $\alpha \le 0{,}01$ według testu NIR

Table 2 shows the influence of cultivar, rootstock and cultivar/rootstock combination on TD. The measured TD values were similar in both seasons, irrespective of cultivar, rootstock and year (1.22±0.03 cm in 2007 and 1.24±0.03 cm in 2008). 'Conference' and 'Starking Delicious' had significantly lowest and highest TD, respectively, in both years. Tree diameter of the rootstocks was similar in 2007 and 2008, although somewhat higher in BA 29 than MA.

Tree diameter was significantly affected by cultivar in both years ($p \le 0.01$) and by rootstock in 2008 ($p \le 0.05$). Cultivar/rootstock interactions did not have a significant effect on TD.

Table 2. Influence of studied treatments on the diameter of pear nursery trees (TD), mean ±SE, n = 40
Tabela 2. Wpływ badanych czynników na średnicę okulantów gruszy (TD), średnia ±SE, n = 40

Treatment – Czynnik		Tree diameter – Średnica drzewa 2007	2008
Cultivar – Odmiana (A)			
Abbé Fétel		1.29 ± 0.03 b	1.28 ± 0.05 b
Conference		1.01 ± 0.03 c	1.04 ± 0.02 c
Starking Delicious		1.37 ± 0.04 a	1.41 ± 0.03 a
Rootstock – Podkładka (B)			
Quince – Pigwa MA		1.18 ± 0.03 a	1.22 ± 0.04 b
Quince – Pigwa BA 29		1.26 ± 0.04 a	1.27 ± 0.03 a
A × B			
Abbé Fétel	Quince – Pigwa MA	1.23 ± 0.03 a	1.25 ± 0.04 a
	Quince – Pigwa BA 29	1.35 ± 0.05 a	1.31 ± 0.05 a
Conference	Quince – Pigwa MA	1.01 ± 0.03 a	1.04 ± 0.02 a
	Quince – Pigwa BA 29	1.00 ± 0.03 a	1.04 ± 0.02 a
Starking Delicious	Quince – Pigwa MA	1.32 ± 0.04 a	1.35 ± 0.03 a
	Quince – Pigwa BA 29	1.43 ± 0.04 a	1.47 ± 0.03 a
Average over years Średnia wieloletnia		1.22 ± 0.03 A	1.24 ± 0.03 A
ANOVA			
Cultivar – Odmiana (A)		**	**
Rootstock – Podkładka (B)		ns	*
A × B		ns	ns

*see table 1 – patrz tabela 1

Number of sylleptic shoot (LSC). The influence of cultivar, rootstock and cultivar/rootstock combination on LSC are presented in table 3. Sylleptic count was significantly higher in the first year than in the second one, the highest being recorded in ‘Abbé Fétel’ (6.12±0.93 shoot/tree in 2007 and 4.37±0.81 shoot/tree in 2008) and the lowest in ‘Starking Delicious’ (0.35±0.12 shoot/tree in 2007 and 0.47±0.12 shoot/tree in 2008), in both seasons.

Number of sylleptic shoots was significantly affected by cultivar in both years ($p \le 0.01$), whereas the rootstock effect was not significant. The cultivar/rootstock interactions effect on LSC were not observed.

Correlations among traits. Correlations between TH, TD and LSC in the nursery trees of pear grafted on MA and BA 29 rootstocks are given in tab. 4. A positive correlation was found between TH and TD in all cultivars except ‘Conference’ on MA rootstock, in 2007, the correlation for the said cultivar being a negative one ($r = -0.091^{ns}$). However, in 2007, the correlation between TH and TD was significant only for ‘Abbé Fétel’ ($r = 0.710^{**}$) and ‘Starking Delicious’ ($r = 0.619^{**}$) on BA 29. Other cul-

Table 3. Influence of studied treatments on the number of sylleptic shoots (LSC) in pear nursery trees (mean±SE, n = 40)
Tabela 3. Wpływ badanych czynników na liczbę pędów syleptycznych okulantów gruszy (średnia ±SE, n = 40)

Treatment – Czynnik		Number of sylleptic shoots Liczba pędów syleptycznych 2007	2008
Cultivar – Odmiana (A)			
Abbé Fétel		6.12 ± 0.93 a	4.37 ± 0.81 a
Conference		1.97 ± 1.77 b	2.10 ± 0.39 b
Starking Delicious		0.35 ± 0.12 c	0.47 ± 0.12 c
Rootstock – Podkładka (B)			
Quince – Pigwa MA		2.40 ± 0.38 a	1.90 ± 0.39 a
Quince – Pigwa BA 29		3.23 ± 0.66 a	2.73 ± 0.23 a
A × B			
Abbé Fétel	Quince – Pigwa MA	5.55 ± 0.70 a	3.90 ± 0.77 a
	Quince – Pigwa BA 29	6.70 ± 1.15 a	4.85 ± 0.84 a
Conference	Quince – Pigwa MA	1.60 ± 0.40 a	1.80 ± 0.39 a
	Quince – Pigwa BA 29	2.35 ± 0.48 a	2.40 ± 0.31 a
Starking Delicious	Quince – Pigwa MA	0.05 ± 0.03 a	0.00 ± 0.00 a
	Quince – Pigwa BA 29	0.65 ± 0.20 a	0.95 ± 0.24 a
Average over years Średnia wieloletnia		2.81 ± 0.62 A	2.31 ± 0.41 B
ANOVA			
Cultivar – Odmiana (A)		**	**
Rootstock – Podkładka (B)		ns	ns
A × B		ns	ns

*see table 1 – patrz tabela 1

Table 4. Correlations between tree height (TH), tree diameter (TD) and shoot count (LSC) in nursery trees of 'Abbé Fétel', 'Conference' and 'Starking Delicious' grafted on Quince MA (MA) and Quince BA 29 (BA 29) rootstocks
Tabela 4. Korelacje pomiędzy wysokością drzewa (TH), średnicą drzewa (TD) oraz liczbą pędów (LSC) u drzew gruszy 'Abbé Fétel', 'Conference' i 'Starking Delicious' okulizowanych na podkładkach pigwy MA (MA) i pigwy BA 29 (BA 29)

Cultivar – Odmiana	Rootstock Podkładka	Correlation coefficient – Współczynnik korelacji (*r*)					
		TH vs. TD		TH vs. LSC		TD vs. LSC	
		2007	2008	2007	2008	2007	2008
Abbé Fétel	MA	ns	0.571**	ns	0.503*	0.797**	0.885**
	BA 29	0.710**	0.502**	0.464*	0.700**	0.840**	0.694**
Conference	MA	ns – ni	ns – ni	0.571**	0.581**	ns – ni	ns – ni
	BA 29	ns – ni	ns – ni	ns – ni	0.474*	ns – ni	ns – ni
Starking Delicious	MA	ns – ni	ns – ni	ns – ni	-	ns – ni	-
	BA 29	0.619**	0.517*	ns – ni	ns – ni	ns – ni	0.456*

The asterisk(s) in columns indicate a significant correlation coeficient (r) at $p \le 0.05$ and $p \le 0.01$– Gwiazdka(i) w kolumnie oznacza istotny współczynnik korelacji (r) przy $\alpha \le 0,05$ oraz $\alpha \le 0,01$
ns – non significant – ni – nieistotne

tivar/rootstock combinations did not exhibit significant positive correlation between TH and TD. In 2008, the correlation was significant at $p \leq 0.01$ for 'Abbé Fétel' on MA and BA 29 and at $p \leq 0.05$ for 'Starking Delicious' on BA 29. No significant correlation between TH and TD was observed in other cultivar/rootstock combinations.

The correlation between TH and LSC was significant at $p \leq 0.01$ and $p \leq 0.05$ only for 'Conference' on MA rootstock and 'Abbé Fétel' on BA 29, respectively, in 2007 (tab. 4). In the following year, the correlation was significant at $p \leq 0.01$ for 'Abbé Fétel' and 'Conference' on MA rootstock, and at $p \leq 0.05$ for cvs. 'Abbé Fétel' on MA and 'Conference' on BA 29 rootstock. Other cultivar/rootstock combinations did not reveal significant correlations TH versus LSC in either year.

The correlation between TD and LSC was significant at $p \leq 0.01$ for 'Abbé Fétel' on both MA and BA 29 in both years, and at $p \leq 0.05$ only for 'Starking Delicious' on BA 29 rootstock in the second year. No significant correlation TD vs. LSC was found in other cultivar/rootstock combinations in either year.

DISCUSSION

Evaluation of nursery tree height and tree diameter. This study was focused on determining the effect of cultivar, rootstock and cultivar/rootstock interaction on the primary growth and spontaneous or natural branching in the nursery trees of 'Abbé Fétel', 'Conference' and 'Starking Delicious', or in other words, the formation of primary structure or desirable future tree architecture.

The pear nursery trees in our study reached substantial height in both seasons, the greatest in 'Starking Delicious' and the smallest in 'Conference'. Tree height of 'Conference' was much greater than that reported by Kobelus [2002] for the same cultivar. Some authors reported that vegetative growth in nursery based on the genetic constitution of species and/or cultivars [Lespinasse and Delort 1986, Lauri et al. 1995, 2006], the fact testifying to significant differences in TH observed between pear cultivars in both seasons (tab. 1), also previously described by Jacyna [2004]. Furthermore, the differences in TH were also attributable to the effect of different levels and proportions of auxin and cytokinin in the apical meristem in different pear cultivars [Cline 1991, Wang et al. 1994, Kamboy and Quinlan 1997].

On the other hand, it is not quite clear how a rootstock affects the growth of a nursery tree. An important role has been attributed to hormones by some authors. In this way, Kamboy and Quinlan [1997] reported higher cytokinin levels in the root exudates of vigorous apple rootstocks as compared to dwarf ones, moreover, being lower in the former rootstocks than in the latter ones. The results in our study showed that the influence of rootstocks on TH was not observed, and suggested that TH in nursery trees was more affected by cultivar than rootstock (tab. 1). Similar findings reported Seleznyova et al. [2008], who underlined that rootstocks did not affect on TH of apple trees during the first year after bud-grafting. In addition, the effect of the cultivar/rootstock interaction on TH in pear was not significant over the period of observation, in agreement with previous work in pear [Jacyna [2004], but opposed those for apple recorded by Ferree et al. [2001a, 2001b], which most likely resulted from the strong dominance of scion cultivar in nursery [Tubbs 1974, Webster et al. 1985].

The values of TD for the cultivars in our study were highly analogous to those of TH, being similar over the years (tab. 2). Tree diameter was highest in the cultivar that produced the greatest TH ('Starking Delicious'), and lowest in 'Conference'. The effect of cultivar on TD in this work was highly significant in both years, in accordance with previous work in pear nursery trees [Jacyna 2004]. Moreover, TD was greatly affected by rootstock in 2008, since the BA 29 in this year induced significantly higher TD as compared to the MA rootstock. Similar data for TD in a nursery reported Jacyna [2004] for pear and Baryła and Kapłan [2005, 2006] for cherry and sweet cherry. In addition, Lewko et al. [2007] reported that in 'Conference' grafted on a different rootstock after the first year in the nursery, the highest vigour, indicated by stem diameter, was observed in Caucasian pear seedlings, followed by 'Pyrodwarf' and the lowest one in quince MC; a similar pattern was noted in rootstock stem diameter after the second year.

Tree diameter was not significantly affected by the cultivar/rootstock interaction in either year in our study (tab. 2). In contrast, the apple rootstock/cultivar interactions suggested that overall growth is controlled by rootstock [Ferree et al. 2001a, 2001b]. The above results could be rationally attributed to the specific influence of cultivar of a specific fruit species, in agreement with previous studies [Lespinasse and Delort 1986, Lauri et al. 1995, 2006].

Evaluation of branching in nursery trees. Branching is a key factor in the evolutionary diversification of plants and a main criterion used in plant architecture analysis [Lauri 2007], cultivar being the primary factor affecting branching in fruit trees [Quinlan and Tobutt 1990]. Syllepsis is a type of branching that is based on a decrease in apical dominance [Cook et al. 1998], the loss thereof being used in cases of accelerated growth [Lauri and Costes 1995].

The development of LSC in our study was more intensive in 2007 than 2008 (tab. 3). More importantly, irrespective of the year of observation and the rootstock used, 'Abbé Fétel' produced a significantly greater LSC than 'Conference' and 'Starking Delicious' which exhibited a very weak tendency to produce sylleptic shoots during the first year after bud-grafting in the nursery, which is in accordance with previous works [Cody et al. 1985, Popenoe and Barritt 1988, Volz et al. 1994, Wertheim and Estabrooks 1994]. In addition, some authors reported that differences in the capacity to produce sylleptic shoots among cultivars were likely due to different levels of carbohydrates and/or phyto-hormones in the shoots [Costes et al. 2004]. Řezníček and Salaš [2001] reported that 'Conference' grafted on MA rootstock belonged to the group producing more syllepic shoots in a nursery, which was oposite to the results in our study. The differences between our results and those of Řezníček and Salaš [2001] could be explained by differences in weather and pedological conditions. Also, some authors underlined the key role of ecological and agronomical implications of branching and branch hierarchies [Novoplansky 2003, Baryła and Kapłan 2006], since a single cultivar can produce different phenotypes in different environments due to the phenotypic plasticity of plant organisms [Sultan 2000, de Jong 2005].

The effects of rootstock and cultivar/rootstock interactions on branching were not significant in our study (tab. 3). The studies of pear nursery trees carried out by some authors showed that branching was considerably more affected by cultivar than rootstock [Jacyna 1996], particularly so when the rootstocks exhibited similar vigour, as in this study. The results of the present study did not confirm that the cultivar/rootstock interactions show that the rootstock controls total growth, while the scion controls distribution of growth, such as short vs. long shoots [Ferree et al. 2001a, 2002b], the reason being that from the first year, the length, diameters, volume and sylleptic branching of nursery trees were influenced by cultivar [Legave et al. 2006]. Rootstock can induce branching by affecting vigour [Kamboy and Quinlan 1997], as the trees grafted on vigorous rootstocks produce a higher amount of branching than the ones grafted on dwarf and semi-dwarf rootstocks, as in apple [Seleznyova et al. 2008]. According to Řezníček and Salaš [2001], the number of shoots on pear seedling rootstock was statistically notably higher than that on rootstock quince MA. However, some studies reported opposing results on pear. Namely, better branching was recorded in pear cultivars grafted on low-vigour MA rootstock than on those grafted on vigorous 'Bartlett' seedling, which was due to the lower branching capacity of this species as compared to the other ones [Jacyna 2004]. On the other hand, the effect of cultivar and rootstock on shoot length was highly significant, shoot length being more affected by pear seedlings than MA [Řezníček and Salaš 2001], and rootstocks affecting more the type of growth units [Seleznyova et al. 2008].

Given the fact that LSC did not practically develop in 'Starking Delicious' and that their number was quite moderate in 'Conference' (tab. 3), and therefore insufficient to produce quality nursery trees suitable for establishing HDP [Sansavini et al. 2008]. Generally, it is necessary to apply non-genetic or exogenic measures to stimulate the development of syllepic shoots by „diminishing" the apical dominance in the nursery such as pinching of seedlings [Oullette and Young 1994], removal of immature subterminal leaves [Popenoe and Barritt 1988] or treatment with plant hormones facilitating the growth of sylleptic shoots [Volz et al. 1994, Buban 2000].

Evaluation of correlations among nursery tree traits. This study revealed correlation between TH, TD and LSC in both seasons, though of different intensity (ranging from weak to strong), depending on the cultivar/rootstock combination (tab. 4). Since 'Starking Delicious' on MA rootstock did not develop syllepic shoots in 2008, there was no correlation between TH and LSC or TD and LSC, the reason being a very low branching capacity of these cultivars during the first year after grafting in the nursery [Cody et al. 1985].

The highly significant correlation between TH and TD in 'Abbé Fétel' and 'Starking Delicious' on BA 29 in 2007 and in 'Abbé Fétel' on MA and BA 29 rootstock in 2008 as well as the significant correlation in 'Starking Delicious' on BA 29 suggested that TH and TD were strongly positively correlated, indicating that tree thickness could be estimated from TH with great certainty in the above cultivars. With respect to that, TD may be a useful indicator of the quality of nursery pear trees [Ostrowska and Chełpiński 1997, Kowalik 2001, Łanczont 2004]. However, the above rule cannot be applied with certainty to 'Conference' in this study, as the correlation coefficient was not significant. The differences were most likely induced by the strong effect of cultivar on the height and thickness growth of nursery trees and therefore on their correlation, in agreement with previous works [Tubbs 1974, Webster et al. 1985].

A highly significant positive correlation between TH and LSC in 2007 was only found for 'Abbé Fétel' on BA 29. In 2008, it was only in 'Starking Delicious' that no significant correlation between the above parameters was found, in accordance with previous study in pear [Jacyna 2004], and indirectly with those obtained by Tromp [1996]. However, Kowalik [2001] and Łanczont [2004] did not find significant correlation between TH and LSC in 'Lucas', 'Concorde' and 'Conference', since they considered both LSC and the short shoot count.

Long sylleptic shoots could be most accurately estimated from TD in 'Abbé Fétel' grafted on MA and BA 29 in both seasons due to the highly significant positive correlation (tab. 4). The significant correlation between TD and LSC in 'Starking Delicious' on BA 29 in 2008 pointed to a similar conclusion, whereas in other cultivar/rootstock combinations in both seasons this was not the case. According to Ostrowska and Chełpiński [1997], there was a high correlation between TCSA and total shoot count in nursery-grown pear seedlings. On the other hand, [Jacyna 2004], Kowalik [2001] and Łanczont [2004], found a moderately strong and very strong correlation, respectively, between TD and total shoot count in pear seedlings. Better understanding of the above correlations in our study provides a true insight into the ways of using morphogenetic mechanisms and branching traits in tree training, i.e. tree architecture, in accordance with previous study [Barthélémy and Caraglio 2007].

CONCLUSION

1. The results obtained in this study clearly show that pear cultivar plays a key role in defining the early growth and branching in nursery trees.

2. The effect of rootstock, as compared to that of the cultivar, was incomparably smaller due to the similarity of rootstocks with respect to vigour, whereas the effect of both cultivar/rootstock interaction was not significant.

3. Sylleptic shoot did not practically develop in 'Starking Delicious' and 'Conference', is necessary to apply non-genetic and/or exogenic measures to stimulate their development.

4. Nevertheless, it should be emphasized that the effect of pear cultivar resulted from the responses in the local environment combined with the overall interaction and correlation effecats that were due to integration.

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WZROST I ROZGAŁĘZIANIE SIĘ DRZEW GRUSZY (*Pyrus domestica*, *Rosaceae*) W SZKÓŁCE

Streszczenie. Badanie przeprowadzono w dwóch kolejnych latach w celu zbadania zdolności tworzenia pędów syleptycznych u drzewek gruszy odmian 'Abbé Fétel', 'Conference' oraz 'Starking Delicious' okulizowanych na podkładkach pigwy MA oraz BA 29 w pierwszym roku wzrostu okulantów. W każdym sezonie mierzono wysokość drzewa, średnicę pnia na wysokości 10 cm nad miejscem okulizacji, a także liczbę pędów syleptycznych. Wysokość drzewa mierzono od poziomu gruntu. Najwyższą liczbę pędów syleptycznych zanotowano w obu sezonach dla ‘Abbé Fétel’, natomiast najmniejszą dla ‘Starking Delicious’. Na wysokość i średnicę drzewa istotny wpływa miała w obu latach odmiana, a w roku 2008 – podkładka. Współzależność między komponentami nie wpłynęła w sposób istotny na badane parametry. Badania wykazały, że na wzrost oraz rozgałęzianie się drzew gruszy podczas pierwszego roku po okulizacji większy wpływ miała odmiana niż podkładka.

Słowa kluczowe: drzewa w szkółce, odmiana gruszy, podkładka, korelacja, pędy syleptyczne

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