

## **Influence of Cultivar and Rootstock on Early Growth and Syllepsis in Nursery Trees of Pear (*Pyrus communis* L., Rosaceae)**

**Tomo Milošević<sup>1\*</sup> and Nebojša Milošević<sup>2</sup>**

<sup>1</sup>Department of Fruit Growing and Viticulture; Faculty of Agronomy; Cara Dusana 34; 32000; Cacak - Serbia.

<sup>2</sup>Department of Pomology and Fruit Breeding; Fruit Research Institute; Kralja Petra I/9; 32000; Cacak - Serbia

### **ABSTRACT**

*A two-year field study was conducted to examine the capacity of spontaneous formation of long sylleptic shoots (LSS) in nursery trees of pear cvs. 'Abbé Fétel', 'Conference' and 'Starking Delicious' grafted on Quince MA (MA) and Quince BA 29 (BA 29) rootstocks in a nursery during the first year after bud grafting. Tree height (TH), trunk diameter (TD) - 10 cm above the bud union and number of LSS were measured at the end of each season. The TH was measured from the ground level. The highest number of LSS was developed by cv. 'Abbé Fétel' in both the seasons, and the lowest by cv. 'Starking Delicious'. Tree height and TD were highly significantly affected by the cultivar in both the years and by the 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 the cultivar than by the rootstock under similar weather conditions and on the same soil in a crop rotation system.*

**Key words:** Branching, cultivar, long sylleptic shoot, nursery tree, *Pyrus communis* L., rootstock

### **INTRODUCTION**

Modern orchards are planted at 2,000-5,000 trees ha<sup>-1</sup> or under High Density Planting (HDP), as in pear, if it is grafted on dwarf or semi-dwarf quince rootstocks, yielding at least 40-50 t ha<sup>-1</sup> (Sansavini et al., 2008). High-density pear orchards use one-year-old or two-year old nursery trees with LSS. With respect to that, nursery trees should be branched and should have a number of spirally distributed LSS 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 in a nursery, due to the low natural tendency of nursery-grown fruit trees to develop sylleptic shoots during the first year after grafting (Popenoe and Barritt, 1988; Volz et al., 1994; Wertheim and Estabrooks, 1994). In fruit trees, lateral buds of growing shoots usually do not leaf out (Tromp, 1996) and 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. There are striking differences between the cultivars of diverse fruit species (Wertheim, 1978). Also, the differences in the development of sylleptic shoot over the years are

\*Author for correspondence: tomom@tfc.kg.ac.rs

due to environmental conditions (Tromp, 1996). Fruit tree architecture is defined by a number of criteria related to primary growth (Lauri et al., 1995). 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 the species and/or cultivar (Lespinasse and Delort, 1986; Lauri et al., 1995), and the second is the root system, studied from different standpoints, most commonly in terms of trees grafted on rootstocks (Seleznyova et al., 2008).

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 the 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). With reference to the above, the main objective of this study was to define the capacity to spontaneously produce LSS, i.e. syllepsis intensity in pear cvs. 'Abbé Fétel', 'Conference' and 'Starking Delicious' grafted on quince MA and quince BA 29 rootstocks in a fruit-tree nursery in the first year after bud-grafting.

## MATERIALS AND METHODS

### The study area

The study was conducted in a commercial fruit-tree nursery in 2007. The whole trial was repeated in 2008 on the same soil, but under a crop rotation system involving field pea [*Pisum sativum* var. *arvense* (L.) Poir.]. The nursery was located at Prislonica, 15 km north-east of the town of Cacak (43°53'N; 20°21'E), situated on the border between Central and Western Serbia.

This is mainly an upland area, with an average altitude of about 320 m, characterized by moderate continental climate. Mean annual air temperature was 10.47°C, air humidity - 80.7%, mean annual precipitation - 692.9 mm (the data cover the period 1970 to 2008).

The nursery soil was vertisol, mildly acid (a pH of 6.39 in the topsoil), with a moderate humus supply (3.01%) and a very low total nitrogen content (0.15%), the values thereof gradually decreased with the depth. The contents of available phosphorus ( $P_2O_5$ ) and potassium ( $K_2O$ ) in the 0-40 cm soil depth were 290.0 mg kg<sup>-1</sup> and 300.0 mg kg<sup>-1</sup>, respectively. The soil was kept fallow during

the development of pear nursery trees. Fertilization treatments included applications of mineral nitrogen fertilizers at the rate of 80 kg N ha<sup>-1</sup> 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 the seasons. Drip irrigation was employed in the nursery.

### Plant material and methods

The plant material used in this study included commercial pear cultivars 'Abbé Fétel', 'Conference' and 'Starking Delicious' grafted on MA and BA 29 quince rootstocks. 'Abbé Fétel', 'Conference' and 'Starking Delicious' is the most important cultivars in Serbia. Grown in HDP systems, they offer yearly yields of 60-70 t ha<sup>-1</sup> (Milošević, 1997). 'Abbé Fétel' is a medium vigour tree, while 'Conference' and 'Starking Delicious' are medium vigour to vigour trees. In addition, in Serbia, the majority of pears are grown on quince MA, but quince BA 29 is also used. Quince MA has originated from East Malling in England and is the most common quince in Serbia. This rootstock is not resistant to calcareous (limestone) soil types. On the other hand, quince BA 29 has originated from France and is a high yielding dwarfing rootstock with resistant to calcareous soil types.

In nursery trial, the trees were planted at a spacing of 100 × 10 cm (100,000 trees ha<sup>-1</sup>) 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), trunk diameter (TD) - 10 cm above the bud union and number of LSS. Tree height was measured from the ground level. Total sylleptic shoots were counted and classified as short shoots (<20 cm) or LSS (>20 cm) according to the method described by Volz et al. (1994). Ruler and a digital caliper (Starrett, 727 Series, Athol, NE, USA) were used. These short shoots were not included in the study.

### 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 (two-way) ANOVA, followed by *F*-

test at  $P \leq 0.05$  and  $P \leq 0.01$ . For each cultivar, the significance of differences between the rootstocks was evaluated by LSD test at  $P \leq 0.05$  and  $P \leq 0.01$  and expressed as absolute values. The data were analyzed by MSTAT-C statistical package (M-STAT, 1990).

## RESULTS

### Nursery tree height and trunk diameter

The analysis of TH values among the cultivars showed that TH was lowest in 'Conference' and highest in 'Starking Delicious' in both the seasons, whereas in 'Abbé Fétel' was intermediate (Table 1). For rootstocks, higher TH values were recorded for BA 29 as compared to MA in both the years. The effect of cultivar on TH was significant in both the seasons at  $P \leq 0.01$ , and that of rootstock

only in 2008 at  $P \leq 0.05$ . The effect of years on TH was significant for pear cultivars evaluated, while cultivar/rootstock interactions were not observed.

Table 1 also shows the effects of cultivar, rootstock and cultivar/rootstock combination on TD. The TD values were similar in both the seasons, irrespective of the cultivar, rootstock and year ( $1.22 \pm 0.03$  cm in 2007 and  $1.24 \pm 0.03$  cm in 2008). 'Conference' and 'Starking Delicious' had the lowest and highest TD, respectively in both seasons. Trunk diameter of the rootstocks was similar in 2007 and 2008, although somewhat higher in BA 29 than in MA. On the other hand, TD was significantly affected by the cultivar in both the years ( $P \leq 0.01$ ) and by rootstock in 2008 only ( $P \leq 0.05$ ). Cultivar/rootstock interactions did not have a significant effect on TD (Table 1).

**Table 1** - Influence of cultivar and rootstock on the height, trunk diameter and number of long sylleptic shoots of pear nursery trees (mean $\pm$ SE,  $n = 40$ ).

Treatment	Tree height (cm)		Trunk diameter (cm)		Number of long sylleptic shoots		
	2007	2008	2007	2008	2007	2008	
Cultivar (A)							
Abbé Fétel	156.75 $\pm$ 2.05 b	156.85 $\pm$ 3.06 b	1.29 $\pm$ 0.03 b	1.28 $\pm$ 0.05 b	6.12 $\pm$ 0.93 a	4.37 $\pm$ 0.81 a	
Conference	117.27 $\pm$ 7.69 c	119.70 $\pm$ 6.13 c	1.01 $\pm$ 0.03 c	1.04 $\pm$ 0.02 c	1.97 $\pm$ 1.77 b	2.10 $\pm$ 0.39 b	
Starking Delicious	189.40 $\pm$ 5.49 a	195.00 $\pm$ 4.56 a	1.37 $\pm$ 0.04 a	1.41 $\pm$ 0.03 a	0.35 $\pm$ 0.12 c	0.47 $\pm$ 0.12 c	
Rootstock (B)							
Quince MA	151.90 $\pm$ 3.56 a	150.75 $\pm$ 3.32 b	1.18 $\pm$ 0.03 a	1.22 $\pm$ 0.04 b	2.40 $\pm$ 0.38 a	1.90 $\pm$ 0.39 a	
Quince BA 29	157.05 $\pm$ 4.29 a	163.62 $\pm$ 3.82 a	1.26 $\pm$ 0.04 a	1.27 $\pm$ 0.03 a	3.23 $\pm$ 0.66 a	2.73 $\pm$ 0.23 a	
A $\times$ B							
Abbé Fétel	MA	165.35 $\pm$ 2.05 a	150.00 $\pm$ 3.06 a	1.23 $\pm$ 0.03 a	1.25 $\pm$ 0.04 a	5.55 $\pm$ 0.70 a	3.90 $\pm$ 0.77 a
	BA 29	148.15 $\pm$ 5.15 a	163.70 $\pm$ 4.96 a	1.35 $\pm$ 0.05 a	1.31 $\pm$ 0.05 a	6.70 $\pm$ 1.15 a	4.85 $\pm$ 0.84 a
Conference	MA	108.45 $\pm$ 3.85 a	112.15 $\pm$ 2.74 a	1.01 $\pm$ 0.03 a	1.04 $\pm$ 0.02 a	1.60 $\pm$ 0.40 a	1.80 $\pm$ 0.39 a
	BA 29	126.10 $\pm$ 3.03 a	127.25 $\pm$ 2.89 a	1.00 $\pm$ 0.03 a	1.04 $\pm$ 0.02 a	2.35 $\pm$ 0.48 a	2.40 $\pm$ 0.31 a
Starking Delicious	MA	181.90 $\pm$ 5.49 a	190.10 $\pm$ 4.16 a	1.32 $\pm$ 0.04 a	1.35 $\pm$ 0.03 a	0.05 $\pm$ 0.03 a	0.00 $\pm$ 0.00 a
	BA 29	196.90 $\pm$ 5.18 a	199.90 $\pm$ 4.56 a	1.43 $\pm$ 0.04 a	1.47 $\pm$ 0.03 a	0.65 $\pm$ 0.20 a	0.95 $\pm$ 0.24 a
Mean over years	154.47 $\pm$ 4.35 B	157.18 $\pm$ 4.31 A	1.22 $\pm$ 0.03 A	1.24 $\pm$ 0.03 A	2.81 $\pm$ 0.62 A	2.31 $\pm$ 0.41 B	
ANOVA							
Cultivar (A)	**	**	**	**	**	**	
Rootstock (B)	ns	**	ns	*	ns	ns	
A $\times$ B	ns	ns	ns	ns	ns	ns	

A and B represent 'Cultivar' and 'Rootstock' treatment, respectively;

Means followed by the same small letters, within the same column, are not significantly different (LSD at  $P \leq 0.05$  and  $P \leq 0.01$ );

Means followed by the same capital letters, within the row, are not significantly different (LSD at  $P \leq 0.05$  and  $P \leq 0.01$ );

\* and \*\* - significant at  $P \leq 0.05$  and  $P \leq 0.01$  by LSD test, respectively; ns - non significant differences.

### Number of long sylleptic shoot

The influence of cultivar, rootstock and cultivar/rootstock combination on the number of LSS are presented in Table 1. The average number of LSS was significantly higher in the first year than in the second, the highest being recorded in

'Abbé Fétel' ( $6.12 \pm 0.93$  shoot/tree in 2007 and  $4.37 \pm 0.81$  shoot/tree in 2008) and the lowest in 'Starking Delicious' ( $0.35 \pm 0.12$  shoot/tree in 2007 and  $0.47 \pm 0.12$  shoot/tree in 2008) in both the seasons. The number of LSS was significantly affected by the cultivar in both the years, whereas

the rootstock and cultivar/rootstock interactions effect on number of LSS were not observed.

## DISCUSSION

### Analysis of nursery tree height and trunk diameter

The pear nursery trees examined in this study reached good height in both the seasons, the highest in 'Starking Delicious' and the lowest in 'Conference'. Tree height of 'Conference' was much higher than that reported by Kobelus (2002) for the same cultivar (Table 1). Vegetative growth is 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 among the cultivars in both the seasons (Table 1), as previously observed by Jacyna (2004). Moreover, the differences in TH are also attributable to the effect of different levels and proportions of auxin and cytokinin in the apical meristem in different pear cultivars (Wang et al., 1994). It is not quite clear how a rootstock affects the growth of a nursery tree. An important role has been attributed to the hormones by some authors. Kamboj and Quinlan (1997) reported a higher cytokinin levels in the root exudates of vigorous apple rootstocks as compared to dwarf ones. In the present study, the influence of rootstock and cultivar/rootstock interaction on TH was not significant. Similar findings were found by Seleznyova et al. (2008), who reported that rootstocks did not affect on TH of young apple trees during the first year after bud-grafting. The results conformed to those for pear reported by Jacyna (2004).

The values of TD for the cultivars examined in the present study were highly analogous to those of TH and were similar in both the seasons (Table 1). A significant effect of cultivar on TD in both the years was observed, which was in agreement with the previous work on pear (Jacyna, 2004). The TD was greatly affected by the rootstock in 2008, since the BA 29 in this year induced significantly higher TD when compared with MA rootstock. Similar data on TD in a pear nursery were found by Jacyna (2004). Some authors reported that 'Conference' after first year in the nursery, had the highest vigour on Caucasian pear seedlings, followed by 'Pyrodwarf' and the lowest on quince MC; a similar pattern was noted in the rootstock stem diameter after the second year (Lewko et al.,

2007). In the present study, TD was not significantly affected by the cultivar/rootstock interaction in both the years. However, the apple rootstock/cultivar interactions suggested that overall growth was controlled by the rootstock (Ferree et al., 2001). The above results could be rationally attributed to the specific effect of the cultivar of a specific fruit species (Lespinasse and Delort, 1986; Lauri et al., 1995, 2006). The TD is used to calculate the trunk cross-sectional area (TCSA), both values testifying to the strength of the tree growth. The TCSA in apple 'Royal Gala' is significantly affected by rootstock and/or interstock (Seleznyova et al., 2003), the finding being in conformity with the results of the present study for the second season, though, when the effect of BA 29 on TD was facilitated and that of MA diminished most likely by a factor that was not controlled in the trial.

### Analysis of syllepsis intensity

The syllepsis intensity in this study was significantly affected by the cultivars (Table 1). 'Abbé Fétel' produced significantly higher number of LSS when compared with the 'Conference', especially when 'Starking Delicious' exhibited a very weak tendency to produce sylleptic shoots during the first year after grafting. Wertheim (1978) reported that syllepsis were striking differences between the cultivars of diverse fruit species. According to Lewko et al. (2007), 'Erika' feathered spontaneously more than 'Conference'. In addition, the differences in the capacity to produce sylleptic shoots among the cultivars were likely due to different levels of carbohydrates in the shoots or phyto-hormones levels and their ratio in apical meristem (Wang et al., 1994). Řezníček and Salaš (2001) reported that the 'Conference' on MA quince belonged to the group producing more LSS in a nursery, which was contrary to the results in the present study. The differences between these results and those of Řezníček and Salaš (2001) could be explained by the differences in the climatic and soil conditions. Therefore, the main factor determining the tree vigour and branching is genetics (Quinlan and Tobutt, 1990). Studies on pear carried out by other authors showed that branching, i.e., syllepsis was considerably more affected by the cultivar than by the rootstock, though less so than in other fruit species (Jacyna, 1996, 2004), particularly when the rootstocks had similar vigour, as was the case in this study. Air temperature, soil temperature and relative

humidity also play important role in sylleptic branch formation (Tromp, 1996)

The influence of rootstock and cultivar/rootstock interactions on syllepsis was not found in this study (Table 1). The effect of rootstock on syllepsis was a function of their effect on scion vigour (Lewko et al., 2007). Moreover, trees grafted on vigorous rootstocks usually produce more sylleptic shoots than those grafted on dwarf and semi-dwarf rootstocks (Kamboj and Quinlan, 1997). For example, Lewko et al. (2007) reported that 'Pyrodwarf' and OH×F 333 rootstocks developed more numerous and longer feathers than on quince. According to Řezníček and Salaš (2001), the number of sylleptic shoots when cultivars grafted onto seedling was significantly higher than on quince MA. However, some authors have reported contrasting results. Better branching was recorded in pear cultivars grafted on low-vigour MA than those grafted on vigorous 'Bartlett' seedlings, which was due to the limited syllepsis capacity of maiden pear trees as compared to the other ones such as apple and sour cherries (Jacyna, 2004). The rootstocks grown in a hot and humid climate might also have some effect on branch formation in nursery. Given the fact that LSS did not practically develop in 'Starking Delicious' and that their number was quite moderate in 'Conference' and hence insufficient to produce the quality nursery trees suitable for HDP system, it was necessary to employ non-genetic or exogenic measures to stimulate the development of LSS. These measures include pinching of seedlings (Wertheim, 1978), removal of immature sub-terminal leaves (Popenoe and Barritt, 1988) or treatment with plant hormones to facilitate the growth (Volz et al., 1994; Henrique et al., 2006). Also, reduction in apical dominance and increase in lateral ramification under nursery production are most commonly achieved through growth enhancement measures (Tromp, 1996). Nevertheless, pear is usually considered as a vigorous species and its branching habit is often naturally erect. Dwarfing rootstocks are commonly used to reduce more rapidly the vigour of the pear trees, and consequently to promote earlier flowering (Seleznayova et al., 2003). However, the present study showed that the trees which developed fewer sylleptic shoots in the first years of growth were not the best solution to obtain an entrance into the productive period in the second and third year. For this reason, cultural practices in pear orchards such

as summer pruning, artificial bending or fruit thinning could be crucial interventions in orchard management and should be used for controlling the tree vigour, penetration of light into the canopy and the equilibrium between vegetative and reproductive growth (Fumey et al., 2008).

In conclusion, the results obtained in the present study clearly showed that cultivars played a key role in defining the early growth (TH and TD) and syllepsis intensity in nursery trees of pear. The effect of MA and BA 29 dwarf rootstocks was only observed on TH and TD in 2008, whereas the effect of cultivar/rootstock interaction was not found. In addition, year-by-year variation was significant for TH and syllepsis. This suggested the necessary to reduce apical dominance in the 'Conference', especially in 'Starking Delicious' cultivars grafted on MA and BA 29 rootstocks in order to stimulate the development of LSS and syllepsis in nursery trees of pear.

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