Evaluation of *Pyrus* and Quince Rootstocks for High Density Pear Orchards

F. Maas
Applied Plant Research
Research Unit Flower Bulbs, Nursery Stock & Fruits
Lingewal 1, 6668 LA Randwijk
The Netherlands

Keywords: *Cydonia oblonga*, production efficiency, graft compatibility, growth control, high density orchard, *Pyrus communis*

Abstract

High density planting systems are a prerequisite to economise the use of land and labour costs of orchards. Dwarfing rootstocks controlling the vigour of the scion cultivars form the basis for such orchards (Wertheim and Webster, 2005). In the Netherlands, rootstock research is limited to and focussed on testing rootstocks selected abroad. For the Dutch pear growers the main selection criteria for new rootstocks are: 1) control of tree size; 2) production; 3) fruit size; 4) fruit quality; 5) production efficiency; 6) frost resistance. Additional criteria for Dutch fruit tree nurseries exporting trees to other countries are: 1) compatibility with scion cultivars; 2) suitability for growth in calcareous soils; 3) easy propagation. In all trials rootstock performance is compared to Quince MC, the most commonly used rootstocks for pears in the Netherlands. Recently, a number of *Pyrus* (*Pyrus communis)* and Quince (*Cydonia oblonga*) rootstocks have been tested with 'Conference' and 'Doyenné du Comice' as the scion cultivars. Generally, the production efficiency of the *Pyrus* rootstocks was much less than for Quince MC. Another disadvantage of the evaluated *Pyrus* rootstocks was their high sensitivity towards pear decline. Several rootstocks were rejected after examination of the graft union because of suspected compatibility problems. Of the tested Quince rootstocks C 132 shows promise because of its control of tree growth in combination with good fruit size and Eline® because of its reduction of fruit russeting in 'Conference'.

INTRODUCTION

High density planting systems are the starting point of modern orchards. Small trees that come into production in the second year after planting are a prerequisite to achieve regular yields of high quality fruits and to economise the use of land and labour costs for pruning and picking. Dwarfing rootstocks, controlling the vigour of the scion cultivars and inducing precocity of cropping, form the basis for such high density orchards.

European pears are predominantly grown on rootstocks of Quince (*Cydonia oblonga*). In the Netherlands, the majority of pears are grown on Quince MC, but Quince MA and Quince Adams are also used. 'Conference' is the most important cultivar. Grown in high density planting systems yearly yields of 60 to 70 tons/ha are feasible. To obtain this production level a good control of shoot growth, flower bud development and fruit set is required.

Although Quince MC has been used successfully for many decades in the Netherlands, there are several reasons to look for alternative rootstocks. Until 2001, the growth retardant chlormequat (CCC) was used the reduce shoot growth and stimulate flower bud development. The withdrawal of CCC for use by fruit growers has renewed the interest in rootstocks more dwarfing than Quince MC. Besides dwarfing of the scion cultivar other desired traits of new rootstocks for pears are: 1) precocity of cropping, to ensure early yields starting in the second year after planting; 2) fruit size, for 'Conference' pears the proportion of pears with a diameter >65 mm should be as large as possible; 3) disease resistance, especially towards fire blight and pear decline; 4)

compatibility with scion cultivars; 5) frost resistance; 6) ease of propagation; 7) suitability for growth on calcareous soils (absence of lime-induced chlorosis). In addition, new rootstocks may also be used to meet the changes in market demands for 'Conference' pears like larger and less russeted fruits.

Since there is no breeding program for pear rootstocks in the Netherlands, the research on pear rootstocks is limited to testing rootstocks selected in other countries. The main selection criteria for the Dutch pear industry are: 1) tree size; 2) production; 3) production efficiency; 4) fruit size distribution. Additional criteria for nurseries exporting fruit trees to other countries are: 1) compatibility with as many modern scion cultivars as possible; 2) suitability for growth in different soils; 3) easy propagation.

During the past decades a large number of rootstocks were collected by Wertheim (1998). The results of evaluation trials with several of these rootstocks have already been published (Wertheim, 2002; Wertheim and Vercammen, 2000). This paper contains the results of three more recent trials with the cultivars 'Conference' and 'Doyenné du Comice' grafted on a number of other Quince and *Pyrus* rootstocks.

MATERIALS AND METHODS

Plant Materials

All trials were planted in the experimental orchard of the fruit research station at Randwijk (5.707° East, 51.937° North) in fresh soil consisting of river clay with 30% silt. Trees were planted at a distance of 3.5 x 1.5 m and were trained as spindle trees according to local commercial practice. Growth of the trees was not regulated by chemical growth regulators, root pruning or girdling of the trunks. No gibberellins were applied to stimulate fruit set. Contrary to common practice the rootstocks were not protected by a layer of mushroom compost during the winter in order to evaluate the frost resistance of the different rootstocks.

During a period of at least 5 years the growth and production of the trees was monitored by:

- Annual or biennial measurement of the girth of the trunk at a fixed point ca. 30 cm above the graft union
- Annual shoot growth on a scale from 1 (no shoot growth) to 9 (very vigorous growth)
- Annual flower intensity on a scale from 1 (no flowers) to 9 (very abundant flowering)
- Annual fruit production (number of fruits and kg fruits per tree)
- Analysis of mineral content of leaves and fruits (once for each trial 3 to 5 years after planting)
- Fruit size distribution (at least once for each trial 4 to 5 years after planting)
- Calculation of production efficiency (number of fruits/cm² trunk cross sectional area)

Trial 1 (code 044-Ra99107)

Trees were planted on April 8th, 1998. The statistical design of the trial was a split plot with the scion cultivar being the whole plot and the rootstocks the sub plots. Plots were replicated 8 times and contained one tree of each treatment. In this trial the growth of 'Conference' and 'Doyenné du Comice' budded at 10 or 25 cm height was compared for the Quince rootstocks MC, C132, and the *Pyrus* rootstock BP10030 (Trajkovski and Andersson, 1990). Rootstocks were obtained from Naktuinbouw (Netherlands Inspection Service for Horticulture) (MC), HRI East Malling, UK (C132), Eliteplantstation Balsgård, Sweden (BP10030) and Fleuren Nurseries, Netherlands (Eline®). MC, C132 and BP10030 were virus free. The virus-status of Eline® was unknown.

Trial 2 (code 044-Ra00105)

Trees were planted on March 30th, 2000. The statistical design of the trial was a split plot with the scion cultivar being the whole plot and the rootstocks the sub plots. Plots were replicated 10 times and contained one tree of each treatment. The growth of 'Conference' and 'Doyenné du Comice' grafted on Quince MC was compared with trees

grafted on Quince Sobu, the *Pyrus communis* cultivars 'Delbuena', 'Dolacomi' and 'Gieser Wildeman' and the clonal *P. communis* rootstock Pyrodwarf. Plant materials of 'Delbuena', 'Dolocomi' and 'Gieser Wildeman' were considered to be virus-free as they were grown from seed. MC and Sobu were obtained as virus-free material. The virus status of Pyrodwarf was unknown.

Trial 3 (code 044-Ra01101)

Trees were planted on March 13th, 2001. The statistical design of the trial was a split plot with the scion cultivar being the whole plot and the rootstocks the sub plots. Each plot was replicated 6 times and consisted of 3 trees per treatment. In this trial the growth of 'Conference' and 'Doyenné du Comice' grafted on Quince MC was compared with trees grafted on the Quinces Adams, Sigwa 3, MC Peters, MH (=QR 193-16), ME and the pyrus 'Gieser Wildeman'. The virus status of Sigwa 3 and MH was unknown, all other rootstocks were assumed to be virus-free as they were obtained from virus-free stock plants or grown from seed (Gieser Wildeman).

Statistical Analysis

The data were analysed using the Genstat statistical program (release 8.1). In trial 1, the results of the trials with 'Conference' and 'Doyenné du Comice' were analysed separately because of the difference in the duration of the trials. If possible, the data of all other trials were analysed using the analysis of variance for a split plot design. In case of significant differences ($p<0.05$), LSD values were calculated and used for comparing treatment means in pairs.

RESULTS

Trial 1 (044-Ra99107)

As no significant effect of budding height was observed on growth and production, the data of both budding heights were taken together. *Pyrus* BP10030 gave the lowest shoot growth index and the smallest increase in trunk circumference (Table 1). With 'Conference' the growth was very weak. Quinces C.132 and Eline® gave comparably slightly more growth in both 'Conference' and 'Doyenné du Comice'.

The cumulative production of 'Conference' on BP10030 was only 45% of that on Quince MC (Table 2). On Quince C.132 'Conference' produced slightly less and on Quince Eline® slightly more than on Quince MC, but these differences were not statistically significant. From 2000 to 2005 'Conference' produced the largest number of fruits on Quince MC and Quince Eline®, about 20% less fruits on Quince C.132 and approx. 50% less on BP10030. Despite the low number of fruits, the average fruit weight was lowest on BP10030. On the Quince rootstocks the average fruit weight was the highest for the rootstock with the lowest number of fruits. Production efficiency (number of fruits per cm² TCSA) was highest on Quince Eline®, but not statistically different from that on Quince MC. Cumulative production and total number of fruits of 'Doyenné du Comice' was similar for all 4 rootstocks, but with an average production of only 32 kg and 125 fruits per tree much lower than the 87 kg and 500 fruits per tree for 'Conference' on the tested Quince rootstocks (Table 3). Average fruit weight of 'Doyenné du Comice' was highest on C.132 and least on Eline®. Production efficiency was highest for BP10030. The fruits harvested in 2003, 2004 and 2005 were graded in size. Table 4 shows that C.132 gave the highest percentages of fruit with a diameter > 65mm. However due to the large variation between the observation trees these differences were not statistically different in this trial.

Leaf appearance of both 'Conference' and 'Doyenné du Comice' grafted onto BP10030 was not as healthy as on any of the other rootstocks. Many leaves were pale green to yellowish. Mineral analysis of the leaves during the summer of 2002 revealed lower contents of K, Mg and Ca in Conference and Mg and Ca in 'Doyenné du Comice' (Table 5). Flowering of 'Conference' was quite regular and good over the years 2000 to

2005. Average flower intensity over this period was between 5.5 and 6.2. Flowering of 'Doyenné du Comice' was less regular. Average flower intensity from 2000 to 2005 varied between 3.5 and 5.3, with the lowest observed in 2001 (1.0 to 3.4) and the highest in 2005 (7.3 tot 7.8). In both cultivars rootstock BP 10030 resulted in the highest flower intensities.

At the end of the trial the graft unions of 'Conference' and 'Doyenné du Comice' grafted on BP10030 were examined. The bark was removed and longitudinal sections were made of the graft unions. Figure 1 shows the longitudinal sections of the graft unions of both scion cultivars grafted onto BP10030. As can be seen in this figure, compatibility between BP10030 looks good and Conference (this previous part of the sentence does not make sense also the figure is missing from the paper sent to me) is very poor, while that between Sobu and 'Doyenné du Comice' seems to be much better. However, also in the latter combination a clear separation line between the wood of the scion and the rootstock is visible indicating both tissues are also not fully compatible.

Trial 2 (044-Ra00105)

Table 6 summarises the production of 'Conference' and 'Doyenné du Comice' grown on four different *Pyrus* cultivars and Quince Sobu as rootstocks in comparison with the standard rootstock Quince MC. Production was highest on Quince MC and did not differ significantly between the 4 *Pyrus* rootstocks and Quince Sobu. Despite the lower fruit numbers, average fruit weights on 'Dolacomi' and 'Gieser Wildeman' were lower than on MC and Pyrodwarf. With 'Doyenné du Comice' Quince Sobu was second best with respect to production and production efficiency.

Table 7 shows that 'Conference' grew weakest on rootstock Sobu. Differences in growth between all other combinations were quite small. With 'Doyenné du Comice' the growth indices and increases in trunk diameter were similar for all rootstocks used in the trial. 'Conference' trees on Sobu did not look as healthy as on the other rootstocks and growth of the cultivar was much weaker than that of 'Doyenné du Comice' on the same rootstock, indicating some kind of incompatibility between 'Conference' and Sobu. At the end of the trial longitudinal sections was made of the graft unions of both scion cultivars grafted onto Sobu. These sections revealed that part of wood of the graft unions between Sobu and 'Conference' was black, a clear sign of incompatibitily. The union between Sobu and 'Doyenné du Comice' looked much healthier. However, also in the latter combination a clear separation line between the wood of the scion and the rootstock was visible, indicating that also in this case both tissues are not fully compatible.

Average flower intensities over the trial period were between 4.4 and 5.4 for 'Conference' and 3.4 and 4.9 for 'Doyenné du Comice'. In both cultivars the lowest flower intensities were noted for trees grown on Gieser Wildeman and the highest for trees grown on Quince MC.

Trial 3 (044-Ra01101)

In Table 8 the growth and production of 'Conference' and 'Doyenné du Comice' on Quince MC is presented together with that on 4 other Quinces (Adams, MC Peters, MH (= QR 193-16), ME, and Sigwa 3) and on the *Pyrus* Gieser Wildeman. Both scion cultivars showed similar patterns in growth. Compared to growth on Quince MC a significantly higher growth index and a larger increase in trunk circumference was noted on both Gieser Wildeman and Sigwa 3. On MC Peters the growth index and increase in trunk circumference equalled those on MC. On Adams the growth index of 'Conference' equalled that on MC, while that of 'Doyenné du Comice' was slightly higher. No differences were observed in the increases in trunk circumferences of either scion cultivar on MC and Adams. With the exception of a smaller increase in trunk circumference of 'Doyenné du Comice', growth of both scion cultivars on MC Peters equalled that on MC. Significantly lower growth indices were observed in both scion cultivars on Quinces MH and ME. Increases in trunk circumferences were also smaller on these rootstocks, but these differences were only statistically significant in 'Doyenné du Comice'.

The average growth on Gieser Wildeman presented in Table 7 was somewhat reduced by the occurrence of pear decline in several observation trees in some. In all years, trees on Gieser Wildeman without any visual symptoms of pear decline showed a much stronger growth than on MC.

Contrary to an earlier experiment at the former location of the research station in Wilhelminadorp (Wertheim, 2002), growth on Sigwa 3 was stronger than on MC. The most probable explanation for the weaker growth in Wilheminadorp was the use of virus-infected Sigwa 3. The growth on virus-free Sigwa 3 in the experiment in Randwijk indicates that this rootstock is too vigorous for Dutch high density orchards.

Cumulative productions of 'Conference' and 'Doyenné du Comice' are shown in Table 9. 'Conference' produced the highest number of fruits on the MC, Adams and MC Peters. On Sigwa 3, Gieser Wildeman and MH trees produced about 100 fruits less. On ME trees produced only one third of the number of fruits as compared to trees on MC. 'Conference' trees produced similar kg fruits on MC, Adams and MC Peters. On Sigwa 3 and MH trees produced about 15 kg less. Trees on Gieser Wildeman and ME produced about 26 and 34 kg less, respectively, than on MC. Average fruit weight was only significantly reduced for 'Conference' grown on Gieser Wildeman. Production efficiency was highest for 'Conference' on MC. Trees on Adams and MC Peters had slightly lower production efficiency, but the difference to MC was not statistically significant. Significant lower efficiencies compared to MC were noted for 'Conference' on MH (-17%), ME (-46%), and Sigwa 3 (-52%) and Gieser Wildeman (-54%).

Compared to 'Conference' fruit production of 'Doyenné du Comice' was lower for all rootstocks. The highest number of fruits and kg/tree were produced on Adams, MC Peters and MC, the lowest numbers on Gieser Wildeman and ME. Average fruit size was highest on ME and lowest on Gieser Wildeman. Production efficiency was highest on MC Peters followed by Adams, MC and MH. Gieser Wildeman gave by far the lowest production efficiency.

Flower intensity over the trial period was generally good and averaged between 4.9 and 6.4 in 'Conference' and 3.6 and 6.0 in 'Doyenné du Comice'. In both cultivars the lowest flower intensities were observed for trees grown on *Pyrus* Gieser Wildeman or Quince ME, the highest flower intensites for trees grown on the Quinces MC, Adams and MC Peters.

DISCUSSION

'Conference' and 'Doyenné du Comice' trees rose from the same batch of rootstocks and scion buds and at the same nursery in the Netherlands were also planted in 1999 in a trial at East Malling Research in England (Johnson et al., 2005). Compared to the Dutch trial production of 'Conference' in the UK was lower and the percentage of fruits having a diameter of 65 mm or more was much lower for trees grown on rootstocks MC and C132. With 'Conference' the *Pyrus* rootstock BP10030 was less productive. In the trial in England this was not yet noticeable in 2003 (Johnson et al., 2005), but became very clear in 2004 (Johnson, pers. commun., 2006). The observed tendency of C132 increasing fruit size of 'Conference' in the Dutch trial was confirmed by the results of the trial in England. The negative effect of leaf appearance of 'Conference' grafted on BP10030 together with the decreased productivity warrants further attention and may possibly be the result of a cultivar-specific incompatibility. Although such negative effects were not observed with cultivar 'Doyenné du Comice', the formation of a very thickened graft union may possibly affect graft compatibility in the future and thus necessitates further research. An interesting observation was the reduction of russeting of 'Conference' when grown on the rootstock Eline®. This may be of interest when the market demands fruits with less russeting in pears. Frost resistance is expected to be another advantage of both Eline® and C132 as they originate from areas with much more severe winters. However, lack of severe winter frosts during the trial period made it impossible to evaluate this characteristic.

Pyrus rootstocks are attractive from the point of view of better compatibility, frost

hardiness and tolerance to lime-induced chlorosis than most Quince rootstocks. However, all *Pyrus* rootstocks evaluated so far resulted in stronger growth, a lower production efficiency and generally smaller fruit size than Quince MC. In addition, another negative aspect of *Pyrus* rootstocks is their observed sensitivity to pear decline. Of the tested Quinces the weakest growth and highest production efficiency was observed for 'Conference' and 'Doyenné du Comice' grown on Sobu. However, based on the anatomy of the graft union and the poor leaf quality the dwarfing by this rootstock seems to be caused by incompatibility, especially with 'Conference'. Large variation was observed in vigour between the 10 replicate trees of the trial, indicating variability in the establishment of a successful graft union. As virus free plant material of Sobu was used, it is unlikely that viruses were the reason for the differences in growth between the trees. Quinces MH, Eline® and C132 were the best performing rootstocks of the trials and their control of tree vigour and production efficiency were quite similar to Quince MC. Specific characteristics like slightly more dwarfing (MH), bigger fruit size (C 132) and expected greater frost resistance (C 132, Eline®), less russeted fruits with 'Conference' (Eline®) may favour their choice above the currently most used Quince rootstocks MC and Adams, depending on the desired planting system, scion cultivar and market demands for fruit size and russeting. A larger demonstration trial is in preparation to compare the growth and production of 'Conference' with these three rootstocks in comparison with MC and Adams in the Netherlands and to further optimise cultivation practises.

ACKNOWLEDGEMENT

This research was financed by the Dutch Product Board for Horticulture.

Literature Cited

Johnson, D., Evans, K., Spencer, J., Webster, T. and Adam, S. 2005. Orchard Comparisons of New Quince and *Pyrus* Rootstock Clones. Acta Hort. 671:201–207.

Trajkovski, V. and Andersson, G. 1990. Rootstock Breeding. Sveriges Lantbrukuniversitet. Balsgård – Avdelningen För Hortikulturell Växtförädling. Verksamhetsberättelse 1988–1989. p.27–30.

Wertheim, S.J. 1998. Rootstock guide. Apple, pear, cherry, European plum. Publication Fruit Research Station, Wilheminadorp. p.144.

Wertheim, S.J. 2002. Rootstocks for European pear: a review. Acta Hort. 596:299–309.

Wertheim, S.J. and Vercammen, J. 2000. A multi-site pear-interstem trial in the Netherlands and Belgium. J. Amer. Pomol. Soc. 54:199–207.

Wertheim, S.J. and Webster, A.D. 2005. Rootstocks and interstems. p.156–175. In: J. Tromp, A.D. Webster, S.J. Wertheim (eds.), Fundamentals of Temperate Zone Tree Fruit Production. Backhuys Publishers, Leiden.

Tables

Table 1. Average growth ‘Conference’ and ‘Doyenné du Comice’.

Rootstock	Growth index[1]		Increase trunk circumference (cm)	
	Conference 2001–2005	Doy. du Comice 2001–2004	Conference spring 1999–autumn 2005	Doy. du Comice spring 1999–autumn 2004
Quince MC	4.7 b	5.9 b	12.6 b	14.7 b
BP10030	2.4 a	4.2 a	7.9 a	12.0 a
C.132	5.0 bc	6.2 b	13.6 b	15.9 bc
Eline®	5.4 c	6.0 b	13.7 b	16.4 c
F-test	p<0.001	p<0.001	p<0.001	p<0.001
$LSD_{0.05}$	0.6	0.6	1.6	1.8

[1]on scale 1 (no growth) to 9 (very strong growth).

Table 2. Cumulative production ‘Conference’.

Rootstock	kg/tree 2000–2005	Fruits/tree 2000–2005	Fruit weight (g) 2000–2005	Fruits/cm^2 TCSA[1]
MC	87.0 b	503 c	193 b	19.0 bc
BP10030	39.7 a	266 a	176 a	17.4 ab
C.132	81.4 b	433 b	212 c	15.5 a
Eline®	92.3 b	563 c	186 ab	20.5 c
F-test	p<0.001	p<0.001	p<0.001	p<0.05
$LSD_{0.05}$	12.2	68	12	3.0

[1]Total number of fruits per tree n 2000–2005 per cm^2 trunk cross sectional area (TCSA) autumn 2005.

Table 3. Cumulative production ‘Doyenné du Comice’.

Rootstock	kg/tree 2000–2005	Fruits/tree 2000–2005	Fruit weight (g) 2000–2005	Fruits/cm^2 TCSA[1]
MC	34.2	133	287 ab	4.4 ab
BP10030	31.6	128	299 b	5.5 b
C.132	31.2	112	304 b	3.4 a
Eline®	31.6	129	268 a	4.3 a
F-test	ns	ns	p<0.05	p<0.01
$LSD_{0.05}$			26	1.1

[1]Cumulative number of fruits per tree n 2000–2005 per cm^2 trunk cross sectional area (TCSA) autumn 2005.

Table 4. Fruit size ‘Conference’ (% of total kg/tree).

Rootstock	2003		2004		2005	
	>55 mm	>65 mm	>55 mm	>65 mm	>55 mm	>65 mm
MC	91 b	52 c	89	33	89	48
BP10030	50 a	6 a	-	-	-	-
C.132	94 b	54 c	92	40	94	62
Eline®	88 b	42 c	93	40	86	40
F-test	p<0.001	p<0.001	ns	ns	ns	ns
$LSD_{0.05}$	16	17				

Table 5. Mineral analysis[1] of leaves harvested on August 26th, 2002.

Rootstock	N	P	K	Mg	Ca	Fe	Mn	Zn	B	Cu
					Conference					
Quince MC	2.12	0.19	1.21	0.24	1.76	75.8	75.0	58.2	22.2	6.5
C132	2.14	0.23	1.55	0.18	1.74	77.2	56.8	56.8	24.8	7.0
BP10030	2.10	0.18	0.99	0.14	1.22	68.0	85.5	68.2	24.5	6.0
Quince Eline®	2.05	0.18	1.28	0.22	1.72	68.8	73.2	51.5	22.8	4.4
F-test	ns	ns	*	***	***	ns	*	ns	ns	ns
$LSD_{0,05}$			0.4	0.03	0.18		19.0			
					Doyenné du Comice					
Kwee MC	1.83	0.17	1.36	0.30	1.81	64.0	80.2	69.0	22.5	5.8
C132	1.89	0.17	1.46	0.22	1.59	72.2	65.8	62.8	24.5	4.7
BP10030	1.77	0.17	1.32	0.14	1.14	62.2	72.8	57.5	25.0	4.9
Kwee Eline®	1.87	0.18	1.42	0.26	1.76	70.5	69.5	64.5	22.5	5.8
F-test	*	*	ns	***	***	*	~	ns	~	**
$LSD_{0,05}$	0.08	0.01		0.04	0.20	9.1	10.4		2.2	0.6

[1]expressed as % of dry matter content (N, P, K, Mg, Ca) or as mg/kg dry weight (Fe, Mn, Zn, B, Cu).

Table 6. Cumulative production ‘Conference’ and ‘Doyenné du Comice’ 2001–2004.

Rootstock	kg/tree	Fruits/tree	Fruit weight (g)	Fruits/cm^2 TCSA[1]
		Conference		
Quince MC	28.9	172	190	10.2 e
Delbuena	16.4	114	160	6.4 d
Dolacomi	17.3	118	153	4.6 bc
Gieser W.	18.6	138	139	5.3 cd
Pyrodwarf	17.3	123	175	4.3 bc
Sobu	16.3	109	151	10.6 e
		Doyenné du Comice		
Quince MC	24.3	98	263	4.1 bc
Delbuena	11.5	44	270	1.4 a
Dolacomi	8.1	36	232	1.1 a
Gieser W.	9.5	33	259	1.2 a
Pyrodwarf	8.6	30	263	0.9 a
Sobu	17.0	69	243	3.2 b
		Average Conference & Doyenné du Comice		
Quince MC	26.6 b	135 b	227 b	
Delbuena	13.8 a	80 a	212 ab	
Dolacomi	12.6 a	77 a	194 a	
Gieser W.	13.8 a	85 a	197 a	
Pyrodwarf	13.1 a	77 a	224 b	
Sobu	17.4 a	91 a	204 ab	
F-test	p<0.001	p<0.001	p<0.05	p<0.01
$LSD_{0.05}$	5.6	31	25	1.5

[1]Total number of fruits per tree n 2001–2005 per cm^2 trunk cross sectional area (TCSA) autumn 2004.

Table 7. Average growth of ‘Conference’ and ‘Doyenné du Comice’.

Rootstock	Growth index[1]		Increase trunk circumference (cm)	
	Conference 2000–2004	Doy. du Comice 2000–2004	Conference spring 2000–autumn 2005	Doy. du Comice spring 2000–autumn 2005
Quince MC	3.6 ab	5.0	8.6 b	11.6
Delbuena	4.3 bc	6.2	8.5 b	13.5
Dolacomi	5.1 c	5.0	11.3 b	13.0
Gieser W.	5.6 c	6.1	11.9 bc	12.7
Pyrodwarf	5.7 c	5.5	12.8 c	14.3
Sobu	2.5 a	4.9	5.4 a	11.9
F-test	p<0.001	n.s.	p<0.001	n.s.
$LSD_{0.05}$	1.1		2.8	

[1]on scale 1 (no growth) to 9 (very strong growth). n.s = not significant.

Table 8. Average growth index and increase in trunk circumference.

Rootstock	Growth index[1]		Increase trunk circumference (cm)	
	Conference 2002–2005	Doy. du Comice 2002–2005	Conference spring 2001–autumn 2005	Doy. du Comice spring 2001–autumn 2005
MC	4.6 cde	4.3 bcd	8.2 ab	10.4 c
Adams	5.0 def	5.1 ef	9.0 b	10.9 c
Sigwa 3	6.0 g	5.9 g	12.1 d	14.0 e
Gieser W.	5.5 fg	6.8 h	10.3 c	14.8 e
MC Peters	4.4 bcd	4.3 bc	8.1 ab	9.0 b
MH	3.8 ab	3.4 a	7.7 a	7.9 ab
ME	3.2 a	2.9 a	7.5 a	7.8 ab
F-test	p<0.001	p<0.001	p<0.001	p<0.001
$LSD_{0.05}$	0.6	0.6	1.2	1.2

[1]on scale 1 (no growth) to 9 (very strong growth).

Table 9. Cumulative production ‘Conference’ and ‘Doyenné du Comice’ 2002–2005.

Rootstock	Fruits/tree	kg/tree	Fruit weight (g)	Fruits/cm^2 TCSA[1]
		Conference		
MC	329 h	54.8 g	177 b	18.9 f
Adams	327 h	55.5 g	176 b	17.0 ef
Sigwa 3	211 g	38.4 ef	190 b	9.0 d
Gieser W.	215 g	27.1 c	134 a	8.6 d
MC Peters	293 h	52.0 g	188 b	16.9 ef
MH	222 g	40.0 ef	188 b	15.8 e
ME	109 def	19.6 b	187 b	10.3 d
		Doyenné du Comice		
MC	90 cde	28.4 cd	324 ef	4.8 bc
Adams	135 f	38.0 ef	294 d	5.6 c
Sigwa 3	79 cd	24.9 bc	317 def	2.9 b
Gieser W.	25 a	6.1 a	247 c	0.7 a
MC Peters	119 ef	35.0 de	301 de	6.2 c
MH	66 bc	19.9 b	330 f	4.7 bc
ME	37 ab	12.4 a	362 g	3.3 b
F-test	P<0.001	P<0.05	P<0.05	P<0.001
$LSD_{0.05}$	40	7.0	26	2.1

[1]Cumulative number of fruits per tree (2002–2005) per cm^2 trunk cross sectional area (TCSA) autumn 2005

Figures

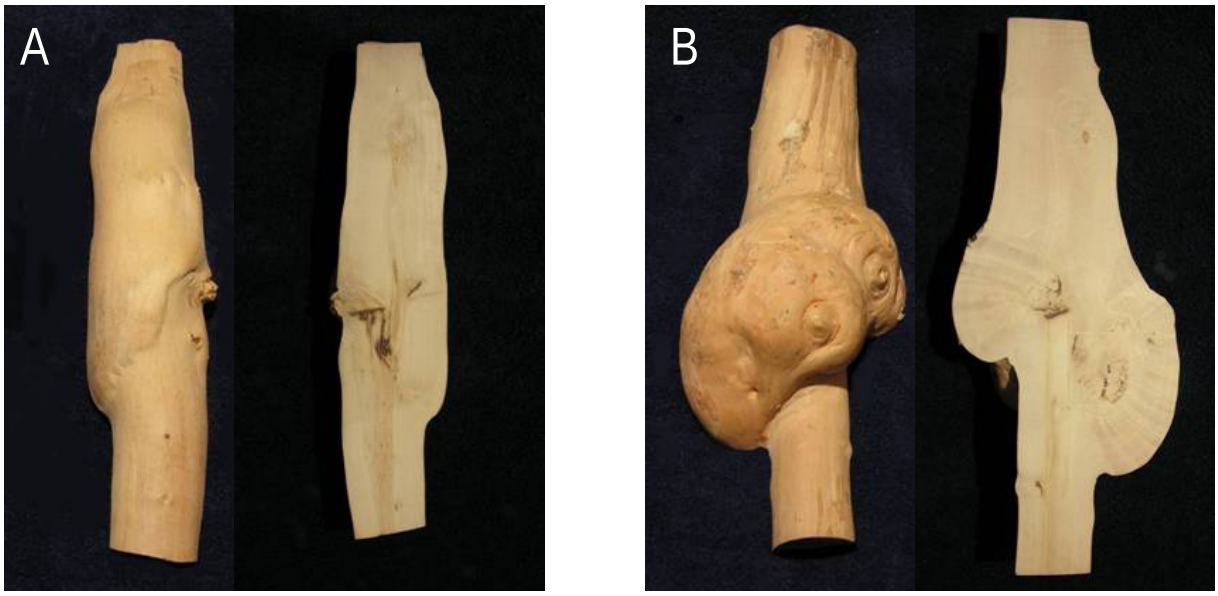

Fig. 1. Longitudinal sections of graft unions of 8-year old trees of ‘Conference’ (A) and ‘Doyenné du Comice’ (B) grafted on rootstock BP10030.

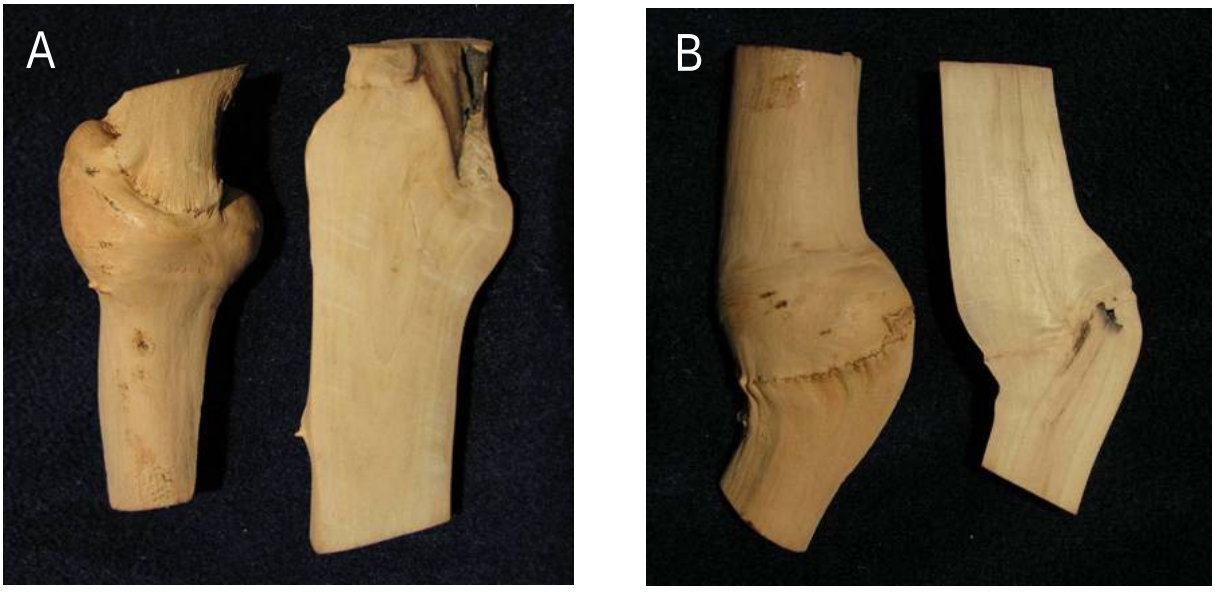

Fig. 2. Longitudinal sections of graft unions of 8-year old trees ‘Conference’ (A) and ‘Doyenné du Comice’ (B) grafted on rootstock Sobu.