Performance of 'Carrick' pear grafted on quince rootstocks

Mateus da Silveira Pasa[1], Juliano Dutra Schmitz[2], Carina Pereira da Silva[3] e Marcos Antônio Giovanaz[4]

Abstract – The performance of 'Carrick' pear grafted on different quince rootstocks was evaluated at the experimental field of the Federal University of Pelotas. Plant material consisted of 6-year-old 'Carrick' pear in spacing 1 x 5m (2000 trees ha^{-1}), trained as central leader and grafted on quinces 'Portugal', 'MC', 'BA29', 'D'vranja' and 'Inta 267'. Assessed parameters were: yield, yield efficiency and trunk cross sectional area (TCSA). Yield efficiency was higher with 'Portugal' and 'MC' in all growing seasons. Rootstock 'Portugal' induced the greatest yield in all growing seasons but 2011/2012, when no differences were found among the rootstocks. The greatest cumulative yield was found with 'Portugal'. By TCSA, rootstocks 'Inta 267', 'D'Vranja' and 'BA29' are more vigorous than 'MC' and 'Portugal'. 'Portugal' was the most productive rootstock for 'Carrick' and also one of the most dwarfing.

Index terms: *Pyrus* sp.; *Cydonia oblonga*; vigor control; cumulative yield.

Desempenho de pereiras 'Carrick' enxertadas em porta-enxertos de marmeleiro

Resumo – O desempenho da pereira 'Carrick' enxertada em diferentes porta-enxertos de marmeleiro foi avaliado durante quatro safras no campo experimental da Universidade Federal de Pelotas. O material vegetal consistiu de plantas de pereira 'Carrick' com seis anos de idade (1x5m; 2.000 plantas ha^{-1}; conduzidas no sistema de líder central), enxertadas nos porta-enxertos Portugal, MC, BA29, D'vranja e Inta 267. Os parâmetros avaliados foram: produtividade, eficiência produtiva e área da seção transversal do tronco (ASTT). A eficiência produtiva foi maior com 'Portugal' e 'MC' em todas as safras, exceto em 2011/12. O porta-enxerto Portugal induziu a maior produtividade em todas as safras, com exceção de 2011/2012, em que não houve diferenças entre os porta-enxertos. Os resultados da ASTT mostram visivelmente que os porta-enxertos 'Inta 267', D'Vranja e BA29 são mais vigorosos que MC e Portugal. Pode-se concluir que a produtividade de pereira 'Carrick' é maior com o porta-enxerto 'Portugal', o qual também reduz significativamente o vigor.

Termos para indexação: *Pyrus* sp.; *Cydonia oblonga*; controle de vigor; produção acumulada.

Introduction

Pear leads Brazilian fruit imports both in quantity and in value (189,696 tons and US$ 196,301 million in 2013 respectively) (FAO, 2015). This scenario results from various factors, among which the most important is the low productivity in the Brazilian orchards caused principally by the excessive vegetative growth of the main cultivars and the lack of suitable rootstocks (PASA et al., 2011; PASA et al., 2012).

Most of pear orchards in Brazil are set on *Pyrus* sp. rootstocks, such as *Pyrus calleryana*, which induce excessive vegetative growth, delayed onset of production and low yields in the scion cultivars. Moreover, the long and warm summers observed in Brazil contribute to the excessive vegetative growth issue. Excessive vigor leads to overcrowding and reduced light penetration (SHARMA et al., 2009) and distribution (EINHORN et al., 2012), which potentially decrease fruit quality, yield and difficult pest control. In addition, pruning costs are increased by excessive shoot growth.

Since the development of new *Pyrus* rootstocks has been limited by insufficient size control (BREWER & PALMER, 2011), alternatively, quince rootstocks could be used to reduce the size and vigor of scion cultivars in order to increase yield and yield efficiency. In some of the main pear growing regions their use has increased precocity, yield and quality of European pears (JACKSON, 2003). Besides, the reduced tree size provided by dwarfing rootstocks like quince have allowed pear planting at higher densities and the mechanization of the orchards (reducing the need for hand-labor).

Given the negative effects of excessive vegetative growth provided by the climatic conditions and current rootstocks used in Brazilian pear orchards, we assumed the vigor control provided by quince rootstocks would improve yield efficiency, then allowing pear planting at higher densities. The objective of this study was to investigate the performance of 'Carrick' pear grafted on different quince rootstocks over four growing seasons.

Material and methods

The trial was carried out at the experimental field of the Federal University of Pelotas located in the city of Capão do Leão, RS, Brazil (31° 52' 00'' ►

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[1] Engenheiro-agrônomo, Dr., Epagri / Estação Experimental de São Joaquim, e-mail: mateuspasa@epagri.sc.gov.br.
[2] Engenheiro-agrônomo, Dr., Instituto Federal Catarinense, Campus Concórdia, Departamento de Fitotecnia, e-mail: jdsagro@gmail.com.
[3] Bióloga, Dra., e-mail: carpers.rs@gmail.com.
[4] Engenheiro-agrônomo, M.Sc., Universidade Federal de Pelotas/Faculdade de Agronomia Eliseu Maciel - Departamento de Fitotecnia, e-mail: giovanazmarcos@gmail.com.

S; 52° 21' 24'' W; altitude: 48m), during the growing seasons of 2009/2010, 2010/2011, 2011/2012, and 2012/2013. Soil was a Eutrophic Yellow Argissol. The average accumulation of chilling hours (accumulation of temperatures ≤ 7.2°C) in the region is 400h. The average annual rainfall is 1367mm, minimum and maximum temperature are -3°C and 39.6°C respectively, and the annual average temperature is 17.8°C.

Plant material consisted of 6-year-old 'Carrick' pear (Seckel-Garber cross) grafted on quinces (*Cydonia Oblonga* Mill.) 'Portugal', 'MC', 'BA29', 'D'vranja', and 'Inta 267'. This pear variety was chosen by its low chilling requirement to overcome dormancy (~300h). Trees were trained in a central leader system and supported by a three-wire frame at 0.5, 1.1 and 1.7m from the ground. Trees were planted spaced 5m x 1m (2000 trees ha^{-1}). Soil fertility was corrected at the inception of the experiment based on soil analysis. Cultural practices were similar for all treatments: fertilization, shoot bending, pruning, disease and pest control, and weed control. In the summer, trees were irrigated by drip irrigation when necessary. At the end of the winter, at the stage of green tip, trees were sprayed with hydrogen cyanamide (0.2%) and mineral oil (3%) to standardize budburst and flowering.

Trees were arranged in a randomized complete block design with three replications of five trees. Trunk diameter was measured at 5 cm above the graft union with a digital caliper, at the inception of the trial, and at the end of each growing season, and converted to trunk cross sectional area (TCSA) (expressed as the increment relative to the previous season). Cumulative TCSA is the result of the sum of the TCSA increment of all growing seasons. TCSA was calculated according to Pasa et al. (2012). In the summer, trees were harvested at commercial maturity (~60 N). The total number of fruits per tree was counted and weighed (kg). From these data the following parameters were calculated: a) Yield efficiency (kg cm^{-2}); b) Estimated yield (Mg ha^{-1}); c) fruit weight (g), obtained from the division of total weight per tree by number of fruits per tree. Cumulative yield efficiency and estimated yield were also calculated.

Statistical analyses were performed using the R software (R CORE TEAM, 2014). Data were analyzed for statistical significance by means of the F test. Duncan's test was performed to compare treatments when analysis of variance showed significant differences among means.

Results and discussion

Rootstock 'Portugal' showed the greatest yield in all growing seasons but in 2010/2011, when 'Portugal' yield did not differ from 'MC', and in 2012/2013 from 'BA 29'. In 2011/2012, no differences of yield were found among the rootstocks (Figure 1). On the other hand, 'Inta 267' and 'D'Vranja' had the lowest yield in all growing seasons (Figure 1). The greatest cumulative yield was found with 'Portugal' (~60 Mg ha^{-1}). Cumulative yield efficiency was greater with 'Portugal' and 'MC' (Table 1).

The results of cumulative TCSA clearly shows that rootstocks 'Inta 267', 'BA29' and 'D'Vranja' are more vigorous than 'MC' and 'Portugal' (Figure 2). As it is possible to observe, there is a great variability of vigor among quince rootstocks. This variability of vigor induced by the rootstocks is of great importance, since it would allow pear growing in different edaphoclimatic situations. According to Wertheim (2002), besides the influence of the rootstock, tree vigor is also influenced by soil, climate and scion cultivar. In this sense, the most vigorous quince rootstocks could be used in soils of low natural fertility, and vice versa.

The analysis of correlation between TCSA and accumulated yield through Pearson coefficient showed a negative relationship between them (-0.33), i.e., as TCSA increases, yield decreases. Similar relationship was found for 'Granny Smith' apple, in which yield was increased when vigor was reduced

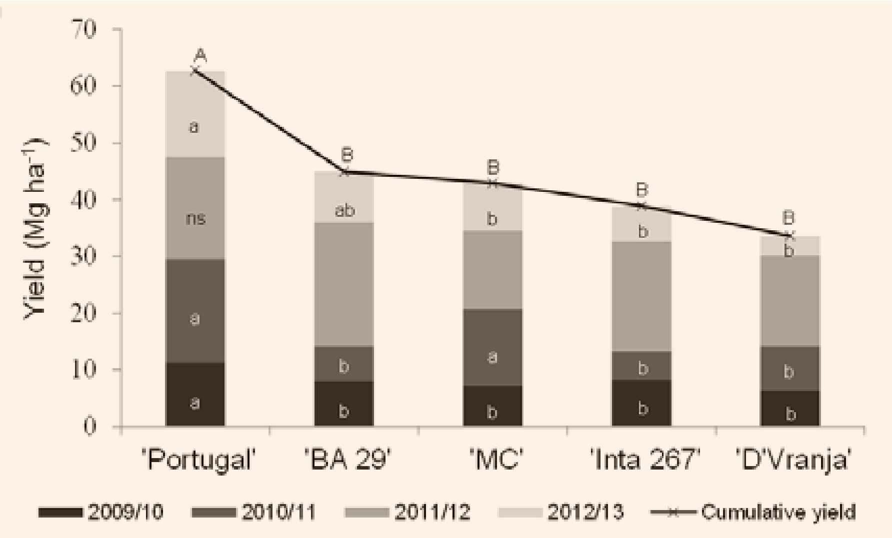

Figure 1. Yield from growing seasons 2009/10 to 2012/13 and cumulative yield of 'Carrick' pear grafted on quince rootstocks

Table 1. Yield efficiency from growing seasons 2009/2010 to 2012/2013 and cumulative yield efficiency of 'Carrick' pear onto different quince rootstocks

Rootstock	Yield Efficiency (kg cm^{-2})				
	2009/10	2010/11	2011/12	2012/13	Cumulative
'Portugal'	0.122 a*	0.212 a	0.198 a	0.156 a	0.688 a
'MC'	0.121 a	0.171 a	0.167 ab	0.111 a	0.570 a
'BA 29'	0.058 b	0.053 b	0.169 ab	0.061 b	0.341 b
'Inta 267'	0.058 b	0.038 b	0.124 b	0.036 b	0.256 b
'D'Vranja'	0.060 b	0.058 b	0.106 b	0.014 b	0.239 b
P>F	0.001	<0.001	0.044	0.001	<0.001

*Different letters in the column indicate significant differences by Duncan's test ($p < 0.05$).

by the rootstock (GJAMOVSKI & KIPRIJANOVSKI, 2011). We have found similar relationship between "Carrick" and rootstocks 'Portugal' and 'MC' that show the lowest vigor, expressed as TCSA increment (Figure 2), and higher production, when compared with the vigorous rootstocks (Figure 1). Maas (2008) found that dwarfing rootstock 'MC' was among the ones that induced the greatest production in 'Conference' and 'Doyenne du Comice'. Pasa et al. (2012), studying the effect of different rootstocks for 'Packham's Triumph' pear in the same climatic conditions, found that rootstock 'Adam's' (dwarfing) showed the highest yield. However, Alonso et al. (2011) observed 'Doyenne du Comice' was more productive with 'Adam's', but 'Conference' less productive with this rootstock, suggesting a scion-rootstock cultivar.

These effects might be explained by the reduction of the competition of vegetative growth and production. Even though fruits are stronger sink than shoots in situations of traditional temperate climate regions (SMITH & SAMACH, 2013), this behavior is not the same in a warm winter and in a warm-night summer, such as the conditions of the present experiment. Firstly, during the summer, the warm nights increase the carbon losses by respiration as opposed to cooler night conditions, thus reducing the available carbohydrates to supply fruit growth and storage for the initial growth in the next season. In warm-winter conditions, where temperature fluctuations are usual (weeks of temperatures around 20-25°C), the stored carbohydrates are partially used to restore growth when temperature rises during the winter (dormancy), when it was not supposed to happen. Consequently, the reserves are partially depleted and are not sufficient to supply both fruit set and initial shoot growth next spring, resulting in low fruit set. In this situation, a dwarfing rootstock would induce less competition of vegetative growth with reproductive organs, leading to increased carbohydrate storage to support the adversities of unfavorable climatic conditions.

Differences in fruit weight were observed only in the 2010/2011 growing season, when the smallest fruit size was observed with rootstock 'Inta 267' (Table 2). Overall, the rootstocks tested have little influence on fruit weight, since differences were found in only one out of four growing seasons. Similar results were found by Pasa et al. (2012) with cultivar 'Packham's Triumph', in which differences among rootstocks were found in only one growing season. According to Wertheim (2002), fruit quality attributes like fruit weight are little affected by rootstocks.

While these results are encouraging, only rootstock 'Portugal' showed an average yield (~15.5 Mg ha^{-1}) greater than the average yield of Brazil (~12 Mg ha^{-1}) (IBGE, 2014). However, it should be emphasized that the region where the study was performed does not have the best conditions for pear production, so future studies testing these rootstocks in regions with more suitable conditions are very important.

Conclusions

1 – Cumulative yield of 'Carrick' pear is greater when grafted on rootstock 'Portugal'.

2 – Yield efficiency is higher with rootstocks 'Portugal' and 'MC'.

3 – The most dwarfing quince rootstocks for 'Carrick' pear are 'Portugal and 'MC'.

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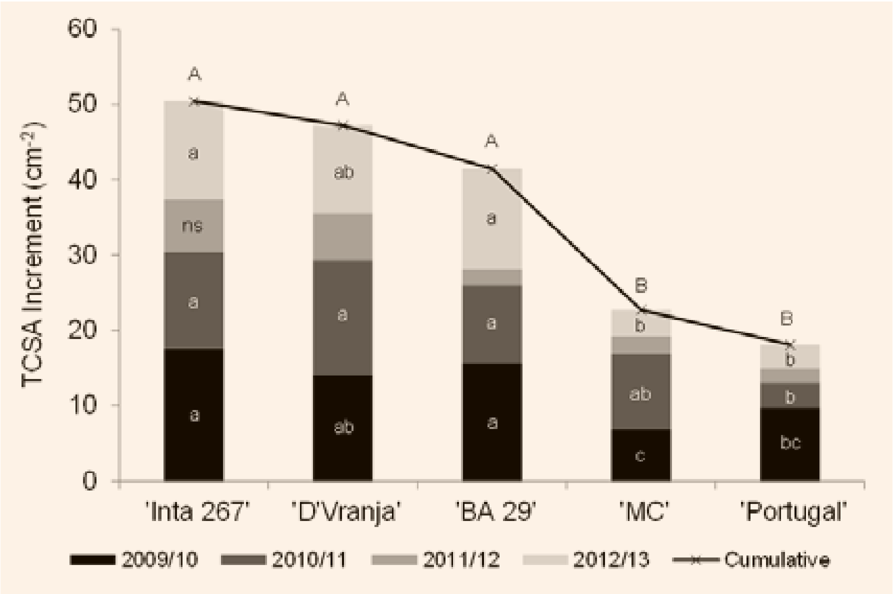

Figure 2. Trunk cross sectional area increment from growing seasons 2009/10 to 2012/13 and cumulative TCSA increment of 'Carrick' pear grafted on quince rootstocks

Table 2. Fruit weight of 'Carrick' pear onto different quince rootstocks from growing seasons 2009/10 to 2012/13 and average

Rootstock	Fruit weight (g)				
	2009/10	2010/11	2011/12	2012/13	Average
'Portugal'	217.4	195.3 ab	166.8	187.3	191.7
'MC'	274.1	213.3 a	140.0	172.8	200.1
'BA 29'	210.9	223.3 a	186.0	192.3	203.1
'Inta 267'	179.4	168.0 b	176.0	185.3	177.2
'D'Vranja'	251.7	226.7 a	191.5	176.0	211.4
P>F	0.233	0.030	0.145	0.909	0.123

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