Performance of 'William's' pear grafted onto three rootstocks[1]

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ABSTRACT

Pears are the most imported fruit from Brazil and thus, being an important opportunity to Brazilian growers. However, there are still some problems that restrict pear production, such as the lack of suitable rootstocks. The aim of this study was to assess growth, yield efficiency and fruit quality of 'William's' pear grafted on quinces 'Champion' and 'Melliforme' and *P. calleryana*. The experiment was performed during 2009/2010 growing season at the Centro Agropecuário da Palma, FAEM/UFPel. The experimental design was a completely randomized block with three replications per treatment. The assessed parameters were trunk cross sectional area, shoot length, yield efficiency, number of fruit per tree, soluble solids, flesh firmness, fruit weight and fruit size. It was found that 'William's' pear is more efficient and less vigorous when grafted on 'Champion' quince, thus being a potential scion x rootstock combination for commercial pear planting at medium densities. Moreover, fruit of trees grafted on quince rootstocks accumulated higher amount of soluble solids.

Keywords: *Pyrus communis, Pyrus calleryana*, quince, vigor, production.

INTRODUCTION

Pear (*Pyrus communis*) leads fruit fresh imports of Brazil. According to Food and Agriculture Organization of the United Nations, FAO (2019), Brazil has imported nearly 156,000 Megagram (Mg) of pears in 2017, accounting for ~88% of domestic consumption. The other 12% were produced in Brazil, mainly in Rio Grande do Sul (58%), Santa Catarina (33%), and Paraná (6%) (IBGE, 2019). In this way, pears are an important opportunity for Brazilian growers. However, there are still some problems that restrict pear production, such as bud abortion, inadequate orchard management and the lack of adapted cultivars and suitable rootstocks (Fachinello *et al*., 2011). The lack of information about the rootstocks suitable for different soil and climate conditions, as well as to different scion cultivars is widely known for pears (Stern & Doron, 2009).

The existence of different levels of vigor induced by rootstocks is very important for pear production. Besides the influence of rootstock on vigor, according to Wertheim (2002) tree vigor is also affected by soil, climate, and scion cultivar. Thus, vigorous rootstocks may be used in soils of low natural fertility, as well as low vigorous in high fertility soils, thereby allowing and adequate balance of vegetative and reproductive growth. In a recent study, Pasa *et al*. (2012) observed differences in the vigor induced by several quince rootstocks and *Pyrus calleryana* on 'Carrick' and 'Packham's Triumph' pears, where yield and yield efficiency were inversely correlated with vigor induced by rootstock.

Worldwide, growers aim for early returns on capital and labor saving. These goals could be achieved with intensive plantings of small trees. Nevertheless, pear orchards in Brazil are set mainly on *Pyrus* sp. rootstocks, which induce excessive vegetative growth and late cropping (Pasa *et al*., 2012). Alternatively, quince rootstocks can be used to induce rapid cropping and reduce vigor of pear trees (Dondini & Sansavini, 2012) in

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order to enable planting at higher densities. Besides, rootstocks should keep or improve fruit quality. Rootstock effects on fruit quality have been shown for some fruit trees, such as pear (Fallahi & Larsen, 1981) and peach (Orazem *et al*., 2011).

The aim of this study was, therefore, to evaluate the growth, yield and fruit quality of 'William's' pear grafted onto two quince rootstocks and *P. calleryana*.

MATERIAL AND METHODS

The trial was performed in the 2009/2010 growing season, at the Centro Agropecuário da Palma, Federal University of Pelotas (UFPel), Capão do Leão, Rio Grande do Sul (31º 52' 00" S; 52º 21' 24" W; elevation: 48 meters). The climatic classification of the region according to Köppen is 'Cfa' (Kuinchtner & Buriol, 2001), temperate humid climate with hot summer. Historical chilling hour accumulation (hours below 7.2 ºC) of the area the experimental field is located is 307 h (Agromet, 2019), and in 2009 was 445 h (Pasa *et al.*, 2012). The soil of the experimental field is an Argissolo Amarelo distrófico (Ultisol) (Pasa *et al*., 2015).

The scion variety tested was 'William's' and 'Packham's Triumph' was used as pollinator. The orchard was planted in the winter of 2002, using single axis trees, which were propagated by whip grafting in June 2001, using cuts of the scion cultivar with two to three buds. Thus, trees of both cultivars were 7-year-old at the inception of the experiment. The following rootstocks were tested: 'Champion', Melliforme' and *P. calleryana*. Trees were planted at 5 x 1m spacing and trained in a central axis system. Cultural practices were similar for all treatments: fertilization based on soil analysis; shoot bending during the winter; disease and pest control; weed control and drip irrigation in the summer. Pruning was performed during the summer and consisted on the removal of water sprout shoots, with light pruning of fruiting branches. At the end of the winter in 2009, at the green tip stage, trees were treated with hydrogen cyanamide (0.2%) and mineral oil (3%) to standardize budburst and flowering.

The experimental design was in randomized complete blocks with three replications of five trees per replicate. Measurements were made on the two central trees of each replication. At harvest (10 February of 2010), the yield from each of the monitored trees was weighed, and a randomly selected sample of 25 fruit per replication was collected for fruit quality measurements. After that, fruit samples were kept in cold storage (0 ± 1 °C; 85 ± 5% RH) for 30 days.

The assessed variables were: Trunk cross sectional area (TCSA – cm^2), calculated through the following expression: TCSA= $\pi . r^2$, where π= 3,1416 and r= d/2, where d= trunk diameter, measured at 5cm above graft union in March 2010 using a digital caliper; Shoot length (SL - cm), measured monthly on four marked terminal shoots over the growing season; Production per tree (PT), obtained from fruit of each tree weighed at harvest, expressed in kg; Yield efficiency (YE), obtained from the relation between PT and TCSA, expressed as kg cm^{-2}; Fruit size (FS - mm), monthly measured with a digital caliper in two points of the maximum width of ten selected fruit, beginning 64 days after full bloom (DAFB) up to the harvest. Full bloom occurred on September 26, 2009; Number of fruit per tree (NFT), counted at harvest; Soluble solids (SS – ºbrix) and; Flesh firmness (FF - kgf). The last two parameters were quantified by Vis/NIR reflectance spectroscopy (NIR-Case Sacmi), a non-destructive method for analyzing fruit quality previously calibrated for this cultivar (Machado *et al*., 2011).

The data were analyzed regarding the normality by Shapiro-Wilk's test, the homogeneity of variances by Bartlett's test, and the independence of residues by graphical analysis. After that, data were submitted to analysis of variance (ANOVA) by F test (p d" 0,05). The number of fruit was transformed to square root (n + 1), to provide a normal distribution. Tukey's test was performed to compare treatments when analysis of variance showed significant differences among means.

RESULTS AND DISCUSSION

Trees on all rootstocks had similar TCSA with no significant differences between them (Table 1). Even though *P. calleryana* is usually more vigorous than quince rootstocks, there is a great variability of vigor among them. This effect was observed in 'Packham's Triumph' pears, where the quinces 'Smyrna' and 'D'Angers' showed similar TCSA as *P. calleryana*, whereas 'Alongado' and 'Adam's' had lower TCSA (Pasa *et al*., 2012). These authors also reported great variability among TCSA of quince rootstocks for 'Carrick' pear. The differences on vigor induced by the same rootstock among cultivars is probably due to different levels of grafting compatibility.

The SL was similar for all rootstocks until 111 DAFB (Figure 1A). After that, trees on *P. calleryana* had a second flush of growth with its shoots being significant longer than that on quince until the end of the growing season.

Similar results were found in pear (Watson *et al*., 2012) and apple (Hooijdonk *et al*., 2011), where the most vigorous rootstocks induced the greatest SL when compared with more dwarfing rootstocks. In addition, they showed that vegetative shoots produced on more dwarfing rootstocks were likely to terminate sooner, when compared with more vigorous rootstocks, such as found in this study. The greatest SL of *P. calleryana* has probably led to excessive vegetative growth, resulting in reduced light penetration (Sharma *et al*., 2009) and distribution (Einhorn *et al*., 2012) into the canopy, thus impairing flower bud formation. This situation may be one of the reasons trees on *P. calleryana* showed the lowest YE in the present study.

Quince ‘Champion’ achieved the highest PT, YE and NFT while *P. calleryana* showed the lowest (Table 1). Similar results were found by Stern & Doron (2009), which observed higher yield efficiency of quince EMA (0.32) when compared to *Pyrus betulifolia* (0.19). The highest PT, YE and NFT observed with some quince rootstocks can be explained in part because they are not fully compatible with common pear and this partial incompatibility accelerates cropping while restraining shoot and root growth (Dondini & Sansavini, 2012). In such a situation, the negative effects of the competition among vegetative tissues and developing fruit are reduced, mainly during the early stages (first 3-4 weeks of growth) of fruit and shoot growth, given during this time they are highly dependent on stored carbohydrates. An inverse relationship among vegetative growth induced by rootstock and yield was shown by Pasa *et al*. (2012) for ‘Carrick’ and ‘Packham’s pear.

Table 1: Trunk cross-sectional area (TCSA), production per tree (PT), yield efficiency (YE), number of fruit per tree (NFT), fruit weight (FW), soluble solids (SS) and flesh firmness of ‘William’s’ pear grafted onto different rootstocks

Rootstock	TCSA (cm^2)	PT (kg)	YE (kg cm^{-2})	Fruit (n° $tree^{-1}$)	FW (kg)	S S (° brix)	FF (Kg)
Champion	39.00 ns	8.17 a	0.21 a	44.00 a	0.18 ns	12.04 a	2.72 ns
Melliforme	45.08	4.55 b	0.11 ab	20.75 b	0.22	11.53 a	3.05
P. calleryana	54.87	4.42 b	0.08 b	22.50 b	0.2	10.53 b	3.00
CV (%)	19.52	19.90	26.24	8.36	16.39	2.98	21.76

Means followed by the same letters are not significantly different according to Tukey’s test ($p < 0.05$). ns: not significant.

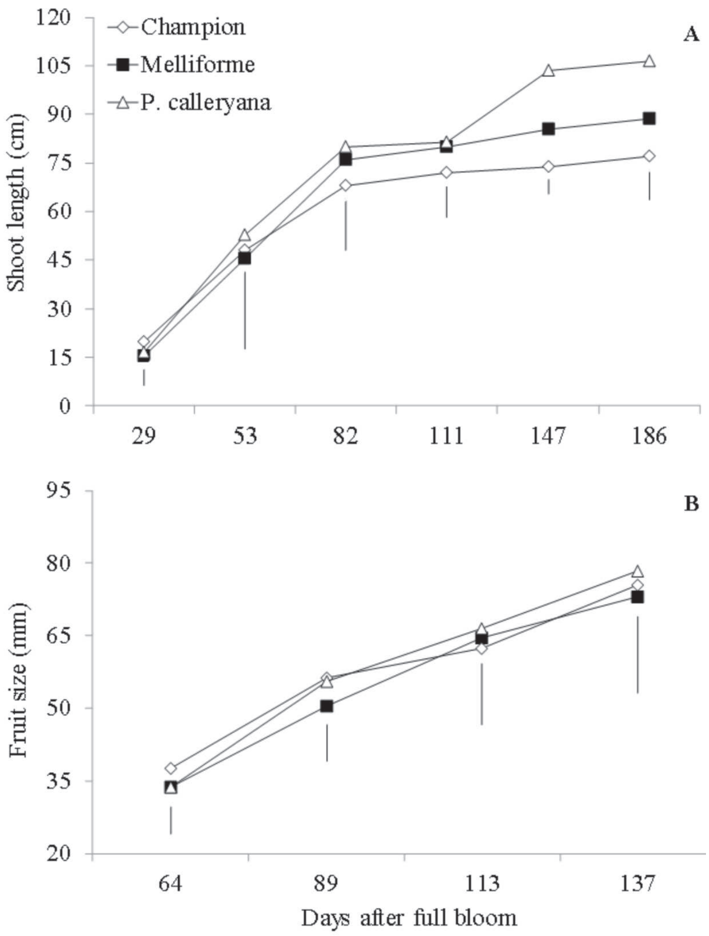

Figure 1: Shoot length (a) and fruit size (b) of ‘William’s’ pear grafted onto different rootstocks, during the growing season of 2009/2010. Vertical bars indicate HSD ($p < 0.05$) according to Tukey’s test, within each assessment date.

Significant differences were not found for FW, FF (Table 1) and FS (Figure 1B). According to Wertheim (2002), fruit quality parameters are little affected by rootstock in pears. However, fruit of trees on quinces ‘Champion’ and ‘Melliforme’ had higher SS than that on *P. calleryana*, with no differences between them (Table 1). A possible explanation for this effect is the lower root volume of less vigorous rootstocks due the decreased auxin transport from scion to its roots, thus restricting root growth (Hooijdonk *et al*., 2011). In this sense, water translocation from roots to fruit at ripening time would be decreased and so, leading to higher SS fruit concentration. Pasa *et al*. (2012) found similar results for ‘Carrick’ and ‘Packham’s’ pears, where the highest SS concentration was observed with the less vigorous rootstocks.

CONCLUSIONS

The results found in the present study show that ‘William’s’ pear is more efficient and less vigorous on ‘Champion’ quince, thus being a potential scion x rootstock combination for commercial pear planting at medium densities at places with similar environmental conditions. Furthermore, fruit of trees on quince rootstocks accumulate higher amounts of SS, which is an important trait of fruit quality. However, further studies are needed to confirm the horticultural behavior of the combinations studied.

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