Scientia Horticulturae 119 (2009) 252–256

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Performance of 'Coscia' pear (*Pyrus communis*) on nine rootstocks in the north of Israel

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ARTICLE INFO

Article history:
Received 12 March 2008
Received in revised form 22 July 2008
Accepted 1 August 2008

Keywords:
Pear
Rootstock
Yield
Fruit size
Pyrus communis L

ABSTRACT

The vegetative and reproductive performances of 'Coscia' pear (*Pyrus communis* L.) grown on nine rootstocks [OHF 69, OHF 97, OHF 217, OHF 333, OHF 513 and BP 1 (*P. communis*), clonal seedling (Davis AxB) of *Pyrus betulifolia* and quince BA 29 and EMA (*Cydonia oblonga*)] were compared during a 9-year period. The trial was conducted at the Experimental Station 'Avnei Eitan' in northern Israel (elevation 400 m above sea level, a.s.l.), on a well-drained soil with pH 7.1. Trees were planted in December 1998, spaced at 4.0 m $\times$ 2.0 m and trained with a central axis. The most vigorous trees were on *P. betulifolia* seedlings, followed by the four OHF rootstock (69, 97, 333, 513) and BP 1 (with no significant difference between them). All the above rootstocks demonstrated greater vigor than OHF 217 and quince BA 29 or EMA. The highest cumulative yields per tree were harvested from trees on the four OHF rootstocks (69, 97, 333, 513) and *P. betulifolia* followed by the BP 1. The two quince rootstocks, as well as OHF 217, had the lowest cumulative yield and the lowest yield of large fruit. A positive correlation was found between the vigor of the tree, as affected by the rootstock, and both the total yield and the fruit size. We conclude that in a warm climate, yield efficiency is not the only parameter that should be taken into account, and building a strong tree for a weak cultivar is the first requirement for establishing an orchard.

1. Introduction

'Spadona' and 'Coscia' are the main pear cultivars grown in the warm climate of Israel. Both of them are grafted on the same clonal quince A (EMA) (*Cydonia oblonga*) rootstock. While the performance of 'Spadona' is satisfactory for tree vigor, cumulative yield and fruit quality, 'Coscia' suffers from poor vegetative growth, leading to a low yield of small fruit (Stern et al., 2003; Flaishman et al., 2001). Thus, the advantage of the dwarfing rootstock for the more vigorous 'Spadona' becomes a disadvantage for the weaker 'Coscia'. As consumers prefer large pears (Stern et al., 2002, 2007b; Flaishman et al., 2005), fruit size has become an important marketing consideration, and the economic benefits of treatments capable of improving average fruit size are potentially very high (Looney, 1983). Although plant growth regulators of the cytokinin family have been shown to improve fruit size (Stern et al., 2003; Flaishman et al., 2005), a more fundamental approach could be the choice of the appropriate rootstock for each cultivar, thereby affecting tree vigour and consequently fruit size (Westwood, 1993; Jackson, 2003; Webster, 2003).

The lack of a rootstock adapted to different soil conditions and to different graft cultivars is widely acknowledged in pear culture. Quince rootstocks as well as *Pyrus* rootstocks (seedling or clonal) have their advantages and disadvantages. In each case, site-specific ecological characteristics, specific cultivar response and production objectives must be considered before deciding on the best strategy (Lombard and Westwood, 1987; Masseron, 1989). For example, the use of quince rootstock is almost universally satisfactory for 'Coscia' cultivation in the temperate climate of Europe, whereas in the hot and dry weather of Israel, it is very poor (Gur, 2000; Gur et al., 1968, 1978; Stern et al., 2007a).

The selection of clonal quince (*Cydonia oblonga*), such as EMA, EMC and BA 29 in Europe, or clonal *Pyrus communis* L., such as 'Old Home' $\times$ 'Farmingdale' (OHF) in the USA or BP in South Africa, as substitutes for pear seedling rootstock, have clearly improved the precocity, productivity and quality of some European pear cultivars (Westwood, 1993; Jackson, 2003; Webster, 2003; Iglesias and Asin, 2005; Carrera et al., 2005).

A noticeable improvement in 'Coscia' performance was observed in a 10-year trial, conducted in the warmest pear-growing

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doi:10.1016/j.scienta.2008.08.002

region in northern Israel (the Hulla valley—100 m a.s.l.), with trees grafted on *P. betulifolia* as compared to those on quince A (EMA) rootstock (Stern et al., 2007a). The improvement was expressed as higher yields and larger fruit, as well as precocity in fruit bearing. However, the question arose as to whether the same result would be applicable to orchards grown on the surrounding hills with a somewhat cooler climate, and whether the vigour contributed by the *P. betulifolia* rootstock might not be excessive and upset the desired balance between growth and productivity.

The objective of this study was therefore to determine the best rootstock for 'Coscia' cultivated in a warm climate at higher altitude. With the increase in global warming, the findings in this study might well be of a wider relevance.

2. Materials and methods

Pear trees were planted in December 1998 with 1-year-old scions, at the Avnei Eitan Experimental Station in the Golan Heights in the north of Israel (33.0°N; 35.5°E; alt. 400 m). The following rootstocks were tested: 'Old Home X Farmingdale' (OHF) 69, 97, 217, 333, 513 and BP 1 (*P. communis* L.); BA 29 and quince A (EMA) (*Cydonia oblonga*); and a clonal seedling of *Pyrus betulifolia* (Davis AxB). The trees in each block (one row) were pollinated by one row of 'Spadona' trees.

The Avnei Eitan Experimental Station is located in a semi-arid area with high temperatures (*ca.* 32 °C max.) and low humidity (<40% RH) during the summer (May–October). Annual precipitation during winter (November–April) is about 500 mm with low night temperatures (*ca.* 2 °C min) from December to February. The soil is 0.8 m deep, well-drained, basaltic protogromosol (60% clay). Soil pH is 7.1 with a $CaCO_3$ content of 5% (w/w).

Trees were spaced at 4 m × 2 m, headed at 80 cm and trained in a vertical (central) axis system to a height of 3.5 m, supported with posts and three wires at 0.5, 1 and 1.5 m. Pruning was minimal until the fifth leaf, when the trees had occupied their allotted space. Drip irrigation was conducted with pressure-compensating drippers, placed at 0.60 m intervals along rows, one pipe per row. Water needs were determined according to the Penman-Monteith evapo-transpiration (ETo) and the recommended Ministry of Agriculture coefficients for pear (*ca.* 0.3 at the beginning of irrigation until 0.8 at harvest, about 700 mm annually). Total water applied ranged from *ca.* 100 mm in the 1st year to *ca.* 700 mm in the 6th year. NPK solution was applied through the irrigation system based on the development of the orchard (up to 80N–$20P_2O_5$–$120K_2O$ from the 5th year).

The experimental design was a randomized complete block with 5 replications × 3 trees per replicate. Measurements were made on the center tree of each replicate.

2.1. Fruit and tree size

At harvest, the yield from each of the monitored trees was weighed and all fruit were sorted by diameter into small (<50 mm), medium (50–60 mm) and large (>60 mm). In the years 2006 and 2007 the fruit size distribution was shifted to a smaller size range for 'Coscia' trees on all rootstocks, probably due to fertilization problem which caused only three seeds per fruit compared to an average of six seeds per fruit in a regular year. In this case, fruit size was reclassified as small (<50), medium (50–55) and large (>55).

Tree size was monitored every year in December by measuring the circumference of the trunk 20 cm above the graft union and was expressed as a trunk cross-sectional area (TCSA). Cumulative fruit yield efficiency (CYE) was expressed as kg cm^{-2}.

2.2. Midday stem water potential

Midday stem water potential (SWP) was measured in 2003 with a pressure chamber (Naor, 2006). Two shoot tips per tree were selected from the inner part of the canopy, and were enclosed in plastic bags covered with aluminum foil, while still attached to the tree. After an equilibration period of 90 min, the shoot tips were detached from the shoot, and the SWP was determined immediately in the field with a pressure chamber (Ari-Mad; Kfar Charuv, Israel). The two measurements were averaged before being subjected to statistical analysis.

2.3. Statistical analysis

Percentage data were subjected to arcsine transformation before analysis, to provide a normal distribution. Data were analyzed for statistical significance, by means of the general linear model (GLM) procedure. Duncan's new multiple range test was used to compare treatments when analysis of variance showed significant differences among means. Statistical Analysis Systems Software for PC (SAS Institute, Cary, N.C.) was used to analyze these data.

3. Results and discussion

3.1. Tree size

At the end of the 1st year (December 1999) trees on all rootstocks had similar TCSA's with no significant differences between them. However, at the end of the 4th year (December 2002), the differences started to be significant ($P < 0.05$) especially between the two weak quince rootstocks (EMA and BA29) and all the rest. The gap between these two groups was significantly expanded every year. At the end of the 9th year (December 2007), the differences were considerable and significant (Fig. 1). Except for the OHF 217, all the other four OHF rootstocks, as well as BP 1 and *P. betulifolia*, produced larger trees compared to the quince rootstocks—EMA or BA 29. However, in contrast to parallel trials at the Hula Valley Experimental Orchard Farm at the lower latitude, with warmer temperature (Stern et al., 2007a), the trees on *P. betulifolia* were not significantly larger than trees on OHF (69, 97, 333, 513) or BP 1.

As at the Hula Valley Experimental Orchard Farm (Stern et al., 2007a), the weakest rootstocks were the two quinces—BA 29 and EMA. These results are in accordance with a number of studies, which show that *Cydonia oblonga* rootstocks, especially of the quince types —EMA and EMC, are dwarfing or semi-dwarfing (Westwood, 1993; Webster, 2003; Iglesias and Asin, 2005). The 'Coscia' scion on these two rootstocks reached the established height (3.5 m) and the maximum canopy spread only in their 6th year compared to OHF (69, 97, 333, 513), BP 1 and *P. betulifolia*, which did so by the 3rd year (data not shown).

3.2. Yield and fruit size

The annual yield (from the first yield in 2002 until the last yield in 2007) and the cumulative yields are shown in Table 1. 'Coscia' on the four stronger OHF (69, 97, 333, 513) rootstocks, together with *P. betulifolia*, gave the highest cumulative yield, while the BP 1 rootstock had a lower cumulative yield, although the differences were not significant. This result is in contrast to the results from the Hula Valley Experimental Orchard Farm, which showed a significantly higher cumulative yield on *P. betulifolia* and BP 1 compared to the OHF series (Stern et al., 2007a).