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Agronomical performance under Mediterranean climatic conditions among peach [*Prunus persica* L. (Batsch)] cultivars originated from different breeding programmes

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ABSTRACT

Nowadays more than 70 active peach breeding programmes are developed around the world, all of them, regardless of country, with their specific objectives. Nevertheless, there is no currently available information comparing different peach cultivars based in their origin in terms of agronomic performance and fruit quality under Mediterranean climatic conditions. For this reason, we evaluated the influence of fruit type, origin (continent and breeding programme) and cultivar on adaptability, production and susceptibility to powdery mildew. A study was carried out on 112 cultivars at the IRTA-Experimental Station of Lleida (Spain) during the 2009 and 2011 seasons in which melting peach cultivars presented better agronomical performance than nectarine, nonmelting peach and flat peach cultivars. Comparing continents, USA versus Europe, in terms of fruit type, melting peach and nectarine cultivars from Europe were best adapted to Mediterranean conditions. According to origin by fruit type, melting peach cultivars from Monteaux-Caillet, ASF, Zaiger and A. Minguzzi showed the best agronomical performance. In the case of nectarine, the ASF, PSB and Bradford breeding programmes provided the most interesting cultivars. The fact that there are only a few breeding programmes for flat peaches makes them all the more interesting to producers. In most of the traits studied important variability among cultivars was recorded, either within the same breeding programme. In spite of these results, the cultivars in each breeding programme were clearly different; this explains why producers tend to adopt the strategy of choosing cultivars from different breeding programmes.

1. Introduction

The peach [*Prunus persica* (L.) Batch.] is the third most important deciduous fruit crop in the world (Llácer et al., 2009c) and the second most important in the European Union (EU), after the apple. Spain is the second larger producer in the EU, after Italy, with 29% of the total production (Europêch, 2011). In Spain, peach production is mainly located in the Mediterranean area, with the Ebro Valley (Catalonia and Aragon) being the most important production area, followed by Murcia, Extremadura and Andalusia (Iglesias and Casals, 2007; Llácer et al., 2009a). Most of these regions are characterized by warm summers and cold winters. In contrast, Andalusia has warm summers and mild winters, and produces only low-chilling cultivars. Spain's climatic diversity allows it to produce a large range of cultivars, ranging from very early harvest (mid-April) to very late harvest (late October) (Llácer et al., 2009b).

The peach is the most dynamic of deciduous fruit species grown in the world. About 100 new peach and nectarine cultivars have been introduced per year over the last 10 years (Badenes et al., 2006; Byrne, 2002, 2005; Fideghelli et al., 1998; Sansavini et al., 2006). For this reason, there are more than 70 active breeding programmes around the world, led by the United States and followed by Europe, and particularly France and Italy, with a smaller percentage in South Africa, Australia, China, Japan, Mexico and Brazil (Byrne, 2002). The new cultivars currently planted in Spain are mainly in the Ebro Valley and have their origins in private programmes such as those of: Zaiger Genetics Inc. and N. & L. Bradford (California, USA) and universities (Davis and Michigan) in the United States; the DCA-Università di Bologna, University of Pisa and University of Florence in Italy; public institutes (such as INRA in France, CRA-Roma and Forlí in Italy); and public or private breeding programmes like CIV, CAV, A. Minguzzi, Martorano in Italy and AgroSelection Fruits (ASF), Europépinières and R. Monteux Caillet-Star Fruits in France (Iglesias et al., 2012). Due to its traditional dependence on foreign peach cultivars, Spain only started its own programmes about 12 years ago. This has involved several breeding

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programmes. These have been mainly private (Provedo, Frutaria-ALM, Planasa and PSB), public (CITA and IVIA) or with mixed public and private participation (IMIDA-NOVAMED, ASF-IRTA-Fruit Futur, etc.) in order to reduce the cost of royalties and to guarantee adaptation to local growing conditions (Llácer et al., 2009c). This large number of improvement programmes has provided a very large and varied offer of peach varieties, but has left little time for evaluating their behaviour. The main objectives of all of these programmes were to improve fruit quality and agronomical performance by modifying tree size, simplifying training techniques (Byrne, 2002) and offering a range of cultivars capable of covering the whole harvest season and that are well-adapted to the local conditions for which they were selected (Batlle et al., in press).

The recent discovery of the *Prunus* genome sequence (IPGI) and, as a consequence, our knowledge of which genes and quantitative trait loci (QTLs) are related to agronomical characters (flower colour, ripening time, blooming time, powdery mildew resistance, etc.) is providing new tools to help select varieties for the global market, along with long shelf life and good handling resistance (Martínez-Calvo et al., 2006; Cantín et al., 2006). Recent studies have demonstrated the low level of genetic variation among peach cultivars from breeding programmes in Europe and North America (Aranzana et al., 2010). For example, Monet detected an index of consanguinity of up to 0.80 in Californian varieties obtained by Anderson and Bradford (Sansavini et al., 2006). This could lead people to think that there would not be any significant differences between varieties from different breeding programmes because of high-levels of inbreeding of quantitative traits. However, fruit growers say that they have clear evidence of the different productive behaviour of different cultivars. For this reason, the main objectives of this study were to ascertain whether or not the low genetic variation between varieties from different breeding programmes is relevant for agronomical performance and, at the same time, which of the tested origins offers the best adaptation to the Mediterranean conditions of the Ebro Valley.

2. Materials and methods

One hundred and twelve varieties of peach and nectarine were tested over two seasons. Their origin, fruit type, harvest date and shape are described in Table 1. The study included: 30 melting peach cultivars, of which 19 had yellow flesh and 11 had white flesh; 54 nectarine cultivars, of which 40 had yellow flesh and 14 had white flesh; 9 nonmelting peach cultivars; 14 flat peach cultivars; and 5 flat nectarine cultivars. In order to simplify the analysis, the flat nectarine cultivars were analyzed together with the flat peach cultivars. Most of these cultivars came from different breeding programmes in the United States of America (California) and Europe (France, Italy and Spain).

Data for the different cultivars were recorded in 2009 and 2011. In 2010, a frost (−6 °C) during the period 7th–10th March differentially affected cultivar yields, so these data were not considered. The different varieties were planted on an experimental collection plot located at the IRTA-Experimental Station of Lleida, located in Mollerussa (Catalonia, Spain). The experimental orchard contained three trees per cultivar which were planted in a single block and grafted onto INRA®GF-677 rootstock. The trees were at full production in 2009. They were trained using a central axis system, with a 4.5 m × 2.5 m spacing, and with the rows oriented from NE to SW. The trees were irrigated using two drippers per tree, delivering 4 litres per hour. Standard commercial management practices recommended for the area were followed including: fertilization, plant disease and pest control, using guidelines for integrated fruit production. The weather conditions for the period 2009–2011 were usual for this continental Mediterranean area: with daily maximum summer temperatures of >30 °C and accumulated annual rainfall of around 370 mm. In each season, hand thinning was carried out in early May, using similar criteria for all cultivars in order to obtain similar crop loads.

The trunk perimeter of each tree was measured at the end of the season (in November 2009 and 2011) at a point 20 cm above the graft union. The trunk cross sectional area (TCSA) (cm^2) was then calculated for each cultivar and season. Tree vigour was assessed based on the relative increase in TCSA (RI) (cm^2), because not all the cultivars were planted in the same year.

2.1. Blooming date, flower density, fruit set and thinning requirements

The blooming period was recorded for both seasons for all the cultivars, according to Baggiolini (1952). Records were taken on three dates per cultivar and year: the date of the start of bloom (SB) (2% of flowers open), full bloom (FB) (70–80% of flowers open) and the end of bloom (EB) (beginning of stage G, last flowers on the tree). Periodic controls were carried out at the experimental orchard for this purpose. From each one of the three trees, we chose two homogeneous one-year-old shoots of similar height but with different orientations; these were marked and their length was measured at full bloom. The number of flowers on each shoot was counted to obtain the flower density (FD) which was expressed as the number of flower buds per linear metre of shoot (Lombard et al., 1988). Each season, one month after blooming, and before thinning (end of April), we counted the number of fruitlets on each shoot to determine the fruit set percentage (FSE). Thinning requirements (THR) were evaluated according on a scale from 0 to 4: (0) No thinning; (1) Light thinning; (2) Normal thinning; (3) Intense thinning; (4) Very intense thinning (Iglesias and Carbó, 2009).

2.2. Sensitivity to diseases: powdery mildew

In order to test the sensibility of the cultivars to powdery mildew, from mid-August we did not apply any fungicide treatments on the testing plot. Then, at the end of September, we evaluated the presence of powdery mildew (PM). We then recorded the presence or absence of powdery mildew on 10 shoots from each of three trees of each cultivar. Cultivar sensitivity to powdery mildew was assessed on the basis of 5 categories organized by the percentage of mildew infection: (0) No sensitivity: 0% of shoots with the presence of powdery mildew; (1) Low sensitivity: 0–25% of shoots with the presence of powdery mildew; (2) Medium sensitivity: 25–50% of shoots with the presence of powdery mildew; (3) High sensitivity: 50–75% of shoots with the presence of powdery mildew; (4) Maximum sensitivity: 75–100% of shoots with the presence of powdery mildew.

2.3. Yield parameters

The value of firmness established to determine the harvest date was around 55 N. This parameter was determined using a penetrometer (Penefel, Copa technologie, St-Etienne du Gres, France) mounted on a laboratory bench an 8 mm diameter plunger tip. At harvest time, all the fruits from each tree were harvested in a single pick, weighed and then graded, using an electronic grading calibration manager (SAMMO s.r.l., Model S2010, Cesena, Italy) to obtain: yield (Y) (kg $tree^{-1}$), fruit size (FS) (mm), fruit weight (FW) (g) and fruit number (FN). Afterwards, crop load (CL) (no. fruits cm^{-2}) and yield efficiency (kg cm^{-2}) were calculated according to the TCSA obtained for each cultivar and season.