Scientia Horticulturae 122 (2009) 399–403

Contents lists available at ScienceDirect

Scientia Horticulturae

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

Fruit weight is related to ovary weight in olive (*Olea europaea* L.)

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ARTICLE INFO

Article history:
Received 23 March 2009
Received in revised form 14 May 2009
Accepted 16 May 2009

Keywords:
Ovary
Fruit
Flower
Size
Weight
Olea europaea
Genetic control

ABSTRACT

Fruit size is an important parameter both for scientific understanding and for commercial purposes. In many species, mature fruit size is often related to floral ovary size, but no literature exists in olive that demonstrates such a relationship. Previous work suggests that olive cultivars with different fruit sizes have similar cell number and size in the ovary transectional area, but ovary and fruit dry weight was not measured. In the present study, ovary dry weight and fruit dry weight during the whole fruit development season until harvest were measured in olive cultivars with different fruit size, over three years. Flower dry weight was also measured. Fruit weight at harvest was strongly correlated to ovary weight at bloom, both in single-year data and when data from three years were pooled. Flower dry weight, excluding the ovary, was also correlated to ovary dry weight. Ovary dry weight was strongly correlated not only to the fruit dry weight at maturity, but also at any date during fruit development. The mature fruit/ovary dry weight ratio ranged between 1000 and 4000 among cultivars, but was not correlated to the fruit dry weight at maturity. These results suggest that, in olive, fruit weight is genetically controlled through the ovary weight at bloom. This knowledge may have implications in the understanding of fruit set and source-sink relationships in olive.

1. Introduction

Fruit size is a very important parameter both for scientific understanding and for commercial purposes. Much research has been carried out in several species to understand the mechanisms that control fruit size (Westwood and Blaney, 1963; Scorza et al., 1991; Grossman and DeJong, 1995; Famiani et al., 2000; Nesbitt and Tanksley, 2001; Jackson, 2003; Zhang et al., 2005a,b).

Fruit size is determined by the interaction of the environmental factors with the genetically determined growth potential of the fruits. Among these factors photosynthate availability, which depends on the source-sink balance, is very important. The interaction between genetic growth potential and source-sink relationship has been widely studied and implemented in growth models, such as the "Peach" model (Grossman and DeJong, 1994).

Fruit size is determined by cell number and size (McPherson et al., 2001). Fruits from early opening flowers are larger at harvest than those from later blooms in several species such as apple (Marguery and Sangwan, 1993), persimmon (Hasegawa and Nakajima, 1990), citrus (Praloran et al., 1981), peach (Scorza et al., 1991), grape (Coombe, 1973), and strawberry (Cheng and Breen, 1992). In kiwifruit, early flowers had larger ovaries than late flowers on the same vine, and produced larger fruits with a higher cell number in the outer pericarp than fruits from late flowers, while cell size was the same (Lai et al., 1990; Lawes et al., 1990; Cruz-Castillo et al., 1991). The high number of cells was already found in the ovary tissues of early flowers. Similarly, peach cultivars with larger fruits had fruits with more cells than in fruits from small-fruited cultivars, and this difference appeared early in the growth of the ovary (Scorza et al., 1991). In strawberry, cultivars with larger/heavier flowers had bigger fruits (Handley and Dill, 2003). These findings suggest that final fruit size in some species is determined, at least in part, by the characteristics of the flower, particularly the ovarian tissues and cells. This hypothesis was tested in tomatoes where two nearly isogenic lines, differing for one gene affecting ovary cell division in the ovary primordia, and leading to ovaries of different size at bloom, had proportional variation in fruit size, independent of the source-sink balance (Nesbitt and Tanksley, 2001).

In olive, Rapoport and Martins (2006) stated that, although it stands to reason that the initial size and growth potential of each ovarian tissues could be a factor in its growth as part of the fruit, little experimental information is available. Martins (2006) reported a strong correlation ($R^2 = 0.67$) between the pulp/pit and ovary mesocarp/endocarp tissue ratios, among nine cultivars, but no data exist to correlate fruit size at harvest and ovary size at bloom. On the contrary, Rapoport et al. (2004) reported that while fruit size was mostly related to cell number among eight olive cultivars with different fruit size, at four weeks after bloom, cell size and number were similar in the ovary at bloom. This indicates that olive cultivars with different fruit sizes start out with similar ovaries, but have different rates of fruit development.

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0304-4238/$ – see front matter
doi:10.1016/j.scienta.2009.05.034

However, in the work of Rapoport et al. (2004), cell number and size were measured in olive fruit/ovary transections (not in the endocarp of the mature fruit, however), while fruit and ovary volumes were not considered. Given that different cultivars have different proportions between transection area and fruit/ovary volume, and different pulp to pit ratio, the hypothesis that final fruit size is related to initial ovary size in olive, cannot be ruled out. Surprisingly, no studies yet have measured directly ovary and fruit dry weight. As Rapoport and Martins (2006) stated, the critical tests to determine the degree of dependence still need to be performed.

Testing whether fruit size is related to ovary size at bloom, or whether different cultivars start out with similar sized ovaries is important since it has implications in the understanding of fruit set and development and, ultimately, on productivity.

The aim of the present study was to test whether fruit weight at maturity is correlated to ovary weight at bloom among olive cultivars with different fruit size.

2. Materials and methods

Ovaries and fruits from several olive (*Olea europaea* L.) cultivars were collected from bloom to harvest in 2006–2008. Cultivars were chosen on the basis of the different fruit size, including table and oil cultivars. In 2006 the following cultivars were chosen: Koroneiki, Canino, Nocellara del Belice, Ascolana tenera, Arbequina, Moraiolo and Frantoio. In 2007 few more cultivars (Carolea, Leccino, Rosciola) were added while Arbequina did not set fruits. In 2008, the same cultivars as in 2007 were chosen, except for Nocellara del Belice, which did not set enough fruits for the

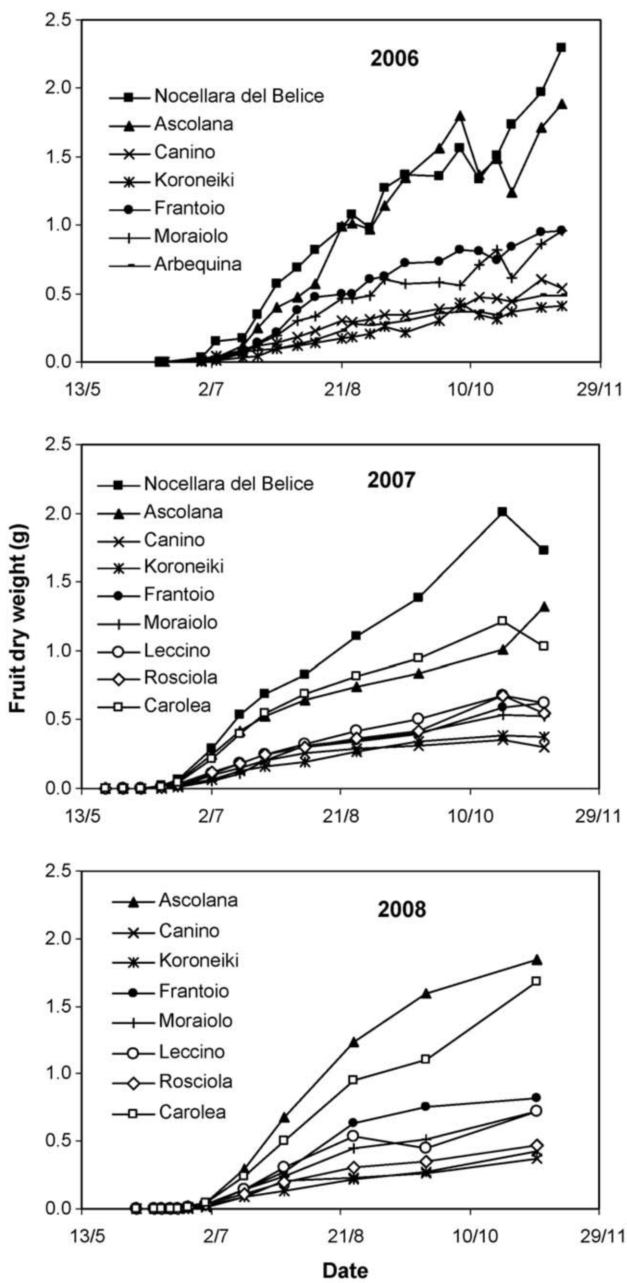

Fig. 1. Seasonal pattern of fruit dry weight for many olive cultivars with different fruit size, during 2006–2008.

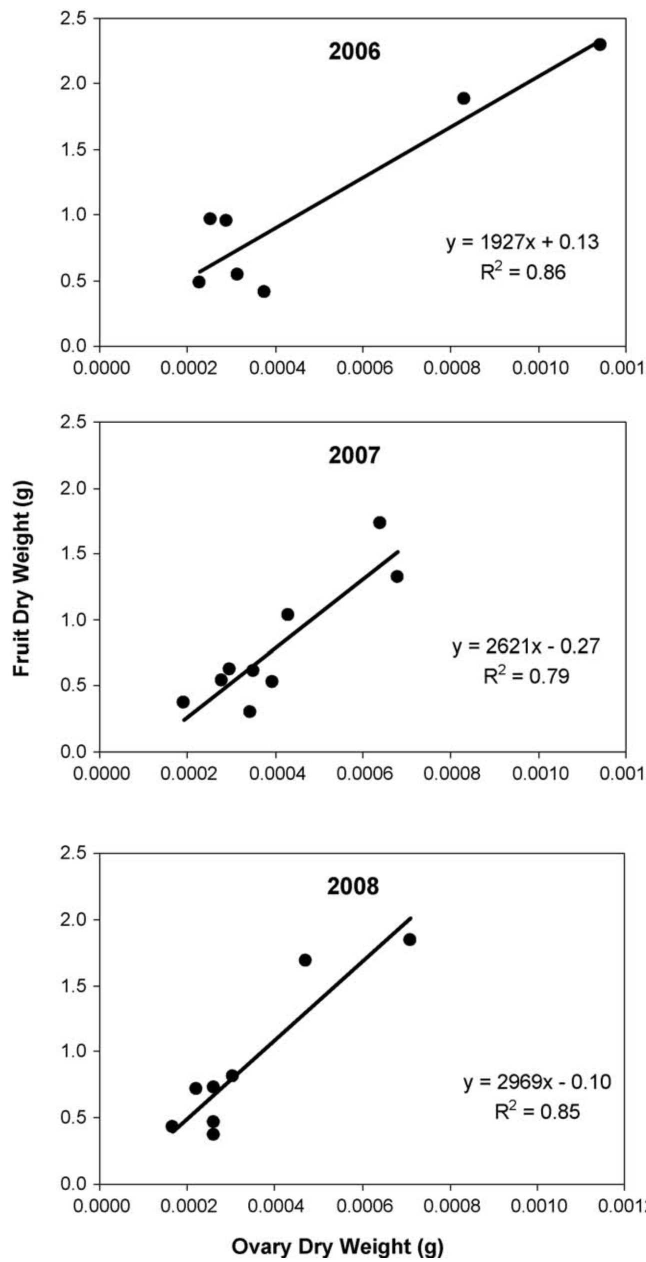

Fig. 2. Relationship between fruit dry weight at maturity and ovary dry weight at bloom for many olive cultivars with different fruit size, in 2006–2008. All fits are statistically significant ($P < 0.001$).