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Thinning and Pruning to Overcome Alternate Bearing in Peach Trees

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Summary

Different tree fruit loads and intensities of winter pruning were combined in an early-maturing peach cultivar 'Alexandra', sensitive to biennial bearing, so as to assess the impact of the number of fruit per meter shoot length on the regularity of fruit production. Crop load was shown to vary in the next year from a factor of one to a factor of 11, underlining the major incidence of the treatments tested on alternate bearing in peach. There was a close and negative relationship between flower density (number of flower per m shoot length) and fruit density (number of fruit per m shoot length) in the previous year. As a consequence, fruit density and number of fruit per tree were also negatively correlated to fruit density in the previous year, which could then be considered as a major parameter triggering alternate production in peach. A maximal fruit load of four fruit per m shoot length could be recommended for a regular 'Alexandra' peach production. Because peach number per tree was positively correlated to total length of fruit-bearing shoots, light winter pruning should be performed in order to limit the detrimental effect of a weak return bloom on production of the year in progress.

Key words. biennial bearing – *Prunus persica* – flowering – fruit cropping – leaf water potential

Introduction

The volume of fruit produced each year in many tree species fluctuates dramatically (Goldschmidt 2005). Biennial or alternate bearing occurs in many commercial fruit trees where yield alternates from high (on-year) to low (off-year) (Smith and Samach 2013). Biennial bearing has been reported in several members of the *Roseacea* species, almond (Lampinen et al. 2011), apple (Greer et al. 2002; Li et al. 2003) and plum (Couranjou 1989). However, little information has been reported for peach despite the importance of this crop grown throughout Italy, Spain, France and Greece in Europe.

Peach trees often produce many fruit, and hand-thinning is commonly required in order to maintain consistent and quality production (Marini 2003). Fruit thinning is one of the most expensive cultural practices in peach production: hand-thinning is time-consuming, in France it takes between 15 and 30 min by tree. Chemical thinning as an option for stone fruit is both limited and unpredictable then very scarcely used (Martin-Gorriz et al. 2012). Hence, cultivars that have fewer flowers can be more profitable than cultivars with many flowers (Seehuber et al. 2011). However, these cultivars may be sensitive to biennial bearing, particularly under unfavourable climatic conditions in spring. It has been reported that peach production is depressed, particularly after cold weather in spring (Bussi et al. 1994). Identifying cultural practices that influence alternate bearing in peach therefore appeared necessary for improving peach production under these conditions.

For other tree species, the distribution of fruit throughout the whole canopy effected fruit quality and return bloom (Titayon and Strik 2004). In peach, thinning and pruning in winter can affect the number and distribution of fruit within the tree (Bussi et al. 2009).

The objective of our study was to report on the relationship between fruit yield in one year and flower and fruit production in the previous year in the biennial bearing 'Alexandra' growing in the Middle Rhône Valley in France. The number of flowers and fruit on a tree were manipulated by hand thinning and pruning the trees in winter. Two separate experiments were conduced over two years. Fruit production depends on the levels of flowering and fruit abscission, and the lengths of the fruit bearing shoots (Perez-Perez et al. 2008). The effects of the different treatments on these parameters were particularly explored.

Materials and Methods

Plant material

The peach cultivar 'Alexandra' was grown on GF305 rootstocks, and planted in 2002 at Valence in the Middle-Rhône Valley, France. The trees flowered about March 20 each year, with mature fruit about June 25.

The orchard had five rows of 22 trees (three rows of experimented trees inside the orchard and two guards) in a Y-training system (two main scaffold branches per tree), with 2 m between the trees and 4.5 m between the rows. The trees were full-irrigated without any water restriction. The trees were grown as a marketable crop except for pruning in February and thinning in early May.

In 2004, when treatments for Experiment I (Exp. I) were differentiated, trees from two tree rows were sampled to arrange the three treatments into five blocks, each with two replicates (10 trees per treatment). In 2006, three blocks, each including the five treatments, were sampled on the third experimental tree row for Experiment II (Exp. II) (three trees per treatment).

Pruning and thinning treatments

The treatments were applied in 2004 and 2006. The on-years were 2004 and 2006, and the off-years were 2005 and 2007.

In 2004 (Exp. I), the trees had 100 fruit per tree and were pruned in winter to give 20, 30 or 40 fruit-bearing shoots (FBS) per tree. This gave about 5.0, 3.3 or 2.5 fruit per bearing shoot. In 2006 (Exp. II), there were five treatments with the trees pruned and thinned to give 60 fruit per tree and 120 FBS per tree; 60 fruit per tree and 60 FBS per tree; 270 fruit per tree and 120 FBS per tree; 270 fruit per tree and 60 FBS per tree; 420 fruit per tree and 120 FBS per tree. This gave about 0.5, 1.0, 2.2, 4.5 and 3.5 fruit per FBS. In 2005 (Exp. I) and 2007 (Exp. II), pruning was light (about 30 % of FBS length removed) across all the treatments and there was no thinning in these years.

Measurements

Peach trees bear fruit on one-year-old shoots (Gordon and DeJong 2007). All these shoots in spring 2005 or 15 of these shoots in spring 2007 were chosen on the main scaffold branches oriented east at the beginning of the growing season.

The number of flowers per meter of FBS (flower density per m), and the number of fruits per meter of FBS (fruit density per m), were counted on each tree. Fruit abscission was calculated as (100 – PRF), where PRF is the Percentage of Ripe Fruit relative to the number of flowers on each tagged shoot.

The total length of FBSs per tree was measured after pruning in winter for all trees in 2005 and for one or two trees per treatment in 2007.

Statistical analysis

Regression curves were adjusted using the least squares technique to test the relationships between the parameters measured. Data from Exp. I and Exp. II were pooled to be globally tested. If no significant relationship was detected, the data of each experiment were separately tested (Statgraphics® Plus software). The best-fitted functions were found to be logarithmic. The regression curve was shown if the correlation coefficient was found to be significantly different from zero. Statistical significance was established at $P \leq 0.05$ (*) and $P \leq 0.01$ (**).

Results

Relationship between flower and fruiting, and the previous crop

Flower density varied from 4 to 18 in 2005 and from 11 to 30 in 2007, and was negatively correlated with fruit density the previous year (Fig. 1A). Fruit density varied from 1 to 4 in 2005 and from 2 to 9 in 2007, and was negatively correlated with crop load the previous year (Fig. 1B). The relationship between fruit density and the previous crop was not as strong as the relationship between flower density and the previous crop (Fig. 1B). A stable fruit production would occur with about four fruit left per m of FBS, inducing 15 flowers and four fruit per m of FBS in the subsequent year (Fig. 1A and B).

Relationship between fruit abscission and flower density

Relative fruit abscission varied from 30 to 90 % of the initial flowers on the two experiments and was positively correlated with the density of flowers the same year (Fig. 2). Fifteen flowers per m of FBS would induce about 75 % of fruit abscission and four fruit per m of FBS (Fig. 2). Overall fruit abscission tended to be higher in 2005 than in 2007 (Fig. 2). In parallel, frost affected the experimental orchard in spring 2005 with a temperature of −1 °C in early April two weeks after full bloom.

Relationship between yield and fruiting the previous year

In 2005 and in 2007, from 15 to 178 fruits (ratio of one to 11) and from 88 to 358 fruits (ratio of one to 4) were borne per tree, respectively (Fig. 3). There were strong negative correlations between the number of fruit harvested per tree and the density of cropping the previous year, with relatively higher yields in 2007 than in 2005 (Fig. 3A). Four fruit left per m of FBS were likely to insure a next year mean production of about 200 fruit per tree

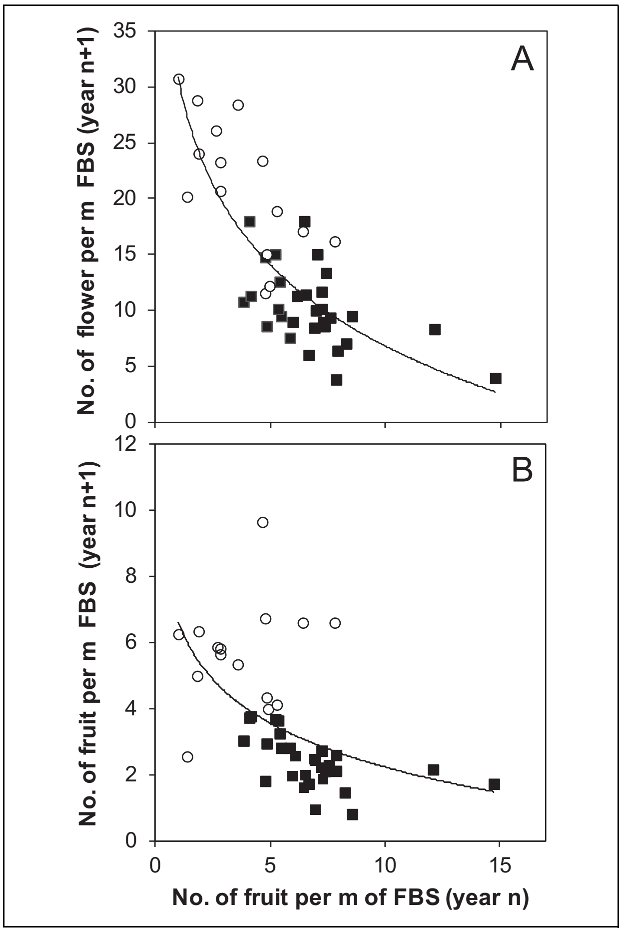

Fig. 1. Relationships between flower (A) and fruit (B) productions and cropping the previous year in 'Alexandra' peach trees. Data are the mean of each sampled tree. The trees were thinned and pruned to provide a range in the number of fruit per tree, number of bearing shoots and number of fruit per bearing shoot in two experiments conduced in 2004/2005 (■) and 2006/2007 (○). For A, y = −10.51 ln(x) + 30.97 (r^2 = 0.66**). For B, y = −1.90 ln(x) + 6.59 (r^2 = 0.28*). *, ** Significant at $P \leq 0.05$ or $P \leq 0.01$.

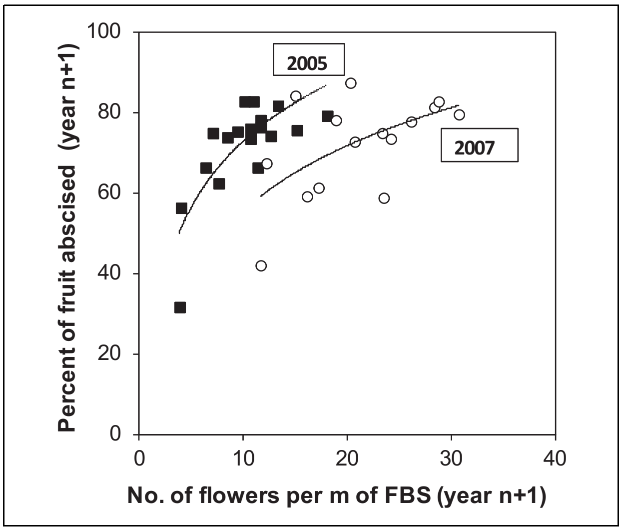

Fig. 2. Relationships between percentage of fruit abscission and number of flower per m of FBS of the year in 'Alexandra' peach trees. In 2005, y = 23.61 ln(x) + 18.48 (r^2 = 0.64**); in 2007, y = 23.25 ln(x) + 2.03 (r^2 = 0.33*). For the legend see Fig. 1.

(Fig. 3A). Overall yield per tree was strongly correlated with the length of the fruit-bearing shoots on a tree in the same year, with 2007 more fruitful than 2005 (Fig. 3B).

Discussion

In fruit trees, high numbers of fruit in bearing shoots decrease flower production for the following crop (Shalom et al. 2012). Fruit mature in 'Alexandra' concomitant at the time when the trees initiate floral buds (Li et al. 1989). Thus, flowering can be reduced by competition for nutrients or carbohydrates or by plant growth substances, possibly gibberellins like GA7 produced by the seeds in the fruit (Smith and Samach 2013).

From bloom to ripe fruit, climatic conditions are of major importance in terms of the fruit number per tree, so they are considered as possibly accentuating biennial bearing (Bangerth 2000; Turktas et al. 2013). Under our conditions, the lower fruit number per tree detected in the off-year 2005 compared to that in 2007 might be partly attributed to the climatic conditions, which differed between the two experiments. Early spring frost that occurred in 2005 was possibly the cause of the trend towards a higher percentage of fruit abscission compared to the one measured in 2007 (Perez-Perez et al. 2008). Nevertheless, we only presented data for two years. Supplemental data should be collected in order to draw firmer conclusions about the relationship between peach productivity and the weather, notably frost.

The relationship between fruit number per tree and fruit density of the previous year logically resulted from the relationships linking flower and fruit densities to the fruit density of the previous year. As a consequence, fruit density in an on-year possibly appeared as a major parameter for determining tree crop load in the subsequent off-year (Bustan et al. 2013). Because fruit density was mainly controlled by fruit growers through thinning, this cultural practice should be skilfully managed in order to minimise crop load fluctuations in the subsequent year and thus contribute to economically cost-effective peach production (Seehuber et al. 2011). Krasniqi et al. (2013) showed that the relationship between flower number in year 1 and subsequent yield in year 2 in an alternate bearing apple cultivar could be used to determine the target number of flower suitable for a sustainable apple production. Under our conditions and for a stable production of approx. 200 peaches per tree, the recommended thinning in an on-year could be to leave a maximal fruit load of

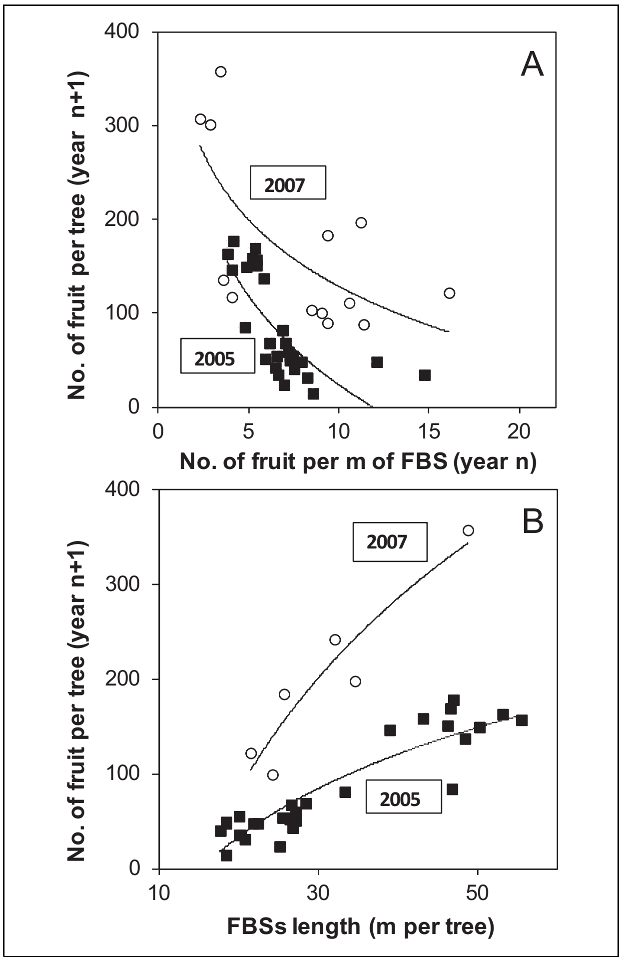

Fig. 3. Relationship between number of fruit per tree and number of fruit per m of FBS of the previous year (A) and between number of fruit per tree and length of FBSs per tree of the same year (B), in 'Alexandra' peach trees. In 2005, y = –137.04 ln(x) + 339.38 (r^2 = 0.57**) for A; y = 126.19 ln(x) –344.73 (r^2 = 0.83**) for B. In 2007, y = –102.60 ln(x) + 364.95 (r^2 = 0.48*) for A; y = 287.58 ln(x) –791.43 (r^2 = 0.83**) for B. For the legend see Fig. 1.

four fruit per m of FBS. In addition, FBS total length was shown to have an impact on the variation of the number of fruit per tree of the year in progress. The positive and close relationship between FBS total length and the number of fruit per tree suggested that FBS total length was a major yield component (Bevacqua et al. 2012). Subsequently, because FBS total length can be managed each year by winter pruning, light winter pruning should be performed in order to limit the detrimental effect of a weak return bloom on peach production.

In conclusion, crop load was shown to strongly vary according to the treatments applied during the previous year, highlighting the incidence of the treatments tested, winter pruning and thinning, on alternate bearing in peach. Fruit density, usually managed by thinning, may be considered as the trigger or promoter of alternate bearing for the subsequent year, whereas total length of FBSs, usually managed by winter pruning, possibly mitigates the reduction of the year's peach production.

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