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It's great to be the King: Apple fruit development affected by the position in the cluster

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ABSTRACT

Apple trees (*Malus domestica* Borkh.) develop an abundance of flowers and shed the majority of fruitlets in the first developmental stages. In this study the process of abscission was monitored in cultivar 'Golden Delicious' and linked with the position of fruitlets in the cluster, focusing on differences among central or king flower/fruit (K1), flowers/fruit nearest to the king flower (lower on the peduncle; L2) and flowers/fruit located at different positions near the base of the peduncle (L3-L6). Individual clusters consisted of 3–7 flowers the most frequent were clusters with 5 flowers. Abscission was biphasic with the first peak 29 days after full bloom (DAFB) and the second peak 48 DAFB. At the end of the abscission process approx. 70% of all fruitlets shredded. Fruitlets at the central position (K1) were frequently unaffected by this process and developed to fruit in 70% of the analyzed clusters. The ratio between subsisting and shedded fruitlets was the opposite for lateral positions in the cluster; approx. 70% of fruitlets abscised in the clusters with 4/5 flowers. No significant differences in the level of abscission have been observed between the lateral positions in the cluster (L2-L6). A tendency to abscission has been detected for L2 position (lateral fruitlet nearest to the king flower) in clusters consisting of 6 flowers. This was further confirmed at harvest. Fruit from the lateral position nearest K1 were smaller and firmer in comparison to K1, L3 and L4. This demonstrates the obvious dominance of the central fruit in comparison to lateral fruit, especially those nearest to the king fruit. This is particularly evident in clusters with many flowers.

1. Introduction

Apple trees, like many other fruit crops, form an abundance of flowers but not all develop into fruit. Many fruit tree species have perfected a system of regulation of the fruit load where part of it is shed. In apple trees, three periods of increased fruit drop can be highlighted. The first one occurs soon after flowering (1–2 weeks) and is usually the consequence of incomplete pollination. The second fruit drop is the most severe and can be observed 4–6 weeks after bloom. It is frequently referred to as the June drop. The third period is the shedding of nearly mature fruits (Kolaric, 2010). The latter is unwanted by fruit growers as additional assimilates are lost and therefore, they attempt to stop the final fruit abscission. Early season fruit abscission, which occurs during the initial fruit developmental stages, controls the fruit load. In some circumstances fruit abscission is sufficient for fruit load regulation; however, in apple trees the physiological shedding frequently insufficiently reduces the number of fruits (Botton et al., 2011; Eccher et al., 2013, 2014). Authors report that natural drop alone cannot reduce the crop load to commercial levels (Bregoli et al., 2007; Hampson and Bedford, 2011). Too many fruit on the tree not only leads to poorer apple quality of the crop year, but a small floral set for the following year, which in turn can lead to alternate bearing. This results in interchangeable years of extremely heavy blooming (ON year) and years of exceedingly low blooming (OFF year) (Byers, 2003; Zadravec et al., 2013). Often 90% or even more fruitlets need to shed (Lakso and Goffinet, 2013) to allow the remaining fruit to achieve commercial standards (Link, 2000) and to improve the return bloom (Tromp, 2000).

There are two main theories clarifying the abscission of young fruitlets. According to the first theory the fruitlets are insufficiently supplied with assimilates as a result of limited assimilate pro-

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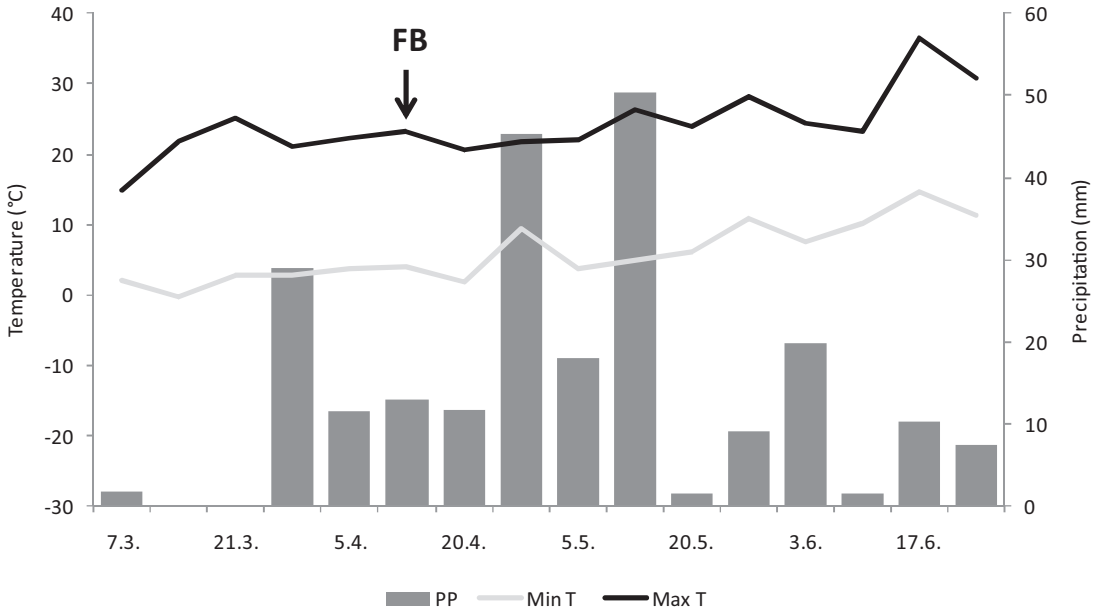

Fig. 1. Average high (Max T) and low (Min T) weekly temperatures and average weekly precipitation (PP) from 1st March to 23rd June; FB, full bloom.

duction and/or allocation to the fruit cluster (Lakso and Goffinet, 2013). An alternative belief is, that selected fruit are regulated by a hormonal mechanism by which the plant safeguards fruit from assimilate limited growth later in the season (Bangerth, 2000). Scientists support both theories and many studies have been conducted to validate them, but a clear answer as to why some fruitlets fall off sooner, others later and some remain on the plant is still to be found.

Many authors who investigated the process of apple abscission categorized only two fruitlet types: central/lateral fruitlets (Dal Cin et al., 2007; Ferree et al., 2001) or fruitlets differing in their size (Botton et al., 2011; Eccher et al., 2013; Ferrero et al., 2015). Studies confirmed that smaller fruitlets had higher abscission potential. However, the tendency to abscess might already be linked with a decrease in fruit growth rate which always precedes shedding (Magein, 1989).

The aim of the present study was to investigate the abscission process prior to the reduced growth caused by thinning as this is already a result of various factors. Abscission can be stimulated or inhibited by several technological measures and thereby influencing the factors that are important for crop quality and regular fertility. The advanced knowledge on the natural process of abscission is crucial for the implementation of these measures. The natural phenomenon of fruitlet shedding has been monitored in apple tree and clusters with a different number of flowers have been evaluated. Each flower/fruitlet position in the cluster has been monitored separately and to our knowledge this is the first study, which aims to determine the link between specific position and abscission. In addition, the link between the initial stages of fruitlet development and various quality parameters at maturity has been evaluated and potential reasons for these phenomena presented.

2. Material and methods

2.1. Plant material

The study was carried out in 2014 on 12 year-old apple trees cv. 'Golden Delicious', grafted on M9 rootstock, growing at the experimental orchard of Biotechnical faculty in Ljubljana (latitude 46.05 N, longitude 11.47 E, altitude 289 m). Trees are planted at a distance of 3.5 × 1.2 m and trained to a solaxe. Rows are N-S oriented and the space between the rows is covered with grass. The orchard has a permanent 2.5 m high support, no hail net and no irrigation system. The data on temperatures and precipitation during the period of fruit shedding are presented in Fig. 1. The orchard is maintained according to the integrated production method.

2.2. Sampling

On six homogenous trees ten branches on the same side of the tree were chosen. The branches were full of short generative shoots (up to 10 cm) bearing multiple blooms. The number of flowers in each cluster was counted at full bloom (April 11th), and at the beginning of shedding. Weekly samplings were performed until the end of June (June drop) and on each occasion the number of shedded fruitlets and their position in the cluster was determined. The central flower/fruitlet was positioned at the top of the cluster (position K1), and each lower lateral flower was assigned a subsequent number from 2 to 6 (L2, nearest to the king flower - L6, flower at the basal position) (Fig. 2). The survey was conducted until the end of June drop.

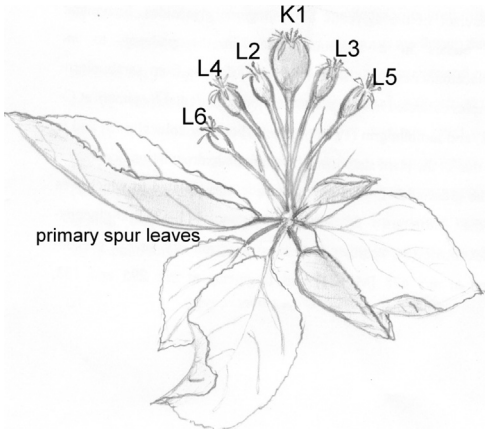

Fig. 2. The hierarchy of positions in the fruit cluster; K1, central or king fruitlet and L2-L6, lateral fruitlets from the top to the base.