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The Precise Growing of Pomefruit Orchards for the Production of High Quality Fruit and Yields in Emilia-Romagna

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ABSTRACT

Research over the years has shown that it is possible to set production targets for pomefruit orchards. Based on tree density, targets can be set for yield levels and fruit size, that translate into the optimal crop load (fruit number per tree). When this is achieved via thinning, the question remains open: how to make sure that growth of the fruit is progressing correctly? Precision fruit growing research answers this, by making it possible to evaluate the management carried out by the grower, and to assess whether or not it is in line to achieve the desired quality and yields targets.

Keywords: Precision Horticulture, Pomefruit, Apple, Pear, Fruit Growth Monitoring

1. INTRODUCTION

The concept of sustainable agriculture has become widely accepted by growers, consumers, and policymakers as an important guide for the future directions of fruit production systems. That concept is also an integrating part of the newer concept of precision horticulture. This philosophy embodies concepts that allow decisions on future orchard management: economically viable, environmentally sound, and socially responsible. Unfortunately unanswered questions on crop status often make the seasonal production cycle difficult to be read, not responding to the latter three points. Many hidden data from the crop and the environment are available in the field and are an important source of information for the growers (Manfrini et al., 2012). Despite the available knowledge and the advances in technology of the latest years, it is still quite common to fail finding real-time data monitoring practices within orchards, to relieve management from performing subjective practices. For example, in apple production growers routinely apply plant growth regulators to remove excess fruitlets to promote annual cropping and improve fruit size and quality (Marini, 2003; Link, 2000) but often there is no information about the dosage of the chemical thinner that should be applied and a real time feedback of their efficacy after application. Moreover, no guidelines are available to fine tune the following manual thinning to real orchard needs, let alone any feedback on the effect that these practices will have on fruit development. In other

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words, many crucial management decisions in the field are not made based on sound information, nor checked as to their usefulness before harvest or, if checked by a non appropriate methodology, results and forecasts could be misleading (Ellis et al., 2010). Taking into account this existing situation and building on more than two decades of ecophysiological studies, an integrated data collection and information support system to describe and forecast pomefruit (apple and pear) growth and variation of quality/production parameters along the season was developed. This has led to the formation of HK-Horticultural Knowledge ltd (HK), whose goal is to help both growers and consultants by providing them with support information needed for critical decision making during the growing season. An additional HK product, aimed to those involved in fruit marketing is a forecast of fruit distribution within size classes, valuable information to devise market segmentation and sale strategies.

2. MATERIALS AND METHODS

2.1 Orchard Characteristics

The study was conducted during the 2011 growing season in a commercial apple orchard located near Cesena, Italy. Data were collected from a 2 ha block of Pink Lady® apple trees planted in 2004, grafted on M9 rootstock and trained as slender spindle at the density of 2857 trees ha^{-1} (3.5 X 1.0 m); the trees were under a standard management approach. HK during 2011 monitored a total of 50 ha circa of Pink Lady® apple in the Emilia-Romagna Region.

2.2 The Suite of Tools to Be Used and Rationale for Their Use

A desired average tree fruit load target can be calculated coupling the basic field information of tree density, desired yield and fruit size target. Tree density for the orchard is 2857 tree/ha and the desired target production was set at 75 t/ha. Pink Lady® apple to be considered of high value needs to be within the 75/85 mm size class corresponding to a fruit of 210/220 g/fruit. From these data, the desired average fruit load per tree is computed to be 120 fruit/tree. Monitoring began on June 25, 2011, when the maximum diameter of a sample of fruit was recorded. The measurements took place every other week for a total of 4 times. In addition, tree crop load was assessed by fruit counts on July 10, 2011. This allowed to determine whether the post-chemical, manual, thinning had been effective. This assessment was repeated at harvest. Average harvest fruit size forecasts were released at each sampling date (except the first one). These allow a verification for the grower whether or not the management is on track, at a time when it can still be modified. Concurrently, a forecast was released of the breakdown of the whole crop into size categories, which in turn allows to release a very accurate estimate of orchard yield (fig. 2).

2.3 Method of Data Collection

The fruit measurements for the estimation of fruit load per tree was assessed on 20 randomly chosen trees and followed the protocol described by Manfrini et al., 2009 (fig. 1). All fruit on each tree were counted two times and their count were then

averaged to obtain a single count/tree. The maximum equatorial diameter was measured on 20 fruit on the 20 randomly selected trees for a total of 400 fruit/orchard.

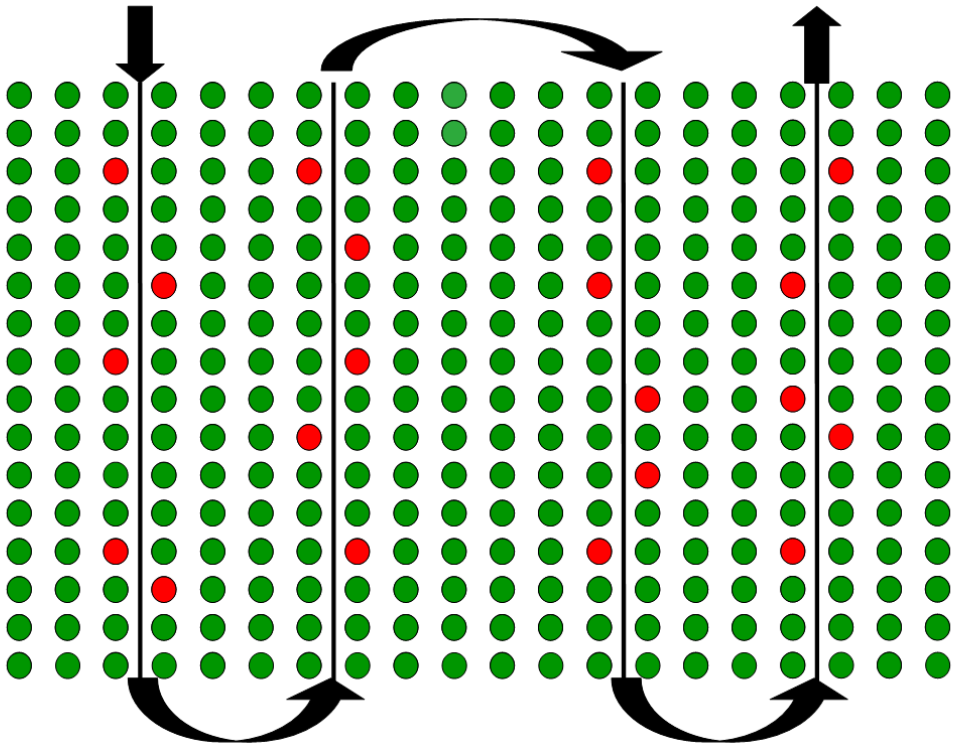

Figure 1. Data collection and selection strategy.

3. RESULTS AND DISCUSSION

As the initial forecast for the orchard, released on July 10, 2011, indicated that fruit would be under the desired size target, the fruit load per tree was checked, and was found to be 136 fruit/tree, while it should have been, based on the calculations reported above, of 120. This prompted the suggestion of a further thinning (by hand) of the trees. The grower decided to perform an additional thinning, and the positive impact of this decision was immediately apparent in the subsequent forecast, released on July 26 (tab. 1), which showed the fruit had recovered their growth rate and were now forecast to be around 75 mm diameter, i.e. the targeted size. It is worth pointing out that, on a daily growth rate basis, the difference between the July 10 and 26 forecasts is only 0.02 mm (0.42 vs. 0.44 mm/day) but, because of the compound interest nature of these changes, the end point moves up by more than 3 mm in fruit diameter (tab. 1). The last forecast released and the data recorded at harvest confirmed the effectiveness of the thinning treatment.

Table 1. Fruit growth at different time during the season and crop load parameters

Measurements	25/6/11	10/7/11	26/7/11	10/8/11	Harvest
Average Diameter forecast (mm)	-	72.1	75.6	76.4	76.5
AGR (mm/day)	-	0.42	0.44	0.34	
Average fruit number	Suggested 120	Counted 136	-	-	Counted 124

Apart from the forecast of the average fruit size, our approach allows to release a forecast of the breakdown in size categories of all the orchard production. This computation was made for the expected harvest size before and after the thinning, and the data clearly demonstrated that, even at such a late stage, apples respond to removal of competitive sinks (e.g., of the apples). In this particular case, the effect of thinning (demonstrated by the increase in fruit growth explained above) was large enough to shift the entire orchard fruit production up by one size class. HK during the 2011 season has monitored a total of almost 50 ha in the Emilia-Romagna Region, releasing a very accurate forecast of the size class breakdown of all the apples produced (fig. 3). The largest error incurred has been in the 75/80 size class (3.4%) if compared to the data for all the orchards monitored, which was provided to us by the Apofruit cooperative, based on their in-house assessments. This information is greatly valuable for the sales people, who can thus have a very good idea of the product they have to sell, much earlier than they are currently used to (2 month before harvest time). This provides them with the opportunity to start contacting perspective clients sooner in the season, and with a much clearer picture of the upcoming marketing scenarios.

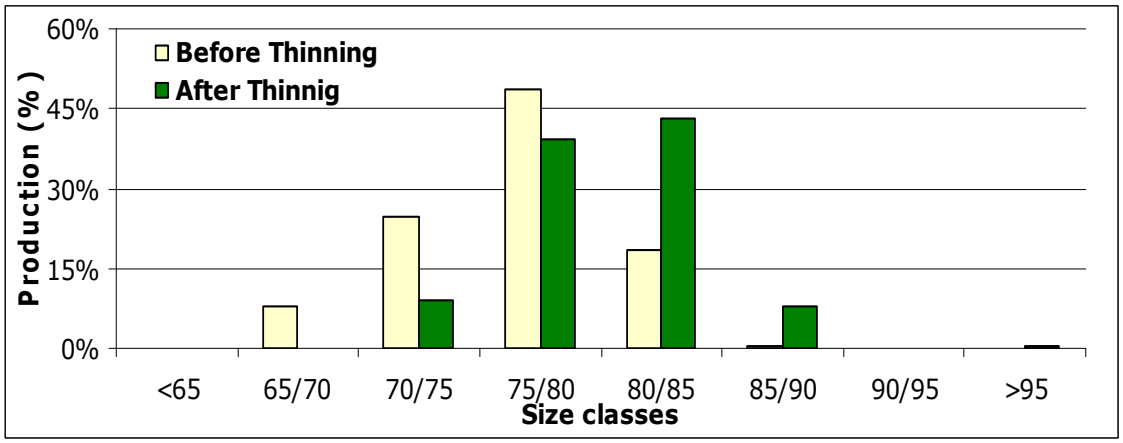

Figure 2. Fruit size class distribution before and after fruit thinning

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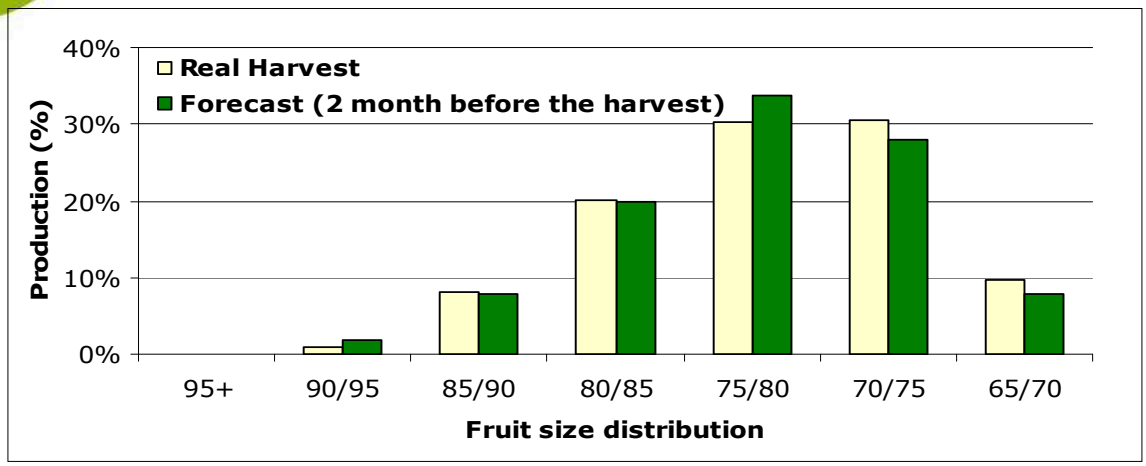

Figure 3. HK fruit size forecast (2 month before harvest time) compared with the real orchards production on a total of 50 ha.

5. CONCLUSIONS

This paper offers a case study illustrating the possibility and the advantages provided by adopting precise management of orchards, if this is based on sound assessment of orchard performance, and robust modelling tools. We were able to provide feedback to the grower about a looming (but not yet obvious) problem of excessive crop load, which would have caused insufficient fruit size at harvest, and corroborated this observation with the average fruit load per tree, which resulted over 10% higher than desired. The removal of fruit carried out at mid-July was effective and allowed to increase fruit growth enough to fulfil the yield and fruit size targets. In addition to this real-time decision-supporting information, we were able to deliver to the sales department of the packing house crucial information on their crop make-up in terms of size distribution, up to two months before harvest. This is valuable because it allows the best market segmentation and storage management, to minimize losses and increase efficiency of storage. The effort required by the grower for this type of monitoring, and the costs associated are by far smaller than the associated benefits. In terms of time, the 5 measurements performed did not take more than 4 hours per ha. The cost of the service is but a fraction of the measured benefits to the grower, in terms of orchard packout and farmgate value.

To date, type of this information on apple fruit load and growth during the season and at harvest has not been recorded and used as a driver of labor, resource and other management inputs. This investigation indicates options available to growers who would like to increase their knowledge on the field status and potentially better respond to market demands of higher quality fruit at a lower cost.

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4. REFERENCES

Ellis, K., Baugher, T. A., & Lewis, K. (2010). Results from survey instruments used to assess technology adoption for tree fruit production. *HortTechnology*, *20*(6), 1043–1048.

Link H. 2000. Significance of flower and fruit thinning on fruit quality. Special issue: Abscission and thinning of young fruit - from molecular to applied aspects. *Plant Growth Regulator* 31: 17-26

Manfrini, L., J.A. Taylor, and L. Corelli Grappadelli. 2009. Spatial Analysis of the Effect of Fruit Thinning on Apple Crop Load. *European Journal Horticultural Science.* 74 (2). 54–60.

Manfrini, L., Pierpaoli, E., Taylor, J.A., Morandi, B., Losciale, P., Zibordi, M., Corelli Grappadelli, L., Bastías, R.M. 2012. Precision fruit growing: How to collect and interpret data on seasonal variation in apple orchards. *Acta Horticulturae*, 932, pp. 461-470.

Marini, R.P. 2003. Fruitlet size and position within the cluster influence apple fruitlet susceptibility to chemical thinners. *Journal of Horticultural Sciences & Biotechnology* 78:813-820

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