# A model for canning peach crop value using a software for dynamic modeling

G. Reginato, C. Pinto and R. Infante

Universidad de Chile, Facultad de Ciencias Agronómicas, Casilla 1004, Santiago, Chile.

***Abstract***

**In order to optimize fruit thinning of canning peaches, considering yield and pulp fraction or canned fruit as a function of crop load, a model to estimate crop value was built using the software Stella®. Since crop value depends on fruit weight, size distribution and total yield, the relationships were estimated from experimental data collected over 10 years with different cultivars and orchards. The model estimates average fruit weight as a function of crop load, fruit set, thinning date, harvest date (cultivar) and maturity. The degree of maturity at harvest is defined as pulp firmness. Size distribution is estimated from the average fruit weight, considering three commercial categories: "for pulping", "for canning" and "oversized fruit". Total yield is based on fruits tree$^{-1}$, trees ha$^{-1}$ and fraction of intercepted radiation. The intercepted radiation of each situation is estimated from the coverage of the largest and the smallest tree, assuming a normally distributed population. Prices can be modified to generate different scenarios based on the requirements and allowances set by the industry. Although the validation of the model has not yet been done, the model can be a promising tool for determining the thinning strategy for canning peach by understanding and quantifying the yield response to crop load.**

**Keywords:** *Prunus persica*, crop load, fruit size, fruit thinning, yield

## INTRODUCTION

The profitability of a canning peach orchard is determined by the yield that can be used for canning in halves. Fruits in this category have a weight between 100 and 250 g, are ripe and firm are without bruises or split pits and in good condition. Fruits that are smaller than 100 g are classified as fruit "for pulping" and receive lower prices than those for canning in halves. Fruits weighing more than 250 g are classified as "oversized fruit" and receive the same price as those for canning in halves, but are not preferred by the industry because they must be hand pitted (Ojer et al., 2009). Thus, the maximum return for the grower depends on fruit weight, size distribution and yield. These three factors are a function of fruit thinning, which is considered a critical orchard management action, as it ensures the economic result (Costa and Vizzotto, 2000). Thinning increases average fruit weight, but also reduces the total yield, so it does not necessarily increase the returns (Reginato et al., 2007; Stover et al., 2001). Additionally, the economic result also depends on biological, environmental, cultural or economic factors (Johnson and Rasmussen, 1990), harvest date (Inglese et al., 2002), thinning date (Njoroge and Reighard, 2008), initial crop load (Ojer et al., 2001), potential fruit size of the cultivar (Grossman and DeJong, 1995), and price (Stover et al., 2001), among others.

The main objective of this study was to create a dynamic model for integrating the factors that interact in thinning response and to estimate crop value in canning peaches as a predictive tool to guide thinning decisions.

## MATERIAL AND METHODS

### Structure of the model

This model was built using the modeling software Stella® (Isee Systems, Lebanon, NH, USA) and is a first approach to estimate crop value of canning peaches considering orchard



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characteristics and crop management, which determine yield, fruit size and quality, and considering the average fruit price. The relationships of the model are based on information from literature and experiments with different varieties and production situations collected over 10 years. The yield model is divided into 3 parts: orchard, management, yield and quality (Figure 1). The model begins with the number of fruits per tree. Also, a sub model calculates the average fruit price beginning a base price (for pulping), grower decisions and industry demands (Figure 2).

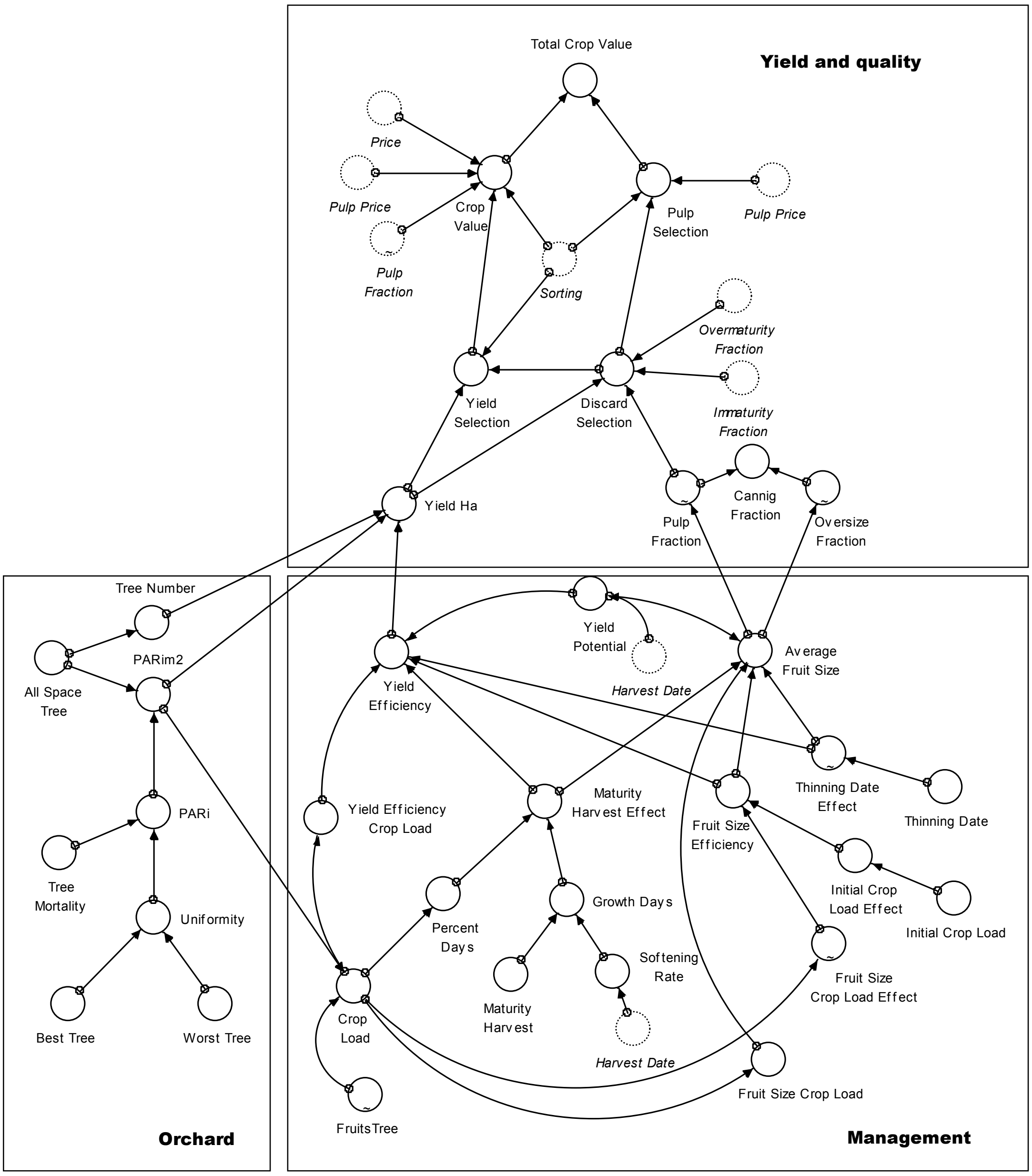


Figure 1. Core model structure for predicting crop value in canning peaches using the Stella® programming language.

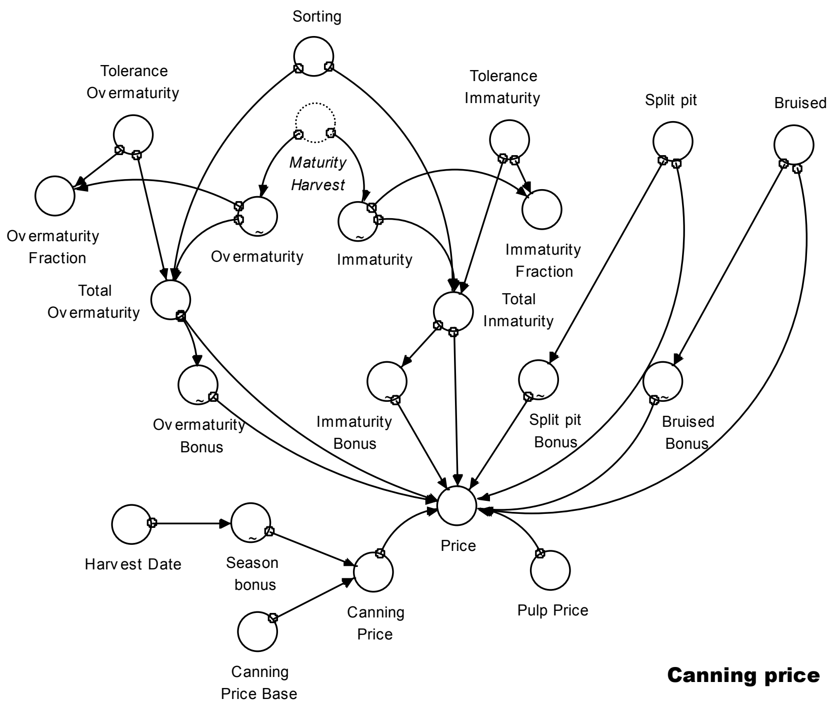


Figure 2. Price sub model.

**Orchard factors used by the model**

The main orchard components are allocated space for each tree and the fraction of solar radiation intercepted at harvest. The intercepted radiation at harvest is estimated from the coverage of the largest and the smallest tree, assuming a normally distributed population. The fraction of intercepted radiation normalized by planting distance ($PAR_i m^2$) is used to express crop load and yield efficiency for each production unit (Reginato et al., 2007).

**Management factors used by the model**

This section of the model determines yield components and average fruit size. The model starts with fruits tree$^{-1}$ post-thinning, the most important component of yield (Lakso and Corelli Grappadelli, 1992). Subsequently, it defines crop load normalized by the intercepted radiation (fruits/$PAR_i m^2$). Crop load determines fruit size and yield (Costa and Vizzotto, 2000); a lower crop load increases fruit weight (Figure 3A), but reduces total yield (Figure 3B). Also, the model considers the effect of other factors that contribute to fruit weight and yield efficiency such as: 1) harvest date, late cultivars have a longer growing period so they can accumulate more dry matter than early cultivars (Pavel and DeJong, 1993); 2) thinning date, because early thinning results in larger fruit due to less competition for assimilates (Grossman and DeJong, 1995) (Figure 3C); 3) initial crop load, because a lower crop load will result in less resource limitation and therefore the fruit will achieve their growth potential (Ojer et al., 2001); and 4) fruit maturity measured as flesh firmness, because a delayed harvest will improve fruit size (Marini et al., 1991) (Figure 3D).

**Yield and fruit quality factors used by the model**

Fruit size distribution is function of average fruit weight and fruits are categorized according to three commercial categories: “for pulping”, “for canning” and “oversized fruit”. Finally, the size distribution, total yield and average fruit price define the crop value (Byers and Marini, 1994). The model allows users to evaluate the economic benefit of any thinning management practice performed (Stover et al., 2001).

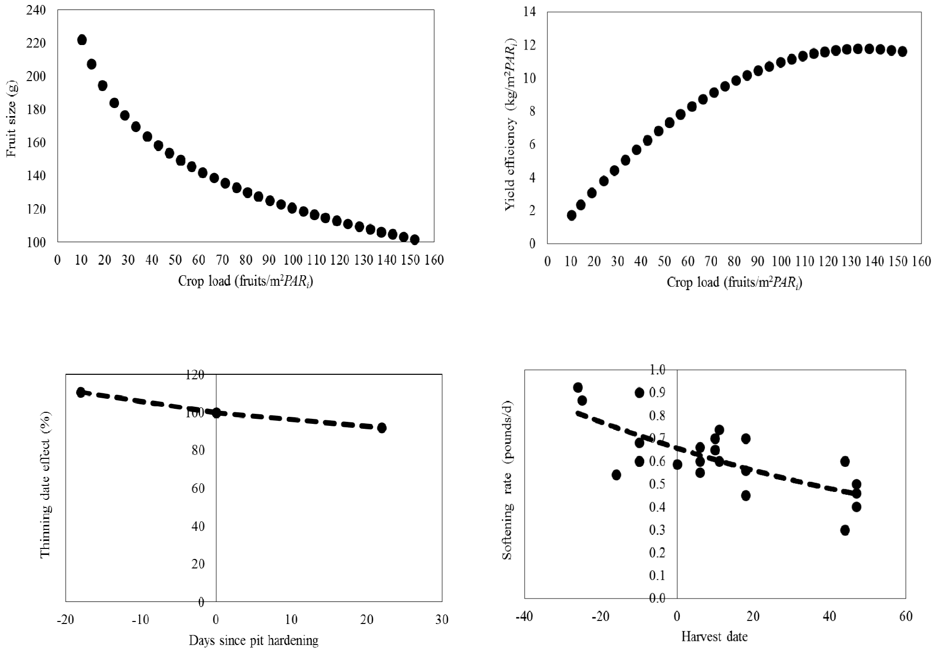


Figure 3. Model components. (A) Fruit size as function of crop load; (B) Yield efficiency as function of crop load; (C) Thinning effect according date; and (D) Softening rate as function of harvest date of the cultivar.

**Price sub model**

The price sub model calculates average fruit price for Chilean canning peaches, considering grower decisions and bonuses or penalties of the industry (immaturity, over maturity, split pits and bruising) (Figure 2). The sub model evaluates some grower decisions such as sorting at harvest, and the efficiency of these tasks.

The whole model simulates multiple scenarios considering the market prices (canning and pulp), permitting users to choose the most convenient strategies for the grower. To run the model 15 inputs are required, which are values and decisions that each grower can enter (Table 1).

Table 1. Inputs of the model and their units, needed for crop value simulations.

| Section | Parameter input | Unit |
|---|---|---|
| Orchard | Best tree PAR interception | % |
| | Worst tree PAR interception | % |
| | Tree mortality (of the orchard) | % |
| | Allocated space for each tree | $m^2$ |
| Management | Harvest date with respect to ‘Carson’ peach | d |
| | Thinning date with respect to beginning of pit hardening | d |
| | Initial crop load (relative) | no. |
| | Harvest maturity | pounds |
| Price sub model | Sorting at harvest | conditional |
| | Pulp price | $ |
| | Base price for canning | $ |
| | Tolerance for immaturity | % |
| | Tolerance for over maturity | % |
| | Tolerance for splitting of pits | % |
| | Tolerance for bruising | % |

## RESULTS AND DISCUSSION

Simulations for early and late peach varieties under Chilean conditions (January 15 and February 15, respectively), which intercept 70% of incident PAR, were performed, leaving the other inputs constant. The optimum crop value was considered the maximum crop value expressed in Chilean pesos per ha. The crop value was optimized when crop load was 90 and 100 fruits/$PAR_i m^2$ (Figure 4) and the average fruit size was 129.5 and 148.1 g (Figure 5) for early and late cultivars, respectively. The model clearly showed the differences between cultivars, in the sense of that early cultivars are more sensitive to excess crop load than late cultivars and require more intense thinning (Pavel and DeJong, 1993).

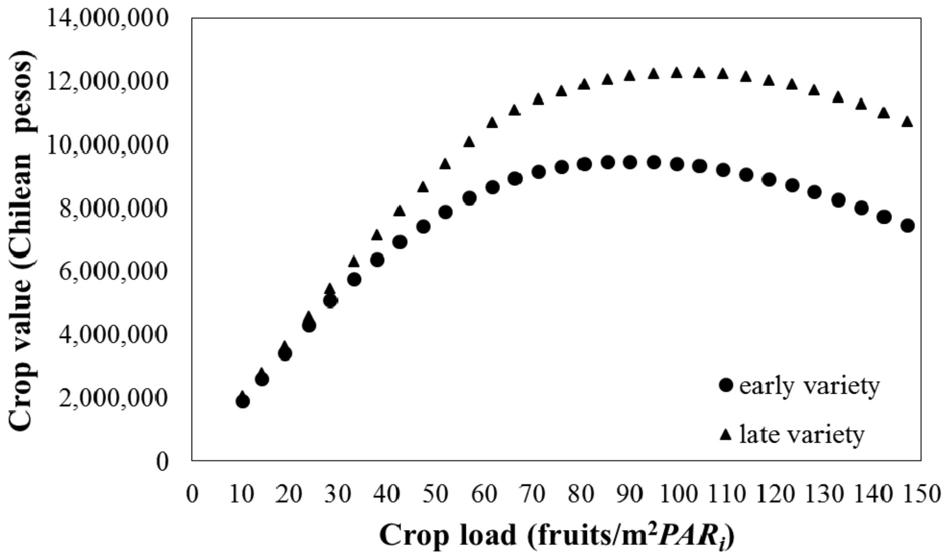


Figure 4. Model output for crop value as a function of crop load in early and late peach cultivars.

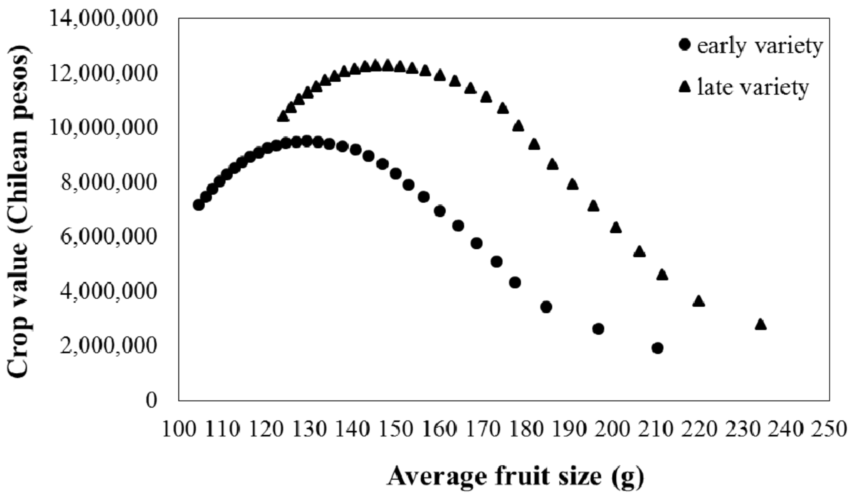


Figure 5. Model output for crop value as function of average fruit size in early and late peach cultivars.

Additionally, if the grower sorts the fruit in the field during harvest, to segregate canning and pulp fruit, as it is usually done in Chile, crop value is optimized when 25 or 13% of the yield is destined for pulp in early and late cultivars, respectively (Figure 6).

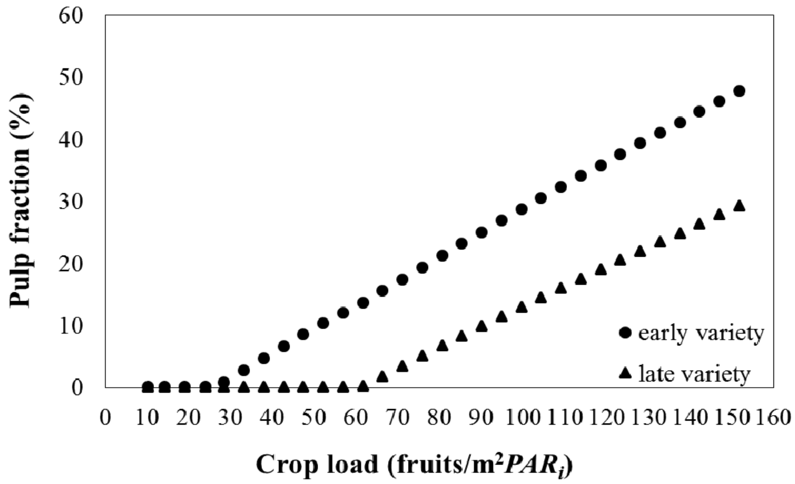


Figure 6. Model output for pulp fraction as function of crop load in early and late peach cultivars.

This model provides a generalization to optimize the orchard management of an average orchard. If additional orchard-specific inputs were used such as entering the tree size, the model would give greater precision for a particular situation (Johnson and Rasmussen, 1990; Reginato et al., 2007). Also, maturity can be specified as flesh firmness, which results in changes of yield and quality ultimately changing the price (Diezma-Iglesias et al., 2006).

Future modifications to the model that may be useful to adapt it to other situations, could be adding a climate component, specifically to consider the effect of growing degree hours for the first 30 days after bloom (GDH30) on fruit size (DeJong, 2006), or a canopy component, to consider interactions of crop load with shoot growth (Marini, 2003).

**CONCLUSIONS**

We have developed a dynamic model as an accessible tool to integrate orchard factors through mathematical relationships to predict optimum crop load by estimating maximum crop value. The ability to predict different scenarios early in the season increases the opportunity for adjusting the severity of fruit thinning in order to optimize the crop value. However, further research is required to improve and validate this approach before using it for orchard decisions.

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