Using Spring Weather Data to Predict Harvest Date for 'Improved French' Prune

C. DeBuse
Plant Sciences
University of California
Davis
USA

G. Lopez
Irrigation Technology
IRTA
Lleida
Spain

T. DeJong
Plant Sciences
University of California
Davis
USA

Keywords: decision support, fruit development, harvest prediction, *Prunus domestica*, temperature effects

Abstract

The Californian dried plum/prune (*Prunus domestica*) industry is almost entirely dependent on a single cultivar, 'Improved French'. Thus the entire crop must be harvested over a relatively narrow harvest period of about three weeks with the harvest times of individual orchards varying as a function of location within the state. The mean fruit maturity dates for the 'Improved French' can vary by as much as thirty days from year to year, with weather patterns seemingly becoming more variable annually. There is a need to be able to predict fruit maturity dates early in the growing season to facilitate planning for orderly harvest and fruit drying. Recent research with peach and nectarine (*Prunus persica*), and fresh-market plum (*Prunus salicina*) cultivars indicate that fruit maturity dates can be predicted reasonably well from full bloom dates and the accumulation of growing degree hours 30 days after full bloom (GDH 30) after the relationship between GDH 30 and the length of the fruit growth period between full bloom and GDH 30 is established from historical records. Thus bloom and fruit maturity data were analyzed for the 'Improved French' cultivar for several years from two locations in California, and there was a clear relationship between the length of the fruit growth period and GDH 30. This relationship has subsequently been used to establish an industry oriented "decision support" system that allows growers and dehydration plant managers to use publicly available weather data for their local area and bloom dates from individual orchards to predict fruit maturity dates after only 30 days after bloom.

INTRODUCTION

Early estimation of harvest date can help prune growers plan crop management practices efficiently and substantially aid the prune drying industry in planning for optimization of drying facilities and energy usage in the drying process; especially since the California prune industry is reliant on one cultivar 'Improved French' (*Prunus domestica*). Traditionally, the California prune growers have used bloom dates and fruit pressure measurements within one month of harvest to estimate harvest date. This procedure only enabled predicting harvest dates within a few weeks of harvest and there was no quantitative way to link annual variations in weather to predictions of harvest date. Ben Mimoun and DeJong (1999) and Marra et al. (2002) have shown that the number of days between full bloom and harvest for several peach, nectarine (*Prunus persica*) and fresh market plum (*Prunus salicina*) cultivars was related to growing degree hours accumulated during the first 30 days after full bloom (GDH 30); increased GDH 30 values were related to decreases in the number of days between full bloom and harvest. However, because commercial harvest dates for drying plums (prunes) are determined by a combination of fruit soluble solids content and fruit firmness (Miller, 1981) and fruit firmness is known to be influenced by temperatures during the few weeks prior to biological fruit maturity it was assumed that the commercial harvest date of prunes was primarily governed by temperatures in late summer and not by weather patterns during the spring.

However, in 2004 it was noticed that the harvest of California prunes was unusually early when the linear models established by Ben Mimoun and DeJong (1999) predicted early harvests of California peaches, nectarines and Japanese plums and record high temperatures were registered during and after full bloom (DeJong, 2005). Based on these experiences we began to investigate the relationship of growing degree hour accumulation during the thirty days after full bloom and the harvest date (GDH 30) of 'Improved French' prune.

MATERIALS AND METHODS

Data of full bloom date (FBD) and harvest date from 'Improved French' prune (*Prunus domestica*) were collected from trees of a prune breeding program located in two different centers in California: Kearney Research and Extension Center (Parlier, Fresno County) and Wolfskill Experimental Orchard (Winters, Yolo County). We monitored 10 and 9 trees in Parlier and Winters, respectively. FBD was considered to be the time when 90% of the flowers on a tree were estimated to be fully open. Fruits were harvested according to commercial fruit firmness. Data was collected from 1988–2005 and 2002–2005 in Parlier and Winters, respectively.

Growing degree hour accumulation during the thirty days after full bloom (GDH 30) was calculated using hourly air temperature data based on the GDH equation presented by Anderson et al. (1986) (growing degree hours between 7 and 35ºC). Hourly air temperature data were obtained for Parlier and Winters weather stations by using the California Irrigation Management Information System (CIMIS).

Relationships between GDH 30 and the number of days from FBD to harvest date were evaluated by regression analysis.

RESULTS

There were substantial differences in FBDs and harvest dates among years over the period for which data were collected. The variance among years was higher in the harvest dates than in the bloom dates (Table 1). In Parlier, the mean FBD from 1988 to 2005 was March 15 (S.D. = 4.5), while the mean harvest date was August 20 (S.D. = 7.3). In Winters, the mean FBD from 2002 to 2005 was March 18 (S.D. = 3.8) and the mean harvest date was 24 August (S.D. = 11.1).

The number of days from FBD to harvest date also varied from year to year (Fig. 1). Differences of about 30 days were observed between the earliest harvest years (145 days) and the latest harvest years (175 days) (Fig. 1). Although we only collected four years of FBD and harvest date in Winters, the patterns of harvest dates in Winters followed the same trend than that observed in Parlier (Fig. 1).

Independent of location, there was a significant negative correlation between GDH 30 and the number of days from FBD to harvest (Fig. 2).

DISCUSSION

In this study significant variations in prune harvest date were observed among years (Fig. 1). The observed variability was partially explained by the accumulation of growing degree hours 30 days after full bloom (GDH 30): almost 50% of the variance in harvest date could be explained from GDH 30 data (Fig. 2). Although factors other than spring air temperatures, such as weather near the time of harvest and local growing conditions, may explain some of the variance in the length of the fruit growth period from year to year, our results were consistent with the importance of temperatures shortly after bloom in determining the length of the fruit growth period for other *Prunus* species reported in previous studies (Ben Mimoun and DeJong, 1999; Marra et al., 2002; DeJong, 2005; Lopez et al., 2006, 2007).

When the relationship established in Figure 2 was used to predict harvest dates in 2006, the predicted harvest date was within five days of the actual harvest at both locations. In Parlier, the predicted harvest date using Figure 2 was September 10 and the actual harvest date was September 5. In Winters, we predicted that the date of harvest would be about September 4 and actual harvest date was August 30. Taking into account that the year 2006 registered very late harvest dates (compare with historic data in Table 1), the experience in 2006 increased our confidence that harvest date can be easily predicted by using full bloom data and spring air temperatures within 30 days after bloom.

Using the results from this study, harvest date prediction for 'Improved French' prune in California can be easily accomplished 30 days after bloom by the following procedures. First, prune growers need to record full bloom date. Second, one month after full bloom, they can visit the Fruit Nut Research and Information Center (FNRIC) web site (http://fruitsandnuts.ucdavis.edu). At that site they can select the 'Weather Services' module and proceed to the 'Harvest Prediction Module'. Once there they can select the California Irrigation Management Information System (CIMIS) weather station nearest to their orchard and enter the date of full bloom they recorded. The web tool will provide data on the accumulated GDH during the first 30 days after bloom (GDH 30) for the current year compared to the previous five years. Using the obtained GDH 30 data, fruit growers can use our model (Fig. 2) to estimate how many days they can expect to be between full bloom and harvest. They can then calculate predicted harvest date by adding that number to the full bloom date.

This simple decision support tool can increase California dried plum/prune grower ability to predict harvest dates based on currrent season weather conditions. This information is valuable for planning in-season horticultural operations such as fruit thinning as well as orderly harvest operations.

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Tables

Table 1. Recorded full bloom date (FBD) and harvest date for 'Improved French' prune for two different locations in California. Data was collected from 1988–2005 and 2002–2005 in Parlier and Winters, respectively.

Location	FBD			Harvest date		
	Earliest	Mean	Latest	Earliest	Mean	Latest
Parlier	9 March	15 March	24 March	8 August	20 August	1 September
Winters	14 March	18 March	23 March	9 August	24 August	2 September

Figures

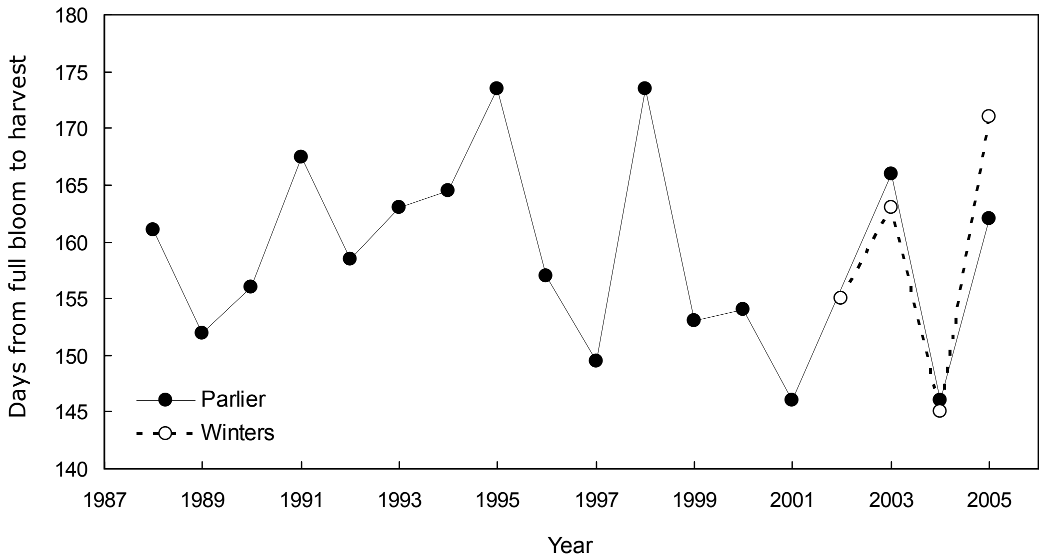

Fig. 1. Number of days from full bloom date to harvest date for 'Improved French' prune. Data was collected from 1988–2005 and 2002–2005 in Parlier and Winters, respectively.

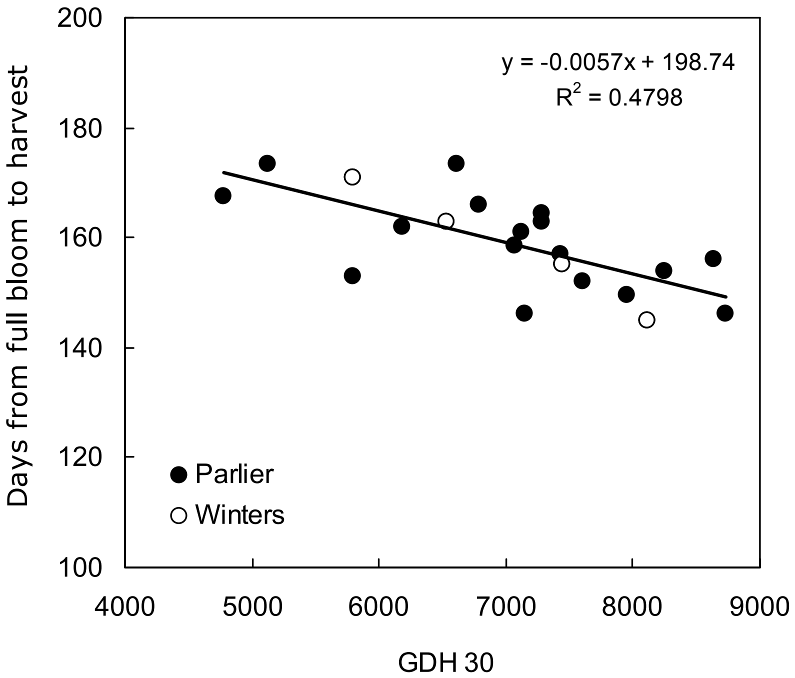

Fig. 2. Relationships between sum of growing degree hours 30 days after full bloom date (GDH 30) and number of days between full bloom date and harvest date for 'Improved French' prune. Data was collected from 1988-2005 and 2002-2005 in Parlier and Winters, respectively.