# Challenges to prune production in increasingly variable Californian weather conditions

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***Abstract***

**There are approximately 20,000 ha of bearing prune trees in California but the industry is heavily reliant on one cultivar (*Prunus domestica* 'Improved French'). While, prior to a decade ago, the central valleys of California presented almost ideal conditions for growing prunes (winters cool enough to provide ample chilling, minimal risk of frost and moderate temperatures during and after bloom in the spring, a long, warm summer growing season and ample water available for irrigation) in the recent decade prune growers have experienced increasingly volatile winter and spring weather patterns and several years in which yields have been limited by environmental stresses. Interestingly, while California has experienced a number of "low-chill" winters in recent years this has had little apparent effect on prune crop production. The most important weather-related limitation to prune yields has been excessive temperatures that occur during bloom. In the past decade there have been 4 years in which crops yields appear to have been significantly reduced because of unusually warm temperatures during bloom and because statewide production is dependent on one cultivar in some years most of the trees bloom at nearly the same time. A second important weather related issue affecting cropping is the accumulated heat-units during the first 30 days after bloom. High heat accumulation after bloom shortens the period between bloom and harvest and can lead to smaller fruit sizes. The UC Davis prune breeding program is attempting to address these issues by developing new cultivars that present a broader range of bloom and harvest timings, have higher tolerance to high spring temperatures, while increasing fruit size and quality. Details of weather-related problems experienced in California and progress toward achieving our breeding goals will be discussed.**

**Keywords:** *Prunus domestica*, spring temperatures, dried plums, climate change, excessive heat, fruit set

## INTRODUCTION

In most years California supplies the majority of the world market for prunes/dried plums. This prune production is almost exclusively dependent on a single cultivar, 'Improved French'. In recent years Californian prune production has become increasingly unstable with significant low crop years occurring in 2004, 2005, 2007, 2013 and 2014. It has been reported that substantial reductions in Californian dried plum yields are apparently linked with low fruit sets associated with high temperatures during bloom (De Ceault and Polito, 2010) and such was the case in four of the low crop years in the last decade. Analysis of ambient temperatures during bloom indicate that fruit set of the 'Improved French' cultivar can be severely limited if temperatures exceed 27°C for several hours during the 2-3 days of peak flowering (Figure 1). Such was especially the case for 2004, but it has become increasingly clear that low yields in specific locations appear to be correlated with the bloom-time temperatures at those locations. A second important weather related issue affecting cropping is the accumulated heat-units during the first 30 days after bloom. High heat accumulation after bloom shortens the period between bloom and harvest and can lead to smaller fruit sizes (Lopez and DeJong, 2007; Lopez et al., 2007; DeBuse et al., 2010). To

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address these issues the UC Davis Prune/Dried Plum Breeding Program is attempting to develop new prune cultivars that have a broader range of flowering times and/or tolerance to high temperatures during bloom.

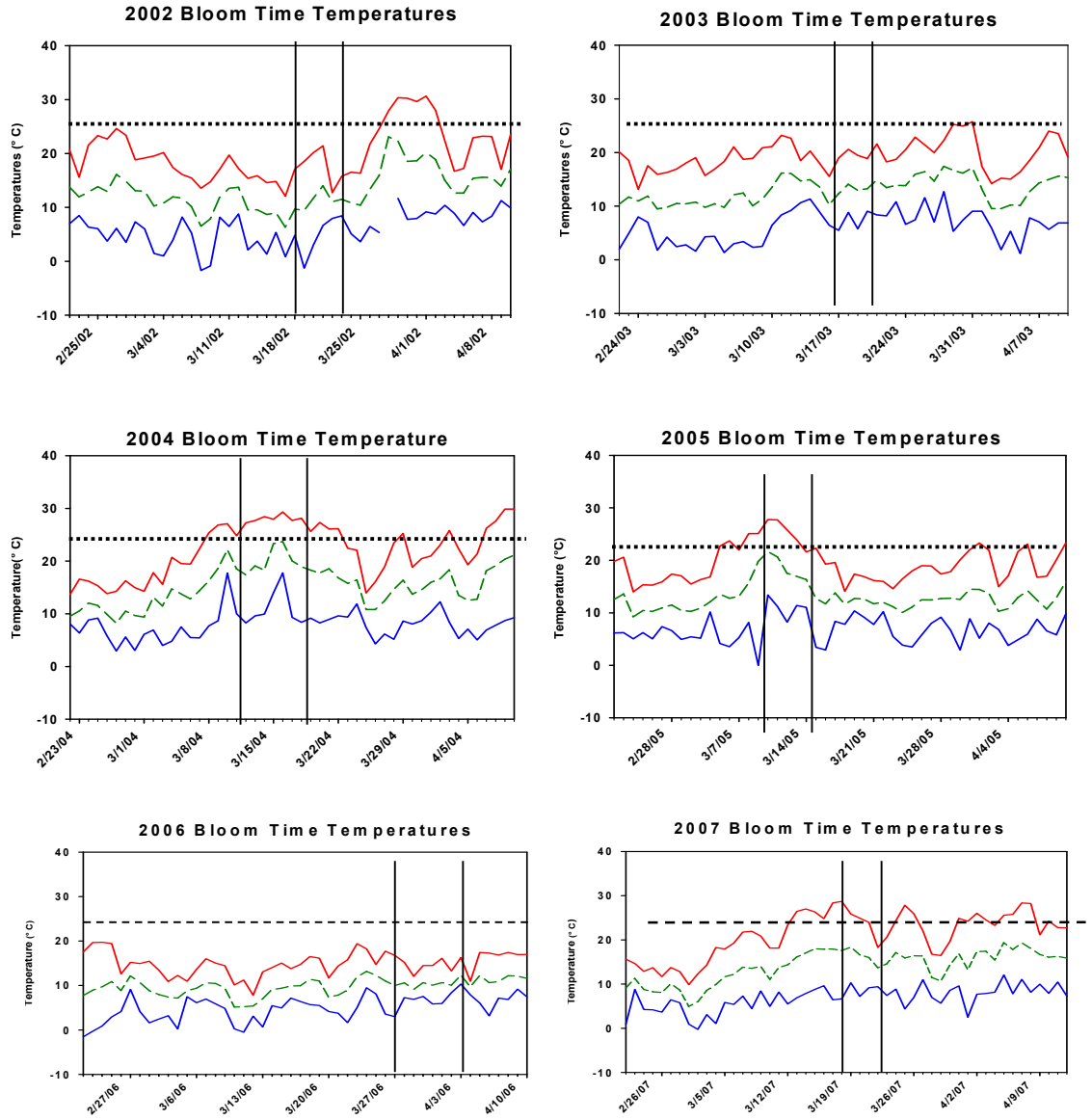


Figure 1. Maximum, minimum and mean air temperatures during bloom time in Yuba County for years 2003-2007. Vertical bars indicate peak bloom periods for 'Improved French' prune in that county. Statewide yields of dried prunes in California were 128,935, 152,712, 43,313, 84,753, 171,250, and 86,167 metric tons for years 2002, 2003, 2004, 2005, 2006 and 2007, respectively.

The California Dried Plum Board became aware of the risks of having an industry dependent on one cultivar and initiated funding for a breeding program at the University of California in 1985 with the goal of developing new cultivars for the Californian dried plum industry (Castro et al., 2013). The goal of this program was initially to create new cultivars that have processing characteristics similar to 'Improved French' with increased spread in bloom and harvest timing, and increased production and drying efficiency. Current target characteristics for increasing production and drying efficiencies are traits that reduce

pruning requirements and decrease fresh to dried fruit weight loss. However, increasing attention is being paid to the timing of bloom due to recent problems with fruit set in years with warm springs.

**MATERIALS AND METHODS**

The program uses traditional horticultural breeding practices by making controlled crosses among selected genotypes. Initially, cultivars from California, the eastern United States and Europe were used as germplasm for such crosses but more recently we use parent genotypes that are products of the last 25 years of breeding. These new parents have traits increasingly appropriate for the breeding goals. Parents are selected for their positive horticultural traits, their breeding history and their pedigree. Fruit characteristics such as small pit size, relatively freestone pits, fruit tolerance to heat stress, high sugar content and good flavor are standard positive traits in addition to bloom and harvest timing. Tendencies to produce fruit with large or split pits, side or end cracks and double fruits on a pedicle are standard negative traits. Over the first decades of the program we also selected for floral precocity to reduce time between successive generations. The breeding history of each potential parent is examined. Trees that produce progeny that have been selected for outstanding positive characteristics and a minimum of negative characteristics are selected to be parents and their progeny are expected to have a better likelihood of being a successful parent as well. Controlled hybrid crosses are made by emasculating flowers on maternal trees and hand pollinating with harvested pollen from paternal trees. Usually >20,000 flowers are emasculated and pollinated on several genotypes in a specific year. The seedlings produced from crosses are evaluated using the program's evolving objectives.

**RESULTS AND DISCUSSION**

The UC Davis Prune Breeding Program has developed a number of new prune selections with characteristics of interest to Californian prune growers such as a range of harvest dates, excellent fruit fresh/dry weight ratios, dried fruits sizes, small-medium pit sizes and excellent taste/flavor (Table 1). Growers are particularly interested in fruit fresh/dry weight ratios because they are paid on the basis of fruit weight after drying and are assessed fruit drying costs on the basis of this ratio. Optimal dried fruit sizes for marketing fruit in California range from 85-110 dried fruit $kg^{-1}$ and many of the new selections fall within this range. The taste/flavor ratings are based on dried fruit comparisons with the 'Improved French' which is arbitrarily given a value of three. Thus, all but one of the selections in Table 1 have been rated as tasting better than the current industry standard. Significant progress has been made in identifying potential new cultivars with a range of flowering dates (Table 2). However, there is no indication that any of these selections are less susceptible to high temperatures at bloom and thus the objective of having increased tolerance to high spring temperatures is more elusive and will likely require more in-depth physiological studies. However, if the Californian industry decides to plant some of these new selections it is likely that the industry would be less susceptible to industry-wide crop failures because, in most years, some of the prune cultivars would escape fruit set problems due to high heat at bloom since high temperatures at bloom usually occur sporadically for only one or two days, even in years when they are thought to have caused low fruit crops (Figure 1).

In addition, 'Improved French' prune is known to have self-compatible pollen and thus almost all commercial prune plantings consist of a single cultivar (Doyle et al., 2012), making them extreme examples of a mono-cultural system. In recent years some anecdotal evidence indicates that, in rare cases when 'Improved French' trees are planted adjacent to cultivars that bloom earlier, the rows of 'Improved French' trees closest to the early blooming cultivar have heavier crop loads. This may lead to some rethinking of current practices of planting 'Improved French' trees in solid blocks. Planting genotypes with earlier but overlapping bloom, as shown in Table 2, may increase yields in prune orchards, especially in years with questionable whether during bloom. This concept still needs to be tested under Californian conditions.

Table 1. The characteristics of dried fruit of the top 2014 prune selections in the UC Davis Prune breeding program in December 2014.

| Item ID | Harvest date | Fresh/dry weight ratio | Dry count $kg^{-1}$ | Dried skin color | Dried pit size | Skin quality | Average taste eval. |
|---|---|---|---|---|---|---|---|
| G36N- 65 | 8/1/14 | 2.6 | 110.7 | Dark brown | Small | Good | 3.7 |
| G41N- 27 | 8/4/14 | 2.4 | 88.6 | Dark brown | Small | Good | 3.3 |
| G37S- 72 | 8/4/14 | 2.6 | 101.2 | Dark brown | Medium | Excellent | 2.8 |
| G41N- 14 | 8/11/14 | 2.6 | 64.1 | Black | Medium | Excellent | 3.8 |
| H17N- 88 | 8/12/14 | 2.8 | 81.8 | Dark brown | Small | Excellent | 3.8 |
| H19S- 47 | 8/15/14 | 2.9 | 81.6 | Dark brown | Small | Good | 4.0 |
| H16S-70 | 8/20/14 | 2.5 | 105.8 | Mahogany | Small | Good | 4.0 |
| G16N- 19 | 8/21/14 | 2.8 | 75.6 | Brown | Small | Excellent | 3.8 |
| G2S- 8 | 8/25/14 | 2.8 | 79.6 | Mahogany | Small | Excellent | 4.5 |
| H7N- 71 | 8/25/14 | 3.0 | 90.6 | Brown | Medium | Good | 3.3 |
| H10N- 38 | 8/29/14 | 2.7 | 84.9 | Dark brown | Medium | Good | 3.3 |
| E7S- 83 | 9/8/14 | 2.9 | 93.5 | Dark brown | Small | Good | 3.0 |

Table 2. 2013 bloom data for eight selections and two cultivars ('Tulare Giant' and 'Improved French') in the UC Davis Dried Prune Breeding Program.

| Cultivar | Full bloom date (90%) | Days in bloom 2013 | Days from French Imp. 2013 | Average days from French Imp. |
|---|---|---|---|---|
| G33N- 27 | 10-Mar | 9 | -12 | -13 |
| G43N- 1 | 15-Mar | 6 | -7 | -8 |
| G39N- 57 | 15-Mar | 10 | -7 | -9 |
| Tulare Giant | 16-Mar | 7 | -6 | -8 |
| G39N- 34 | 16-Mar | 8 | -6 | -8 |
| F11S-38 | 16-Mar | 9 | -6 | -9 |
| G31N- 27 | 17-Mar | 13 | -5 | -6 |
| G16N-19 | 17-Mar | 5 | -5 | -4 |
| G5N- 35 | 21-Mar | 9 | -1 | -1 |
| Imp. French | 22-Mar | 8 | -- | |

Note all items bloom earlier than 'Improved French'.

## Literature cited


Castro, S., DeBuse, C.J., and DeJong, T.M. (2013). The University of California *Prunus domestica* cultivar development program. Acta Hortic. *985*, 77–82 http://dx.doi.org/10.17660/ActaHortic.2013.985.9.

DeBuse, C., Lopez, G., and DeJong, T. (2010). Using spring weather data to predict harvest date for 'Improved French' prune. Acta Hortic. *874*, 107–112 http://dx.doi.org/10.17660/ActaHortic.2010.874.13.

DeCeault, M.T., and Polito, V.S. (2010). High temperatures during bloom can inhibit pollen germination and tube growth, and adversely affect fruit set in the *Prunus domestica* cultivars 'Improved French' and 'Muir Beauty'. Acta Hortic. *874*, 163–168 http://dx.doi.org/10.17660/ActaHortic.2010.874.22.

Doyle, J.F., DeBuse, C.J., and DeJong, T.M. (2012). Varieties. Prune Production Manual. Publication 3507 (University of California, Division of Agriculture and Natural Resources), p.75–92.

Lopez, G., and DeJong, T.M. (2007). Spring temperatures have a major effect on early stages of peach fruit growth. J. Hortic. Sci. Biotechnol. *82* (*4*), 507–512 http://dx.doi.org/10.1080/14620316.2007.11512266.

Lopez, G., Johnson, R.S., and DeJong, T.M. (2007). High spring temperatures decrease peach fruit size. Calif. Agric. *61* (*1*), 31–34 http://dx.doi.org/10.3733/ca.v061n01p31.