



**Chill requirement for pistachio.** Studies conducted by UC scientists determined that ‘Peters’ males have a higher chilling requirement than their ‘Kerman’ female counterpart. ‘Peters’ males require at least 900 hours below 45°C to achieve 50% bloom. The ‘Kerman’ female requires 700 hours below 45°C to achieve 44% bloom (Ferguson et. al., 2002). The chilling requirements for new varieties such as ‘Golden Hills’ and ‘Lost Hills’ have yet to be assessed. A rough conversion of 900 chill hours converts to approximately 69 chill portions in CA’s Central Valley (Pope et al, 2015). Katherine Pope, UCCE Farm Advisor and colleagues recently published a paper elucidating that historic pistachio yields did not fall below average until chill portions dropped below 57 (Pope et al, 2015). This work suggests a disparity between the amount of chill required for budbreak and attainment of yield thresholds.

**What happens when the chilling requirement is not met?** During the winter of 1977-1978, in the infancy of the California pistachio industry, growers experienced firsthand the effects of a low chill winter on the crop. That winter, only 670 hours of chill were recorded in Davis, as compared to the long-term average of 1,445 hours (Crane and Takeda, 1978). Low chill accumulation results in delayed and irregular bloom, late vegetative development, altered leaf morphology, poor pollen production, death of stigma, reduced fruit set, increased proportion of blanks and unsplit nuts, late maturation, and general reduction in yield (Crane and Takeda, 1978). The 2015 crop was similarly affected by low chilling hour accumulation over the 2014/2015 winter.

**How does the winter of 2015-2016 compare with that of 2014-2015?** Using the chilling hours calculator on the UC Fruit and Nut Research and Information Center (FNRIC) website, [www.fruitandnuts.ucdavis.edu](http://www.fruitandnuts.ucdavis.edu), it is possible to look up the cumulative chilling hours for both the current year as well as historical data. More chilling hours were accumulated during the 2015-2016 winter than during the winter of 2014-2015, which fell short of sufficient chill for pistachio (Figure 1). If we use 900 hours as a ‘benchmark’ amount of desired chill for CA pistachios, and specifically for ‘Peters,’ then most pistachio-growing regions attained enough chill during the 2015/2016 winter (Figure 1). Davis, CA and Coalinga, CA, however, both fell short of sufficient chill for pistachio this winter, at 796 and 878 chilling hours, respectively. Let’s look at a couple of sites to best conceptualize the difference in chill hour accumulation between the 2014/2015 and 2015/2016 winters. In Arvin, the 2014/2015 winter was characterized by 535 chilling hours; the same site accumulated 904 chilling hours in 2015/2016. In Delano, 983 and 1307 chilling hours accumulated 2014/2015 and 2015/2016, respectively. To summarize, although the past winter felt warm, there were generally sufficient chilling hours below 45°C to fulfill the chilling requirement for pistachio.

**Chill Models:** Chilling Hour Model is a summation of the hours below 45°F. A modified model accounts only for chilling hours accumulated between 32°F and 45°F; these are called ‘Modified Chill Hours’. Another model, The Utah Model, was designed in the 1970s to accommodate for the fact that warm temperatures may have a negative effect on chill accumulation; the Utah Model represents chill in ‘Chill Units’ (Table1). The Dynamic Model is a newer model

developed in the 1980s, that defined a new concept for the process by which warm temperatures negate chill. The Dynamic Model is represented by ‘Chill Portions.’ The Chilling Hour and Utah Models have historically been utilized to study the chill requirements of pistachio; however, Zhang and Taylor (2011) recently found the Dynamic Model best for determining fulfillment of chilling requirements on ‘Sirora’ pistachio in Australia.

<b>Table 1. The Utah Model, a weighted Chilling Hour Model</b>	
<b>Temperature Range</b>	<b>Units Accumulated or Deducted</b>
<34°F	0 units
35-36°F	0.5 units
37-48°F	1.0 unit
49-54°F	0.5 units
55-60°F	0 units
61-65°F	-0.5 units
>65°F	-1.0 units

**Limitations of Chill Models.** The various chill models used by physiologists are not laws of nature, but statistical models used to represent plant response to a chill-related variable. In short, each model simply calculates the chill-related variable slightly differently. The model achieving the “best fit” may vary from year to year simply because no two years have identical temperature fluctuation profiles from November through February. Second, chill accumulation data is generally derived from CIMIS (California Irrigation Management Information System) stations. CIMIS station-derived data may have gaps due to station malfunction (ie. vandalism). Because the purpose of CIMIS stations is to provide data for irrigation management, maintenance may be delayed in the winter months when the stations are not utilized for their intended purpose. Last, CIMIS stations capture data in specific locations, and data does not capture the variance of chill accumulation over regions or in microclimates.



Figure 2. Male pistachio flower (Photo: G. Brar).

**What to expect during bloom.** ‘Kerman’ represents approximately 90% of the current bearing California pistachio acreage with an estimated bloom time for the first week in April in NW Kern Co (Kallsen, et al. 2009). Two new female cultivars developed and released by University of California, ‘Golden Hills’ and ‘Lost Hills,’ precede ‘Kerman’ bloom by 5-7 and 4-7 days, respectively (Kallsen, et al. 2009). In seasons or

locations with low chilling hour accumulation, flowering may be more uniform for ‘Lost Hills’ and ‘Golden Hills’ than ‘Kerman.’ The male pollinator ‘Randy’ flowers 1-3 weeks earlier than ‘Peters,’ but has a long

bloom period, similar to ‘Peters.’ ‘Randy’ may be of benefit as a pollinizer for ‘Kerman’ in low chill seasons, but generally blooms too early to pollinate ‘Kerman’ and is more suited to ‘Golden Hills’ and ‘Lost Hills.’

**Pollination.** Pistachio is a dioecious, wind-pollinated crop; neither the male (Figure 2) nor female (Figure 3) flowers have petals or nectaries. For ideal pollination, the male pollinizer should be at peak bloom during the first 2-3 days of female bloom. The earliest pollinated flowers result in higher nut set (ie. nuts per cluster) than later pollinated flowers (Crane and Iwakiri, 1982). Supplemental, topical application of pollen has not been found effective in enhancing nut set in the ‘Kerman’/‘Peters’ system (Crane and Iwakiri, 1985, Sibbett and Weinberger, 1994). To date there is no published data on the potential benefit of supplemental pollination of other varieties (ie. ‘Golden Hills’ or ‘Lost Hills’), or the potential benefit of supplemental pollination during low chill seasons where male and female bloom may not be temporally compatible.



Figure 3. Female pistachio flower (Photo: G. Brar).

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### Select References

- Crane, J.C. and Iwakiri, B.T. 1982. Effect of time of pollination on nut production in ‘Kerman’ pistachio. California Pistachio Research Reports.
- Crane, J.C., and Iwakiri, B.T. 1985. Is artificial pollination advisable in pistachio production? California Pistachio Research Reports.
- Crane, J.C., Takeda, F. 1978. Response of the pistachio to the mild winter of 1977-1978. California Pistachio Research Reports.
- Ferguson, L., Driever, G., Hadj-Hassan, A., Michailides, T. 2002. Chill requirements of pistachios. California Pistachio Research Reports.
- Kallsen, C.E., Parfitt, D.E., Maranto, J., Holtz, B.A. 2009. New pistachio varieties show promise for California cultivation. California Agriculture 63:18-23.
- Pope, K.S., Dose, V., DaSilva, D., Brown, P.H., DeJong, T.M. 2015. Nut crop yield records show that budbreak-based chilling requirements may not reflect yield decline chill thresholds. International Journal of Biometeorology 59:707-715.

Rahemi, M., Pakkish, Z. 2009. Determination of chilling and heat requirements of pistachio (*Pistacia vera* L.) cultivars. *Agricultural Sciences in China*. 8(7): 803-807.

Sibbett, G.S. and Weinberger, G. 1994. Effect of topically applied supplemental pollen of sound and blank Kerman pistachio nuts. *California Pistachio Industry Annual Report Crop Year*. P. 81-82.

Sibbett, G.S., G. Weinberger. 1994. Effect of Topically Applied, Supplemental Pollen on Sound and Blank Kerman Pistachio Nuts. *California Pistachio Industry Annual Report Crop Year*. p. 81-82.

Zhang, J., Taylor, C. 2011. The Dynamic Model provides the best description of the chill process