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Rational Early Season Drought Planning for Almond Growers

by Dave Goldhamer, Ph.D., Extension Water Management Specialist, UC Davis and Brent Holtz, Ph.D., Farm Advisor Madera County

Regulated deficit irrigation research on almond was funded by the Almond Board of California from the late 1980s to the mid 1990s. Additional deficit irrigation field studies continued with other public and private funding after the 1990s. We have heard growers speculate on practices they should implement in their almond orchards based on the projected lack of irrigation water deliveries from the Westlands Irrigation District.

Some growers are considering taking out old orchards and other drastic measures such as "dehorning" (stumping), severe pruning, and even early season crop removal; all designed to help trees that receive little or no irrigation water to survive. We view this as very short sighted and offer the following explanation:

1) Additional rain/snow this winter/early Spring may result in additional water deliveries,

2) Almond orchard water use (ETc), even in mature trees, will use only 1 to 2 inches of water through the end of March due to the fact that the evaporative demand (ETo) and the crop coefficient (Kc) are both very low early in the season. Thus, little water is being saved by eliminating the orchard now,

3) While we've found that stumping can reduce or eliminate tree stress by reducing ETc, it also eliminates yields for at least two seasons. Moreover, if such a drastic step is contemplated, the grower should carefully consider whether all trees need to be stumped or can only a certain percentage be stumped, leaving others intact to produce some yield,

4) Work by Scott Johnson with his peach lysimeter, a device that takes extremely accurate water use measurements, showed that crop removal has little, if any, impact on tree water use. On the other hand, research on apples, using less accurate methods than a lysimeter, showed that crop removal can reduce ETc by up to 30%. There is no work worldwide we know of on almond ETc response to crop load. However, since peach and almond are both Prunus species, we believe that almond more closely mirrors peach and we, and our Spanish colleagues, believe that crop removal can only reduce almond ETc by no more than 10%,

5) Our recent work showed that the almond yield does not decline at a one-to-one rate with reduced irrigation, as is the case with most field and row crops. It declines slower, allowing growers to still

achieve reasonable yields with reduced water supplies,

6) Thus, there is little to be gained and a lot to be lost by pushing out trees early, trying to remove crop, or stumping your trees.

We believe that a mature almond orchard needs to use between 6 - 8 inches of water to survive. This does not mean 6-8 inches of irrigation. Stored winter rainfall and/or carryover of soil water from the 2008 season can supply a lot of this 6-8 inch requirement. However, one key in facilitating tree survival, and maximizing sustained productivity, is to stretch this water use over as much of the season as possible. For example, we did an experiment where we applied about 16 inches of water, all early in the season, with irrigation ending in mid June. We killed a few of the more drought sensitive trees (Carmel) with this approach. On the other hand, Tim Smith simulated a one year drought on West Side trees where he applied 16 inches of water in various regimes, followed by a return to full irrigation for the next two years. He got the maximum sustained yields by stretching the 16 inch water application through the end of August and worst sustained yield when the water was applied early.

Almond trees have very poor stomatal control of their internal water balance; their primary approach to water deficits is to begin to defoliate. Partial defoliation is not necessarily a bad thing and can actually be used to guide drought irrigation strategies. The key for growers to optimally handle a drought is irrigation timing, especially in June-August when evaporative demand is at its highest point of the season. Growers should become intimately acquainted with their trees leaf stem water potentials (SWP), through the use of pressure chambers (www.pmsinstrument.com), in order to critically follow orchard stress and make the best drought irrigation management decisions.

We will cover the entire spectrum of drought irrigation planning and management in the "Drought Irrigation Management for Almond" meeting scheduled for Tuesday, March 31, 2009, 7:30 AM-12:30 PM, Panoche Creek Packing, 1221 South Madera Avenue, Kerman CA (see attached flyer).

Information at this meeting will include:

- Water requirements of almond trees
- Physiological responses of almond trees to deficit irrigation
- Yield and yield component responses to deficit irrigation
- How to predict yield reductions to reduced water supply
- The importance of timing drought irrigation correctly
- When are stumping or severe pruning viable strategies?
- Are antitranspirants useful with almond trees?
- How to develop a drought irrigation regime for your particular orchard

SEVERE DROUGHT MANAGEMENT RECOMMENDATIONS FOR ALMOND

By: David Doll, Farm Advisor UCCE Merced County

UC researchers have urged growers not to take aggressive actions in reducing tree size or crop load. Severe pruning (de-horning) will increase new growth which would increase the leaf surface and evapo-transpiration rates (ET) of the tree. Crop thinning does a similar thing and is also not recommended. By reducing crop load, the source/sink ratio of the tree is disturbed, causing the tree to put nutrients into vegetative growth instead of the nuts. Furthermore, data suggests that less than 10% of ET may be attributed to crop load. The tree should thin naturally when it undergoes a late-spring water stress period. In season nitrogen applications should also be reduced in order to reduce vigorous shoot growth.

In scheduling irrigation, the pressure chamber should be used to determine the stem water potential of the trees. Orchard irrigations should not be initiated until the trees reach -15 bars. Irrigations should be at the percentage of ET that can be afforded - for example: if 15% of water available for the season, water at 15% ET at each irrigation. Research by David Goldhamer suggests that almond trees can survive through the year on as little as 6-8 inches of water (5- 10% ET). This includes the 2-4 inches of water available within the soil profile.

Further reduction of inputs this coming year is advised for the West side growers facing water restrictions. Reductions of in-season fertilizers and foliar nutrients will help decrease the vigor of the tree. Use judgment in making these cutbacks as the goal is to reduce tree vigor, not to make the trees deficient. Post harvest fertilizer applications are still recommended. Furthermore, it is not advised to cut back on miticides. With severely stressed trees, mites can flare up easily, causing defoliation and adding to tree stress. If the orchard has a history of pyrethroid use, miticides will most likely be necessary for the coming growing season. If softer chemistries have been used, sprays may be limited or unnecessary. In these cases, monitoring the population of mites and beneficials will be needed throughout the season to see if they approach the treatment threshold.

A light pruning or topping, may be a feasible practice to stop new shoot growth in the spring. Once the trees push new growth, heading cuts would terminate shoot growth, thus reducing leaf surface area. This may work if nitrogen rates were reduced - otherwise the tree would push again causing more tree stress. There is no direct data that supports this practice, and it may not be worth the effort or expense.

In general, if the tree is able to maintain some of its leaves until the fall, the tree probably will survive. Yields will be affected severely for the next 2-3 years. This year would be a good year to remove older blocks with declining production and divert the water to younger blocks if possible.

Irrigation Management of Almond Trees with a Limited Water Supply

From the UC Drought Management Website (http://ucmanageddrought.ucdavis.edu/almonds.cfm)

For maximum growth, yield, crop quality and orchard longevity almonds trees should be supplied with water to meet their full water requirement. There are some disease concerns with hull rot under full water conditions which can be addressed with moderate water stress during hull split. If water availability is limited, growers can react by applying irrigation water when trees are most sensitive to stress and by taking measures to minimize water losses that occur during irrigation events. Supplying less water than the trees can potentially use reduces soil water availability, causes tree water deficits, and reduces transpiration. Cover crops, depending on the coverage and the time of the season in which they are grown can increase the orchard water use by up to 30%. Cover crops should be removed when water is in limited supply.

Water deficits affect almond orchards not only in the year in which stress occurs, but also in the following seasons. Generally, nut size is reduced in the first season of significant water stress. Because water stress also reduces vegetative growth and potentially decreases productivity per unit canopy volume, nut load can be reduced in subsequent years. Recent research indicates some stages of almond fruit growth are more sensitive to water stress than others. Understanding these stages permits growers to withhold water while minimizing damage to trees and to current and subsequent crops.

Early season stress. Water stress affects more tree and crop development processes during the early season - from leaf out through shoot growth and development of terminal and lateral buds. During this period, rapid vegetative development is necessary for canopy development and fruiting positions for the following season. In addition, orchard water use during this time is low compared to summer demand, reducing potential water savings from an early-season deficit irrigation strategy.

Fruit growth and development. Nuts undergo a rapid growth phase early in the fruit growth and development period and are sensitive to water deficits during this time. However, trees can tolerate drought stress fairly well during the two months prior to harvest, allowing for the successful use of deficit irrigation strategies during this period. Providing less than the full water requirement to cause moderate water stress during this period, will have little influence on kernel weight. However, severe water stress in the months leading up to hull split will reduce kernel

weight and significantly reduce hull spliting. A one-inch irrigation prior to hull split will mitigate the water stress impacts and will improve hull split and reduce the
number of hull-tights. If drip irrigation is used, possibly less irrigation can provide the same benefit, but this has not been proven in the field.

Post harvest stress. The effect of water deficits during the postharvest period are substantially affected by 1) pre harvest water deficits and 2) the quantity of water use over the remainder of the season. Bud differentiation can continue through mid-September. Moderate stress during this period will have little effect on subsequent year's nut numbers, but severe stress during bud differentiation has been found to dramatically reduce fruit set the following spring. In early harvest (early August) districts, particularly with early varieties, more of the high water use season remains after harvest. This increases the necessity for postharvest irrigation. Later harvest (north State) districts and later varieties have a slightly shorter postharvest period which occurs at a time of lower crop water demand. These factors reduce the chance of moderate water deficits causing bud differentiation problems.

Tree response to postharvest stress can be influenced by the type of irrigation system used, and the previous irrigation management. Low volume systems with limited soil water reserves can result in severe water deficits very quickly after irrigation cut off. In the southern San Joaquin Valley where harvest is earlier than in the north, or with drought-sensitive varieties, postharvest irrigation is a necessity. Deep rooted, surface irrigated trees may have enough pre-harvest deep moisture remaining to carry them through the critical period of bud differentiation. This all depends on the irrigation management occurring pre-harvest.

Developing a Deficit Irrigation Strategy

Crop Water Use. Almond water use begins when the leaves develop and shoot growth begins. Concurrent with canopy development, the climatic demand increases, driven by longer days and higher temperatures and low humidity as the season progresses. Both of these factors result in a seasonal water use starting at a low level, peaking in mid-season and falling as season ends. Sources of water available to trees include: soil-stored moisture (including frost protection water applications if the root zone is less than field capacity when applications are made), any in-season rainfall absorbed by the soil, and applied irrigation water. These all combine to determine the total seasonal water available to the orchard.

Mature conventionally spaced almond trees in the Southern Sacramento Valley can use about 41- 44 inches of water in an average year of unrestricted water use. High-density orchards, long pruned orchards, or those with a cover crop can have even higher use. Soil moisture monitoring demonstrations in more than 40 almond orchards in Kern County indicate that seasonal water use in the southern San Joaquin Valley may be as high as 50 - 54 inches. Figure 1 shows a typical water use pattern for fully irrigated and a deficit irrigation regime for almond in the Manteca area. The moderately deficit irrigated orchard used (in a combination of soil supplied and irrigation water) 28 inches of water or about 34 % less than the full potential orchard.

Water Deficits. Water deficits occur when the climatic water demand exceeds the water absorbed by the roots. As the soil becomes depleted of readily available moisture, water uptake by the roots lags behind water use causing plant stress in the mid to late afternoon. This minor crop water deficit has little effect on the crop yield. However, as soil water becomes increasingly difficult to extract water stress increases. One way to measure "tree stress" is to use a portable pressure chamber to measure "midday stem water potential". To use this technique a few leaves from representative trees are first covered with an opaque plastic bag while still on the tree. The covers need to remain on the leaves at least 10 minutes after which they are detached and the water potential measured using the pressure chamber. The pressure chamber measures the amount of pressure needed to force water out of the leaf petiole, indicating trees water status.

A Moderate Water Stress Strategy. From the previous discussion it can be concluded

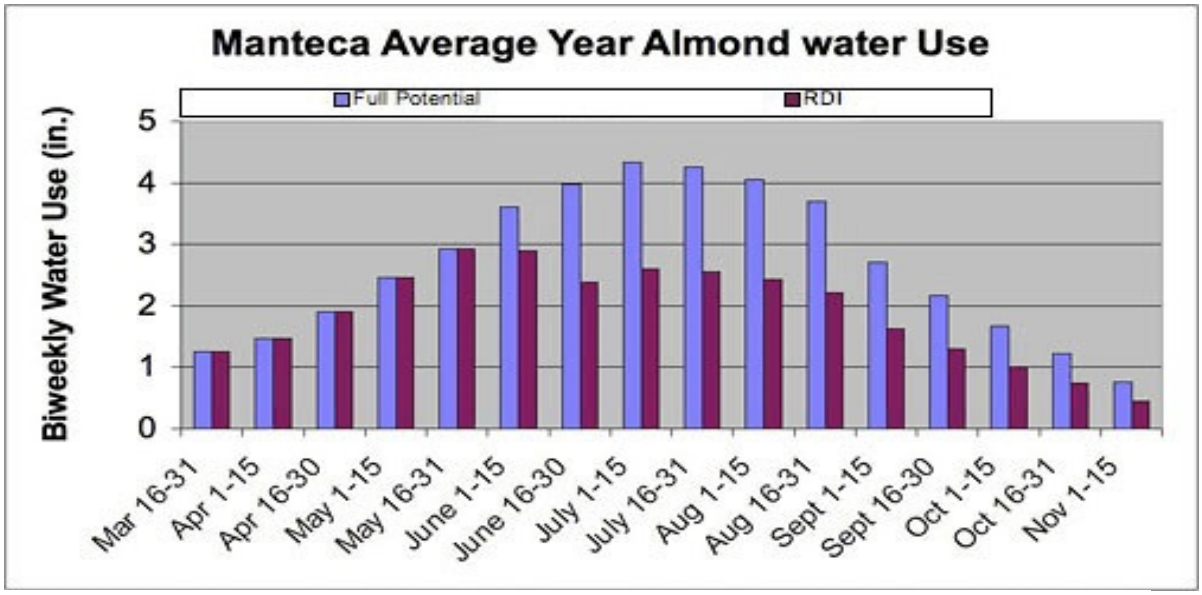
that tree water use from leaf out through mid June should not be compromised. From mid June through harvest, reductions up to 50% of full water use have been successfully used to reduce orchard water use with only minimal reductions in kernel weight. It is important to supply the trees with water near hull split to avoid hull-tights.

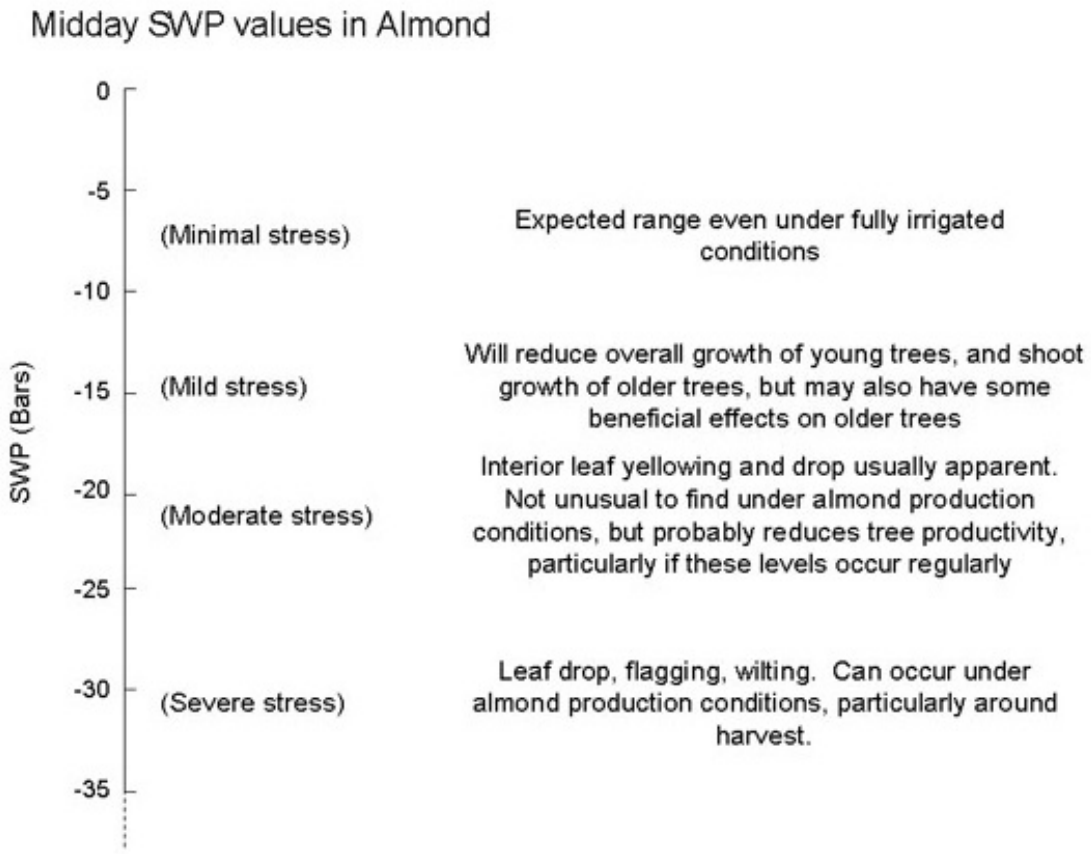
There are various approaches growers can take to manage limited water supplies depending on what types of irrigations scheduling tools interest or are available to them. A simple method is to reduce irrigation run time or lengthen irrigation intervals to obtain the desired percentage of irrigation reduction in applied water. In a four-year study investigating pre-harvest, post-harvest, and uniform deficit irrigation for the entire season, the best results were achieved when water applications occurred at a uniform deficit rate across the season relative to full potential crop ET. The uniform deficit rate does not mean a uniform irrigation amount across the season (e.g. 1.5 inches each week), but rather a uniform (e.g. 85%) reduction of full ET for each period. Deficit irrigation rates of 55%, 70%, and 85% were tested with the 70% and 85% irrigation reduction treatments showing little yield loss compared to the full ET treatment. The 70% and 85% uniform across the season deficit treatments experienced little early season stress, likely because stored soil moisture supplemented the applied irrigations. Another approach that is likely an improvement over the approach outlined above is to schedule irrigations using periodic pressure chamber readings and irrigate when midday stem water potential reaches a pre-determined threshold stress level (see Figure below). This method effectively extends the irrigation interval, but the interval is determined by tree water status rather than the calendar. Irrigations should be in the volume of a normal set as performed with a full irrigation regime. In a deficit irrigation study conducted on mature almond in the Manteca, CA a just prior to irrigation threshold value of -20 to -22 bars midday stem water potential beginning in June resulted in 34% less tree water consumption and no significant influence on yield for the 4-year measurement period. It should be noted that a reduction in vegetative growth was measured in this treatment, indicating that use of this threshold for a longer-term strategy (more than 4 years) may reduce yields by reducing nut numbers. The impacts of stress on a developing tree canopy is much more detrimental as opposed to the impacts on a canopy that has already reached its full volume.

A More Severe Water Stress Strategy. A more severe strategy that reduces seasonal tree water use by 50% requires that stress be imposed early as well as mid to late season. Using this strategy, irrigations in April and May are withheld until trees reach a midday stem water potential of -12 to -14 bars. Using conventional sprinklers, a normal set time is used. If lighter applications are made, more water is lost by evaporation. From June 1st through hull split, midday stem water potential values should be allowed to reach -20 to -22 bars just prior to irrigation. This strategy will require a pre-harvest irrigation of about 2 inches with sprinklers-less with micros and drip--to ensure good hull split. Note: this strategy reduces water use significantly but also reduces nut weight the year it is used and the nut number in succeeding years. In the Manteca trial discussed above, it took 2 years of full irrigation for trees to recover.

A "Staying Alive" Drought Strategy. Less is known about this strategy since it is a rarely used option. However, based on past drought conditions, trees may be kept alive with about a foot of applied water. This strategy does not consider growth and yield-just tree survival. This strategy is best conducted using a micro-irrigation system which maximizes water distribution and minimizes evaporative losses from irrigation. Using this strategy no irrigation is applied until water potential reaches -16 bars from leaf out through the end of May. Monitor stem water potential until the threshold is reached again then repeat the cycle. After June 1st, and for the rest of the season allow the stress to climb to -25 bars prior to irrigation. As a guide, try to just retain the leaves on the tree. Good luck, as this is only a guide. Remember that following this severe deficit strategy, it will take at least 2 years of full irrigation for the trees to recover to normal yields.

Figure 1: Seasonal water use for an almond orchard in Manteca, CA.





Drought Irrigation Management for Almond

Tuesday, March 31, 2009, 7:30 AM-12:30 PM

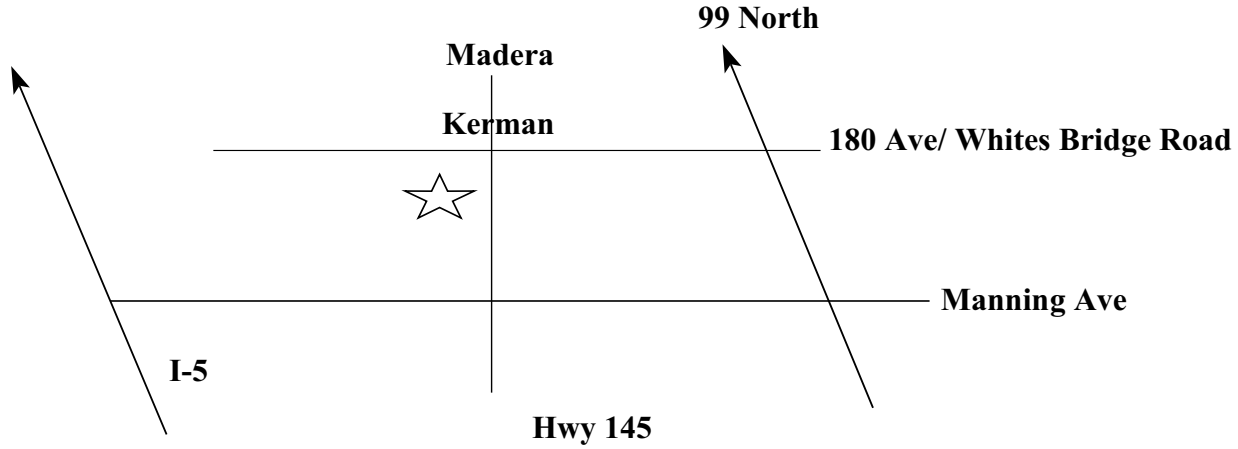
Panoche Creek Packing

1221 South Madera Avenue, Kerman CA 93630

7:30 a.m.	**Sign up and refreshments, moderators and meeting organizers** ***Brent Holtz, David Doll, and Bob Beede, UCCE Farm Advisors***
8:00 a.m.	**Fine tuning your micro-irrigation system** ***Dr. Larry Schwankl, Irrigation Specialist, UC Davis***
8:30 a.m.	**Water relations, water requirements, and irrigation scheduling** ***Dr. David Goldhamer, Irrigation Specialist, UC Davis***
9:15 a.m.	**Drought strategies: how to best manage a limited water supply and impact on current and future production** ***Dr. David Goldhamer, Irrigation Specialist, UC Davis***
10:00 a.m.	**Irrigation questions and discussion with Dr. Goldhamer**
10:15 a.m.	**Break**
10:30 a.m.	**Kaolin-processed clay on almond bud failure and yield** ***Dr. Brent Holtz, Farm Advisor, UCCE Madera County***
11:00 a.m.	**Use of reflective particle films to increase water use efficiency** ***Dr. Michael Glenn, USDA-ARS-Kearneysville, West Virginia***
11:30 a.m.	**Irrigating almonds with groundwater** ***Daniel Munk, Farm Advisor, UCCE Fresno County***
12:00 p.m.	**Acute drought impacts on groundwater basins** ***Dr. Thomas Harter, Water Management and Policy, UC Davis***
12:30 p.m.	**Free Lunch**

Sponsors for a free lunch: Panoche Creek Packing, Superior Almond Hulling, Western Ag Chipping, Agri Valley Irrigation, The Gowan Co., Midland Tractor, American West and West Valley Aviation, Britz Simplot Grower Solutions, Tessenderlo Kerley, University of California, and The Almond Board of California

Please RSVP to Kristi at Panoche Creek for lunch by March 27, at 559-449-1721 or fax 559-435-3481



For special assistance regarding our programs, please contact us.

WORKER PESTICIDE SAFETY TRAINING - Thursday, March 12, 2009 - Madera District Fairgrounds Woman's World. English Session 7:30 a.m. - 12:15 p.m., Spanish Session 12:30 p.m. - 4:30 p.m. Please RSVP to (559) 675-7879. Two hours of continuing education have been requested.

WANT TO GO PAPERLESS? The Pomology Post newsletter is available on the Internet at http://cemadera.ucdavis.edu. Go to NEWSLETTERS, POMOLOGY POST. If you subscribe online, you will receive an email letting you know it has been posted - no more waiting for the mail. **CHECK IT OUT!**

PLEASE NOTE: All Newsletter updates were sent out on February 20th (pink form). If you do not return the update form you will be dropped from the mailing list. Update forms can be faxed, mailed or dropped off at the office.

Sincerely,

Brent A. Holtz, Ph.D.
Pomology Farm Advisor