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## Rehabilitating Frost Damaged Citrus and Avocado

**Ben Faber, Soils and water, avocados and subtropicals Farm Advisor-Santa Barbara and Ventura Counties**

For the first time since the great freeze of '89-90, we have experienced a little more than minor damage to our crops. Compared to the San Joaquin Valley, Ventura County escaped without major damage although there were some areas harder hit like the Ojai Valley and some canyons near Santa Paula. Many parts of the SJV were hard hit.

As in the freeze of 1990, trees must be cared for in the same way during this post freeze period. In 1990, advice was issued to growers about the rehabilitation of their trees, both citrus and avocado. We would like to review that information for you at this time. How can we best aid tree recovery so that tree growth and yield will proceed most rapidly?

### Freeze Damage

Citrus and avocado leaves appear wilted or flaccid during periods of low temperature. This is a natural protective response to freezing temperatures and does not mean the leaves have been frozen. Leaves will be firm and brittle and often curled when frozen. Leaves become flaccid after thawing, and if the injury is not too great, they gradually regain turgor and recover, leaving dark flecks on the leaves. Seriously frozen leaves collapse, dry out, and remain on the tree. Foliage from recent flushes are most susceptible to this damage. If twigs or wood have been seriously damaged, the frozen leaves may remain on the tree for several weeks. If the twigs and wood have not been damaged severely, the leaves are rapidly shed. Trees losing their leaves rapidly is often a good sign and is not, as many growers believe, a sign of extensive damage.

Cold damage to the twigs appears as water soaking or discoloration. In older branches and trunks it appears as splitting or loosening of

bark where the cambium has been killed. Bark may curl and dry with many small cracks. Dead patches of bark may occur in various locations on limbs and trunk.

Sensitivity to frost is dependent upon many variables. In general, mandarins are the most cold-hardy followed by sweet orange and grapefruit. Lemons are very frost sensitive with Eureka decidedly more sensitive than Lisbon. For avocados, Hass is about as cold tolerant as lemons, while Bacon is more cold-tolerant. Limes are the least cold hardy. Healthy trees are more tolerant than stressed ones. The rootstock also imparts sensitivity onto the scion.

Injury to the foliage and to young trees may be immediately recognizable but the true extent of the damage to larger branches, trunks, and rootstocks may not appear for four months following the freeze. No attempt should be made to prune or even assess damage from the frost until spring when new growth appears.

### Whitewashing

The only treatment that should be done rapidly after a freeze is whitewashing. Often the most severe damage following a freeze results from sunburn of exposed twigs and branches after defoliation. Avocados and lemons are the most susceptible to sunburn, oranges are less susceptible; but if the tree has been defoliated, applying whitewash would be precautionary. Temperatures do not have to be extremely high to cause sunburn.



**Frost damage to citrus leaves**

**Pruning** - Pruning should be carried out to prevent secondary pathogens and wood decay organisms from slowing tree recovery. Again, there should be no rush to prune. Premature pruning, at the very least, may have to be repeated and, at the worst, it can slow tree rehabilitation. It should be remembered that

when pruning, all cuts should be made into living wood. Try to cut flush with existing branches at crotches. Do not leave branch stubs or uneven surfaces. Tools should be disinfected in bleach or other fungicide before moving on to the next tree. The extent of pruning is dictated by the amount of freeze damage:

Light Damage	Medium Damage	Severe Damage	Extreme Damage
Where only the foliage and small twigs are injured, pruning is not required	Where a considerable part of the top has been killed but the trunk and main crown limbs show little damage, branches should be removed back to living wood above vigorous sprouts	Where the top and crown limbs are severely damaged but there are sprouts above the bud union, the tree should be cut back to the uppermost sprout	Where trees are killed to the bud union or the rootstock has been girdled, the trees should be removed and replaced with new trees

**Irrigation** - Irrigate carefully! Remember that when leaves are lost, transpiration from leaves is greatly reduced. Therefore, the amount of water required is also greatly reduced. A frost-damaged tree will use the same amount of water as a much younger or smaller tree. Over-irrigation will not result in rapid recovery. Instead, it may induce root damage and encourage growth of root rotting organisms. This is particularly true for avocados. Irrigation should be less frequent, and smaller amounts of water should be applied until trees have regained their normal foliage development.

**Fertilization** - Fertilization of freeze-damaged trees should be carefully considered. There is no evidence that frozen trees respond to any special fertilizer intended to stimulate growth. If trees are severely injured, with large limbs or even parts of the trunk killed, nitrogen fertilizer applications should be greatly reduced until the structure and balance of the tree becomes re-established. Trees should be watched for deficiencies of minor elements - zinc, manganese, copper, and iron are most likely to develop. For citrus, these materials should be applied as sprays, and they should be used as often as symptoms are observed. Two or more applications may be required the first year.

## Advances in mitigation of alternate bearing of olive: vegetative growth response to plant growth regulators

Elizabeth Fichtner, UCCE Farm Advisor, Tulare County, and Carol Lovatt, Professor of Plant Physiology, Botany and Plant Sciences, UC-Riverside.

Alternate bearing (AB) is a phenomenon in olive where fruit production alternates between large crops consisting of smaller, lower value fruit during an "ON" year and smaller crops consisting of larger, higher value fruit during an "OFF" year. The large swings in biennial olive production impact the overall industry, from growers to harvesters, to processors. In olive, the vegetative growth in one year produces the nodes bearing potential floral buds in the spring of the second year. Fruit suppress vegetative shoot growth resulting in fewer nodes available to bear fruit the following year. Our phenological studies have helped characterize the relationship between fruit load and vegetative growth on 'Manzanillo' olives in Tulare County, California.

### **Investigation of vegetative growth response to plant growth regulators**

One strategy proposed to mitigate AB is to stimulate summer vegetative shoot growth to increase the number of nodes with the potential to produce floral buds. To address this strategy, our research team designed and implemented a proof-of-concept study in which plant growth regulator (PGR) treatments were injected into individual scaffold branches on opposing sides of 'ON' and 'OFF' trees. Plant growth regulators utilized in the study included two cytokinins, 6-benzyladenine (6BA) and a proprietary cytokinin (PCK), as well as two auxin-transport inhibitors, tri-iodobenzoic acid (TIBA) and a natural auxin transport inhibitor (NATI). Eight PGR treatments were included, with each PGR tested alone, and each cytokinin tested in combination with each auxin-transport inhibitor. PGR treatments were implemented in Summer (July 2012), and Summer + Spring (July 2012 and February 2013). Vegetative shoot growth was recorded monthly throughout the year to determine the influence of PGR treatments and timings on node production. The study was conducted at the Lindcove Research and Extension Center (Exeter, CA).



**Plant growth regulators were applied to individual scaffolds using large syringes.**

### **Node production in response to plant growth regulator treatments**

Scaffold injection with numerous PGR treatments resulted in significant increase in vegetative shoot growth. For example, nonbearing shoots on 'ON' control trees, produced an average of one node between July 2012 and February 2013, whereas nonbearing shoots on PGR-treated scaffold branches exhibited almost 4 times the new growth of the control trees (Table 1, shaded). Importantly, the new growth in some cases was statistically equal to the new vegetative shoot growth of nonbearing shoots on 'OFF' control trees. The PGR treatments also had a positive effect in increasing vegetative shoot growth on bearing shoots of 'ON' crop trees. Bearing shoots on 'ON' control trees produced an average of 0.8 nodes between July 2012 and February 2013, whereas bearing shoots on PGR-treated scaffold branches of 'ON' trees produced over three-fold more nodes during this period. Some PGR treatments increased the number of new nodes on bearing shoots on 'ON' trees to values equal to those of nonbearing shoots of 'OFF' crop control trees (Table 1, asterisk). Identify the better treatments. On average two additional nodes of growth were added to shoots in all treatments from February through April. Thus, in April shoots treated with some PGRs (Table 1, shaded) remained longer than bearing or nonbearing shoots on 'ON' crop control trees and equal to nonbearing shoots on 'OFF' crop control trees. This result suggests that with regard to increasing vegetative shoot growth there was no advantage derived from supplementing the Summer PGR treatment with the second Spring PGR treatment. However, the effect of the Spring PGR treatments on floral bud break and return bloom and fruit set remains to be determined.

**Table 1.** The effect of scaffold branch injected plant growth regulator treatments on vegetative shoot growth, as number of new nodes produced.

Treatment	Branch Status	New Nodes	
		July-February	July-April
ON Control	Fruit	0.8 l	3.3 jkl
TIBA+6BA SUMMER	Fruit	2.3 hijk*	4.6 cdefghij
TIBA+PCK SUMMER	Fruit	2.5 ghij*	4.9 bcdefghij
NATI+6BA SUMMER	Fruit	2.7 fghij*	4.2 fghijkl
NATI+PCK SUMMER	Fruit	2.2 hijk*	3.9 hijkl
TIBA SUMMER	Fruit	2.4 hij*	4.9 bcdefghij
NATI SUMMER	Fruit	2.5 fghij*	4.3 efg hijkl
6BA SUMMER	Fruit	2.2 ijkl	4.2 fghijkl
PCK SUMMER	Fruit	2.6 fghij*	4.7 cdefghij
TIBA+6BA SUMMER+SPRING	Fruit	2.4 hij*	4.5 defghijk
TIBA+PCK SUMMER+SPRING	Fruit	3.0 efghi*	4.5 defghij
NATI+6BA SUMMER+SPRING	Fruit	2.6 fghij*	5.0 abcdefghij
NATI+PCK SUMMER+SPRING	Fruit	2.2 ijk*	3.7 ijkl
TIBA SUMMER+SPRING	Fruit	2.0 ijkl	4.1 ghijkl
NATI SUMMER+SPRING	Fruit	3.1 defghi*	5.5 abcdefghi
6BA SUMMER+SPRING	Fruit	2.7 fghi*	4.9 bcdefghij
PCK SUMMER+SPRING	Fruit	1.3 jkl	2.5 l
OFF Control	No Fruit	3.6 abcdefgh	5.0 bcdefghij
ON Control	No Fruit	1.0 kl	2.7 kl
TIBA+6BA SUMMER	No Fruit	3.8 abcdefg	4.7 cdefghij
TIBA+PCK SUMMER	No Fruit	4.7 ab	5.9 abcdefg
NATI+6BA SUMMER	No Fruit	4.8 a	6.3 abcd
NATI+PCK SUMMER	No Fruit	4.5 abc	6.0 abcde
TIBA SUMMER	No Fruit	4.4 abcd	6.0 abcdef
NATI SUMMER	No Fruit	4.2 abcde	4.9 bcdefghij
6BA SUMMER	No Fruit	3.4 bcdefghi	4.0 hijkl
PCK SUMMER	No Fruit	4.3 abcde	5.5 abcdefghi
TIBA+6BA SUMMER+SPRING	No Fruit	4.2 abcde	5.2 abcdefghi
TIBA+PCK SUMMER+SPRING	No Fruit	4.8 a	5.7 abcdefgh
NATI+6BA SUMMER+SPRING	No Fruit	3.9 abcdef	5.1 abcdefghi
NATI+PCK SUMMER+SPRING	No Fruit	3.2 cdefghi	4.2 efg hijkl
TIBA SUMMER+SPRING	No Fruit	4.8 a	6.5 ab
NATI SUMMER+SPRING	No Fruit	4.5 abc	6.8 a*
6BA SUMMER+SPRING	No Fruit	4.8 a	6.4 abc
PCK SUMMER+SPRING	No Fruit	3.6 abcdefgh	4.7 cdefghij
<b>P-value</b>		<b>&lt;0.0001</b>	<b>&lt;0.0003</b>

*Note: shading denotes treatments significantly different than ON Control + Fruit treatment. Asterisk denotes treatments significantly different than OFF Control (- Fruit).*

## Summary

These preliminary data demonstrate that PGRs increase shoot growth, which might result in more nodes with the potential to produce inflorescences the following spring. Future studies are anticipated to address the use of promising treatments in foliar applications. Naturally-occurring compounds, such as PCK and NATI, may be easier and less costly to register than PGRs, which are classified as pesticides. Therefore, significant growth response to the natural compounds tested may have commercial benefit even if proven less efficacious than the synthetic PGRs.

**Acknowledgements:** The financial support of the California Olive Committee and the technical support of the Lindcove Research and Extension Center were integral to the success of this project.

## Fertigation – Measuring Uniformity

Larry Schwankl, Land, Air Water Resources, UC Davis

Fertigation is the injection of fertilizers through the irrigation system. Microirrigation systems are well-suited to fertigation because of their frequency of operation and because water application can be easily controlled by the manager. Applying fertilizers through a microirrigation system:

- Allows fertilizer distribution to be as uniform as the water application.
- Allows flexibility in timing fertilizer application.
- Reduces the labor required for applying fertilizer, compared to other methods.
- Allows less fertilizer to be applied compared to other fertilization methods.
- Can lower costs.

**These benefits rely on the uniformity of the application. The following provides points to**

**consider in determining some of the basic steps needed to ensure uniform fertilizer application.**

The injection point for fertilizers should be located so that the injected fertilizer and the irrigation water can become thoroughly mixed well upstream of any branching of the flow. Because of concerns over fertilizers being flushed out when the microirrigation system filters are backwashed, the injection point should be downstream of the filters. To ensure that no contaminants are injected into the microirrigation system, a good quality screen or disk filter should be installed on the line between the chemical tank and the injector.

The system should be allowed to fill and come up to full pressure before injection begins. Following injection, the system should be operated to flush the fertilizer from the lines. Leaving residual fertilizer in the line may encourage clogging from chemical precipitates or organic sources such as bacterial slimes.



### Fertilizer injection fertigation system for avocado trees

Once injection begins, the injected material does not immediately reach the emitters. There is a “travel time” for water and injected chemical to move through a microirrigation system. Measurements made in commercial orchards indicate that this travel time may range from 30 minutes to well over an hour, depending on the microirrigation system design. To ensure that application of any

injected material is as uniform as the water applications, the following steps should be taken:

**Step 1:** Determine the travel time of chemicals to the farthest point hydraulically in the microirrigation system. This is a one-time determination and can be done by injecting chlorine into the microirrigation system (a good maintenance procedure anyway) and tracing its movement through the system by testing the water for chlorine with a pool / spa test kit.

**Step 2:** The injection period should be at least as long as it takes the injected material to reach the end of the last lateral line (determined in Step 1). A longer injection period is usually preferable.

**Step 3:** Once injection is stopped, the irrigation should continue for a period of time as long as it took the injected material to reach the end of the farthest lateral (determined in Step 1). A longer, post-injection, irrigation period is usually preferable. Make sure, especially with injected materials that easily travel with the water (e.g. nitrate materials), that there is no overirrigation which moves water (and injected material) through the root zone. Such overirrigation could waste the injected material and lead to groundwater contamination.

Excerpted from: Schwankl, L. 2013. Fertigation. <http://fruitsandnuts.ucdavis.edu/files/73697.pdf>

## Olive Fly Update (November 2013)

Dr. Frank Zalom, Department of Entomology and Nematology, UC Davis  
Dr. Bob VanSteenwyk, Department of Environmental Science, Policy, and Management, UC Berkeley

Reviewed by UC Olive Workgroup Members 11-6-2013

### Monitoring and Treatment Decisions

There is no tolerance for damage on table fruit and about 10% for oil olives. The most

important aspect of damage levels for oil olives is that the fruit should be harvested early before it begins to rot. Rotten fruit, not just the presence of olive fly larvae, leads to off flavors in the oil. Press infested fruit as soon as possible after harvest (24 hours or less) or hold in cold storage until pressed.

While there is no relationship between fruit damage and the number of insects found in traps, surveying trap catches can evaluate treatment efficacy by comparing trap catches before and after treatment.

Surveying fruit for infestation can give some indication of the severity of an infestation. Looking for maggots infesting fruit that has fallen from trees in late winter and spring is useful as it will give some indication of overwintering olive fly densities. Adult fruit flies can be monitored with McPhail, Olipe or yellow sticky traps. Plastic McPhail traps have proven to be more effective than yellow sticky traps in catching larger numbers of olive fruit flies and catching them earlier in the season, but yellow sticky traps baited with a pheromone lure or ammonium bicarbonate are generally regarded as easier to use. Details on the use of these traps can be found in the UCIPM Pest Management Guidelines for Olives (<http://www.ipm.ucdavis.edu/PMG/r583301311.htm>).

For all trap types, place traps in fruiting trees by March 1 in warmer locations in the second tree row or further in to reduce dust accumulation in the traps. Hang the traps mid-canopy, in the shade (north side of the tree), and in an open area to avoid leaves blocking the trap. Record numbers of flies trapped weekly. The number of flies in the traps likely will decline during the course of a hot summer and increase as the weather cools in late summer.

If flies are captured in spring and the orchard has a history of damage, begin spinosad bait treatments at pit hardening or when fruit reach about 10 mm in length (the point when flies begin to sting fruit and larvae can develop).

Preliminary research indicates that applications of spinosad bait (GF-120 Fruit Fly Bait) should begin when trap captures begin to increase in early summer (mid to late June in the Central Valley). Once initiated, continue to apply spinosad bait according to label directions to protect the crop until harvest.

If fly captures begin to increase on traps late summer, but few fly stings on fruit are found, continue treatments with spinosad and/or kaolin clay. If number of stung fruit is increasing or if greater than normal numbers of flies are being captured in traps, treat with fenpropathrin. Fenpropathrin is a pyrethroid. Early season or excessive use of fenpropathrin can lead to a treadmill effect that may increase mite or scale populations, thereby requiring additional treatment for control of these pests, so the routine use of fenpropathrin unless significant damage is anticipated should be avoided.

#### **Registered Insecticides**

SPINOSAD (GF-120 Fruit Fly Bait)

Application rate: 10 - 20 fl oz/acre or  
1 - 3 fl oz/tree;

REI, 4 hours; PHI, 0 days

IRAC MODE OF ACTION GROUP NUMBER: 5

COMMENTS: For the first or second application, apply when fly numbers are increasing. In very warm spring weather, the first application should start before June 1, but could be as early as March or April if fly catches are heavy. In table olives, apply weekly to every other row or every other week to every row from pit hardening (mid-June) until harvest (mid-Sept). Olives grown for oil production, which are harvested later than table olives, may require additional applications. Dilute one part of product with 1.5 to 4 parts of water (e.g., with 4 gal of product, use from 6±16 gal water for a total of 10±20 gal spray solution.) Ground

application with large droplets (4±5 mm in diameter) will best resist evaporation.

KAOLIN CLAY (Surround)

Application rate: 12.5 - 50 lbs/acre

REI, 4 hours; PHI, 0 days

COMMENTS: Serves as a protectant for olive fruit. Leaves a white coating on the fruit. Apply two or three applications every 5-6 weeks starting at pit hardening to protect fruit from stings.

FENPROPATHRIN (Danitol)

Application rate: 10.67 - 16 fl oz/acre

REI, 24 hours; PHI, 7 days

COMMENTS: Use if fruit monitoring indicates that fly stings are increasing late summer, or if greater than normal fly captures are observed in traps, despite treatments with spinosad bait. Avoid treatments before late August or September as early season treatments may result in outbreaks of mites or scales. Do not exceed 42.67 fl oz/acre per season.

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Volume 11 No. 4

News from the Subtropical Tree Crop Farm Advisors in California

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