Developing Field Strategies to Correct Alternate Bearing (II)

Carol Lovatt
UC Riverside

Growers in Irvine, Santa Paula and Fillmore

The goal of this research is to increase grower profitability by developing plant growth regulator (PGR) strategies to mitigate alternate bearing.

When the avocado tree sets and develops an OFF-crop, a significant number of summer and fall vegetative shoots develop. The nodes (point of leaf attachment) on these shoots have axillary buds that bear floral shoots (in particular determinate inflorescences) the next spring (Year 2) (Fig. 1).

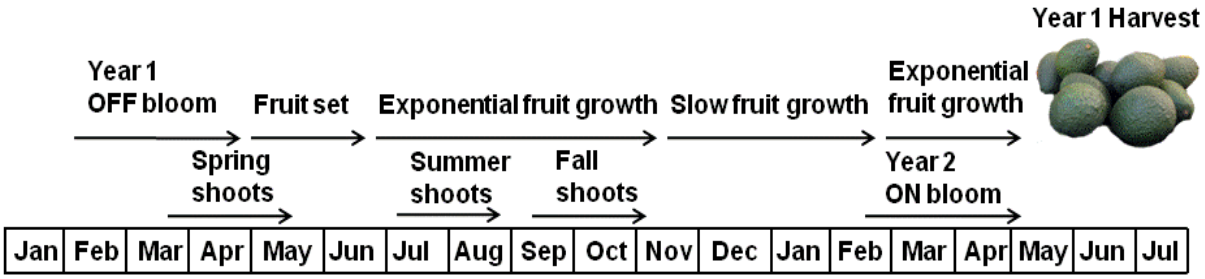

Fig. 1. An OFF-crop year starts with an OFF bloom that sets an OFF crop or is initiated by a climatic or culture event that reduces flower or fruit number during bloom or fruit set, respectively. The low number of young developing fruit in Year 1 results in a significant amount of summer and fall vegetative shoot growth that contributes floral shoots to the ON bloom in Year 2, ~75% and ~10% by summer and fall shoots, respectively. Summer vegetative shoots also contribute the majority of determinate floral shoots, which are present in high numbers only in an ON bloom. Note that the mature fruit of the OFF crop are fewer in number but large in size.

Inhibition of bud break at two key stages of 'Hass' tree phenology was identified in our earlier California Avocado Commission funded research as a mechanism by which fruit of an ON-crop reduce return bloom. First, in Year 1, young developing fruit inhibit growth of the apical (and axillary) buds on Year 1 spring shoots that would normally produce vegetative shoots during the summer and fall, thereby reducing the number and length of summer and fall shoots and the number of nodes that can bear floral (and vegetative) shoots the next spring (Year 2) (Fig. 2 below).

Therefore, to mitigate alternate bearing, we are testing plant growth regulator (PGR) strategies designed (1) to overcome inhibition of bud break to stimulate summer and fall vegetative shoot growth during the ON-crop year and thus, increase the number of nodes that can bear floral shoots the following spring and (2) to increase spring bud break when trees are carrying an ON-crop to increase the floral intensity of the return bloom and increase yield the following year. We are testing the efficacy of strategies that use a cytokinin applied alone or in combination with an auxin-transport inhibitor to increase bud break, return bloom, and yield following the heavy ON-crop. Both synthetic PGRs and naturally occurring plant-based metabolites that are generally recognized as safe (GRAS) are being tested.

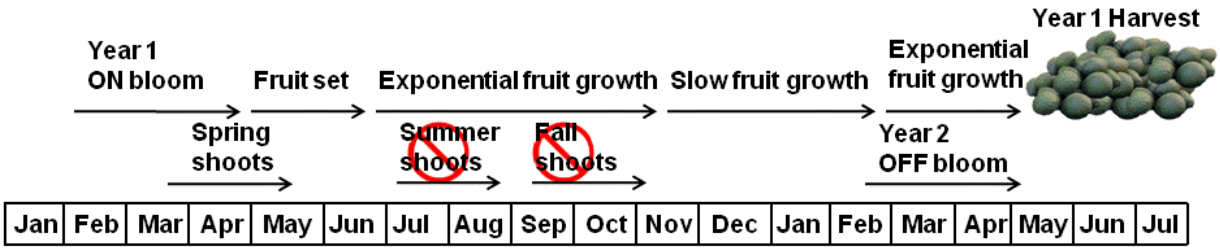

Fig. 2. An ON-crop year starts with an ON bloom that sets an ON crop or is initiated by climatic or culture events that are optimal for flowering and fruit set such that natural fruit thinning fails to take place. The large number of young developing fruit inhibits summer and fall vegetative shoot growth. The loss of summer and fall shoots means there are fewer sites that can bear floral shoots in spring of Year 2, especially determinate floral shoots, which develop predominantly on summer shoots. The result is an OFF bloom in Year 2 that is produced predominantly by the Year 1 spring shoots. Note that there are many smaller mature fruit in the ON crop.

We trunk injected the PGRs and metabolites in order to test many compounds, concentrations and application times. Trunk injection gives a response that is easier to interpret because it eliminates the possibility that treatment failure is due to poor leaf uptake. Trunk injection also makes it possible to test more compounds and application times than could be tested as foliar sprays, because fewer replications are required than would be needed to test foliar-applied compounds. The best PGR treatments will subsequently be tested as foliar- and irrigation-applied strategies. Preliminary results testing the effect of foliar sprays, and branch injections as requested by several growers, on the floral intensity of the return bloom and yield following an ON-crop are discussed below.

Results

'Hass' Avocado Orchards – Irvine. In July 2009 and January and/or February 2010, we trunk injected GA_3, the cytokinin 6-benzyladenine (6-BA), a natural plant cytokinin (CK X), the auxin-transport inhibitor tri-iodobenzoic acid (TIBA), a natural plant metabolite auxin-transport inhibitor (NATI) and these compounds combined. Several treatments increased return bloom in 2010 by 50% compared to the untreated ON-crop control trees, but floral intensity was still less than that of the OFF-crop control trees. The effect of the treatments on yield is reported in Table1. All trees were trunk injected with 1 g per tree of each compound specified in July and again in January unless otherwise indicated in Table 1.

Table 1. Effect of PGRs trunk injected into ON-crop 'Hass' avocado trees in July and January (Yr 1) on yield and fruit size.

	Total yield		2-year cumulative yield	
	Year 1	Year 2	Total	(60+48+40)
	no. of fruit/tree			
OFF-crop Control	79	5	84	45
ON-crop Control	485	3	487	256
CK X	474	9	480	273
CK X + TIBA	546	15	560	207
6-BA	556	39	582	393
6-BA + TIBA	651	139	791	463
CK X + NATI	650	13	659	394
NATI	482	25	507	329
GA_3	405	2	406	261
CK X (Feb not Jan)	684	12	673	331
CK X (+Feb)	633	19	655	421
Branch CK X 0.25 g	730	55	782	496
Branch CK X 0.5 g	305	102	402	337
Branch CK X 1 g	500	79	571	346

Trees selected as OFF-crop control trees in Year 1 turned out to be poor performing trees and failed to produce an ON-crop in Year 2. In contrast, trees selected as ON-crop control trees in Year 1 produced very low yields in Year 2, consistent with alternate bearing. The treatment combining the cytokinin 6-BA and the auxin-transport inhibitor TIBA not only increased yield in the ON-crop year, it also successfully increased yield the following year and thus,

dramatically increased 2-year cumulative total yield compared to the ON-crop control trees. In addition, 6-BA plus TIBA increased the yield of commercially valuable fruit (packing carton sizes 60+48+40) in both years of the research compared to the ON-crop control trees and thus, increased 2-year cumulative yield of fruit of packing carton sizes 60+48+40 compared to the ON-crop control trees. GA_3 reduced yield during the ON-crop year, but failed to increase yield the following year compared to the ON-crop control trees. GA_3 was eliminated from subsequent experiments. Applying CK X alone in July and January and again in February increased 2-year cumulative total yield and 2-year cumulative yield of fruit of packing carton sizes 60+48+40 compared to the ON-crop control trees, but this result was primarily due to the effect of this treatment on the ON-crop.

At the request of several growers, we also tested branch injections. In this initial study, two main branches per tree were injected with 0.25 g, 0.5 g and 1.0 g CK X per tree for comparison with trees that were trunk injected with 1 g CK X per tree. The two higher concentrations of CK X resulted in greater floral intensity and greater yield in Year 2 (Table 1).

We were concerned by the fact that many of the cytokinin and/or auxin-transport inhibitor treatments tested increased yield during the ON-crop year, but were relieved that these treatments, with the exception of GA_3, increased yield to some degree the following year. Further, several treatments had the added benefit of increasing the yield of commercially valuable large size fruit (packing carton 60+48+40) in the ON-crop year and the 2-year cumulative yield of fruit of packing carton sizes 60+48+40. The results are promising and will be used as the basis for deciding which PGR treatments to apply through the irrigation, as foliar-applied sprays and as additional branch injection treatments (if there is continued grower interest in branch injections) in a new experiment being established at the South Coast Research and Education Center in July 2012.

Table 2. Effect of foliar-applied PGRs to ON-crop 'Hass' avocado trees in July and January (Yr 1) on yield and fruit size.

	Total yield		2-year cumulative yield	
	Year 1	Year 2	Total	(60+48+40)
	no. of fruit/tree			
ON-crop Control	403 b[z]	12 a	442 b	236 b
CK X	496 ab	25 a	517 ab	329 ab
CK X + NATI	669 a	15 a	678 a	322 ab
CK X + TIBA	538 ab	47 a	576 ab	399 a
P-value	0.0783	0.2996	0.0506	0.0547

[z] Values in a vertical column followed by different letters are significantly different at the *P*-value specified by Fisher's Protected LSD Test.

In preparation for this new experiment, we conducted a preliminary experiment to test the capacity of the natural plant cytokinin (CK X) alone or in combination with tri-iodobenzoic acid (TIBA) or the natural plant auxin-transport inhibitor (NATI) applied as a foliar spray to mitigate alternate bearing. The yield results are reported in Table 2. While promising, we clearly need to be able to increase yield to a greater degree in the year following the ON-crop. To meet this challenge, we will test the use of higher PGR concentrations, a February application, and different wetting agents.

We have one additional trunk injected PGR experiment to harvest at Irvine in Summer 2012. In this experiment, we replicated our earlier experiment comparing the efficacy of 6-BA, CK X, TIBA and NATI alone and in combination applied in July and January. We also trunk injected these PGR treatments in July and February and September and February to identify the optimal application time.

'Hass' Avocado Orchard – Santa Paula. Treatments discussed above were repeated in an orchard in Santa Paula. This orchard had too few trees that produced inflorescences in the spring following the

heavy ON-crop to provide reliable results on the effect of the treatments on return bloom. This orchard was not harvested due to the absence of crop.

'Hass' Avocado Orchard – Fillmore. With the goal of determining whether trunk injection in January or February is more effective, in 2010 we established a new experiment in an orchard in Fillmore. The cytokinin 6-benzyladenine (6-BA), the natural plant cytokinin (CK X), and the natural plant auxin-transport inhibitor (NATI) were trunk injected into one set of ON-crop trees in July 2010 only, a second set in July 2010 and again in January 2011, and a third set in July 2010 and again in February 2011. The OFF-crop control trees set an average of only 18 fruit per tree, whereas the ON-crop control trees set 183 fruit per tree, with the ON-crop trees in each of the treatments having yields that were not significantly different from the ON-crop control trees but significantly greater than the OFF-crop control trees. The effect of the treatments on the number of summer and fall shoots that developed was determined and the effect of treatments on return bloom was quantified. Only OFF-crop control trees and ON-crop trees trunk injected with CK X in July or July and February produced floral shoots at return bloom. OFF-crop trees produced both indeterminate and determinate floral shoots, whereas ON-crop trees treated with CK X in July or July and February produced only indeterminate floral shoots. In both cases, floral shoots were produced predominantly on summer shoots, consistent with our previous results. The trees in this experiment will be harvested in Summer 2012 to determine the treatment effects on yield following the ON-crop.

Take home message

The goal of our research is to increase the number of summer flush shoots produced by ON-crop trees and to increase spring bud break on ON-crop trees to increase bloom and yield in the year following the heavy ON-crop. The yield results reported provide evidence that combining a cytokinin and an auxin transport inhibitor increases yield following the ON-crop. The greatest increases in yield following the ON-crop were achieved with either 6-BA (trunk injection) or CK X (foliar-spray) combined with TIBA. These treatments did not reduce the ON-crop yield to achieve the yield increase in Year 2. Moreover, these and several other treatments increased the yield of commercially valuable fruit (packing carton sizes 60+48+40) in the ON-crop year. The next step is to increase yield to a greater degree following the ON-crop by testing higher PGR concentrations PGR, making additional PGR applications (September or February), and identifying a more effective wetting agent for the foliar treatments.

Benefits of the research to the industry (includes achievements and future prospects)

Because alternate bearing is most frequently initiated by environmental factors, especially climatic events (e.g., freeze, high temperatures etc), there is a recurring need for a strategy to mitigate alternate bearing once it is initiated. The goal of this research is to provide a PGR strategy that can be used to mitigate alternate bearing. This will contribute significantly to grower profitability.

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