PGR Strategies to Increase Yield of 'Hass' Avocado

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Project overview

California avocado growers must increase yield, including fruit size, and/or reduce production costs to remain competitive in the US market, which now receives fruit from Mexico, Chile, New Zealand, Dominican Republic and an increasing number of other countries (http://www.ers.usda.gov/Data/Fruit VegPhyto/Data/fr-avocados.xls). Despite the popularity, the 'Hass' cultivar (*Persea americana* Mill.) is known to be problematic with regard to fruit retention, fruit size and alternate bearing. Plant growth regulators (PGRs) are powerful, cost-effective tools for increasing yield of commercially valuable large size fruit and mitigating alternate bearing in the field. At the present time, no plant growth regulators are registered for use on avocado. The goal of my research program is to provide growers with a basic understanding of 'Hass' avocado tree phenology and physiology and the tools to increase net income per acre for growers of the 'Hass' avocado in California. To meet this goal we are developing fertilization and plant growth regulator (PGR) strategies to increase total yield and yield of commercially valuable large size fruit. For the PGR strategies we are simultaneously collecting the efficacy data necessary to satisfy the requirements of the California Department of Pesticide Regulation (DPR) to have the successful plant growth regulators added to an existing label so that they can be legally used in avocado production in California. Note that PGRs are considered pesticides. The specific objectives of this research are: (1) to increase yield by annually increasing the number of more highly productive sylleptic shoots (Fig. 1) in the canopy; (2) to increase yield by increasing fruit retention during June drop; (3) to increase fruit size; and (4) to collect dose response data as the next step toward adding avocado to the label for GA_3. To meet these objectives, three separate field projects are being conducted.

Results

Objective 1.
Background. To meet Objective 1, Typy (6-BA; 1.8% + GA_{4+7}; 1.8%) is applied at 250 mg/L and 50 mg/L and ProGibb (GA_3, 4%) is applied at 100 mg/L: *i*) at the initiation of the summer vegetative shoot flush (July) and *ii*) in late winter (February) at stage 6 to 7 of inflorescence development (opening of inflorescence bracts). The following spring we determined the contribution made by sylleptic and proleptic shoots to return bloom (number of indeterminate and determinate floral shoots, vegetative shoots and inactive buds). All treatments are applied in 200 gallons of water per acre. Note: (*i*) that after Year 1, Typy was reduced from 500 mg/L to 250 mg/L due to the negative effect of the higher concentration on yield in Year 1 and (*ii*) that the January application was moved to February with better effect.

Results. PGR strategies initiated in 2005 and applied annually increased the number of sylleptic shoots produced in 2006, 2007 and 2008. The most effective treatment was GA_3 (100 mg/L) applied in July. This treatment increased the number of sylleptic shoots that developed in the summer vegetative shoot flush, increasing the ratio of syllepsis to prolepsis in the canopy and significantly increasing the floral intensity of the return bloom compared to that of untreated control trees (Table 1). Note that the inflorescence floral shoots are proleptic shoots because they develop from dormant axillary buds of the summer flush sylleptic shoots. GA_3 applied in July significantly increased the number of determinate inflorescences, but not indeterminate floral shoots, that developed as proleptic shoots from the dormant axillary buds of summer flush sylleptic shoots to significantly increase return bloom (Table 2). Typy (50 mg/L) applied in February also significantly increased the number of determinate inflorescences produced during return bloom by the summer sylleptic shoot flush (Table 2), but with no significant increase in total inflorescence number during return bloom. However, determinate inflorescences are known to be more productive than indeterminate floral shoots. The anticipated effects on yield were not realized due to freeze in one year and excessive fruit drop in another.

Take home message. ProGibb® (GA_3, 4%) 100 mg/L applied at the initiation of the summer vegetative shoot flush (July) increased summer sylleptic vegetative shoot growth, even in the presence of a heavy on crop, increasing the ratio of syllepsis to prolepsis of the canopy and significantly increasing return bloom. Typy® (6-BA; 1.8% + GA_{4+7}; 1.8%) at 50 mg/L applied at bud break (February) also increased the number of determinate inflorescences. The results of this research provide a PGR strategy (GA_3 at 100 mg/L applied in July) for increasing bud break and development of the summer (sylleptic) vegetative shoot flush during a heavy on-crop year, the first step in mitigating alternate bearing and provide some insight into the type and timing of a PGR strategy to increase bud break in spring. The fact that a February application of Typy at 50 mg/L is more effective than a February application ofGA_3 at 100 mg/L indicates a need to supply cytokinin at this time. The optimal concentration of cytokinin and whether some GA_3 needs to be applied with the cytokinin remains to be determined.

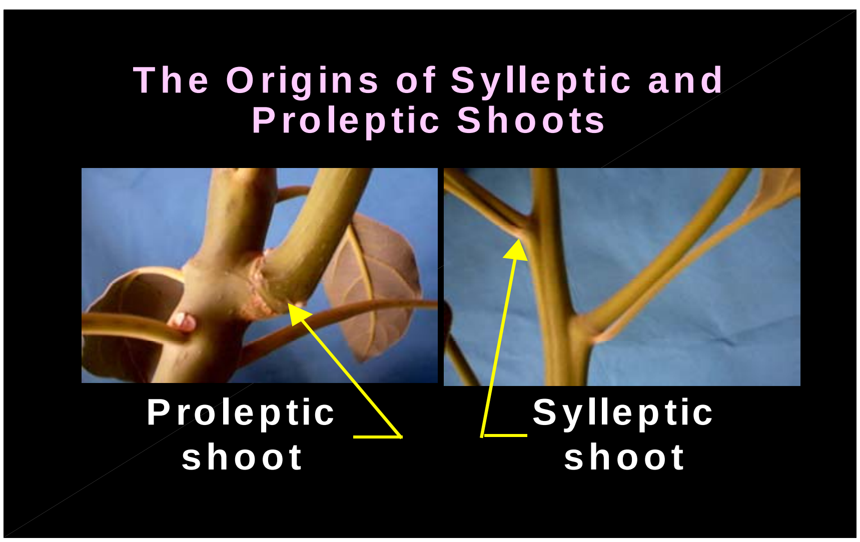

Figure 1. Origin of proleptic shoots from over-wintering dormant buds that results in bud scale scars (left figure) in contrast with sylleptic shoots that develop from buds formed contemporaneously with the development of the shoot axis (right figure).

Table 1. Effect of GA_3 and Typy ($BA+GA_{4,7}$) on number of inflorescences from proleptic and sylleptic shoots of 'Hass' avocado in Irvine, Calif. on 29 April 2008.

	Proleptic shoots				Sylleptic shoots				All shoots			
Treatment	Spring	Summer	Fall	Total	Spring	Summer	Fall	Total	Spring	Summer	Fall	Total
	---No. inflorescences/tree---											
July application												
GA_3 (100 ppm)	0.00	15.25 a	1.50	16.75	0.00	0.00	0.00	0.00	0.00	15.25 a	1.50 bc	16.75 a
TYPY (50 ppm)	1.75	3.00 b	3.25	8.00	0.00	0.50	0.00	0.50	1.75	3.50 b	3.25 ab	8.50 b
TYPY (250 ppm)	0.33	3.78 b	2.11	6.22	0.00	0.11	0.22	0.33	0.33	3.89 b	2.33 abc	6.56 b
February application												
GA_3 (100 ppm)	0.88	4.13 b	1.63	6.63	0.00	0.25	0.50	0.75	0.88	4.38 b	2.13 abc	7.38 b
TYPY (50 ppm)	0.00	7.50 b	0.50	8.00	0.00	0.17	0.17	0.33	0.00	7.67 b	0.67 c	8.33 b
Control	0.00	3.83 b	3.17	7.00	0.00	0.00	0.83	0.83	0.00	3.83 b	4.00 a	7.83 b
P-value	0.4810	0.0040	0.1817	0.1158	.	0.7840	0.5207	0.9365	0.4810	0.0068	0.0689	0.0721

[z] Values in a vertical column followed by different letters are significantly different at specified *P* levels by LSD Test.

Table 2. Effect of GA_3 and Typy ($BA+GA_{4,7}$) on number of determinate inflorescences from proleptic and sylleptic shoots of 'Hass' avocado in Irvine, Calif. on 29 April 2008.

	Proleptic shoots				Sylleptic shoots				All shoots			
Treatment	Spring	Summer	Fall	Total	Spring	Summer	Fall	Total	Spring	Summer	Fall	Total
	---No. determinate inflorescences/tree---											
July application												
GA_3 (100 ppm)	0.00	13.25 a	1.00	14.25 a	0.00	0.00	0.00	0.00	0.00	13.25 a	1.00	14.25 a
TYPY (50 ppm)	1.50	1.00 c	1.25	3.75 b	0.00	0.50	0.00	0.50	1.50	1.50 c	1.25	4.25 b
TYPY (250 ppm)	0.00	0.89 c	0.67	1.56 b	0.00	0.11	0.11	0.22	0.00	1.00 c	0.78	1.78 b
February application												
GA_3 (100 ppm)	0.38	1.38 c	0.25	2.00 b	0.00	0.13	0.38	0.50	0.38	1.50 c	0.63	2.50 b
TYPY (50 ppm)	0.00	5.83 b	0.17	6.00 b	0.00	0.17	0.17	0.33	0.00	6.00 b	0.33	6.33 b
Control	0.00	0.67 c	1.17	1.83 b	0.00	0.00	0.17	0.17	0.00	0.67 c	1.33	2.00 b
P-value	0.2775	0.0002	0.4066	0.0027	.	0.7193	0.7308	0.9340	0.2775	0.0005	0.7299	0.0092

[z] Values in a vertical column followed by different letters are significantly different at specified *P* levels by LSD Test.

Objectives 2 and 3.
Background. To meet Objective 2, AVG is applied at 250 mg/L: *i*) at the cauliflower stage of bloom, *ii*) at full bloom, *iii*) just before June drop starts, and *iv*) at full bloom and again just before June drop starts. To meet objectives 2 and 3, *i*) 2,4-D is applied at 45 g acid equivalents/acre when fruit are 16-20 mm in diameter and *ii*) 3,5,6-TPA is applied at 15 mg/L when fruit are 24 mm in diameter. Both PGRs were applied in 200 gallons of water per acre.

Results. Averaged across the 3 years of the experiment (two off-crop years and one on-crop year), AVG (250 mg/L) applied at full bloom and 2,4-D (45 g acid equivalents/acre) applied when fruit are 16-20 mm in diameter continued to significantly increase the yield of commercially valuable large size fruit of packing carton sizes 60+48+40 and yield of fruit greater than packing carton size 60. Averaged across the 3 years of the experiment, no PGR had an effect on any fruit quality parameter evaluated.

It is of significant benefit that the greatest effect of each PGR on yield of large size fruit was attained in the on-crop year. With harvest data now for two off-crop years and one on-crop year, the net increase in 3-year average yield of commercially valuable large size fruit (packing carton sizes 60 + 48 + 40) was 1,761 and 1,804 lbs/110 trees/acre/year more than the control, for AVG and 2,4-D, respectively. The net increase in 3-year average yield of fruit greater than packing carton size 60 is 1,940 and 1,649 lbs/110 trees/acre/year for AVG and 2,4-D, respectively, compared to untreated control trees.

For the harvest of 2008, 2,4-D significantly increased total yield by an additional 5,301lbs/110 trees/acre and the yield of commercially valuable large size fruit (packing carton 60 + 48 + 40) by an additional 3,305 lbs/110 trees/acre compared to untreated control trees. All AVG treatments were intermediate in effect and not significantly different from trees treated with 2,4-D or untreated control trees.

Take home message. Averaged across the 4 years of the experiment, 2,4-D significantly increased the yield of commercially valuable large size fruit (packing carton 60 + 48 + 40) by 2,091/110 trees/acre/year. The cost of 2,4-D (CitrusFix® AMVAC Corp.) to achieve the net increase in yield of large size fruit was $15/acre/year (not including the cost of application which will vary widely from grower to grower). Averaged across the 4 years of the experiment, the effect of AVG on yield and fruit size was intermediate to and not significantly different from trees treated with 2,4-D and the untreated control. The cost for AVG (ReTain® Valent BioSciences) would be between $757 to $947/acre/year. I received approval from the Production Research Committee to work with AMVAC, the manufacturer of CitrusFix, to obtain a 24 (c) supplemental label for the use of 2,4-D to increase the yield of commercially valuable large size fruit of 'Hass' avocado and 'Hass' hybrids.

Objective 4.
Background. To meet Objective 4, GA_3 was applied at 10, 25, 62.5 and 156 mg/L at the cauliflower stage of inflorescence development for three successive years (March 16, 2006; April 3 and 4, 2007, and March 20, 2008).

Results. In previous research, the potential of GA_3 to increase grower income was demonstrated in two different avocado-growing areas of the state. (1) In Corona, GA_3 (25 mg/L) applied at the cauliflower stage of inflorescence development resulted in a net increase in 2-year cumulative total yield of 6,063 lbs fruit/acre (based on 110 trees/acre) and 2-year cumulative yield of commercially valuable large size fruit (packing carton sizes 60 + 48 + 40) of 4,098 lbs/110 trees/acre more than untreated control trees (from the work of Salazar-Garcia and Lovatt, 2000). (2) In Irvine, GA_3 (25 mg/L) applied at the cauliflower stage of inflorescence development resulted in a net increase in 2-year cumulative total yield of 3,771 lbs fruit/acre (based on 110 trees/acre) and 2-year cumulative yield of commercially valuable large size fruit (packing carton sizes 60 + 48 + 40) of 2,570 lbs/110 trees/acre more than untreated control trees in Irvine. The cost of GA_3 (ProGibb® Valent BioSciences) to achieve the net increase in total yield and yield of large size fruit was $16/acre (this is the cost of the product and does not include the cost of application, which varies among growers). Moreover, GA_3 keeps the external peel green without affecting the length of time for fruit to ripen after harvest. This is a highly desirable additional effect of GA_3 application at the cauliflower stage of inflorescence development (Salazar-Garcia and Lovatt, 2000). Another benefit is that this treatment increases vegetative shoot growth, which shades the fruit and reduces fruit damage caused by sunburn.

For 2008, on tree fruit measurements in November demonstrated that GA_3 at 25 mg/L significantly increased fruit size compared to the untreated control. The GA_3-treated fruit were 10% larger in both diameter and length compared to the control. The length to diameter ratio of the GA_3-treated fruit remained the same as that of the control fruit. By February, the difference in fruit size for fruit treated with GA_3 at 25 mg/L was only 5% for both length and width. Only fruit treated with GA_3 at 62.5 or 156 mg/L were significantly larger by 10% (both length and width) than control fruit.

Take home message. With the permission of Guy Witney, the start of this project was delayed by 1 year because heavy rains prevented application of GA_3 at the correct stage of tree phenology. We were able to get a normal off-crop year harvest the first year, but the anticipated subsequent on-crop was also an off-crop due to the freeze. This year we lost the entire the crop due to excessively high temperatures in early June. This research, as the final research step toward registration of GA_3, is critical. I made a commitment to the Production Research Committee to carry forward approximately $10,000 for Objective 4 and to move the research to two new sites going into an on-crop year since we know that GA_3, as the other PGRs tested, is most effective in an on-crop year. In October 2008, to further support GA_3 research, I wrote and submitted an IR-4 proposal with the support of Valent BioSciences, the manufacturer of ProGibb.

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

Objective 1. The results of this research provide a PGR strategy (GA_3 at 100 mg/L applied in July) for increasing bud break and development of the summer (sylleptic) vegetative shoot flush during a heavy on-crop year, the first step in mitigating alternate bearing, and provide some insight into the type of PGR and timing of the PGR application necessary to increase bud break in spring. The fact that a February application of Typy at 50 mg/L is more effective than a February application of GA_3 at 100 mg/L indicates a need to supply cytokinin at this time. This information will be used in the final phase of our research on alternate bearing.

Objective 2 and 3. The results of this research demonstrated that 2,4-D significantly increased the 4-year average yield of commercially valuable large size fruit (packing carton 60 + 48 + 40) by 2,091/110 trees/acre/year. The cost of 2,4-D (CitrusFix® AMVAC Corp.) to achieve the net increase in yield of large size fruit was $15/acre/year (not including the cost of application which will vary widely from grower to grower).

I am working with the Production Research Committee and AMVAC, manufacturer of CitrusFix, to obtain a 24 (c) supplemental label to use 2,4-D to increase the yield of commercially valuable large size fruit of 'Hass' avocado and 'Hass' hybrids so that 2,4-D will hopefully be available for the growers to use this spring.

Additional research demonstrating the ability of 2,4-D to increase yield of commercially valuable large size fruit in a second orchard in a different avocado-growing area of the state and a dose response to 2,4-D are still required, but in the mean time 2,4-D will possibly be available to growers.

Objective 4. In previous research, the potential of GA_3 to increase grower income was demonstrated in two different avocado-growing areas of the state. Demonstrating that yield parameters respond incrementally to differences in the amount of GA_3 applied (a dose response) in orchards in two different avocado-growing areas of the state is the critical final step in adding avocado to a commercial GA_3 label. After losing the crop in our research orchard due to high temperatures in early June, I made the commitment to the Production Research Committee to carry forward approximately $10,000 for Objective 4 and to move the research to two new sites going into an on-crop year since we know that GA_3, as the other PGRs tested, is most effective in an on-crop year to accomplish this final critical step in one crop year.

To enhance my ability to conduct research on behalf of the avocado growers of California, I wrote and submitted, with an Israeli colleague, a BARD grant in September 2008 and I wrote and submitted and IR-4 proposal in October 2008 for further research with GA_3. To date I personally have obtained $257,218 in funding from the CDFA-FREP program to conduct research optimizing fertilization of the 'Hass' avocado and an additional $245,000 from the CDFA-FREP in collaboration with Dr. Richard Rosecrance, CSU-Chico, and Dr. Ben Faber, UCCE-Ventura and Santa Barbara, for the avocado tree dissection research to determine up-take and partitioning of soil nutrients in response to crop load and for the development of a demand driven web-based fertilization program. Further, Dr. Rosecrance was awarded partial matching funds from CSU for the two collaborative projects. Thus, I have played a key role in brining over half a million dollars from outside CAC to avocado research for improving fertilization and, hence, productivity and grower profitability.

Literature Cited

Salazar-Garcia, S. and C.J. Lovatt. 2000. Use of GA_3 to manipulate flowering and yield of the 'Hass' avocado. J. Amer. Soc. Hort. Sci. 125:25-30.

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Department of Botany and Plant Sciences

Plant Growth Regulator Strategies to Increase Yield and Fruit Size of the 'Hass' Avocado

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Introduction –

At the present time, plant growth regulators (PGRs) are perhaps the most powerful field-applicable tools available to the avocado industry for solving production problems. Over the past 10 years, my lab has identified key stages in the phenology of the 'Hass' avocado (*Persea americana* Mill.) important for targeting cultural practices, especially the application of plant growth regulators (Refer to the poster entitled "*'Hass' Avocado Tree Phenology*"). Over the past 5 years, we have gained experience regarding the response of the 'Hass' avocado to several key commercial PGRs applied at specific stages of tree phenology. The goals of this research is to develop strategies using PGRs to increase the productivity of 'Hass' avocado orchards and to increase grower income. Here we highlight the status of research projects developing the use PGRs to increase yield of commercially valuable large size fruit and grower income.

Note research projects investigating the use of PGRs to increase the ratio of sylleptic to proleptic shoot growth or to mitigate alternate bearing are discussed in a separate poster.

Project 1 – GA_3 to increase total yield and yield of commercially valuable fruit of packing carton sizes 60+48+40.

APPLICATION RATE AND TIME – Cauliflower stage of inflorescence development @ 25 mg/L in 1869 L of water per ha (200 gallons per acre).

ANNUAL COST OF THE STRATEGY PER ACRE – The cost of GA_3 (ProGibb® Valent BioSciences) is $16 per acre.

BENEFITS – GA_3 (25 mg/L) applied at the cauliflower stage of inflorescence development resulted in a net increase in 2-year cumulative total yield of 6,063 lbs fruit/acre (based on 110 trees/acre) and 2-year cumulative yield of commercially valuable large size fruit (packing carton sizes 60 + 48 + 40) of 4,098 lbs/acre more than untreated control trees. The strategy is most effective in the on-crop year. The treatment advances shoot growth, which shades setting fruit, and increases fruit dry matter content and delays peel blackening of mature fruit. The treatment has no significant effect on the number of days for fruit to ripen and no effect on fruit length, fruit diameter, seed diameter, flesh width or internal fruit quality.

STAGE TOWARDS COMMERCIALIZATION – We are now at the next step required by the DPR for making GA_3 available for use in avocado production - demonstration of a GA_3 dose effect on avocado yield. In a commercially producing 'Hass' avocado orchard in Santa Paula owned by the Limoneira Company, we are testing the efficacy of GA_3 (ProGibb® Valent BioSciences) at 0 (control), 10, 25, 62.5 and 156 mg/L applied at the cauliflower stage of inflorescence development to increase avocado yield, fruit size and dry weight and delay peel blackening. Total yield and/or yield of commercially valuable large size fruit, fruit dry weight and/or the proportion of green- vs. black-peeled fruit should increase incrementally with increasing GA_3 concentrations from 0 to 10 to 25 to 62.5 mg/L, with the difference in yield responses to 25 vs. 62.5 mg/L GA_3 not significantly different. The high concentration of 156 mg/L GA_3 is included to establish a phytotoxicity threshold as requested by CA DPR. GA_3 is also more effective in on-crop than off-crop years. Results obtained for 2008-2009, an on-crop year, will be critical to this project.

Project 2 – 6-Benzyladenine, GA_3 followed by Prohexadione-calcium (Ca), or GA_3 alone to increase fruit size.

APPLICATION RATE AND TIME – 6-benzyladenine (25 mg/L) (MaxCel® Valent BioSciences) applied at anthesis (full bloom) and at anthesis and again at the end of July – beginning of August , GA_3 (25 mg/L) (ProGibb® Valent BioSciences) applied in mid-July followed by prohexadione-Ca (125 mg/L) (Apogee® BASF) 30 days later (mid-August), and GA_3 (25 mg/L) applied at the end of June – beginning of July. All treatments are in 1869 L of water per ha (200 gallons per acre).

ANNUAL COST OF THE STRATEGY PER ACRE – The cost per acre for each PGR is: MaxCel®, $26; ProGibb®, $16; Apogee®, $86.

BENEFITS – BA (25 mg/L) applied at full bloom resulted in a net increase in 3-year cumulative yield of commercially valuable large size fruit (packing carton sizes 40 + 36 + 32) of 6,511 lbs/110 trees/acre, an average of more than 2,000 lbs/acre/year, more than control trees. GA_3 (25 mg/L) applied in mid-July followed by the application Prohexadione-Ca (125 mg/L) approximately 30 days later (mid-August) resulted in a net increase in 3-year cumulative yield of commercially valuable large size fruit (packing carton sizes 40 + 36 + 32) of 6,070 lbs/110 trees/acre, an average of approximately 2,000 lbs/acre/year, more than control trees (Table 1). In a separate orchard, GA_3 (25/mg/L) applied at the end of June–beginning of July resulted in a net increase in 2-year cumulative yield of commercially valuable large size fruit (packing carton sizes 60 + 48 + 40) of 5,665 lbs/110 trees/acre, an average of more than 2, 700 lbs/acre/year, more than control trees (Data not shown). This treatment also resulted in a significant net increase in 2-year cumulative total yield of 6,579 lbs/acre, an average of more than 3,000 lbs/ acre/year, above the yield of control trees. The treatments have no significant effect on the number of days for fruit to ripen and no effect on fruit length, fruit diameter, seed diameter, flesh width or internal fruit quality. The PGR treatments are more effective in on-crop than off-crop years.

STAGE TOWARDS COMMERCIALIZATION – Per CA DPR requirements, these treatments are now being tested being tested for their efficacy in a second orchard in a different avocado growing area than the first orchard. The current research is being carried out in an orchard in Santa Paula owned by the Limoneira Company, which is absorbing the loss of revenue due to having to destroy the treated fruit. This project was initiated in spring 2007 and the first harvest will be in 2008. PGR treatments that are successful in the second orchard will move to the final step: demonstrate that the yield of large size fruit responds incrementally to increases in PGR dose.

Project 3 – Aminoethoxyvinylglycine (AVG, ReTain® Valent BioSciences) to increase fruit retention during June drop and 2,4-dichlorophenoxyacetic acid, 2,4-D, CitrusFix® AMVAC) and 3,5,6-trichloropehoxypropionic acid (3,5,6-TPA, Maxim® Agriphar) to increase yield of large size fruit.

APPLICATION RATE AND TIME – AVG (250 mg/L) applied *i*) at the cauliflower stage of inflorescence development, *ii*) at full bloom, *iii*) just before June drop starts, and *iv*) at full bloom and again just before June drop to increase yield by increasing fruit retention during June drop. We are also testing the efficacy of *i*) 2,4- (38 g acid equivalents/acre) applied when fruit are 16-20 mm in diameter and *ii*) 3,5,6-TPA (10 mg/L) applied when fruit are 24 mm in diameter to increase yield of large size fruit by increasing fruit retention during June drop and by increasing fruit size. All treatments are in 1869 L of water per ha (200 gallons per acre).

ANNUAL COST OF THE STRATEGY PER ACRE – The cost per acre for each PGR is: CitrusFix®, $15/acre; ReTain®, $757 to $947/acre, Maxim, unknown as it is not yet sold in the USA.

BENEFITS – Averaged across the 3 years of the experiment (two off-crops and 1 on-crop), AVG and 2,4-D increased the net yield of commercially valuable large size fruit (packing carton sizes 60 + 48 + 40) by 1,761 and 1,804 lbs/110 trees/acre/year more than the control, respectively (Table 2). These two treatments also increased the net yield of fruit greater than packing carton size 60 by 1,940 and 1,649 lbs/110 trees/acre/year more than the control, respectively. The 3-year average net increase in total yield was approximately 1000 lbs/acre/year. The treatments have no significant effect on the number of days for fruit to ripen and no effect on fruit length, fruit diameter, seed diameter, flesh width or internal fruit quality. The PGR treatments are more effective in on-crop than off-crop years.

STAGE TOWARDS COMMERCIALIZATION – The efficacy of these PGR treatments needs to be tested in a second orchard in a different avocado growing area than the first orchard. We are seeking funding from CAC to support this next step. PGR treatments that are successful in the second orchard will move to the final step: demonstration that the yield of commercially valuable large size fruit responds incrementally to increases in PGR dose.

Table 1. Effect of PGR treatments on yield and fruit size of the 'Hass' avocado averaged over the 3 years of the research (2003-2005) in Irvine, Calif.

		Packing carton size							
PGR	Total	84	70	84+70	60	48	40	60+48+40	>40
	---------- *kg fruit/tree* ----------								
Prohexadione-Ca	26.61	0.38	2.20 ab	2.59	4.66	10.37	6.59 ab	21.62	8.99 ab
6-Benzyladenine	26.29	0.31	1.72 b	2.03	3.64	9.81	8.13 a	21.57	10.82 a
CPPU	23.08	0.75	2.50 ab	3.26	4.45	9.01	4.73 bc	18.19	6.37 bc
GA_3+Prohexadione-Ca	25.77	0.40	1.67 b	2.06	3.65	9.55	8.15 a	21.36	10.50 a
Control	25.63	0.73	3.22 a	3.95	5.72	10.53	4.38 c	20.63	5.42 c
P-value									
Trt. (T)	0.8148	0.2390	0.0808	0.1006	0.1814	0.7197	0.0033	0.7072	0.0029
Date (D)	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
T x D	<.0001	0.0148	0.0018	0.0022	<.0001	0.0047	0.0274	0.0008	0.0139

^{z}Values in a vertical column followed by different letters are significantly different at specified *P* levels by LSD Test.

Table 2. Effect of AVG, 2,4-D and 3,5,6-TPA on yield and fruit size of the 'Hass' avocado averaged over the 3 years of the research (2005-2007) in Irvine, Calif.

		Packing carton size							
Treatment	Total	84	70	84+70	60	48	40	60+48+40	> 60
	---------- kg fruit/tree ----------								
AVG									
Full bloom (a)	38.69 a	0.89 b	4.70 a	5.59 ab	9.08 a	14.04 ab	7.43 a	30.56 a	33.10 a
Exp. Fruit growth (b)	37.31 a	1.67 ab	6.91 a	8.58 ab	9.62 a	11.62 bc	5.57 a	26.80 ab	28.73 ab
(a) + (b)	33.89 a	1.33 ab	5.75 a	7.08 ab	8.25 a	11.58 bc	5.09 a	24.92 ab	26.81 ab
2,4-D@20mm	39.07 a	1.39 ab	5.76 a	7.14 ab	10.95 a	15.86 a	3.93 a	30.74 a	31.93 ab
3,5,6-TPA@24mm	35.23 a	0.90 b	4.42 a	5.33 b	8.14 a	12.68 abc	6.78 a	27.60 ab	29.91 ab
Control	34.65 a	2.10 a	7.42 a	9.51 a	9.13 a	9.28 c	4.89 a	23.30 b	25.14 b
P-value									
Treatment (T)	0.5972	0.1526	0.3786	0.2614	0.4795	0.0377	0.3834	0.0153	0.2572
Date (D)	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
T x D	0.1390	0.1563	0.4772	0.3064	0.3719	0.0002	0.6165	0.0130	0.0188

^{z}Values in a vertical column followed by different letters are significantly different at specified *P* levels by LSD Test.

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