

Plant Growth Regulator Use in Citrus Production

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Plant Growth Regulators "Old and New Uses for Citrus"

Credit to Lance W. Beem, Charles Coggins, and Ed Stover

Plant Hormone Classes

- Auxins
- Cytokinins
- Ethylene
- Gibberellins
- Abscisic Acid (ABA)

Multiple effects of Plant Hormones

- **Auxins: Primary regulator**—Promote growth through cell enlargement, cause apical dominance, rooting promotion, fruit thinning, fruit drop prevention
- **Gibberellins:** Promote growth through cell enlargement, cause fruit set, flower induction, flower reduction (thinning), break of dormancy, increase seed germination, delay of senescence, modify sex expression
- **Cytokinins:** Promote growth through cell division, counteract apical dominance, branching agent, delay of senescence, cause fruit abscission
- **Ethylene:** Ripening agent causes leaf & fruit abscission, promotes radical growth
- **Abcisic Acid:** Promotes leaf & fruit abscission, regulates dormancy in perennials, controls hydric status through stomata opening control

Examples of PGR'S (Mimic and/or Stimulate) Plant Hormones

- **Auxins:** IAA, IBA, 2,4-D, NAA, Carbryl, etc.
- **Gibberellins:** GA₁, GA₃, GA_{4/7}, etc.
- **Cytokinins:** 6BA, CPPU, Zeatin, etc.
- **Ethylene:** Ethylene Gas, Ethephon,
- **Abcisic Acid:** ABA

Plant Growth Regulators Commonly used in AZ Citrus

- **Preharvest PGR's of highest importance:**
 - Auxins = 2,4-D & (NAA) for fruit thinning and sizing in mandarins
 - Gibberellic Acid = GA₃ for delayed aging of navel orange fruit.
- **Postharvest PGR's of highest importance**
 - Auxins = 2,4-D for "Button" retention in Lemons
 - Ethylene = Ethylene Gas "Sweating the Fruit"
 - Gibberellic Acid = GA₃ for delay fruit senescence.

Auxins

(IBA), (NAA), & (2,4-D)

(Auxin) Plant Growth Regulator
Post-harvest
Lemons

Retention of Stem End-Calyx Attachment on

Lemons differ from other citrus in that they may be subjected to lengthy packinghouse storage.

The Postharvest application of **isopropyl ester of 2,4-D** can be applied as a final step in the washing or waxing procedure just prior to the storage period.

This treatment will slightly delay the loss of chlorophyll.

However, the major benefit is the resulting increase vigor and persistence of the "button" retards the entry of **Alternaria fungi = Alternaria Rot**

(Auxin) Plant Growth Regulator
Pre-harvest
Mandarins

Enhancement of early fruit drop on

NAA is thought to enhance early fruit drop by increasing competition between fruitlets and increasing production of abscission-inducing ethylene, both encouraging greater physiological-drop (Usually in May).

Only groves which are expected to have excessively large numbers of fruit per tree should be thinned with NAA. Alternate bearing cultivars such as 'Kinnow' in the "on" (high crop) year are obvious candidates, but other cultivars also may be profitably thinned. Perhaps 'Minneola'?

- Apply 100 to 500 ppm
- Spray when temperatures are less than 95F

*http://www.amvac-chemical.com/Images_two/PDF_Files/Label_MSDS/ksaltFF200.pdf

(Auxin) Plant Growth Regulator
Pre-harvest
Mandarins

Fruit size increase

Not yet registered for mandarins

VALENCIA and NAVEL ORANGES*

23 g a.e./a in water spray ...or...	3/16-1/4 inch (5-6 mm)
30 g a.e./a in water spray ...or...	1/4-1/2 inch (6-13 mm)
38 g a.e./a in water spray ...or...	1/2-5/8 inch (13-16 mm)
45 g a.e./a in water spray ...or...	5/8-3/4 inch (16-19 mm)

Fruit-sizing sprays require excellent coverage. May cause an increased roughness of the rind. For Valencia oranges, also controls mature fruit drop and may slightly delay granulation in new crop. For navel oranges, may decrease fruit splitting.

Gibberellic Acid

(GA₃)

(GA₃) Plant Growth Regulator
Pre-harvest Period
Lemons

Gibberellic Acid

Timely sprays of GA₃ when target crop is 0.5 to 0.75 full size and still green will delay lemon fruit maturity. GA₃ may reduce bloom and fruit set the spring following treatment. An increased fruit set during the following summer also may occur. Thus the GA₃ application can result in a harvest of fruit. This allows for larger sized fruit.

**(GA₃) Plant Growth Regulator
Special Local Needs Use
Bloom Period
Clementine Mandarins**

Gibberellic Acid (GA₃) spray at full bloom to increase set of fruit.

Bloom applications of GA₃ has been a standard in Florida, Spain and South Africa for fruit set and is a very effective tool for **Clementine Mandarins**.

Currently registered in California under a Special Local Needs use (SLN).

**(GA₃) Plant Growth Regulator
Special Local Needs Use
Post-harvest
Lemons**

Gibberellic Acid (GA₃) applied in storage wax to lemons, the result is delayed senescence, which maintains natural resistance to "Sour Rot" (*Geotrichum candidum*) and otherwise provides for a longer storage life.

There can be some undesirable post-harvest delay in coloring of regreened Valencia oranges, but other delays in coloring of citrus fruits are considered to be beneficial.

Currently registered in California under a Special Local Needs use (SLN).

Accel (Abbott Labs)

- Gibberellin and Cytokinin blend
- Commonly used to thin apples
- May also reduce fruit abscission in citrus
 - Promoting cell division and enlargement
- Application rate of 30 g ai in 100-150 gallons of water per acre.

Table 1. Yield and packout of 'Lisbon' lemons harvested at the Heffer Ranch as affected by Accel treatment and date.

Accel Treatment Date	Fruit Grade			
	Yield per tree (lbs)	Culls (%)	Second Grade (%)	First Grade (%)
6 May 1996	381 a	29 a	26 a	45 a
6 and 17 May 1996	366 ab	38 a	19 b	43 a
17 May 1996	408 a	37 a	18 b	45 a
Untreated Control	284 b	35 a	17 b	48 a

^a Values within a column followed by the same letter are not significantly different according to Duncan's multiple range test at P=0.05.

Table 2. Fruit size of lemons harvested at the Heffer Ranch as affected by Accel treatment

Accel Treatment Date	Fruit per box				
	200	201	202	140	115
	(%)	(%)	(%)	(%)	(%)
6 May 1996	7.8 b	2.26 a	1.22	10.1 b	6.72
6 and 17 May 1996	14.7 a	3.41 a	1.82	12.4 b	7.62
17 May 1996	12.5 a	3.8 a	1.82	10.5 a	6.32
Untreated Control	11.0 ab	3.5 a	2.02	16.2 ab	6.22

Values within a column followed by the same letter are not significantly different according to Duncan's multiple range test at P=0.05.

ProGibb (Abbott Labs)

- Gibberellins known to delay maturity of lemon fruit
 - Will pre-harvest application improve fruit quality of late harvest lemons?
 - Will the same applications reduce yield the following year?

Table 1. Prograde fruit color determination of lemons harvested at the Bertel Ranch as affected by ProGibb treatment.

ProGibb Treatment	Fruit Color			
	Bronze (%)	Yellow (%)	Light Green (%)	Dark Green (%)
0.24 g ai ac ⁻¹	12.57 ^a	19.42 ^b	35.75 ^a	32.30 ^a
0.32 g ai ac ⁻¹	11.25 ^b	18.92 ^b	36.37 ^a	33.50 ^a
Control	29.12 ^c	36.60 ^a	27.72 ^b	6.30 ^b

^a Values within a column followed by the same letter are not significantly different according to Duncan's multiple range test at P=0.05.

Table 2. Post-coblation average yield, fruit color and fruit grade of lemons harvested at the Bertel Ranch as affected by ProGibb treatment.

ProGibb Treatment	Yield (Cartons)	Fruit Color						Fruit Grade		
		Bronze (%)	Yellow (%)	Light Green (%)	Dark Green (%)	Red (%)	Juice (%)	2nd Grade (%)	1st Grade (%)	
0.24 g ai ac ⁻¹	153 ab	4.5 ^b	29.2 ^b	62.2 ^a	1.8 ^a	2.4 ^a	0.2 ^a	47.7 ^a	27.1 ^a	17.4 ^{ab}
0.32 g ai ac ⁻¹	140 ^a	5.6 ^b	29.9 ^b	60.7 ^a	2.0 ^a	1.8 ^a	0.3 ^a	55.3 ^a	32.0 ^a	20.0 ^a
Control	72 ^b	17.1 ^a	46.5 ^a	35.5 ^b	0.4 ^b	0.7 ^a	0.0 ^a	57.1 ^a	31.0 ^a	11.9 ^b

^a Yield includes only fruit in the pack line. Fruit color determined following storage for coblation, and fruit grade determined after increased juice fruit removed.
^b Values within a column followed by the same letter are not significantly different according to Duncan's multiple range test at P=0.05.

Treatments had no effect on total yield, fruit size nor on any fruit quality parameter.

Table 1. Total chlorophyll determination of lemons harvested at the Bertel Ranch as affected by ProGibb treatment.

Treatment	Chlorophyll (mg)
0.24 g ai ac ⁻¹	3.97 ^a
0.32 g ai ac ⁻¹	3.53 ^a
Control	3.33 ^b

^a Values within a column followed by the same letter are not significantly different according to Duncan's multiple range test at P=0.05.

Total chlorophyll determined using a Minolta Spot Chlorophyll meter which measures leaf chlorophyll content on a relative 0 to 100 scale. Values represent the mean of the highest and lowest chlorophyll values for 100 fruit per treatment.

Treatments had no effect on total yield, fruit grade, fruit size nor on any fruit quality parameter.

Crop Set

- Derived from saponins, fermentation media and trace minerals
 - Contains auxins, cytokinins, gibberellins.
- Preliminary demonstration studies done in 2003-04
- Replicated trial initiated in 2004

Table 1. 2003-2004 packout of 'Eureka' lemons treated with CropSet at two harvest dates.

Treatment	Yield (cartons/ha)		Fruit Size (mm)		Fruit Ripeness (g/100g)
	1st	2nd	1st	2nd	
Untreated Control	107 (80)	120 (64)	75 (5)	75 (5)	38.8 (ab)
0.10 g ai ac ⁻¹ CropSet	0.22 ^a	0.65 ^b	1.07 ^b	1.29 ^a	18.5 (b)
0.20 g ai ac ⁻¹ CropSet	0.41 ^a	0.80 ^a	1.29 ^a	1.11 ^b	21.0 (a)

^a Values are the means of 4 tree plots.
^b Means separation in columns by Duncan's Multiple Range Test, 5% level.
 Percentage of fruit harvested prior to 15 November.

Table 2. 2003-2004 packout of 'Eureka' lemons treated with CropSet on 1/20/04.

Treatment	75	95	115	140	165	200	255	255
Untreated Control	16.25 ^{bc}	46.42 ^{ab}	18.05 ^a	10.75 ^a	5.96 ^a	1.76 ^a	0.82 ^a	0.18 ^a
0.10 g ai ac ⁻¹ CropSet	31.04 ^a	80.53 ^a	10.66 ^b	3.37 ^b	2.15 ^b	0.72 ^b	0.19 ^b	0.05 ^a
0.20 g ai ac ⁻¹ CropSet	13.90 ^{bc}	31.01 ^b	20.94 ^a	13.01 ^a	7.15 ^a	2.00 ^a	1.08 ^a	0.15 ^a

^a Values are the means of 4 tree plots.
^b Means separation in columns by Duncan's Multiple Range Test, 5% level.

Table 1. 2003-2004 fruit quality of 'Mission' lemons treated with CropSet.

Treatment	Yield				Fruit							
	1st	2nd	3rd	Total	Color	Mass	Brix	Acid	Ratio	Length	Width	Thick
Untreated Control	20.75 ^a	17.07 ^a	13.12 ^a	50.94 ^a	26.71 ^b	23.87 ^a	19.99 ^c	5.51 ^c	1.76 ^a	0.37 ^a	0.37 ^a	0.17 ^a
0.10 g ai ac ⁻¹ CropSet	237.6 ^a	17.86 ^c	20.72 ^a	264.0 ^a	22.07 ^a	15.07 ^a	3.45 ^a	0.64 ^a	0.14 ^a			

^a Means separation in columns by Analysis of Variance, P=0.05.

Table 2. 2003-2004 fruit quality of 'Mission' lemons treated with CropSet.

Treatment	Fruit Quality Parameters						
	Juice (%)	pH	Solids (%)	Acid (%)	Solids/Acids Ratio	Fruit Thickness (mm)	
Untreated Control	48.42 ^a	3.12 ^a	10.90 ^a	0.82 ^a	11.98 ^a	4.26 ^a	
CropSet	48.50 ^a	3.18 ^a	10.79 ^a	0.86 ^a	12.59 ^a	4.10 ^a	

^a Values are the means of 20 fruit per tree, 6 trees per treatment.
^b Means separation in columns by Analysis of Variance, P=0.05.

*"New" Potential Uses for Plant Growth
Regulators in CA Citrus
Gibberillic Acid*

*Tangelos and **tangerines*

There is a registration for **GA₃** for increasing fruit set and yield on tangelos and tangerines resulting from beneficial results obtained in Florida and around the world.

Currently not registered for use in California

**SLN exception for Clementine Mandarin=tangerine