Using Plant Growth Regulators (PGR) in Citrus

Ashraf El-Kereamy

UCCE Specialist & UCLREC director

Department of Botany and Plant Sciences

UC Riverside

ashrafe@ucr.edu

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Presentation outline

- Overview of Plant Growth Regulators (PGR)
- Synthesis and function of different plant hormones
- Plant hormones vs PGR
- Categories and the mode of action of PGR
- Handling of registered PGR in citrus
- PGRs role in preventing fruit disorder
- Using PGR to improve fruit set and fruit size
- Reducing fruit drop by PGRs
- PGR and alternate bearing in citrus
- PGR to control suckering and tree size
- Discussion and participants perspectives

PGR vs Hormones

Plant Growth Regulators (PGR):

- **Synthetic form** of the plant hormones which can be used to control or modify plant growth, also called plant growth substances or growth factors

Plant hormones:

- **Endogenous** organic compounds active at **very low concentration**
- **Essential** for regulating plant growth and development
- Produced in one tissue and **translocated** to another tissue
- Have a **specific function** at specific stages and concentrations
- They **act together** in a complex pathway

Classical plant hormones synthesis and function

Hormone	*Where produced or found*	*Function*
Auxin	-Embryos -Meristems of apical buds and young leaves	-Stimulates stem elongation at low concentration -Delays color and ripening -Retards abscission
Cytokinin	-Roots	-Affects root growth -Stimulates cell division and branching -Delays ripening and senescence -Increases fruit set
Gibberellins	-Embryos -Meristems of apical buds and young leaves	-Promote bud growth and seed germination -Promote cell elongation and division
Abscisic acid	-Leaves, stem, roots, and green fruits	-Inhibits growth -Closes stomata -Promotes dormancy -Enhances coloration
Ethylene	-Ripening fruits -Aging leaves and flowers	-Promotes fruit ripening -Promotes senescence -Improve coloration

New plant hormones

Brasinosteroids (BR):

- ❑ Defined as the sixth plant hormone
- ❑ Detected in leaves, stems, roots, flowers, pollen, anthers, and seeds
- ❑ Play a role in plant growth and environmental adaptation
- ❑ Mediating plant responses to stress
- ❑ Not registered for Citrus

New plant hormones

Salicylic acid (SA):

- Essential component in the signal transduction pathway leading to Systemic Acquired Resistance (SAR)
- Improves tolerance to abiotic stress
- Synthesized from phenylalanine and benzoic acid.
- Not registered for Citrus in California

New plant hormones

Jasmonates (JA):

- Lipid-based stress hormones
- Regulate plant adaptations to biotic stresses, including herbivore attacks and pathogens
- Inhibition of seedling growth
- Inhibition of root growth
- Recent study indicates its involvement in ACP aggregation
- Not registered for Citrus

New plant hormones

Strigolactones:

- Control plant development
- Component of root exudates to promote symbiotic interactions between plants and soil microbes
- Stimulate hyphal branching in a fungal symbiont that forms Arbuscular Mycorrhizae (AM) on their host plants
- The fungal hyphae provide the plant with nutrients, especially phosphate and nitrate. The plant provides the fungus with carbon and nitrogen metabolites (energy and amino acids)

All plant hormones are produced in the leaves?

1- YES

2- No

Plant Hormones are classified under two major groups

Growth Promoters	Growth Retardants / Inhibitors
• Cytokinins • Gibberellins • Auxin at low concentrations	•Abscisic acid (Stress hormone) •Ethylene (Ripening / Senescence hormone)
Promote cell division and growth	Inhibit cell division and growth

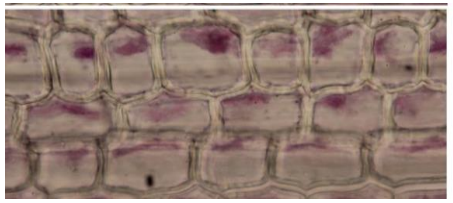
Mode of action of GA and Cytokinin in increasing fruit size

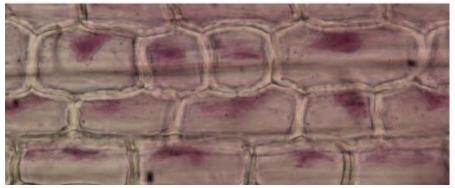
GA application

Cell elongation

Increases cell size

Increases fruit size





Cytokinin application

More cell division

Increases number of cells

Increases fruit size

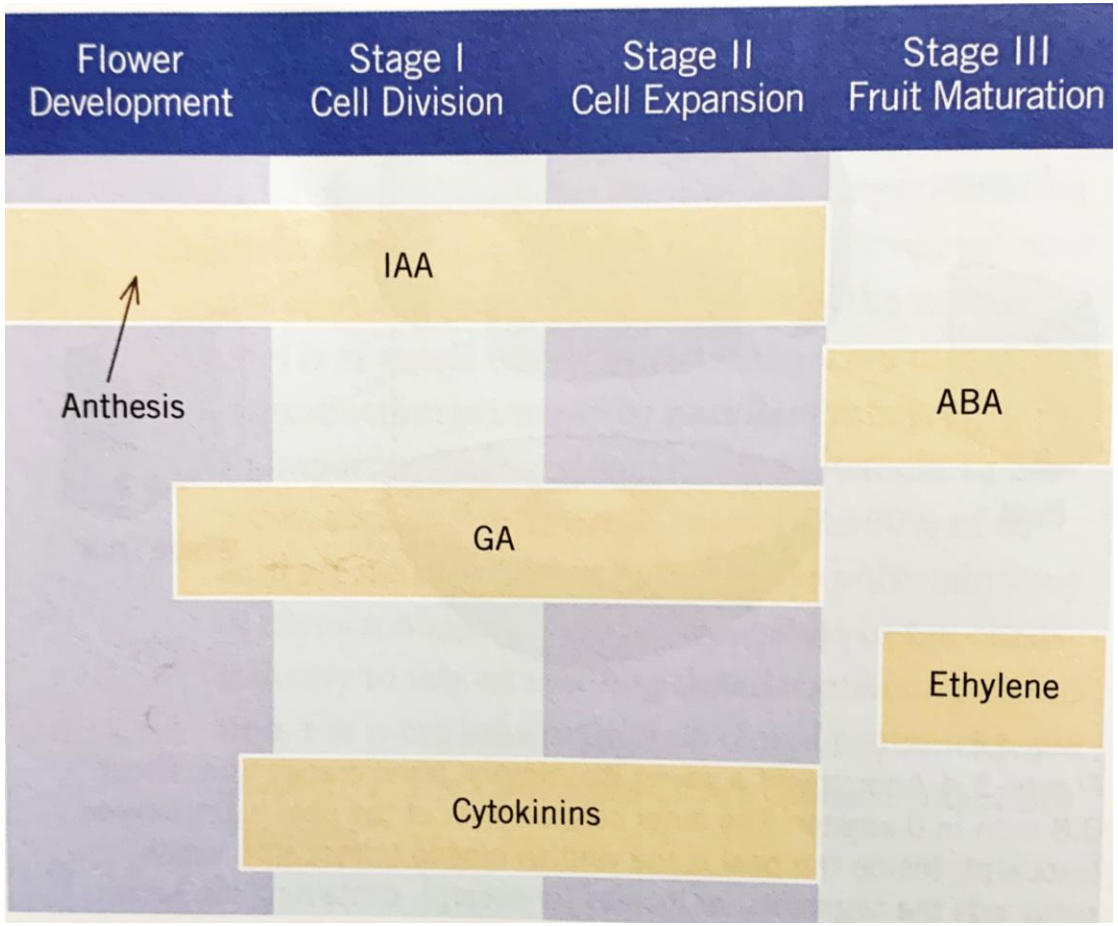
May reduce the following year bud fruitfulness if used at high rate

Hormones associated with citrus fruit development and maturation

- Stage I starts immediately following anthesis.
- Ends in 5-10 weeks after bloom.
- Peel reaches its maximum by the end of stage I.

- Stage II, pulp growth stage.
- Juice sacs enlarge
- Increases in juice and sugar
- Thinner peel

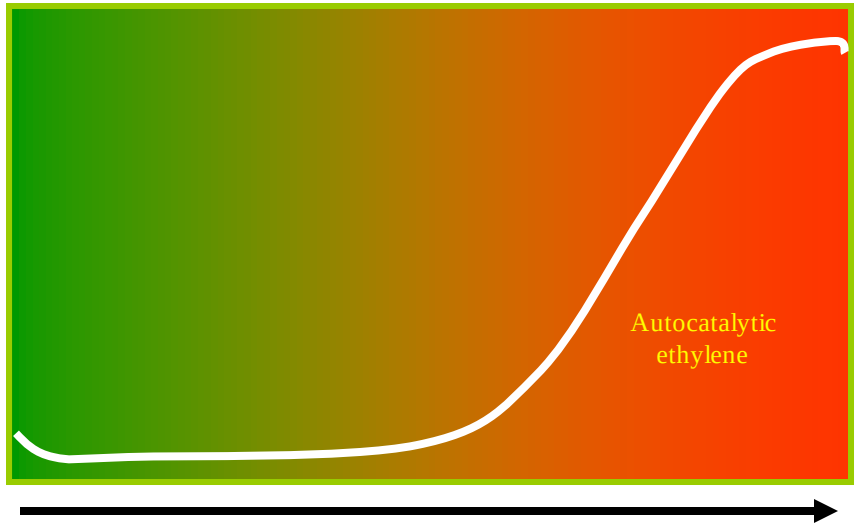
- Stage III, known as fruit maturation phase
- Pulp growth stops
- Color change



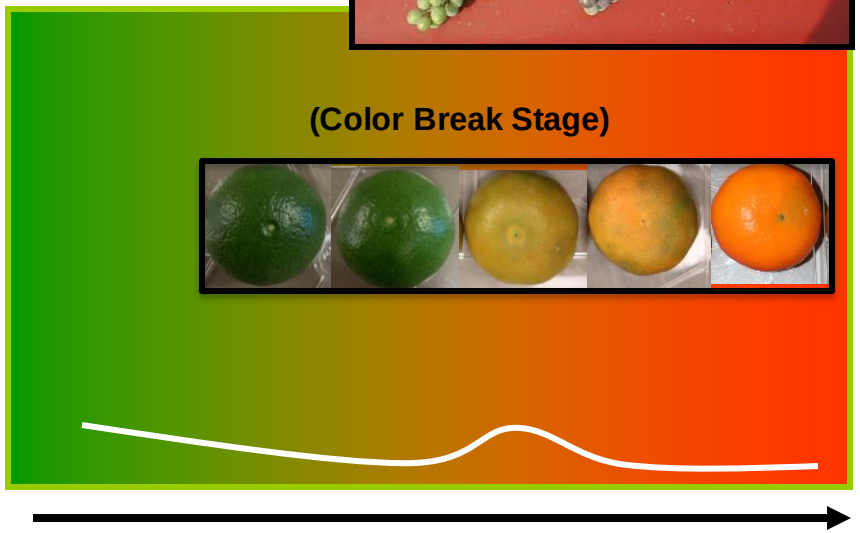
Lovatt, 2014, Citrus Production Manual

Ethylene and ripening of Climacteric and Non-Climacteric fruits

EIM LMG MG Br Tu Orange Pink Red



Ethylene production



Ethylene production

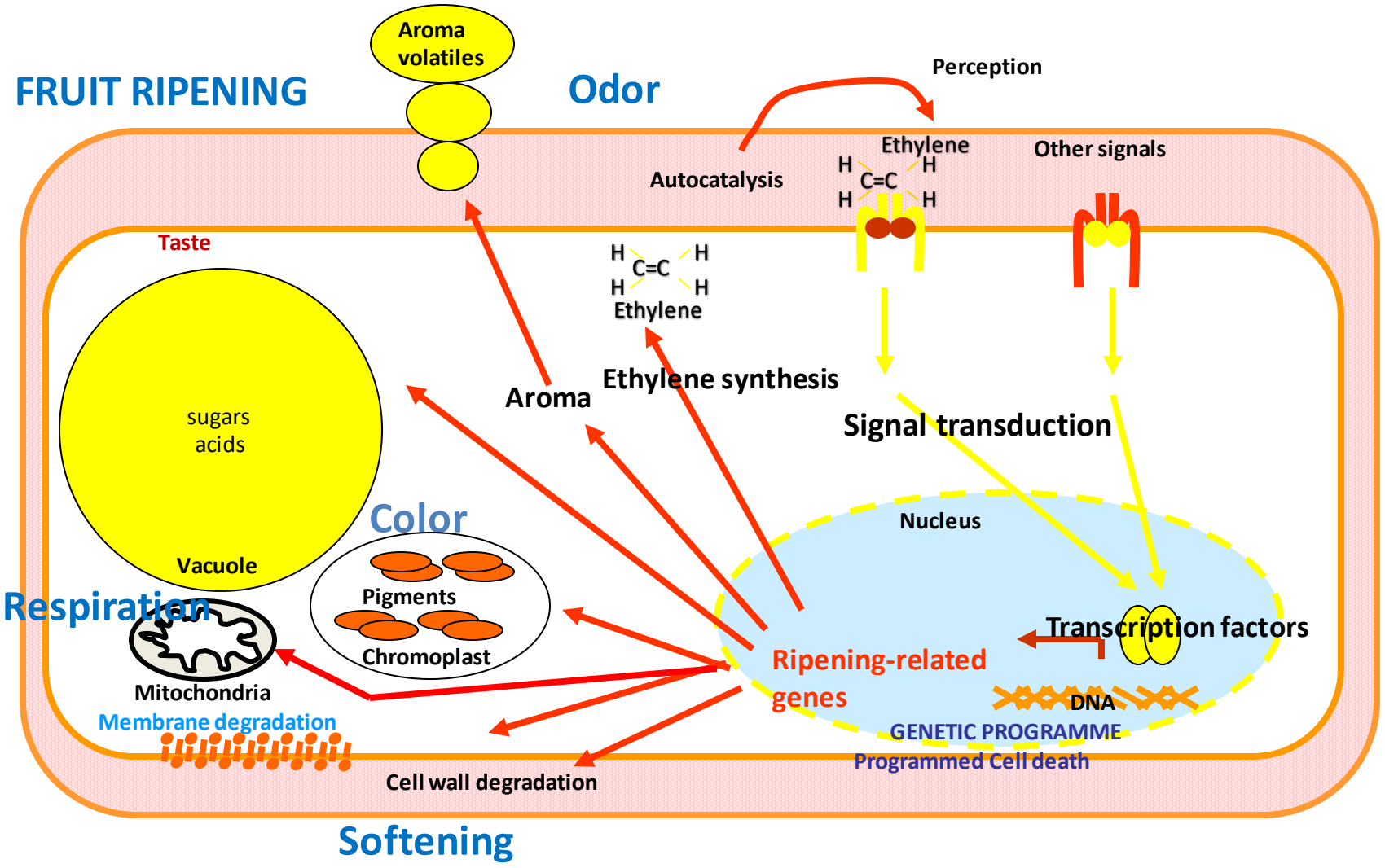
The stress hormones are:

1-Auxin

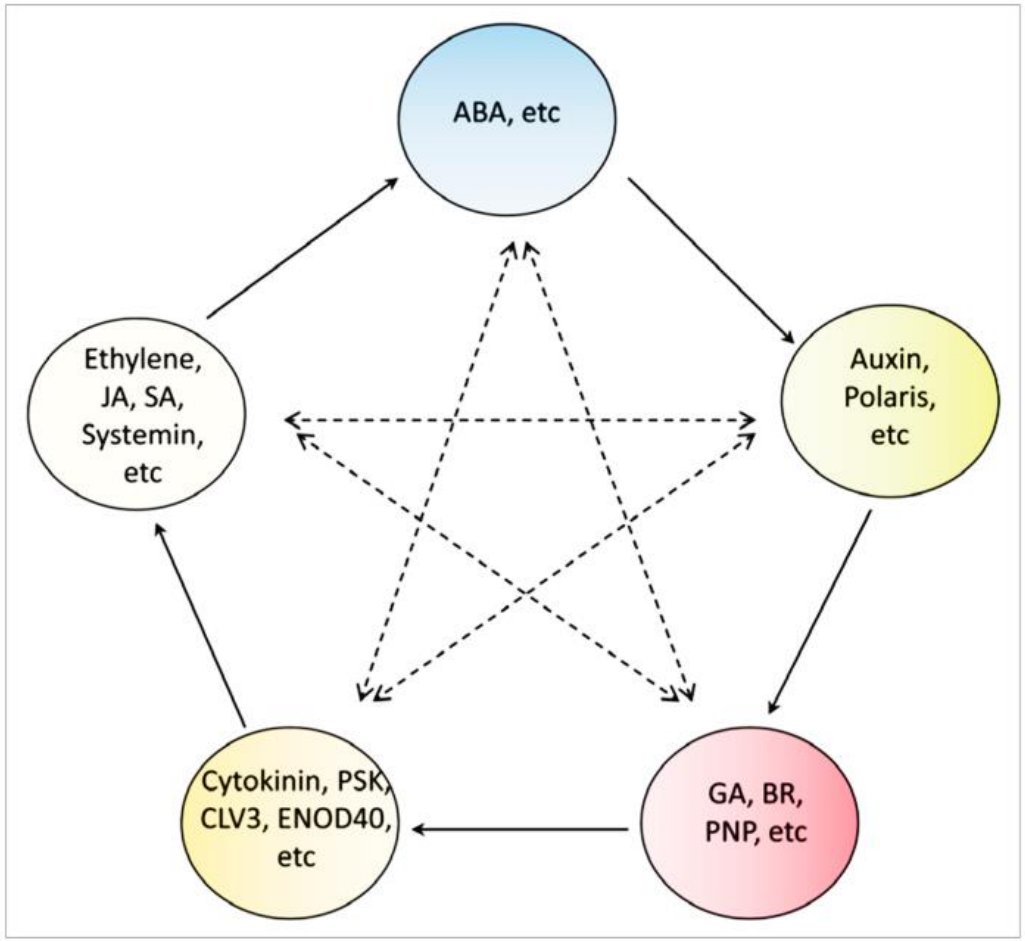
2-Abscisic acid

3-Ethylene

Role of Ethylene in fruit ripening



Plant hormones interaction network

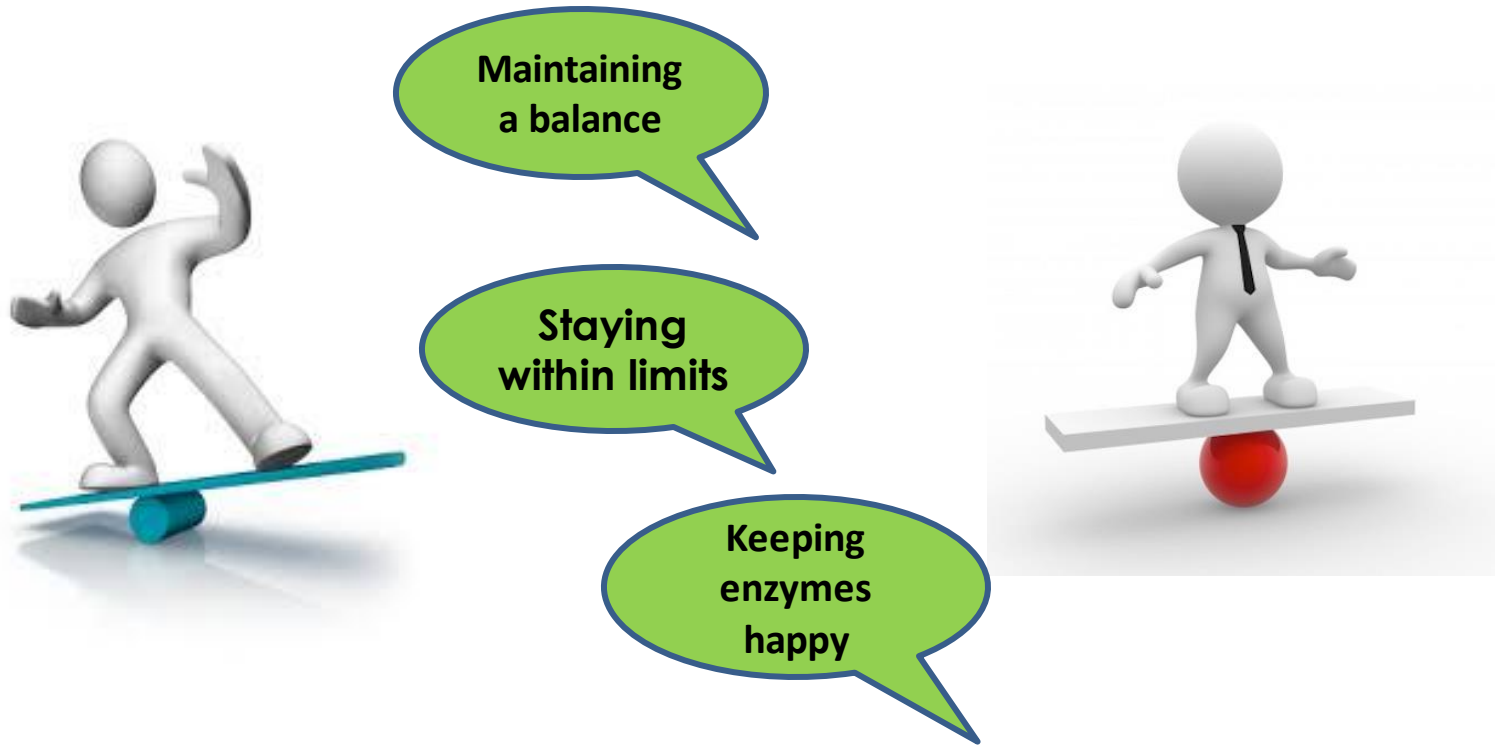


Plant Signaling & Behavior 6:4, 494-500; April 2011

Plant Hormones and PGRs

Endogenous Hormone	Growth Regulators
Auxin	IAA, IBA, NAA, 2,4-D
Cytokinin	kinetin, BA, 2iP, TDZ
Gibberellin	GA_3, GA_{4+7}
Abscisic acid	ABA
Ethylene	Ethephon, Ethrel

Hormones homeostasis in plants



The great balancing act by the negative feedback loop

PGRs application regulations

- Plant Growth Regulators (PGR) are regulated by the DPR as pesticides

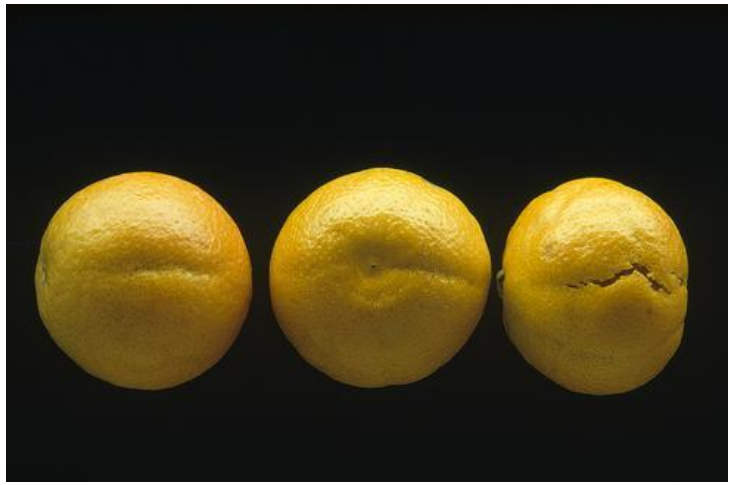
- Handling and application of PGR follow the same pesticide regulations

- Always read the label

- Avoid drift

PGRs role in preventing fruit disorder

Reduce creasing



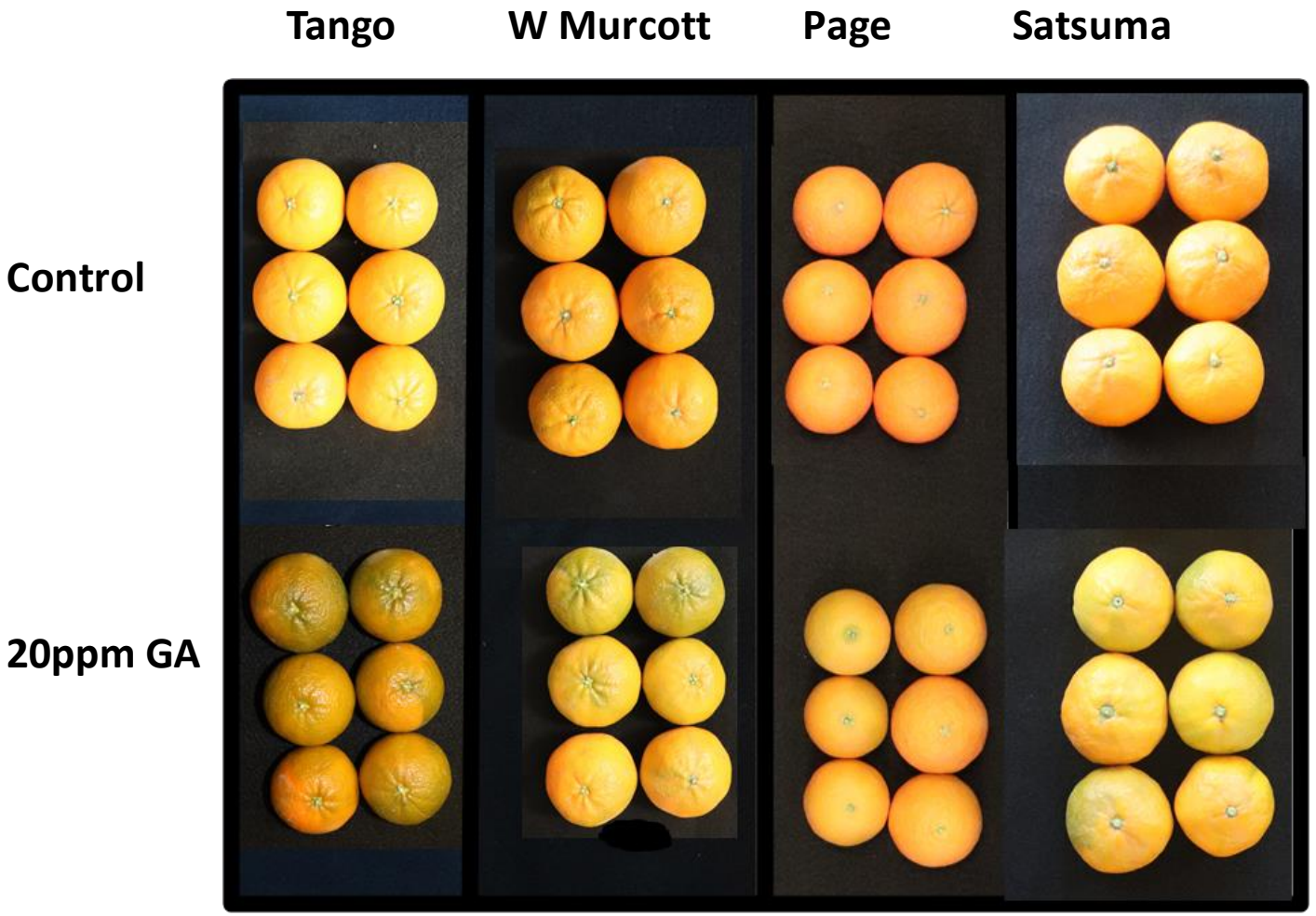
- An uneven appearance develops on the outer surface of rinds when the outer rind has separated from inner fruit. The apparent cause is different growth rates between the inner fruit (endocarp) and the white layer (albedo) under the peel
- GA makes cells more elastic and it can complement other measures to stop creasing
- GA application with the wax can delay rind senescence and reduce water loss during storage

PGRs role in preventing fruit disorder

Preharvest mandarin rind disorder

- ❑ GA at 20 ppm before or at color break stage delays aging and coloration
- ❑ Navel oranges 16-48 g/acre
- ❑ Tangerine hybrid 20-40 g/acre
- ❑ Valencia oranges 40-80 g/acre
- ❑ 1-2 weeks before color break

Varietal differences in response to the same GA concentration



Each hormone acts alone in the plant cell and independently from the others

1- YES

2- NO

PGR and alternate bearing in citrus

Alternate bearing is a problematic phenomenon that occurs in fruit crops :
The “on” crop is characterized by a large number of small fruit in one season followed by the “off” crop typically consisting of few and large fruit

- ❖ Keep the number of fruit bearing reasonably.
- ❖ Fruit **thinning** by PGR
- ❖ No PGR can eliminate completely the alternate bearing

Fruit thinning by NAA (Naphthalene Acetic Acid)

- ❑ Causes changes within the membrane structure
- ❑ Oranges, Tangerines, Tangelos, and Tangors
- ❑ At 5-20 mm fruit diameter
- ❑ Low spary volume is not recomended
- ❑ 200-500mg/Liter
- ❑ One application per year
- ❑ Do not apply within 150 days of harvest
- ❑ Excessive thinning can happen due to high rate or high temperature
- ❑ Do not apply PGR on unhealthy trees

Increase fruit set by Gibberellic Acid (GA3)

- The gibberellins comprise a complex and large group of related compounds which control cell elongation and enzyme secretion
- Improve cell elasticity and pollen grain tube growth
- Increase parthenocarpy (Seedless fruits) in seeded mandarin varieties
- Application of 1-40g/acre at bloom
- Lemons/Lime 10-32 g/acre

Using 2,4-D (2,4-Diclorophenoxyacetic Acid) to reduce fruit drop

- Preharvest fruit drop
- From 15-45 g/acre depends on the crop and the timing
- Far enough ahead of flowering
- Avoid spraying during or before flushes
- 30 g in water is more effective than 45g in hydrated lime (whitewash), it can be applied 3 days before or after
- Can be mixed with GA
- Can be applied at 13 mm fruit diameter to reduce fruit stem dieback and increase the size of the following year's fruits (Grapefruit)
- Can be applied at 19 mm fruit diameter to reduce fruit drop without affecting the size of the following year's fruits (Grapefruit)
- Application to coastal Lemons is risky

Using 2,4-D (2,4-Diclorophenoxyacetic Acid) to increase fruit size

Oranges

One of the following applications:

23g/acre at 5-6 mm

30g/acre at 6-13 mm

38g/acre at 13-16 mm

45g /acre at 16-19 mm

Grapefruit

One of the following applications:

23g/acre at 6-9 mm

30g/acre at 9-16 mm

38g/acre at 16-19 mm

45g /acre at 19-25 mm

NAA (Naphthalene Acetic Acid) to control suckering and tree size

- ❑ Control sprouting from limbs, trunks, and rootstocks
- ❑ Before sprouting
- ❑ Heavy application may damage the tree
- ❑ 500-1500mg/Liter or
  Undiluted formulation (1.15% Ethyl 1-naphthaleneacetate)
- ❑ Do not apply PGR on unhealthy trees

Arpaia et al, 2007, California Avocado Society Yearbook 90: 131-148

PGR can be used to improve the following in the citrus grove:

1-Fruit set
2-Fruit size
3-Fruit color
4-Fruit marketability

Things to consider……

- ✓ Avoid spray drift to other crops
- ✓ Do not apply on young or unhealthy trees
- ✓ Consider the crop and the variety
- ✓ Consider the geographical area where there is more flushes
- ✓ Right physiological stage
- ✓ Respect the rate
- ✓ Good spray coverage, spray volume
- ✓ Read the label twice

Things to consider……

- ✓ Good spray method
- ✓ Avoid temperatures higher than 85ºF
- ✓ Evening or end of the day application
- ✓ Make winter applications during the warmest part of the day
- ✓ Uptake is improved with these application times due to higher relative humidity
- ✓ Surfactants help achieve good spray coverage.
- ✓ Increase efficacy also means increased risks of negative effects, such as excessive leaf drop
- ✓ Twig dieback and rind blemishes have been reported from relatively high adjuvant concentrations

Handling and applying PGRs follow the same regulations as fertilizers

1-YES

2-NO

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