Almond Plant Growth
Regulation & Pest Protection Strategies

Lance Beem,
Beem AgroSciences
Lance’s company Beem Agro Sciences conducts contract research, consulting and demonstrations focused on development of new pesticides, fertilisers, natural products and generally regarded as safe compounds. His business is designed to integrate conventional and non-conventional plant regulation, nutrition and pest management practices. He has extensive expertise in herbicides, insecticides, fungicides, plant hormones, plant extracts, antioxidants, glycoside chemistry. He consults with large and small farmers, companies and individuals seeking registrations. Prior to beginning his own business, Lance was engaged by Stoller Enterprises for numerous years as a Market Development Manager in major and minor crops.
Presentation Outline

• Introduction of California Almond Production

• Introduction of Beem AgroSciences

• Plant Hormones in Almond Production (eg. Roots/Shoots/Bloom)

• Results of Research with Plant Growth Regulating Compounds in Almond Trials.
Introduction California Almond Production
Almond Importance in California

The Scope of the California Almond Industry

Almond orchards span 500 miles from north to south through California’s Central Valley.

- 2014 total acreage: 1,020,000 A
- 2014 bearing acreage: 870,000 A
- 3 growing regions: North, Central, South
- 97,000 almond industry-related jobs generated in Central Valley, 104,000 statewide

100% of Almond Production in USA
Who We Are
Beem AgroSciences
Who and What We Do

Beem AgroSciences, Sacramento, CA

1.) 50% Conventional Product R & D

2.) 50% Organic Product R & D

3.) Trees, Vines, Vegetables, Specialty, etc.
Brief History

Almond Research Trials (1982-2016)

1.) Plant Growth Regulators
2.) Bio-Stimulants
3.) Bio-Regulators
4.) Conventional & Bio-Pesticides
1. Investigations into Pesticides, Plant Growth Regulators and Biologicals
2. Benefit Cost Analysis of Biologicals
3. Greenhouses & Research Farms
4. Replicated Field Trials & Grower Validation Trials.
Biological Plant Products

Derived from:
- Microbials
- Biochemicals
- Minerals

Plant Stress:
Directly benefit plant by actively eliminating pests like weeds, mildew, and bugs.

Plant Health:
Indirectly benefit the plant by acting as a catalyst to stimulate its hormones enhancing plant development

Plant health products (Crop enhancers) are not nutrients, but they improve a plant’s ability to assimilate nutrients by evoking physiological benefits—neither fertilizers or pesticides.

- Bioherbicides
- Biofungicides
- Bioinsecticides
- Bionematicides
- PGR’s*
- Adjuvants
- Inoculants

* PGR’s = Plant Growth Regulators
### REGISTERED BIOPESTICIDE ACTIVE INGREDIENTS BY GEOGRAPHY

<table>
<thead>
<tr>
<th>Geography</th>
<th>Registered active ingredients</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>~400</td>
<td>As of early 2013</td>
</tr>
<tr>
<td>China</td>
<td>85</td>
<td>As of 2011</td>
</tr>
<tr>
<td>EU</td>
<td>79</td>
<td>As of early 2013</td>
</tr>
<tr>
<td>Brazil</td>
<td>26</td>
<td>As of August 2011</td>
</tr>
<tr>
<td>India</td>
<td>15</td>
<td>As of 2008</td>
</tr>
</tbody>
</table>


### TIME AND COST INVESTMENT FOR FOUR AGRICULTURAL PRODUCTS

<table>
<thead>
<tr>
<th>Type</th>
<th>Time to Market</th>
<th>Cost of Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional chemical pesticide</td>
<td>10 years</td>
<td>$260 million</td>
</tr>
<tr>
<td>Genetically engineered trait</td>
<td>8-13 years</td>
<td>$140 million</td>
</tr>
<tr>
<td>Biopesticide</td>
<td>3 years</td>
<td>$8-15 million*</td>
</tr>
<tr>
<td>Biostimulant</td>
<td>1-2 years</td>
<td>$1.5-3 million</td>
</tr>
</tbody>
</table>

Source: CropLife America / ECPA study, CropLife International study 2011, BPIA, Marrone Bio Innovations
Biological Plant Products

UNDERSTANDING How BIOSТИMULANTS Fit

- Genetic potential
- Yield GAP
- Stresses during the growing season reduce crop quality and yield. Biostimulants can help reduce the effects of these stresses and minimize the end of season yield gap.

Benefits of Biostimulants

- Better germination & root development
- Greater vigor and stress resistance
- More efficient energy and nutrient uptake and transport
- Higher crop quality and yield
- Metabolic processes optimized
- Improved forage nutritional value

Beem BioLogic

- 37% Seaweeds
- 12% Microbes, chitin, plant extracts
- 51% Humic & Fulvic Acids

Global Biostimulant Market Share

- 42% Europe
- 13% Latin America
- 21% North America
- 20% Asia Pacific
- 4% Other
It has long been known that the basic unit of most secondary plant metabolites, including terpenes, consists of isoprene, a simple hydrocarbon molecule. The term terpene usually refers to a hydrocarbon molecule while terpenoid refers to a terpene that has been modified, such as by the addition of oxygen. Isoprenoids are, therefore, the building blocks of other metabolites such as plant hormones, sterols, carotenoids, rubber, the phytol tail of chlorophyll, and turpentine.
The Isoprenoid Pathway – a plant based chemical factory
Examples Isoprenes Molecules Interact with Plant Hormones

The isoprene units are always linked 1,4 and head-to-tail in terpenes (the preferred addition orientation even in mineral acid), but are often linked further in bizarre ways to produce rings. Oxygen functional groups are often included, as might be expected from hydrolysis of the pyrophosphate linkage. The diversity of compounds produced is amazing, but the pattern of one methyl group every fourth carbon reveals their origin. The simplest, monoterpines, consist of 2 isoprene units. The stereoisomers of these simplest terpenes provide interesting illustrations of the stereospecificity of odor receptors; for example (+)-(S)-carvone is responsible for the odor of caraway and (-)-(R)-carvone the odor of spearmint.
Plant Hormones
In Almond Production

17th Australian Almond Conference
November 8th - 10th, 2016
What are Plant Hormones?

Chemical Messengers

“.........characterized by the property of serving as chemical messengers, by which the activity of certain organs is coordinated with that of others”.

-Frits Went and Kenneth Thimann, 1937

Frits Went, 1903-1990

Kenneth Thimann, 1904-1997

Frits Went image courtesy of Missouri Botanical Garden ©2010 Kenneth Thimann photo courtesy of UC Santa Cruz
**Plant hormones** regulate cellular activities (division, elongation and differentiation), pattern formation, organogenesis, reproduction, sex determination, and responses to abiotic and biotic stress.
Old & New Plant Hormones

Chemical Messengers

- old timers

Auxin

Cytokinins

Gibberellins

Abscisic Acid

Ethylene

- newcomers

Brassinosteroids

Salicylates

Strigolactones

Jasmonates
Plant Hormone Roles

How hormones work *(25% all plant genes)*

Hormonal control of vegetative development
- Auxin
- Cytokinin
- Strigolactones
- Gibberellins
- Brassinosteroids

Hormonal control of reproduction
- Ethylene
- Abscisic Acid

Hormonal responses to stress
- Salicylates
- Jasmonates

Cross-regulation of hormonal effects
Five Original Plant Hormones

Chemical Messengers

Growth Hormones

- Auxin: The Activator
- Cytokinin: The Dispatcher
- Gibberellic Acid: The Sizer

Stress Hormones

- Ethylene: The Regulator
- Abscisic Acid (ABA): The Terminator

- Plant Hormones regulated Genes
- Plant Hormones respond to Environment.
- Plant Hormones are often Conjugated.
- Plant Hormones are often Eliminated Oxidation
Hormonal responses > abiotic stress

Photo-oxidative stress
High temperature stress
Water deficit, drought
Soil salinity
Air pollution
Wounding and mechanical damage
Cold and freezing stress

Plants’ lives are very stressful.....

ABA and Ethylene help plants respond to stress.

Hormonal responses > biotic stress

Bacteria, fungi, viruses – Biotrophic organisms

Salicylic Acid

Jasmonates
Herbivores – insects, other animals, fungi – Necrotrophic organisms

Photo credits: A. Collmer, Cornell University; Salzbrot.
Plant Hormone Roles

How hormones work (*25% all plant genes*)

Hormonal control of vegetative development

- Auxin
- Cytokinins
- Strigolactones
- Gibberellins
- brassinosteroids

Hormonal control of reproduction

- Ethylene
- abscisic acid

Hormonal responses to stress

- Salicylates
- Jasmonates

Cross-regulation of hormonal effects
Plant Hormone Transport

Chemical Messengers

**Hormones**: Synthesis, transport, perception, signaling and responses

- Production of active hormone
- Conjugation
- Transport
- Binding to receptor
- Signal transduction
- Downstream effects
**Root Tips “Brains” Of The Plant**

Meristematic root tissue responds to the root cap to produce hormones (cytokinin, giberellic acid, & abscisic acid), which together with auxin from the shoots, maintain cell division for root tip growth. If the root tips die, the plant’s “brain” dies and it looses its ability to control hormone cycles and nutrient availability. The plant will lose vigor and eventually die. It is important to feed and maintain a healthy root system.
pdr2 (2d – Pi)
Regulatory Network Controlling Root Meristem Size and Activity

Elongation Zone

Division Zone

Stem Cell Niche

Root Tips “Brains” Of The Plant

Roots are a high source of Cytokinins

Like and infant animal starting out
Balance Hormones in Plants can
Have lifetime implications for orchard.

You should think twice about planting conditions
Cytokinin Hormone

Internal C:Nitrogen Levels

Regulating $N_2$ influences rooting success cuttings

Increased shoot growth

Cytokinin moves up from the roots to stimulate new vegetative shoot growth

High levels of $N_2$ in the soil: Ammonia (NH3) or Nitrate (NO3).
Auxins are made daily in the meristem of the buds & shoots of almond trees & move downward at a speed of approximately 20 cm an hour.

There are 100,000 more auxin in the shoot tips than root tips. But without auxin in root tips there would be no plant growth.
Plant Hormone Movement

Auxin movement - "Polar"

In shoots:
Auxins move **basipetally**
(apex to base)

In roots:
Auxins move **acropetally**
(base to apex)
Vegetative Growth

Cytokinin moves up from the roots to stimulate new vegetative shoot growth.

Auxin moves down from the shoots to stimulate root growth.

Where auxin and cytokinin meet, vegetative buds are formed.

Vegetative buds are differentiated into reproductive buds by ethylene and GA. Ethylene and GA synthesis are stimulated by a higher auxin to cytokinin ratio.
Auxin + Cytokinin stimulate **cell division** giving birth to new cells

**Cell Division:** is important for establishing the type and number of cells needed for normal plant development, vigorous growth and yield **quality**
Plant Hormone Roles

How hormones work (25% all plant genes)

Hormonal control of vegetative development
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Cross-regulation of hormonal effects
Balance of Hormones = vegetative growth: elongation, branching and organogenesis

Hormones: Growth Stages

Gibberellins

Elongation in the shoot and root of a germinating soybean

Germinated seedling

Gibberellins

Growth by elongation

Organogenesis

Growth by branching

Cytokinins

Photo courtesy of Shawn Conley
Stress Generate Oxidation
Plant Hormone Activity

<table>
<thead>
<tr>
<th>Hormones: Deficiencies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gibberellin</strong></td>
</tr>
<tr>
<td>Pea</td>
</tr>
<tr>
<td>Wild type</td>
</tr>
<tr>
<td>Gibberellin biosynthesis mutant</td>
</tr>
<tr>
<td><strong>Auxin</strong></td>
</tr>
<tr>
<td>Arabidopsis</td>
</tr>
<tr>
<td>Wild type</td>
</tr>
<tr>
<td>Auxin response mutant</td>
</tr>
<tr>
<td><strong>Brassinosteroid</strong></td>
</tr>
<tr>
<td>Arabidopsis</td>
</tr>
<tr>
<td>Wild type</td>
</tr>
<tr>
<td>Brassinosteroid biosynthesis mutants</td>
</tr>
</tbody>
</table>

Disrupting hormone synthesis or response interferes with elongation
Phosphate (Pi) Sensing in Root Development

Cell Division Marker
CYCB1::GUS

S
G1
M
G2

Phosphorus Reduction

13 mm
Increasing Ethylene

- Low nitrates: Proper Auxin to Cytokinin ratio
- High nitrates: Increases Ethylene
Sugar Mover at 0.01% increased root hair formation in Arabidopsis
Effect of the "rooting hormone", Auxin = IBA, on hardwood cuttings of the tropical legume, *Inga fueillei*
Plant Hormone Roles

How hormones work (25% all plant genes)

Hormonal control of vegetative development
  Auxin
  Cytokinins
  Strigolactones
  Gibberellins
  brassinosteroids

Hormonal control of reproduction
  Ethylene
  Abscisic Acid

Hormonal responses to stress
  Salicylates
  Jasmonates

Cross-regulation of hormonal effects
Brassinoids, Gibberellins & Cytokinins
During Almond Bloom

- Segundo Maita
- Carlos Sotomayor

Cytokinins = KN
Gibberellins = GA3
Brassinosteroids = BL

http://dx.doi.org/10.1016/j.ejbt.2015.07.004
## Table 1.

Percentage of pollen germination in vitro on Non Pareil and Carmel almond cultivars after 4 h, in the presence of Plant Bio-Regulators in the 2013 and 2014 growing seasons.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>90.0 d</td>
<td>90.9 c</td>
<td>89.2 c</td>
<td>91.9 b</td>
</tr>
<tr>
<td>BL 10 mg L⁻¹</td>
<td>95.3 a</td>
<td>97.7 a</td>
<td>95.5 ab</td>
<td>95.1 a</td>
</tr>
<tr>
<td>BL 30 mg L⁻¹</td>
<td>92.4 cd</td>
<td>94.4 abc</td>
<td>92.6 bc</td>
<td>94.0 ab</td>
</tr>
<tr>
<td>BL 50 mg L⁻¹</td>
<td>91.0 d</td>
<td>91.4 bc</td>
<td>90.4 c</td>
<td>93.6 ab</td>
</tr>
<tr>
<td>GA₃ 10 μL L⁻¹</td>
<td>90.9 d</td>
<td>91.3 bc</td>
<td>92.4 bc</td>
<td>94.3 ab</td>
</tr>
<tr>
<td>GA₃ 30 μL L⁻¹</td>
<td>92.6 bcd</td>
<td>95.2 abc</td>
<td>96.7 ab</td>
<td>94.8 ab</td>
</tr>
<tr>
<td>GA₃ 50 μL L⁻¹</td>
<td>95.1 ab</td>
<td>96.6 ab</td>
<td>96.9 a</td>
<td>95.1 a</td>
</tr>
<tr>
<td>KN 10 μL L⁻¹</td>
<td>90.7 d</td>
<td>92.8 abc</td>
<td>92.9 abc</td>
<td>92.8 ab</td>
</tr>
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<td>94.1 abc</td>
<td>95.9 abc</td>
<td>94.4 abc</td>
<td>94.7 ab</td>
</tr>
</tbody>
</table>

Means followed by the same letter are not statistically different according to the Tukey-Kramer test ($p \leq 0.05$).
PGR Impact on Almond Pollen Tube

Pollen tube length in Non Pareil and Carmel almond cultivars after 8 h, in the presence of Plant Bio-Regulators in the 2013 and 2014 growing seasons (values in μm).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>cv. Non Pareil</th>
<th>cv. Carmel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2013</td>
<td>2014</td>
</tr>
<tr>
<td>Control</td>
<td>937.1 f</td>
<td>945.0 h</td>
</tr>
<tr>
<td>BL 10 mg L⁻¹</td>
<td>1067.4 b</td>
<td>1078.8 b</td>
</tr>
<tr>
<td>BL 30 mg L⁻¹</td>
<td>1032.6 c</td>
<td>1043.0 d</td>
</tr>
<tr>
<td>BL 50 mg L⁻¹</td>
<td>963.9 e</td>
<td>971.6 f</td>
</tr>
<tr>
<td>GA₃ 10 μL L⁻¹</td>
<td>977.0 e</td>
<td>971.7 f</td>
</tr>
<tr>
<td>GA₃ 30 μL L⁻¹</td>
<td>1000.0 d</td>
<td>997.7 e</td>
</tr>
<tr>
<td>GA₃ 50 μL L⁻¹</td>
<td>1100.6 a</td>
<td>1096.0 a</td>
</tr>
<tr>
<td>KN 10 μL L⁻¹</td>
<td>942.0 f</td>
<td>947.3 h</td>
</tr>
<tr>
<td>KN 30 μL L⁻¹</td>
<td>965.1 e</td>
<td>960.6 g</td>
</tr>
<tr>
<td>KN 50 μL L⁻¹</td>
<td>1056.8 b</td>
<td>1066.9 c</td>
</tr>
</tbody>
</table>

Means followed by the same letter are not statistically different according to the Tukey-Kramer test ($p \leq 0.05$).
PGR Impact on Almond Fruit Set

Percentage of fruit set in Non Pareil almond cultivar at 60 days after full bloom, with Plant Bio-Regulators treatments at two phenological stages (2013 and 2014).

Table 3.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Pink Bud</th>
<th></th>
<th>Fallen Petals</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2013</td>
<td>2014</td>
<td>2013</td>
<td>2014</td>
</tr>
<tr>
<td>Control</td>
<td>17.1 d</td>
<td>16.7 d</td>
<td>15.6 c</td>
<td>16.5 c</td>
</tr>
<tr>
<td>BL 10 mg L⁻¹</td>
<td>24.6 ab</td>
<td>22.3 bcd</td>
<td>21.7 abc</td>
<td>22.6 ab</td>
</tr>
<tr>
<td>BL 30 mg L⁻¹</td>
<td>22.5 abcd</td>
<td>19.2 cd</td>
<td>19.5 abc</td>
<td>20.4 abc</td>
</tr>
<tr>
<td>BL 50 mg L⁻¹</td>
<td>22.1 abcd</td>
<td>18.9 cd</td>
<td>17.8 bc</td>
<td>16.7 bc</td>
</tr>
<tr>
<td>GA₃ 10 μL L⁻¹</td>
<td>23.7 ab</td>
<td>26.2 ab</td>
<td>19.8 abc</td>
<td>22.5 abc</td>
</tr>
<tr>
<td>GA₃ 30 μL L⁻¹</td>
<td>27.1 a</td>
<td>28.0 ab</td>
<td>26.2 a</td>
<td>22.7 ab</td>
</tr>
<tr>
<td>GA₃ 50 μL L⁻¹</td>
<td>18.0 cd</td>
<td>22.7 bcd</td>
<td>20.6 abc</td>
<td>19.8 abc</td>
</tr>
<tr>
<td>KN 10 μL L⁻¹</td>
<td>20.1 bcd</td>
<td>22.7 bcd</td>
<td>22.1 ab</td>
<td>19.8 abc</td>
</tr>
<tr>
<td>KN 30 μL L⁻¹</td>
<td>23.5 abc</td>
<td>24.8 abc</td>
<td>23.7 ab</td>
<td>25.6 a</td>
</tr>
<tr>
<td>KN 50 μL L⁻¹</td>
<td>25.8 ab</td>
<td>31.0 a</td>
<td>22.1 ab</td>
<td>24.0 a</td>
</tr>
</tbody>
</table>

Means followed by the same letter are not statistically different according to the Tukey–Kramer test (p ≤ 0.05).
Plant Hormone Roles

How hormones work (*25% all plant genes*)

Hormonal control of vegetative development
- Auxin
- Cytokinins
- Strigolactones
- Gibberellins
- Brassinosteroids

Hormonal control of reproduction
- Ethylene
- Abscisic Acid

Hormonal responses to stress
- Salicylates
- Jasmonates

Cross-regulation of hormonal effects
Problems from adverse temperatures are due to a lack of growth hormone production in the plant.

- High Heat Ethylene suppresses Auxin

Graph showing Auxin levels, Pollination vigour, and Temperature with different production levels at various temperatures.
Reducing poor pollination

Lack of sufficient hormones responsible for cell differentiation and cell division

**Auxin levels**

**Temperature**

Ethylene
What is Ethylene?

- **Ethylene** is a natural plant hormone that affects many processes
  - Nut/Fruit Set
  - Flower Development
  - Fruit Ripening
  - Flower/Fruit Abscission
Plant Health Regulating Compounds During Almond Bloom
Valent Anti-Ethylene PGR Use During Almond Bloom
How Does ReTain Work in Almonds?

- ReTain reduces ethylene evolution in almond flowers and delays flower and stigmatic senescence. This effect results in flowers being viable longer, which allows more time for pollination to occur. Increasing set and potential yield.
# How to Use ReTain on Almonds

<table>
<thead>
<tr>
<th>Use Rate</th>
<th>1 water-soluble pouch/A (333 grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Application Method</strong></td>
<td>Ground (air blast sprayer)</td>
</tr>
<tr>
<td><strong>Timing</strong></td>
<td>From 10% bloom to petal fall (recommended timing: 30–60% bloom)</td>
</tr>
<tr>
<td><strong>REI / PHI</strong></td>
<td>12 hours / 0 hours (none required)</td>
</tr>
<tr>
<td><strong>Rainfastness</strong></td>
<td>8 hours after application</td>
</tr>
<tr>
<td><strong>MRLs</strong></td>
<td>No residue restrictions for export markets</td>
</tr>
</tbody>
</table>
*ReTain* effectively delayed bloom senescence in almonds, thus improving the chances for pollination by 43%.

Source: Valent
ReTain Extends the Pollination Period

Trial Location: Firebaugh, CA
ReTain applied on 2/17/16, 1 bag/A in 100 gpa
Pictures taken on 2/23/16 (6 DAT), Variety: Monterey

ReTain effectively delayed bloom senescence in almonds, thus improving the chances for pollination by 43%

Source: Valent
Replicated Commercial Trials (2014-2016)

Nonpareil (32 sites)

ReTain

+ 185

2768

UTC

2583

Yield (pounds nutmeats/acre)

P=0.01

7.2%
What is Ethylene?

• **Ethylene** is a natural plant hormone that affects many processes
  - Nut/Fruit Set
  - Flower Development
  - Fruit Ripening
  - Flower/Fruit Abscission
Bayer & BASF Fungicides During Almond Bloom
 Suppresses Ethylene, Increases Mitochondria

ALMOND YIELD – 2013 and 2014
Luna Sensation vs. Pristine
Bloom Application at Various CA Locations

Average

No disease pressure observed at any site.

4.1%
ALMOND YIELD – 2015
Luna Sensation vs. Merivon
Bloom Application at Various CA Locations

suppresses Ethylene, increases mitochondria
• Flower Power™ is a complex micronutrient and antioxidant with growth enhancing co-factors resulting in increased fruit set and crop yield.

• Flower Power increases Auxin, the hormone that dictates pollination, in every flower for stronger pollination. Poor pollination is a common problem on many perennial trees, vines, bushes, and multiple fruiting crops resulting in lower yields.
- Boron 3.8%
- Copper 0.1%
- Molybdenum 0.02%
- Zinc 5.0%
- Proprietary Co-Factor
Nutrients and hormonal activity

- B  - Boron reduces IAA oxidase.
- In other words, it increases the half-life of IAA. This is extremely important in the pollination stage.
  - If temperatures are too hot
  - If temperatures are too cool
  - If soils are too dry
- Boron deficiencies will cause poor pollination and physiological problems with seed formation in any crop.
Problems from adverse temperatures are due to a lack of growth hormone production in the plant. High heat ethylene suppresses auxin levels, affecting pollination vigour and temperature production.
Reducing poor pollination

Lack of sufficient hormones responsible for cell differentiation and cell division

Ethylene

Auxin levels

Temperature

5°C 10°C 15°C 20°C 25°C 30°C 35°C
Low Level Low production Very High Level High production Low Level Low production

+ Zinc, Boron & Calcium + Co-factors
+ Zinc & Boron
• Zn - Zinc is necessary to convert Tryptophan to Auxin = IAA. The lack of Indole Acetic Acid in new plant tissue (new leaves) inhibits cell division and causes new leaves to become yellow and small.
Almond Trees

Treatments:

• Hold Program – X-Press at 4 litres/ ha + Action 5 at 4 litres/ ha

• Flower Power at 2.5 litres/ ha and SETT at 2.5 litre/ha

• Control
Almond yield increases

Total Yield %
Average Yields 2250kg/ ha

Percentage Nuts

<table>
<thead>
<tr>
<th>Treatment</th>
<th>15% increase</th>
<th>25% increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flower Power</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Hold Program</td>
<td>25</td>
<td></td>
</tr>
</tbody>
</table>
Almond yield increases

Total Yield %
Average Yields 2250kg/ha

378kg/ha
15% increase

563kg/ha
25% increase
Almond yield increases

Potential Yield
Average Price at A$5.00/ kg

$A1,890/ ha

$A2,815/ ha
ROI almond yield increases

Potential Yield
Nutrient Spray plus labour and machinery cost

$1:$7.71  
$1:$5.63

Percentage Nuts

0 5 10 15 20 25 30

Flower Power  Control  Hold Program

Treatment
Flower Power Almond Trial Calif.

University of California, Merced, CA - Dr. Bill Weir 2011

Almond Nut % Retention

Untreated Check

BioForge @ 1 pt/A + Flower Power @ 2 pt/A

@ Pink Bloom Time

Means followed by same letter do not significantly differ (P<.05, Student-Newman-Keuls)
Mean comparisons performed only when ANOVA Treatment P/F is significant at mean comparison OSL
Stoller’s Sugar Mover
Sugar Mover Analysis

- Sugar Mover
- Boron 10%
- Moly 0.13%
- Plus Stoller’s Co-Factors which enhance Auxin & Cytokinin Balance in Fruit Buds
Sugar Mover Analysis

- Redirects plant food (sugar, carbohydrates, metabolites) from the apical meristems in the leaves to the buds, fruit and roots
- Shorten internode length
- Used to increase sugar levels and bulking prior to harvest
Stoller’s Sugar Mover Trials
Walker Flat, South Australia

17th Australian Almond Conference
November 8th - 10th, 2016
Sugar Mover Trial Aim

- Increase Flower Bud Development for the following season in Almonds.
- Increase yield by 15% in the following years harvest.
- Can be applied with current spray program, compatible with fungicides.
Stoller’s Sugar Mover Trial

Buds per metre stem

Control | Treated
---|---
15 | 30 (62% Increase)

Flower set %

Control | Treated
---|---
25 | 25 (SAME SET %)
Trees without Sugar Mover
Trees with Sugar Mover
• Reduced flower buds
• Flower buds on new wood
Grower View – Sugar Mover

Sugar Mover

Control
Cost-Benefit of Sugar Mover

- Sugar Mover application cost $60 per Ha (product only)

Actual yield increase of = 1046 Kg

Price per kg = $3.50

Total return per Ha = $3661.00

Return on Investment = 61 to 1

Final results after 2011 - 2012 harvest
Stoller’s Sugar Mover Trials
Virginia, South Australia
### Sugar Mover demonstration

#### Results summary

<table>
<thead>
<tr>
<th>Rootstock/Block</th>
<th>Treated/Untreated</th>
<th>Average Fruit set</th>
<th>Improvement (treated&gt;control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almond - Robert Rd</td>
<td>Treated</td>
<td>27.78</td>
<td>17.5%</td>
</tr>
<tr>
<td>Almond - Robert Rd</td>
<td>Control</td>
<td>23.64</td>
<td></td>
</tr>
<tr>
<td>Hybrid – 99 Planting</td>
<td>Treated</td>
<td>33.93</td>
<td>43.6%</td>
</tr>
<tr>
<td>Hybrid – 99 Planting</td>
<td>Control</td>
<td>24.24</td>
<td></td>
</tr>
<tr>
<td>Nemaguard – Homeblock 1</td>
<td>Treated</td>
<td>23.91</td>
<td>134.2%</td>
</tr>
<tr>
<td>Nemaguard – Homeblock 1</td>
<td>Control</td>
<td>10.21</td>
<td></td>
</tr>
</tbody>
</table>
Observations

• The 2006 season was excellent for flowering and pollination. There were a high number of bud chilling hours.

• The trees treated in the trial all showed an improvement in fruit retention over the control and this benchmark.
  
  • The average percent fruit set on all treated almond trees was 28.54%
  • The average percent fruit set on all control almond trees was 19.36%

• The most impressive increase in fruit retention was in the older nemaguard root stock trees where the control had poor fruit retention and retention was increased from approximately 10% to 24%
Saponins are natural transporter of Auxins in Phloem and Cytokinins in the Xylem. They are found widespread in Desert Plants. Natural Plant Hormones and Natural Antioxidants. Thus Nature’s own Plant Growth Regulators. Like Ocean Sea Plants rich in Isoprenes very usually in Agriculture.
Desert Plant Extracts Almond Trials

Desert Plant Extracts (Yucca, Quillaja & Guayule = ISO Extract)

The Isoprenoid Pathway – a plant based chemical factory
Desert Plant Extract on Row Crops

UC Desert Research Center 2013
Holtville, California
Dr. Becky Westerdahl, UC Davis Plant Nematologist

2013-2014 DREC SUGARBEET TRIAL
CYST NEMATODE / LITER OF SOIL
Desert Plant Extract on Row Crops

UC Desert Research Center 2013
Holtville, California
Dr. Becky Westerdahl, UC Davis Plant Nematologist

2013-2014 DREC SUGARBEET TRIAL TONS / ACRE
Desert Plant Extract on Row Crops

26% Increase

0.9690 Kilograms (Treated) 0.7685 Kilograms (Control)

ISO EXTRACT 10% 1 pt/Acre x 3 apps

July 29, 2016
Desert Plant Extract on Fruit Crops

Arona Blueberry Variety, Washington, 2016

Untreated vs Treated ISO

Largest Blueberry Grower in Washington State
Promoted earlier maturity and market timing.
Reported 41% yield increase, Higher BRIX
and Improved Berry Color. 12.3% increase in
individual berry weight at harvest time after 3
applications @ 1 pt/Acre starting at petal fall,
followed by two weeks later and then two weeks
prior to harvest. This is after 2 apps above.
Desert Plant Extract on Almond

Almond (Peerless) Trial 2016

ISO EXTRACT 10% @ 2 pts/100 GPA

90 Days Post Application

31% increase in Weight

ISO EXTRACT 10% @ Full Bloom
1 application
2 pts/100 GPA

Untreated Check
Desert Plant Extract on Almond

Almond (Peerless) Trial 2016

ISO EXTRACT 10% @ 2 pts/100 GPA

Untreated Check

ISO EXTRACT 10% @ Full Bloom
1 application 2 pts/100 GPA

Double Kernels
Almond (Peerless) Trial 2016
ISO EXTRACT 10% @ 2 pts/100 GPA

Hull Length mm

Means followed by same letter or symbol do not significantly differ (P=.05, Duncan's New MRT)
Mean comparisons performed only when AOV Treatment P(F) is significant at mean comparison OSL

June 3rd Evaluation (25% increase in Nut Retention)
June 3rd Evaluation (31% increase in Hull/Nut Weight)
Aug 28th Harvest  (22% increase in Total Yield)
Non-Pareil Nut Retention & Yield

Non-Pareil Almonds

Guayule Extract 10%

Yucca Quillaja Extract 36%

Percent Nut Retention & Yield (Hull+inShell Nut)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>%Ret 4/1</th>
<th>%Ret 5/3</th>
<th>Total Wt (lbs)</th>
<th>lbs in-shell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>29.34</td>
<td>25.72</td>
<td>24.01</td>
<td>5.78</td>
</tr>
<tr>
<td>Stoller Multiple Soil Treats</td>
<td>32.85</td>
<td>28.85</td>
<td>26.83</td>
<td>5.83</td>
</tr>
<tr>
<td>Flower Power 3 pts/Acre</td>
<td>29.64</td>
<td>27.43</td>
<td>17.67</td>
<td>7.15</td>
</tr>
<tr>
<td>Flower Power 6 pts/Acre</td>
<td>32.86</td>
<td>29.39</td>
<td>28.06</td>
<td>7.54</td>
</tr>
<tr>
<td>ISO EXTRACT 30% @ 2 pts/Acre</td>
<td>38.00</td>
<td>35.63</td>
<td>38.00</td>
<td>7.31</td>
</tr>
<tr>
<td>Gra Active @ 2 pts/Acre</td>
<td>34.29</td>
<td>30.97</td>
<td>14.49</td>
<td>7.31</td>
</tr>
</tbody>
</table>

31% 30% 32% 27%
Summary for Almond Production

Plant Hormones Are Powerful
By Plant Hormone Mimics
By Plant Growth Transporters
By Anti-Oxidants and Plant Extracts
By Selected Blends of Nutrients
Yield Increases Range from 7-30%
Thanks and Good Day