Plant Growth Regulation Products – Potential for Increasing Low Desert Production Values

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Wide diversity of crops in the low desert!
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With this wide variety of crops, what’s the probability that plant growth regulation products can not increase crop production values of at least one (or more) crops?
Plant Growth Regulation Use Areas

• HARVEST AID

• GROWTH REDUCTION

• GROWTH/COLORATION INCREASE

• STRESS/DISEASE MANAGEMENT
HARVEST AID

• Dessicants

• Defoliants

• Boll Openers (enhancers/accelerants)
Plant Defoliation

- In low desert agriculture this is mainly cotton
- There are a number of products such as DEF, ET, Sodium chlorate, etc.
Most products are single mode of action, but there are a few products that contain multiple modes, including an auxin transport inhibitor. That latter would be considered a plant growth regulator.
Growth Regulators

• Products that slow/temporarily stop production of various plant hormones.

• There are a number of chemistries in this area.
### Plant Growth Regulators

#### GIBBERELLIC ACID INHIBITORS
- Mefluidide (Embark)
- Mepiquat Chloride (Pix, etc.)
- Prohexadione calcium (Apogee)
- Trinexapac-ethyl (Palisade, Primo Maxx, etc.)

#### AUXIN TRANSPORT INHIBITORS
- Cyclanalide
Potential applications for PGRs (anti-GA products in local agriculture)

• Current widespread uses = cotton

• Cool Season Seed Crops – to prevent lodging and increased harvest efficiency (and potential higher yields) (wheat, small grains, etc.)

• Apples and other trees - vegetation management

• Some PGRs can prevent/lessen seed head development.

• Alfalfa seed production?

• Use in lawns/turf to reduce grass growth

  Possibility for increasing hay quality of cool season grasses?
Recent Plant Growth Regulators
Keeping cool season grass stems shorter by limiting GA production

- Shorter stems
- Less lodging
- Easier and faster harvest
Can we increase alfalfa quality by shortening internodes and do it economically?
The answer is “yes” and “no” (or is the correct answer “it depends”)

- Multiple cuttings involved over the summer, 1 application/cutting

- All PGR applications (Apogee) reduced yields

- Increase in May harvest quality from ‘good’ to ‘premium’, but not in other later summer harvests

- Price differential for the May cutting was not economical when only $20/ton existed between good and premium quality classes
Bermudagrass seed production and growth retardants: Can we make harvest go faster by decreasing volume to be threshed?
Bermudagrass leaf height (cm) Oct. 3, following plant growth regulator application on September 18, 2003

- Apogee 7 oz: 19.5
- Apogee 14 oz: 21.9
- Apogee 29 oz: 18.6
- Palisade 1 pt: 20.6
- Palisade 2 pts: 20.2
- Palisade 3 pts: 18.6
- Palisade 4 pts: 16.8
- Untreated: 24
‘Cheyenne’ Bermudagrass leaf height (cm) Nov. 7-8, following plant growth regulator application on September 18 and Oct. 3, 2003

- Apogee 7 oz: 26.9
- Apogee 14 oz: 24.8
- Apogee 29 oz: 25.9
- Apogee 7 + 7 oz: 24.1
- Apogee 14 + 14 oz: 23.9
- Palisade 1 pt: 23.9
- Palisade 2 pts: 22.6
- Palisade 3 pts: 21.6
- Palisade 4 pts: 19.5
- Palisade 1 + 1 pt: 21.7
- Palisade 2 + 2 pts: 20.6
- Untreated: 26.6
‘Cheyenne’ bermudagrass percent leaf height reduction  Nov. 7-8, following plant growth regulator application on September 18 and Oct. 3, 2003

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Percent Reduction</th>
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<tbody>
<tr>
<td>Apogee 7 oz</td>
<td>1.1</td>
</tr>
<tr>
<td>Apogee 14 oz.</td>
<td>6.8</td>
</tr>
<tr>
<td>Apogee 29 oz.</td>
<td>2.6</td>
</tr>
<tr>
<td>Apogee 7 + 7 oz</td>
<td>9.4</td>
</tr>
<tr>
<td>Apogee 14 + 14 oz.</td>
<td>10.2</td>
</tr>
<tr>
<td>Palisade 1 pt</td>
<td>26.7</td>
</tr>
<tr>
<td>Palisade 2 pts</td>
<td>18.8</td>
</tr>
<tr>
<td>Palisade 3 pts</td>
<td>18.4</td>
</tr>
<tr>
<td>Palisade 4 pts</td>
<td>22.6</td>
</tr>
<tr>
<td>Palisade 1 + 1 pt</td>
<td></td>
</tr>
<tr>
<td>Palisade 2 + 2 pts</td>
<td></td>
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</tbody>
</table>
Faster seed combining speed (less stem to separate from seed) = Less Time in the field (& less wear and tear on combine)

Time = $$$
‘Cheyenne’ bermudagrass seed extended/open inflorescences/sq. ft. on Nov. 7-8 following application of Apogee or Palisade (Sept. 18, Oct. 3, 2004)

- Apogee 7 oz: 86.5%
- Apogee 7 + 7 oz: 65.3%
- Apogee 14 oz: 64.6%
- Apogee 14 + 14 oz: 71.2%
- Apogee 29 oz: 58.7%
- Palisade 1 pt: 73%
- Palisade 1 + 1 pt: 59.2%
- Palisade 2 pts: 52%
- Palisade 2 + 2 pts: 36.6%
- Palisade 3 pts: 48.5%
- Palisade 4 pts: 33%
- Untreated: 86.5%
‘Cheyenne’ Bermudagrass seed production (million seeds/acre) resulting from application of Apogee or Palisade

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Seed Production (million seeds/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apogee 7 oz</td>
<td>9.03</td>
</tr>
<tr>
<td>Apogee 14 oz</td>
<td>6.15</td>
</tr>
<tr>
<td>Apogee 29 oz</td>
<td>6.13</td>
</tr>
<tr>
<td>Apogee 7 oz + 7 oz</td>
<td>7.22</td>
</tr>
<tr>
<td>Apogee 14 oz + 14 oz</td>
<td>6.13</td>
</tr>
<tr>
<td>Palisade 1 pt</td>
<td>7.28</td>
</tr>
<tr>
<td>Palisade 2 pts</td>
<td>4.95</td>
</tr>
<tr>
<td>Palisade 3 pts</td>
<td>4.33</td>
</tr>
<tr>
<td>Palisade 4 pts</td>
<td>2.97</td>
</tr>
<tr>
<td>Palisade 1 + 1 pt.</td>
<td>6.02</td>
</tr>
<tr>
<td>Palisade 2 + 2 pts</td>
<td>3.78</td>
</tr>
<tr>
<td>Untreated</td>
<td>8.43</td>
</tr>
</tbody>
</table>
What about combinations of growth inhibitors?

- Two active ingredients:
  - 1) Cyclanalide (2.1%)
  - 2) Mepiquat chloride (8.4%)
DPL 164B2RF cotton response to Stance or Mepiquat Chloride application, Ripley, CA

Lbs. lint/acre

- Stance 2 oz.: 1832 lbs. lint/acre
- Stance 3 oz.: 1774 lbs. lint/acre
- Mepiquat chloride 12 oz.: 1775 lbs. lint/acre
- Untreated: 1716 lbs. lint/acre
What is easier to do?
It is easier to destroy than to build
The same is true in biological systems!
It is much easier to kill/prevent/reduce growth/other aspect
It is much easier to kill/prevent/reduce growth/other aspect than it is to increase growth and yields due to the multiplicity of systems involved.
Plant hormones & growth

Control of cell division (cytokinins and gibberellic acid)
Control of stem elongation (auxin and gibberellic acid)
Initiation of flowering (flowering hormone from leaves?)
Stomatal closure (abscisic acid)
Growth of young fruits (cytokinins); induction of fruit ripening (ethylene)
Development of abscission zone (ethylene and auxin)

Hormonal Interactions Influence Plant Growth and Development

Gravitropism of roots (auxin)
There are multiple classes of plant hormones, with each class having multiple chemistries

**Historical/Traditional classes:**
- Cytokinins
- Abscisic acid
- Gibberellic acids
- Ethylene
- Auxins

**More recently recognized classes:**
- Brassinosteroids
- Oligosaccharides
- Polyamines (PAs)
- Complex Polymeric Polyhydroxyic Acids (CPPA)
- Others (?)
- GABA, Jasmonic Acids, etc.
Major classes (very powerful hormones)

- Cytokinins
- Abscisic acid
- Gibberellic acids
- Ethylene
- Auxins
Cytokin
Bioregulator Concentrate

A Plant Bioregulator to Increase Crop Production Efficiency

ACTIVE Ingredients:
Cytokin, as kinetin, based on biological activity ............... 0.01%

Includes:
6-(4-hydroxy-3-methylbut-trans-2-enylamino)-purine
N²-methylaminopurine,
N²-dimethylaminopurine,
N²-isopentenylnaminopurine

Other Ingredients ........................................... 99.99%
Total ....................................................... 100.00%

KEEP OUT OF REACH OF CHILDREN

CAUTION

Harmful if swallowed or absorbed through the skin! Causes skin irritation! Do not breath vapor or spray mist.
Do not get in eyes, on skin, or on clothing. Wash thoroughly with soap and water after handling.

Statement of Practical Treatment

If swallowed: Call a physician or Poison Control Center. Drink 1 or 2 glasses of water and induce vomiting by
touching back of throat with finger. Do not induce vomiting or give anything by mouth to an unconscious person.
If on skin: Wash skin with soap and water.
If in eyes: Flush with plenty of water. Get medical attention if irritation persists.

SEE INSTRUCTIONS FOR ADDITIONAL PRECAUTIONARY STATEMENTS

Produced for Plant BioTech, Inc., Deming, NM 88030 USA
EPA Registration Number 58199-1
EPA Establishment #211-KS-1
Net contents: 2.5 gallons (9.45 liters)
Net weight: 24 lbs. (10.8 kgs.)

©Cytokin is a registered trademark licensed to Plant BioTech, Inc.
Cytoplex®

A PLANT HORMONE SUPPLEMENT

Active Ingredients:
Cytokinin (as kinetin, based on bioassay) ................................................................. 0.010%
Includes:
- 6-(4-hydroxy-3-methylbut-trans-2-enylamino)-purine
- N⁵-methylaminopurine,
- N⁵-dimethylaminopurine,
- N⁵-isopentenylaminopurine

Auxin:
- Indole-3-butyric acid ................................................................. 0.005%
Gibberellin:
- Gibberellic acid A₃ ................................................................. 0.004%

Other Ingredients ................................................................. 99.981%

Total ................................................................. 100.000%

KEEP OUT OF REACH OF CHILDREN

CAUTION
Harmful if swallowed or absorbed through the skin! Causes skin irritation! Do not breath vapor or spray mist.
Do not get in eyes, on skin, or on clothing. Wash thoroughly with soap and water after handling.

Statement of Practical Treatment

In case of contact with skin: For eyes or skin irritations, use water to flush eyes for 15 minutes and wash skin with soap and water.

In case of ingestion: Do not inducing vomiting. Give 2-3 glasses of water. In case of accidental ingestion, call a professional immediately.

In case of exposure to the vapors: Remove to fresh air. If symptoms persist, call a professional immediately.

In case of exposure to the mist: Remove to fresh air. Wash face and hands with soap and water. In case of symptoms, call a professional immediately.

In case of accidental contact with the skin: Wash skin with soap and water. In case of symptoms, call a professional immediately.

In case of accidental contact with the eyes: Wash eyes with water for 15 minutes. In case of symptoms, call a professional immediately.

In case of accidental ingestion: Do not inducing vomiting. Give 2-3 glasses of water. In case of accidental ingestion, call a professional immediately.

In case of accidental exposure to the vapor: Remove to fresh air. In case of symptoms, call a professional immediately.

In case of accidental exposure to the mist: Remove to fresh air. Wash face and hands with soap and water. In case of symptoms, call a professional immediately.
Effects of GA$_3$ on grape size
RyzUp SmartGrass

- Gibberellin A₃

- Product used to increase grass re-growth in rotational grazing systems in New Zealand, etc.

- This formulation initially used in southeastern U.S. on winter pasture grasses
Factors that Effect and Biostimulant/Growth Enhancement Effects

- Crop
- Crop Variety
- Biostimulant Rate
- Herbicide
- Growing Environment
- Surfactant
- Timing and Application Method
- Fertility Levels
Growth Response differences to plant hormones and biostimulants
Rate Study – Smooth Brome
0.3, 0.6 and 0.9 oz./acre
Rate Study – Large Plots
Strange things happening!
Smooth Brome Rate Study
Strange things happened!
13 DAT
Differences due to surfactant used with product
Factors that Effect and Biostimulant/Growth Enhancement Effects

- Crop
- Crop Variety
- Biostimulant Rate
- Herbicide
- Growing Environment
- Surfactant
- Timing and Application Method
- Fertility Levels
Soybean growth differences at 8 days post treatment
Mean Soybeans/Plant at Harvest Resulting from Gibberellic Acid (GA-3) Application at Various Stages of Early Development, Rising City, Nebraska, 2016

Beans/Plant

- UNTREATED
- UNIFOLIATE
- V-1
- V-2
- V-3
- UNIF + V-1
- UNIF + V-2
- UNIFOL + V-3

119 119.5 113.4 118 110.7 134.8 139.1 124.8
There are multiple classes of plant hormones, with each class having multiple chemistries

**Major classes:**
- Cytokinins
- Abscisic acid
- Gibberellic acids
- Ethylene
- Auxins

**More recently recognized: Minor classes:**
- Brassinosteroids
- Oligosaccharides
- Polyamines (PAs)
- Complex Polymeric Polyhydroxyic Acids (CPPA)
- Others on the periphery GABA, Jasmonic Acids, etc.
Do chemicals that signal the plant to grow (rather than reduce plant growth) actually bridge the gap between “potential” and “reality of increased profits”?
There are lots of products out there that claim to increase plant growth.

Do any of them provide consistent and economical production returns?
Low Desert Cotton Results
Mixed chemistries
BM86 - Polyamine related product

- Contains GA 142
- Strengthens flower structures responsible for pollination
- Enhances cell formation
- Promotes production of polyamines and other substances that are necessary for a wide range of metabolic reactions
- Provides a nutrient package that efficiently aids in the conversion of photosynthates to carbohydrates and in protein synthesis
Polyamine (PA) low desert research results

Lbs lint/acre

Mepiquat chloride 16 oz: 1520 lbs
Mepiquat Chloride 24 oz: 1571 lbs
BM86 32 oz: 1566 lbs
BM862 32 oz. _ Mep. Chlor 12 oz: 1810 lbs
Untreated: 1681 lbs
Polyamine (PA) low desert research results

$ value/acre

- Mepiquat chloride 16 oz: $881
- Mepiquat Chloride 24 oz: $911
- BM86 32 oz: $908
- BM862 32 oz: $1035
- Untreated: $858
Bermudagrass seed production and plant growth regulators Can we increase yields with GABA?
Bermudagrass seed germination percentages following treatment with GABA and/or surfactants
Bermudagrass seed yields (lbs. Pure Live Seed/acre) following GABA application on June 8, 2004, Blythe, CA

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar 3 oz.</td>
<td>395</td>
</tr>
<tr>
<td>CalMax 1 qt</td>
<td>400</td>
</tr>
<tr>
<td>Foliar Pride 1 qt</td>
<td>451</td>
</tr>
<tr>
<td>AuxiGro 1 oz.</td>
<td>400</td>
</tr>
<tr>
<td>AuxiGro 2 oz</td>
<td>509</td>
</tr>
<tr>
<td>AuxiGro 4 oz.</td>
<td>491</td>
</tr>
<tr>
<td>AuxiGro 8 oz</td>
<td>437</td>
</tr>
<tr>
<td>AuxiGro 4 oz + CalMax</td>
<td>457</td>
</tr>
<tr>
<td>AuxiGro 4 oz + Foliar Pride 1 qt</td>
<td>420</td>
</tr>
<tr>
<td>Untreated</td>
<td>410</td>
</tr>
</tbody>
</table>
Dehydrator onion response to GABA
Tons dehydrator onion yields/acre at harvest following GABA application

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Tons/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>AuxiGro 4 oz. April 16</td>
<td>18.1</td>
</tr>
<tr>
<td>AuxiGro 4 oz. May 10</td>
<td>18.2</td>
</tr>
<tr>
<td>AuxiGro 4 oz. April 16 + May 10</td>
<td>18.7</td>
</tr>
<tr>
<td>Untreated</td>
<td>17.4</td>
</tr>
</tbody>
</table>
Jasmonic Acid pathway/SAR

• SAR refers to the Systemic Activated Response

• This response helps plants to fight disease, and is often valuable in other aspects.
NUMBER OF MARKETABLE MELONS PER ACRE

CASABA
CRENSHAW
HONEYDEW
PERSIAN
SANTA CLAUS

MELON TYPE

MESSENGER
UNTREATED
AntiStress Products

• Stress leads to free radical molecules being produced within plants

• Unless neutralized, the free radical molecules will signal for ethylene production

• Higher ethylene levels in plants then signal for the formation of abscisic acid

• In cotton, abscisic acid causes developing flowers and bolls to be abscised (dropped from plant)
Fruit Retention of DPL 5415 Cotton Grown in Growth Chambers at Various Mean Temperatures during Primary Bloom Cycle
Areas with the highest yields also have the highest risk potential for crop yield reduction.
Several products that are marketed for their anti-ethylene properties
Anti-Ethylene mode of actions

• **Retain** – (AVG) cotton locally, walnuts and tree crops (ethylene biosynthesis blockers)

• 1-MCP (Ethylene compound that inhibits the action of ethylene) Invinsa
ReTain®
PLANT GROWTH REGULATOR

Boost almond nut set.
ReTain®
PLANT GROWTH REGULATOR FOR CALIFORNIA

Boost almond nut set.
Area research thus far has been with ReTain

- Applied latter part of July to four local cotton varieties

- This was probably too late in the season

- A rate effect was noted (some positive differences, others negative)

- Since applied so late in season, may have missed much of the early stress, thus additional testing is probably necessary, especially as varieties have changed
Some plant growth regulation thoughts for the future

• With an ever increasing emphasis on water, will plant growth regulation products provide increased efficiency/water conservation?
Can we increase alfalfa quality with PGRs and reduce water use at the same time at certain times of the year?
Some plant growth regulation thoughts for the future

What is the synergism between various chemistries, such as noted for BM86 + mepiquat chloride?

<table>
<thead>
<tr>
<th>Treatment</th>
<th>$ value/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mepiquat chloride 16 Oz</td>
<td>881</td>
</tr>
<tr>
<td>Mepiquat Chloride 24 Oz</td>
<td>911</td>
</tr>
<tr>
<td>BM86 32 oz</td>
<td>908</td>
</tr>
<tr>
<td>BM86 32 oz. + Mep. Chlor 12 oz.</td>
<td>1035</td>
</tr>
<tr>
<td>Untreated</td>
<td>858</td>
</tr>
</tbody>
</table>
Some products now on market that have multiple chemistries (Cyclanalide in both)
Some plant growth regulation thoughts for the future

• With new chemistries and products being introduced into the marketplace every year, it is difficult to evaluate all potential aspects of plant growth regulation chemistries, especially when interactions exist for variety, surfactant, and other environmental factors.
Questions?