Plant Growth Regulators for Bedding Plant Production

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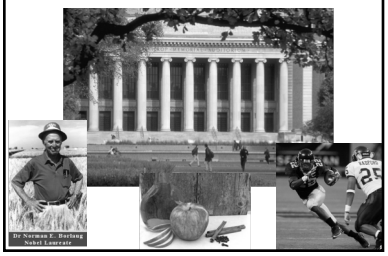


Five Primary Plant Hormones

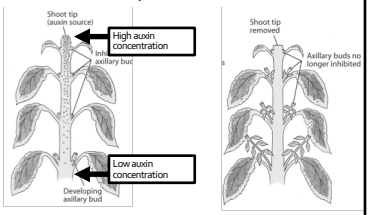
- Auxins - inhibit branching, promote rooting
- Gibberellins – stem elongation, seed germination
- Cytokinins – branching, aging
- Ethylene – ripening, inhibits flowering, bud drop
- Abscisic acid – water stress, inhibits germination

The plant growth regulators we use work to increase or decrease one of these!

Plant Growth Regulators for Spring Crops

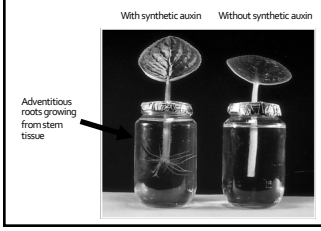
- **Commercial Plant Growth Regulators**
- What affects PGR efficacy?
- New PGRs uses and trends
- Organic height control methods
- New research directions

Evidence for the role of auxin in apical dominance



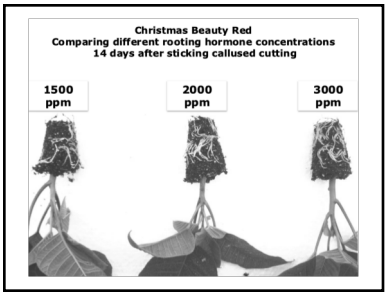
Drawings depicting *Coleus* (Lamiaceae family)

Auxins: We use synthetic auxins to promote rooting!



Rooting promoters:

Natural auxin = indole-acetic acid (IAA)
Synthetic auxins = IBA, NAA



Rooting Hormone

Poinsettia Rooting Hormone Recommendations

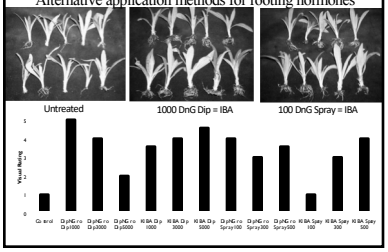
Product	Recommended Rate	Application method	Notes
Hortus IBA Water Soluble Salts	500-1000ppm IBA	Basal stem dip or spray just prior to sticking cuttings.	Mix solution to desired PPM and dip only bottom 1" of the stem. Be careful not to let solution touch leaves, upper stem or growing point.
Hortus IBA Water Soluble Salts	75-150ppm IBA	Course spray applied after sticking cuttings	Spray to runoff so that solution drips down stem toward the base of the cutting. Will likely cause some leaf distortion or curling but plants normally grow out of it. Higher rates = more leaf curl. Trial first.
Rhizopon AA #1	1,000ppm IBA	Basal stem dip or spray just prior to sticking cuttings.	Mix solution to desired PPM and dip only bottom 1" of the stem. Be careful not to let solution touch leaves, upper stem or growing point.
Dip N Grow	1,000ppm IBA + 500ppm NAA	Basal stem dip or spray just prior to sticking cuttings	Mix solution to desired PPM and dip only bottom 1" of the stem. Be careful not to let solution touch leaves, upper stem or growing point.

ROOTING HORMONE CHART

Trade Name	Source	Formulation	Ingredient
Chrysopon	ACP Chemistems	Powder (talc)	0.1% to 8% IBA
C-mono	Cox Farm Supply Services, Inc.	Liquid (isopropyl alcohol)	1% and 2% IBA
C-mono K	Cox Farm Supply Services, Inc.	Liquid (isopropyl alcohol)	1% KIBA
C-mono K+	Cox Farm Supply Services, Inc.	Liquid (isopropyl alcohol)	1% KIBA + 0.5% NAA
Dip 'n Grow	Astoria-Pacific, Inc.	Liquid (alcohol)	1% IBA + 0.5% NAA + tanner
Hormex	Brooker Chemical Corp.	Powder (talc)	Rooting Powder—0.1% to 4% IBA
Hormex	Brooker Chemical Corp.	Liquid	Hormex Concentrate—0.013% IBA + 0.24% NAA + vitamin B-1
Hormodin	E.C. Geiger, Inc.	Powder (talc)	0.1%, 0.3% and 0.8% IBA
Hormo-Root	Rockland Chemical Co.	Powder (talc)	0.1% to 4.5% IBA
IBA Water Soluble Salts	Hortus USA Corp., Inc.	Liquid	20% IBA
Rhizopon	Hortus USA Corp., Inc.	Powder and water-soluble tablet form	0.1%, 0.3% and 0.8% IBA
Stim-Root	Plant Products Co. Ltd.	Powder (talc)	0.1% and 0.4% IBA
Wonda Rooting Compound	Earth Science Products Corp.	Liquid (ethanol)	1.02% IBA + 0.50% NAA

Propagation: *Bracteantha*

Alternative application methods for rooting hormones



IBA Spray Rates

RATES FOR CUTTING TYPES Rates can be lower for juvenile cuttings.	HORTUS IBA WATER SOLUBLE SALTS (ppm IBA)	RHIZOPON AA WATER SOLUBLE TABLETS (tablets/liter water)
Soft perennial cuttings Annual cuttings	80-250	1/2-5
Herbaceous cuttings Woody ornamental cuttings	250-1500 350-1500	5-20 7-20

K-IBA (potassium salts on IBA) are sprayed on foliage the second day after sticking cuttings. Rates range from 100-200 ppm. You can spray K-IBA in combination with the fungicide Pageant.

K-IBA Sprays

Spray 100-200 ppm K-IBA the day after sticking in a tank mix that includes Capsil (4 oz/100 gallons) + a broad spectrum fungicide (consider Pageant or Cease).

Repeat after 2 weeks with more difficult to root species.

Gibberellins: We apply growth retardants to reduce gibberellins and reduce stem elongation

0 ½ 1 2 3 4 ppm

B-9/Dazide

- 24 hr REI
- Broad efficacy
- Rates vary from 1,250-2,500 ppm as a spray.
- Turns leaves darker green
- Leaf absorbed (3-4 hrs.)
- Spray volume is not important
- Do not apply within 3-5 days after Phyton 27.
- Does not affect rooting
- Often tank mixed with Cycocel

Cycocel/Citadel

- 12 hr REI
- Broad efficacy
- Used on begonias, geraniums, hibiscus and dianthus
- Typical spray rates are 250-500 ppm
- Can cause leaf yellowing (especially >750 ppm)
- Leaf and root absorbed (3-4 hrs.).
- Does not affect rooting.
- Often tank mixed with B-9

Bonzi/Piccolo

- 12 hr REI
- Broad efficacy; large species/variety variation
- Typical spray rates are 5-50 ppm; ¼ -10 ppm as a drench.
- Stunts begonias and vinca
- Turns leaves a dark green
- Spray can reduce flower size
- Stem and root absorbed.
- Long residual activity on surfaces and in water.
- Reduces root length/rooting.
- Easy to over-apply on young plants.

In general, 30 ppm Bonzi can be drenched on bulb crops to dramatically reduce elongation.

- 12 hr REI
- Broad efficacy
- Stunts begonia and vinca
- Typical spray rates are ½ -8 ppm
- Can 'lighten' leaf color and narrow leaves.
- Spray can decrease flower size
- Stem and root absorbed.
- More uniformity than Bonzi
- Easy to over-apply – especially young plants!
- Registered for use on tomatoes, peppers, and eggplant.

Sumagic, Consice

- 12 hr REI
- Broad efficacy
- Less variation in efficacy between colors than Bonzi. . . . .
- Rapid absorption (believed)
- 5 – 50 ppm spray, bulb drenches (10 -25 ppm)
- Good option for mixing with other PGRs.
- Darkens leaf color.
- Commonly tank mixed with B-9 for summer pansies.

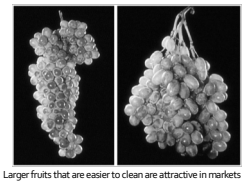
A-Rest, Abide

General Growth Retardant Rates

Name	Low Spray Rate	Rec. Spray Rate	Low Drench Rate	Rec. Drench Rate
B-9	1250 ppm = 5.6 g/gal; 1.9 oz/10 gal	2500 ppm = 11.1 g/gal; 3.8 oz/10 gallons	-	-
Cycocel	250 ppm = 8 ml/gal; 2.7 oz/10 gal	500 ppm = 16 ml/gal; 5.4 oz/10 gal	-	-
Bonzi	5 ppm = 4.7 ml/gal; 1.6 oz/10 gal	10 ppm = 9.5 ml/gal; 3.2 oz/10 gal	½ ppm = 0.5 ml/gal; 0.2 oz/10 gal	2 ppm = 2 ml/gal; 0.34 oz/10 gal
Sumagic	2 ppm = 13.8 ml/gal; 4.6 oz/10 gal	4 ppm = 27.6 ml/gal; 1.36 oz/10 gal	-	-
A-Rest	12.5 ppm = 179 ml/gal; 60.5 oz/10 gal.	25 ppm = 358 ml/gal; 121 oz/10 gal	-	-

Commercial use of GA

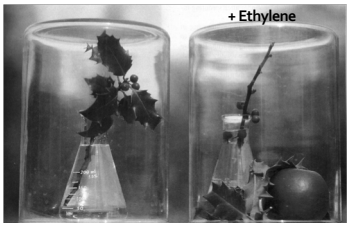
Without GA | With GA



Larger fruits that are easier to clean are attractive in markets

ProGib or Fascination is sprayed to increase fruit size (ProGrib) plant height (Fasciantion).

Ethylene: We apply ethylene to cause flower abortion and stimulate branching



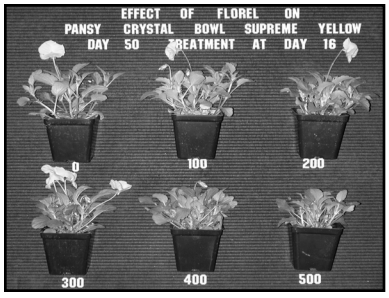
- 48 hr REI
- Inhibits flowering AND stimulates branching.
- Typical rate (250-500 ppm)
- Spray solution must have a pH <4.0 **after** addition of Florel.
- Efficacy varies based on drying time – slow drying =high efficacy.
- Can burn some species – careful with vegetative verbena liners.
- Do not apply later than 4 weeks before the desired flowering date
- 48 hr REI!

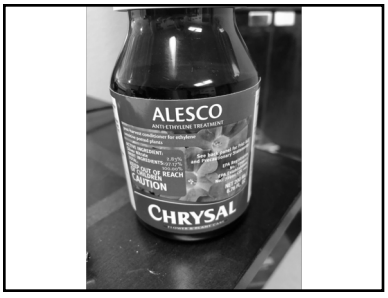
Florel/Collate

Spray Coleus every other week with 200 ppm Florel in increase branching, decrease height, reduce leaf size and eliminate flowering.

Florel Spray Rules

- This is still the best material to stimulate early branching on geraniums and many vegetative annuals for baskets and large pots.
- Only apply after roots hit the edge of the pot ce
- Apply no later than 6-8 weeks before finish.
- Test spray tank pH after addition of Florel – it should be below 6. If not, add an acid to the tank before and check again. Citric acid is a good option.
- Spray when it will sit wet on the leaf for awhile—this is usually early in the morning or on a cloudy day.





Cytokinins: We apply cytokinins to increase branching and delay lower leaf yellowing

Genetic Modification (+rol-2 gene) = increased cytokinin synthesis.

Normal

Configure

- 12 hr REI
- Can increase branching (most crops), reduce elongation and reduce rooting
- Can increase flower number (Thanksgiving cactus)
- Apply 3-5 days after pinch, and sometimes a follow-up application 5-7 days later (200 ppm). Roses need 500 ppm.
- Apply as a pinch replacement on many herbaceous annuals.
- Apply when the material will remain wet on leaves for as long as possible.
- Can cause leaf yellowing if applied when hot and/or bright.
- Good basket finisher.

Configure can be added to the production schedule to reduce labor and/or crop timing.

No Florel – Configure x 2 (200 ppm)

Previous: Florel x 2 (500 ppm)
Now: Florel (500 ppm) then Configure (200 ppm) = 2-3 week reduction in crop timing

Configure Application Rules

- Only apply when rooting is at the edge of the crop
- Apply 100 ppm Configure in propagation.
- Apply 200 ppm Configure after pinching succulents (not portulaca and purslane) and foliage plants.
- Apply 300 ppm Configure when heavily branching after pinching environment.
- Add Capsil (4 oz/100 gallons) as a spreader sticker.
- Apply in the early morning or on a cloudy day. Water before and after you have sprayed to increase humidity.
- You may need a second application 2 weeks after the first
- Only crops you've used Only 3 days after transplant

Plant Growth Regulators for Spring Crops

- Commercial Plant Growth Regulators
- **What affects PGR efficacy?**
- New PGRs uses and trends
- Organic height control methods
- New research directions

In general, the efficacy of PGR spray applications increases as the time the PGR stays wet increases.

Therefore, PGR efficacy will be higher if they are sprayed in the morning or on cloudy days. This is especially the case with Florel and Configure.

Drying time of different droplet sizes at different humiditys.

Table 4 – Mean evaporation time (s) of droplets containing different spray mixtures on waxy geranium leaf at three values of RH. Standard deviations are presented in the parentheses

Sprays[a]	RH (%)	Droplet diameter (μm)				
		246	343	575	762	886
Water only	30	23(2)	45(3)	99(6)	196(3)	315(12)
Water only	60	35(7)	66(5)	156(4)	302(12)	448(21)
Water only	90	58(8)	116(14)	249(8)	500(9)	768(32)
Pesticide[b]	30	26(3)	50(4)	105(7)	201(10)	337(22)
Pesticide	60	40(9)	72(9)	150(15)	275(15)	453(37)
Pesticide	90	64(6)	115(13)	235(16)	441(24)	734(22)
Pesticide + drift retardant	30	34(3)	71(4)	133(8)	242(17)	395(23)
Pesticide + drift retardant	60	59(8)	92(6)	181(16)	315(20)	519(32)
Pesticide + drift retardant	90	91(14)	141(11)	294(31)	521(31)	835(38)
Pesticide + surfactant	30	13(2)	31(5)	65(7)	126(15)	242(17)
Pesticide + surfactant	60	26(3)	53(6)	111(8)	201(14)	324(31)
Pesticide + surfactant	90	42(6)	78(8)	165(15)	304(28)	490(35)

a All sprays used water as the carrier.
b Evaporation time for pesticide was averaged from values of fungicide, insecticide No. 1, insecticide No. 2 and insecticide No. 3.

Yu Y, Zhu H, Frantz JM, Reding ME, Chan KC, Ozkan HE. 2009. Evaporation and coverage area of pesticide droplets on hairy and waxy leaves. Biosystems Engineering, 104:324-334.

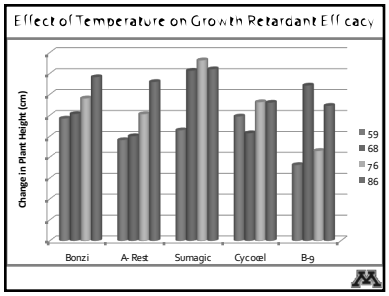
Marigold

Fast-drying

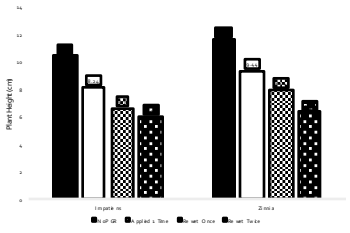
(86 F/ 45% RH)

Slow-drying

(59 F/ 85% RH)



Rewetting increases Bonzi efficacy



Plant Growth Regulators for Spring Crops

- Commercial Plant Growth Regulators
- What affects PGR efficacy?
- **New PGRs uses and trends**
- Organic height control methods
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TopFlor

- 12 hr REI
- Broad efficacy
- Easy to overapply!
- Helpful on herbaceous perennials, woody plants, blue salvia.
- Typical rates are 10-40 ppm ppm as a spray, and ½ -5 ppm as a drench.
- Darkens leaf color
- Believed to be stem and root absorbed.

TopFlor

New Guinea impatiens

0 1.25 2.5 5 10 20 40 80 ppm

Effective on Cannas, vigorous native plants.

Augeo

- Chemical pinching agent.
- Typical rate on woodies (400-600 ppm)
- On soft liners, consider applying 400-800 ppm.
- Efficacy is dependent on how long it sits wet on leaf.
- Can burn some species.
- Remember to give 4 weeks to allow plants to grow out before sale! Minimum of 4 weeks before sale date usually needed.
- Some application on succulents, mandavillea, some woodies.

Tanks Mixes (synergistic responses?)

Applied Together Applied Separately

If you apply more than one PGR at a time you can get more than additive effect i.e. stem elongation + branching.

Plant Growth Regulator	Stem Elongation	Branching	Flowering	Rooting	Ripening
B-9 (Gibberellin)	X				
Cycocel (Gibberellin)	X				
A-Rest (Gibberellin)	X				
Bonzi (Gibberellin)	X				
Florel (Ethylene)	X	X	X		X
Configure (Cytokinin)	X	X			
Sumagic (Gibberellin	X				
K-IBA/N-formadin (Auxin)				X	

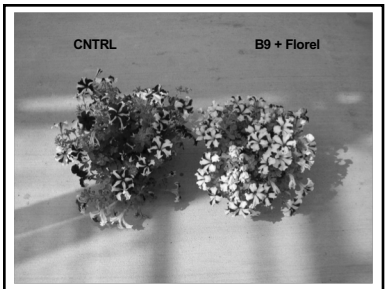
Most Common Tank Mixes

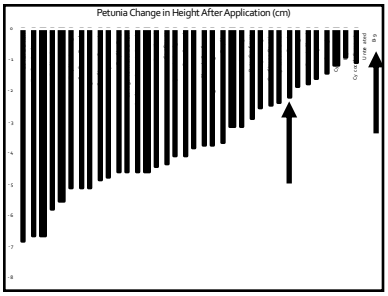
Traditional	New Options
• B-9 + Cycocel	• B-9 + Florel
• B-9 + Arest	• Topflor + Florel
• B-9 + Bonzi	• TopFlor + Configure
	• Sumagic + Florel
	• Sumagic + Configure
	• Just Configure. . . . .

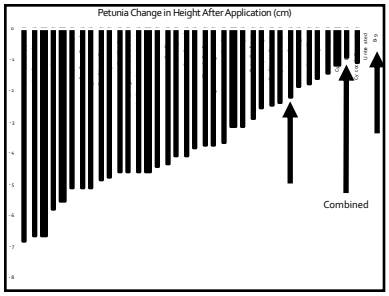
B-9 (2,500 ppm) + Florel (500 ppm)

Lobelia Sahara White with B-Nine Florel

Calibrachoa Noa Blue Legend - (B-Nine and Florel applied wk 13 and 15)







Tanks Mixes
(No synergistic responses observed)

Applied Together | Applied Separately

-1 cm = 0 cm + -2.25 cm

Tanks Mixes
(Achie**ve multiple Desirable Effects Simultaneously – lower labor costs**)

Applied Together | Applied Separately

-3 cm = -4 cm + -1 (-5 cm)
+1 branch +2 days = +1 branch +5 d + -1 branch (0 branches) +0 d (+5 d)

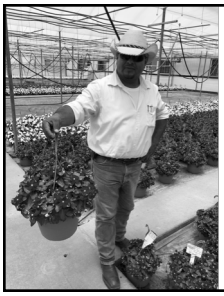
A-Rest + Configure, and Bonzi + Configure are good options for pansy.

Pansy	Florel	Configure	Cycocel	B-9	Bonzi	A-Rest	Control
Florel							
Configure							
Cycocel							
B-9							
Bonzi							
A-Rest							
Control							

Petunia	Florel	Configure	Cycocel	B-9	Bonzi	A-Rest	Control
Florel							
Configure							
Cycocel							
B-9							
Bonzi							
A-Rest							
Control							

Spray combos that reduce elongation, increase branching, and do not delay flowering significantly

- B-9+Florel (1250/2500 ppm+250/500 ppm; 24 h REI)
- Configure (100–200 (most common) ppm, 12 h REI)
- Sumagic + Configure (4 ppm/200 ppm (12 hr REI))
- Topflor + Configure (20 ppm + 200 ppm; 12 h REI)
- Cycocel + Configure (250 + 200 ppm; 12 h REI)
- Configure + Florel (200 + 250 ppm; woodies; 24 h REI)
- A-Rest + Florel (pansies – summer; 12.5 ppm + 250 ppm; 24 h REI)
- A-Rest + Configure (pansies – summer; 12.5 ppm + 100 ppm).



Late drench applications of Bonzi ¼ - ¼ ppm) are a great way to hold a crop for both you and the consumer!

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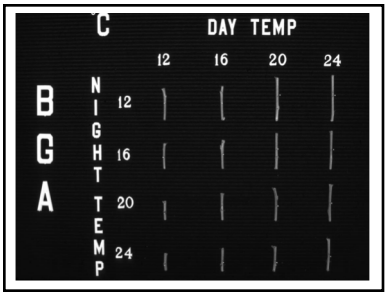
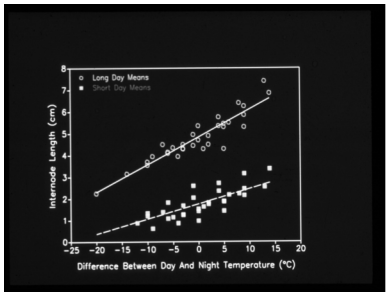
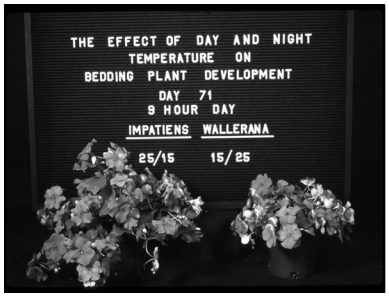
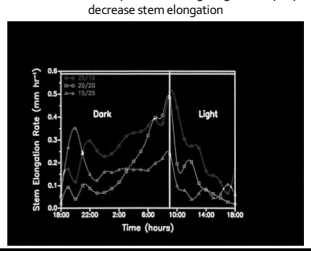






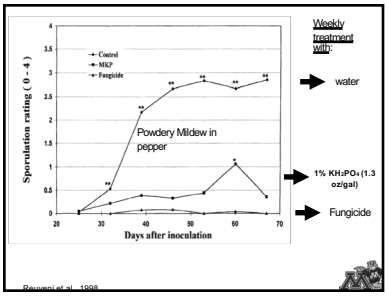
Temperatures can be dropped 7-10°F (the first 3 hours of the day) or brushed at dawn when plants are elongating most rapidly to decrease stem elongation



Touch plants first thing in the morning.

Recent research at Clemson and the University of Minnesota show that salt spray applications reduce elongation and can reduce botrytis.

Spray 1800 ppm calcium chloride (road salt; 6.8 grams/gallon) once a week as a spray (with 4 oz Capsil/100 gallons water)



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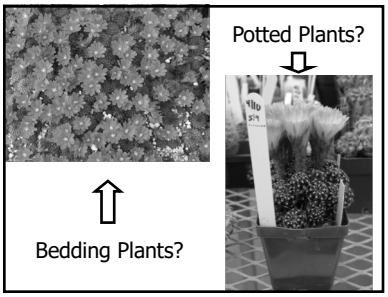
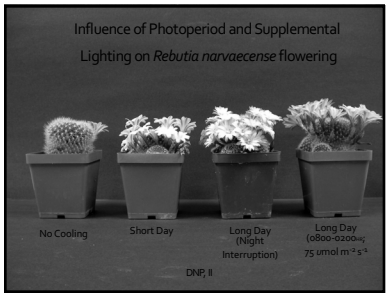
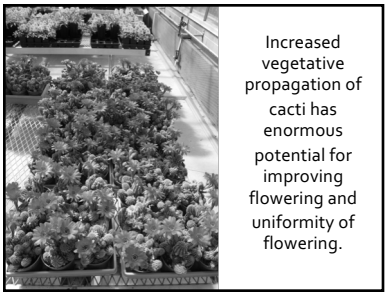
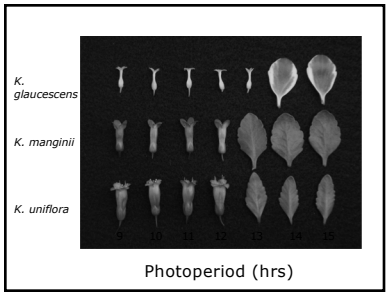
Heat Tolerant Crops

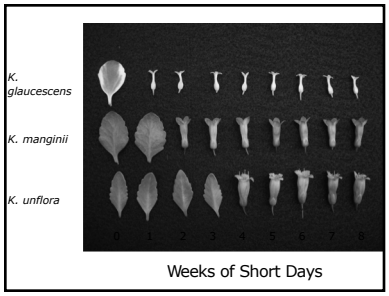


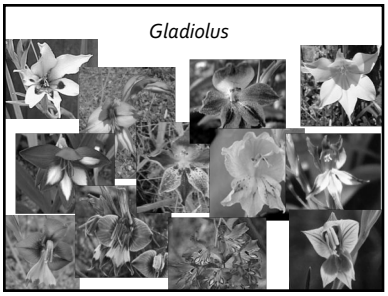


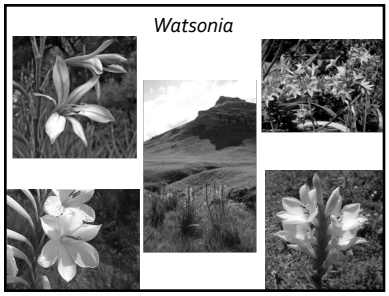


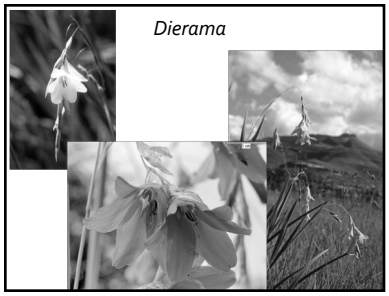
Increased vegetative propagation of cacti has enormous potential for improving flowering and uniformity of flowering.

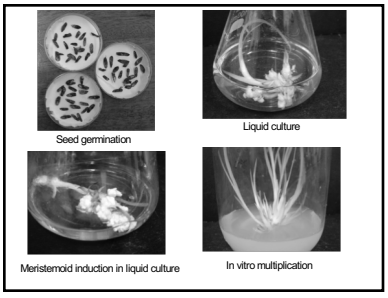


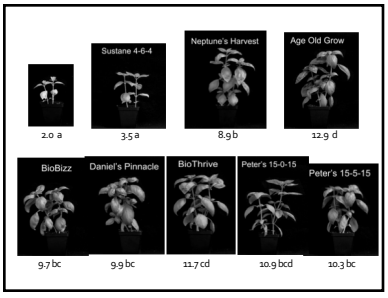



Gladiolus


Watsonia


Dierama


Seed germination
Liquid culture
Meristemoid induction in liquid culture
In vitro multiplication


Sustane 4-6-4
Neptune's Harvest
Age Old Grow
2.0 a
3.5 a
8.9 b
12.9 d
BioBizz
Daniel's Pinnacle
BioThrive
Peter's 15-0-15
Peter's 15-5-15
9.7 bc
9.9 bc
11.7 cd
10.9 bcd
10.3 bc

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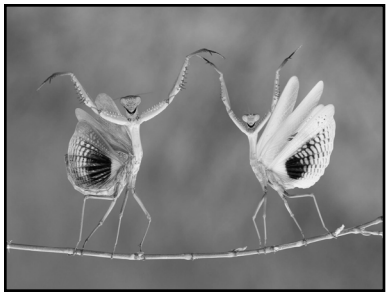

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erwin001@umn.edu