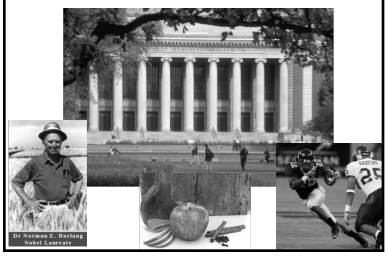
Reducing Inputs Costs for Increased Profitability

John Erwin
Department of Horticultural Sciences
University of Minnesota
erwin001@umn.edu
www.plantgrower.org

University of Minnesota



Much production is focused on indoor crop production, yet much of the production in the US, Mexico and Central America is outdoor. Our program aims to provide information for BOTH indoor and outdoor ornamental plant and greenhouse edible crops growers.

Reducing Inputs to Increase Profitability

- **Reducing Labor**
- Reducing Losses
- Reducing Reducing Energy Costs
- Reducing Chemical and Fertilizer Costs
- New Directions!

Automated watering saves a considerable amount of labor.

Alternative Long-Term Crop Multistick in Packs – A hybrid

- An alternative to direct sticking into the finished container on long-term crops (multiyear) is to stick multiple cuttings into a quart or 24-cell, root them and perform 1-2 pruning cycles in the quart.
- These pruned quarts would then be planted into the finished container in August-September to establish (1 prune) for April-July sales.
- Reduces space/production time dramatically.

With this example, 7 Crape Myrtle cuttings are stuck in a single cell (February-March). They are pruned once in the cell after rooting, transplanted (May) and pruned once more June) after rooting. They are sold that August-September.

Direct seeding

- Sow seed directly into finished container and germinate in a warm location (greenhouse or stacked cart).
- Germination often benefits from covering with a frost cloth if germination is occurring in the finished environment – greenhouse. Remove the cloth after about 3 days (when germination is visible).
- Alternatively, cover more heavily with vermiculite.

Herbs and vegetables can be easily direct seeded with great results. Total crop time for this basil crop is 30 days.

Direct Sow Candidates

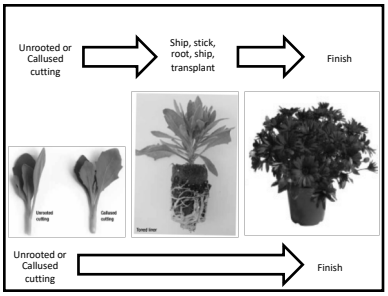
- Herbs:
  - Dill, Basil, Cilantro.
- Vegetables
  - Tomato, Pepper, Eggplant
  - Kale, Chard
  - Radish
  - Squash
  - Cucumber

Direct Sow Candidates

- Flowers (generally larger seeds/pellets)
  - Sunflower
  - Zinnia
  - Marigold
  - Pelleted Lobelia
  - Pelleted Alyssum
  - Vines
    - Thunbergia
    - Morning Glory
    - Nasturtium

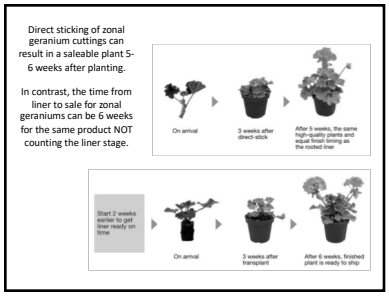
You can root cuttings of some annuals/perennials directly in the finished pot to eliminate the cost of the liner and significantly reduce crop time.

Unrooted Cutting (Left) Callused Cutting (Right)



Direct sticking of zonal geranium cuttings can result in a saleable plant 5-6 weeks after planting.

In contrast, the time from liner to sale for zonal geraniums can be 6 weeks for the same product NOT counting the liner stage.



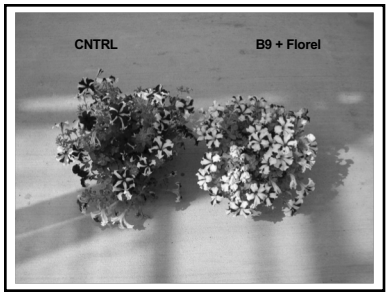
		Liner	URC Direct stick	Callused direct stick
Year 1	Bracteantha Dreamtime Pink	36	66 (29)	51 (15)
Year 1	Bracteantha Dreamtime Red	27	57 (30)	49 (22)
Year 1	Bracteantha Dreamtime Yellow	31	59 (28)	50 (19)
Year 1	Osteospermum Serenity Lavender	47	68 (22)	64 (17)
Year 1	Osteospermum Serenity Pink	45	73 (27)	68 (23)
Year 1	Osteospermum Summertime	54	68 (14)	70 (16)
Year 1	Pelargonium Survivor Dark Red	33	60 (26)	50 (17)
Year 1	Scaevola Bondi Blue	34	60 (27)	60 (26)
Year 1	Scaevola Scalora	31	71 (40)	60 (30)
Year 1	Scaevola White	29	61 (32)	53 (24)
Year 1	Scaevola Scalora Topaz Pink	31	57 (26)	47 (17)
Year 2	Bracteantha Dreamtime Yellow	42	77 (35)	69 (27)
Year 2	Osteospermum Serenity White	41	76 (35)	67 (26)
Year 2	Scaevola Bondi Blue	27	67 (40)	66 (39)
Year 2	Scaevola Scala Blue	35	68 (33)	67 (32)
Year 2	Pelargonium Survivor Dark Red	38	72 (34)	72 (34)
	Average	**36**	**66 (29)**	**60 (23)**

Herbs that can be readily propagated from cuttings

- Oregano (SD; 10 hr)
- Spearmint (SD; 10 hr)
- Peppermint (SD; 10 hr)
- Tarragon (LD, NI Lighting)
- Sage (LD; NI lighting)
- Rosemary (Warm; 74F)

Florel

- 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
- Can burn some species.
- Do not apply later than 4-5 weeks before the desired flowering date
- 48 hr REI!



Configure

- A cytokinin (benzyl adenine). Used to increase branch or flower number.
- Efficacy is related to time of spray. In general, the greatest effect occurs when applied 3-5 days after pinch, and sometimes a follow-up application 5-7 days later (500 ppm).
- Apply when the material will remain wet on leaves for as long as possible.
- Used to increase branching when you do not want a delay in flowering.

Effect of Plant Growth Regulators Applied 5 days after Transplant Alone or as Tank Mixes on Petunia x hybrida Development

Water | TopFlor | Configure | TopFlor + Configure | TopFlor + Florel

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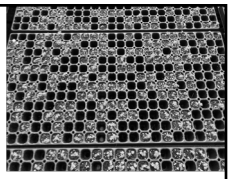


In general, only germinate seed at temperatures between 72-76oF. Tomatoes and peppers germinate best at 76-82oF. It is VERY common for growers to germinate seed at temperatures below the optimal temperature for germination.

It is quite common that cuttings are stored at improper temperatures upon receipt and often for days that impacts the future 'rootability' of a cutting.

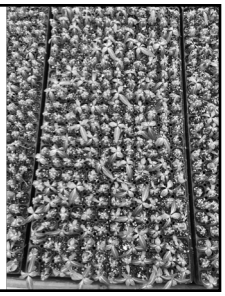
RECOMMENDED URC STORAGE TEMPERATURES

COOL TEMP STORAGE		MEDIUM TEMP STORAGE		COLD SENSITIVE STORAGE	
Argyranthemum, Bacopa, Bidens, Brachyscome, Brachyantha, Calibrachoa, Cuphea, Lobelia, Nemesia, Osteospermum, Petunia, Plectranthus, Salvia, Scaevola, Verbena	45-50F (7.2-10C)	Angelonia, Dahlia, Iresine, Coleus, Erysimum, Heliotrope, Impatiens, Double, Impatiens, NGI, Impatiens, Interspecific, *Impatiens wallerana*, Poinsettia, Perilla, Thunbergia, Strobilanthes	50-55F (10-12.7C)	Basil, Ipomoea, Purslane	55-60F (12.7-15.5C)

STICKING PRIORITY LIST
Prioritizing and grouping your cuttings for success

FIRST PRIORITY	SECOND PRIORITY	THIRD PRIORITY	FOURTH PRIORITY
Dahlia Euphorbia Geranium, Ivy Geranium, Zonal Heliotrope Ipomoea Lantana Lobelia Purslane Thunbergia	Arctotis *Artemesia* Bacopa/Sutera *Begonia boliviensis* Calibrachoa Coleus Diascia Eryesimum Evolvulus Fuchsia Impatiens, Double Impatiens, Exotic Impatiens, Mini Lobularia Nemesia Osteospermum Perilla Petchoa Petunia Plectranthus Salvia Strobilanthes Verbena Viola	Multi-liners Ageratum Alternanthera Angelonia Argyranthemum Bidens Brachycome Bracteantha Chrysocephalum Cuphea Felicia Helichrysum Impatiens, Interspecific Impatiens, New Guinea Iresine Lamium Nierembergia Phlox (all) Scaevola Torenia	Celosia Gaura Hedera Lophospermum Lysimachia Sanvitalia Streptocarpella Vinca major

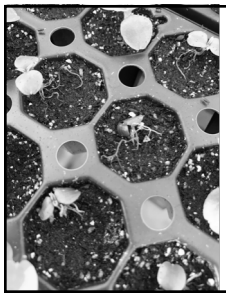
NEVER expose vinca , ipomea, cleome, or celosia to temperatures less than 68oF.



Protective Liner/Plug Drenches

- Subdue + Cleary' s 3336 + Safari (General root rot + mealybugs/aphids/whitefly)
- Subdue + Terraclor + Safari + Heritage (General root rot + mealybugs/aphids/whitefly + Foliar fungal diseases)
- Heritage + Safari (foliar fungal diseases + mealybugs/aphids/whitefly)
- Subdue + Clearys 3336 + Heritage +Safari + Floramite/Sultan (root rots + foliar fungal diseases + pests including mites)
- Subdue + Cleary' s 3336 + Cease (root rots + bacteria)
- Subdue + Medallion + Heritage (Root rots (including fusarium) + foliar fungal diseases)
- Subdue + Medallion + Cease (root rot + fusarium + bacteria)
- Subdue + Clearys 3336 + Kontos or Mainspring (root rot + numerous pests)

Do not left night temperatures drop below 65oF on New Guinea impatiens. It's best to grow this crop above 68oF.



Dense, wet media will result in poor rooting on vinca, gerbera and impatiens.

Uneven rooting is a 'tell tale' sign of non-optimal conditions right after planting.

This can be avoided by starting plants in a warm (>68F) greenhouse for the first 2 weeks until roots hit the edge of the pot, and then moving them to a cooler location.

Perennials for the following spring must be planted early enough the previous summer to bulk before winter. Generally, this means you need to plant around June/July.

Should you get bacteria, rotate among the following bacteriacides as weekly sprays:

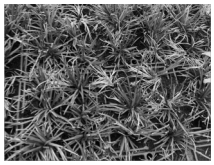
1)Uptake
2)Cease
3)Aliette
4)Zerotol

Root rots are common. Apply a combo of one from List A from one from List B.

List A:
Subdue
Aliette
Truban

List B:
Chipco 26019
Cleary's 3336
Medallion
Heritage

Medallion should always be used regularly on perennials to control Fusarium.



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What temperature should you grow a crop at?

You want to select temperatures that give you both rapid leaf unfolding (rapid days to flower) and a high rate of photosynthesis (high mass – quality).

Plant	Delay when average daily temperature is reduced 1oF
Angelonia 'Angelface White'	2.4 days
Blue Salvia 'Strata'	3.1 days
Calibracoa 'Superbells Pink'	1.5 days
Diascia 'Flying Colors Coral'	1.2 days
Gazania 'Daybreak Red Stripe'	1.5 days
Nemesia 'Sunsatia Peach'	0.8 days
Pansy 'Delta Pure White'	1.0 days/1.6 days
Petunia 'Avalanche Pink'	2.5 days
Petunia 'Purple Wave'	3.3 days
Impatiens 'Super Elfin Lipstick'	1.8 days
Snapdragon 'Liberty Bronze'	1.6 days
Viola 'Sorbet Blackberry Cream'	1.1 days

Plant	Delay when average daily temperature is reduced 1oF (54-78oF)	Delay when average daily temperature is reduced 1oF (63-78oF)
Angelonia 'Angelface Blue'	2.4 days	2.4 days
Argyranthemum 'Butterfly'	1.8 days	0.4 days
Calibracoa 'Superbells Red'	3.5 days	1.3 days
Mercardonia hybrid	2.0 days	2.0 days
Osteospermum 'Orange Symphony'	1.5 days	0.3 days
Osteospermum 'Soprano Purple'	1.7 days	0.5 days
Petunia 'Supertunia Bordeaux'	3.0 days	1.5 days
Scaveola 'New Wonder'	3.8 days	2.1 days
Verbena 'Superbena Burgundy'	3.3 days	1.6 days

Plants for a high temperature house (68-78ºF) – based on DTF

- Angelonia
- Blue Salvia
- Purple Wave Petunia
- Mercardonia
- Scaveola
- Browallia
- Cleome
- Canna
- Tomato
- Coleus
- Pentas
- Zinnia
- Vinca
- Melampodium
- Gomphrena
- Cosmos
- Celosia
- Pepper
- Basil
- Many grasses

Plants for a moderate temperature house (63-72ºF) – based on DTF

- Calibracoa
- Gazania
- Impatiens
- Snapdragon
- Petunia 'Supertunia Bordeaux'
- Verbena 'Superbena Burgundy'
- Cosmos
- African Marigold
- Ageratum
- Some petunias
- Portulaca
- Red Salvia
- Cosmos
- Sunflowers

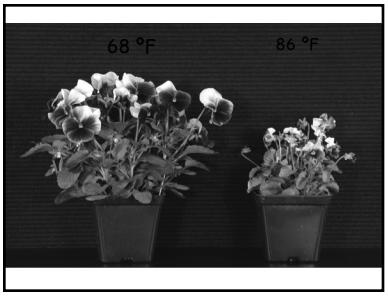
Plants for a low temperature house (55-65ºF) – based on DTF

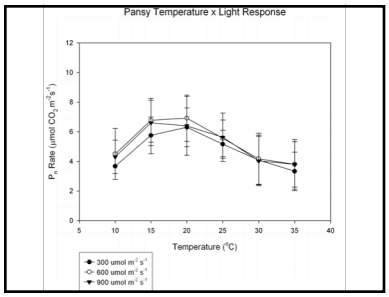
- Argyranthemum
- Osteospermum
- Pansy
- Viola
- Diascia
- Nemesia
- Dahlia
- Some lobelia
- French marigold
- Some petunias
- Some snapdragons
- Dianthus
- Alyssum

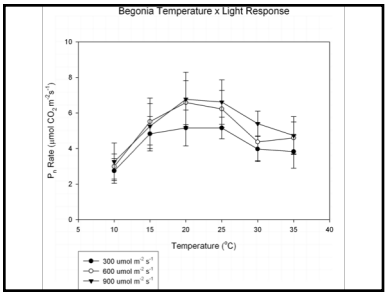
Effect of Increasing Temperature on MandeVino 'Mezzo Red' grown under Short Days (8 hr) and 300 μmol m^{-2} s^{-1}

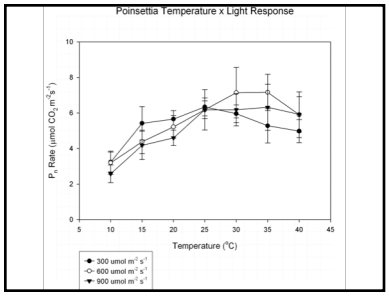
How much light can a plant use for photosynthesis?

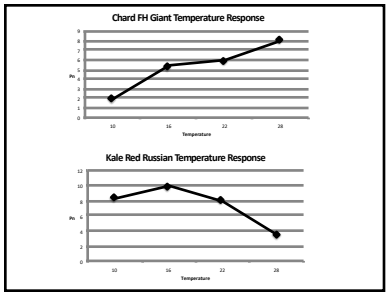
+ $CO_2 + H_2O$ ⇨ $C_2H + O_2$

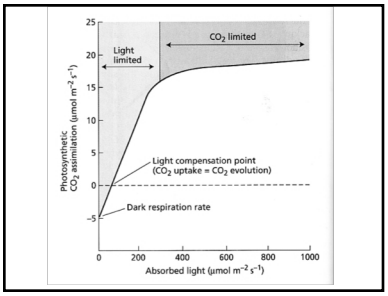


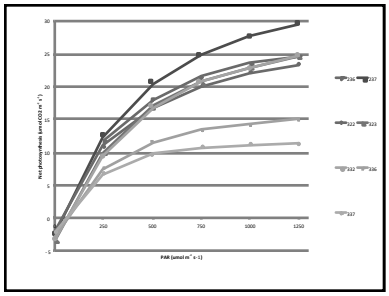


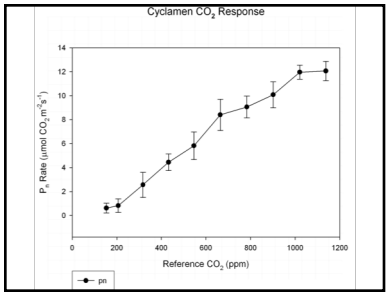




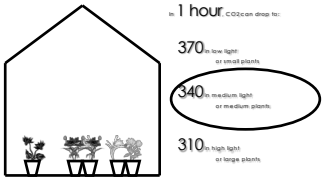








Sealing up gaps lowers CO_2



Plant	Temp Optima	Light Saturation	CO2 Saturation
Cyclamen	68F	500 umol m^2 s^{-1} (2500 ftc)	1000 ppm
Geranium	68-77F	300 umol m^2 s^{-1} (1500 ftc)	800 ppm
Gerbera	68-77F	300 umol m^2 s^{-1} (1500 ftc)	800 ppm
Impatiens	63-68F	400 umol m^2 s^{-1} (2000 ftc)	900 ppm
Pansy	63-68F	500 umol m^2 s^{-1} (2500 ftc)	700 ppm
Petunia	63-68F	400 umol m^2 s^{-1} (2000 ftc)	700 ppm
Poinsettia	77-86F	550 umol m^2 s^{-1} (3250 ftc)	650 ppm
Reiger Begonia	50-59F	200 umol m^2 s^{-1} (1000 ftc)	1000 ppm
Verbena	68-77F	400-500 umol m^2 s^{-1} (2000-3000 ftc)	800 ppm

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Marigold

Fast-drying
(86 F/ 45% RH)

Slow-drying
(59 F/ 85% RH)

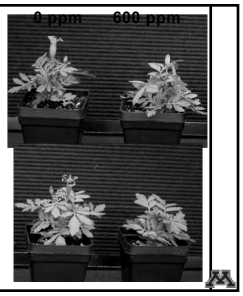
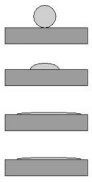
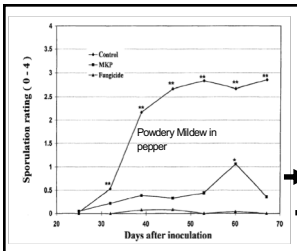


Figure 2. Effect of Surfactants on Surface Tension and Herbicide Activity



Surfactant concentration	Weed Control
0%	45%
0.12%	60%
0.25%	85%
0.50%	98%



Weekly treatment with:
- water
- 1% KH_2PO_4 (1.3 oz/gal)
- Fungicide

Reuveni et al. 1998

Spraying frequency needs to match pest growth rate which is based on temperature.

Average Daily Temp. (°F)	Egg Stage (Days)	Hatch to Adult (Days)	Total Time (Days)	# Generations / Season June 1 - September 30 (122 days)
55.4	19	19	40	3.1
59.9	16	14	30	4.1
64.4	11	10	21	5.8
69.8	8	7	15	8.1
75.2	6	4	10	12.2
80.6	4	3	7	17.4

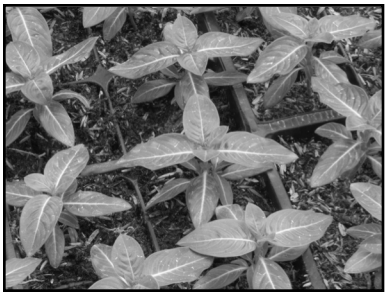
Chart 1. Environmental Effect on Mite Populations

Rice Hull Caps

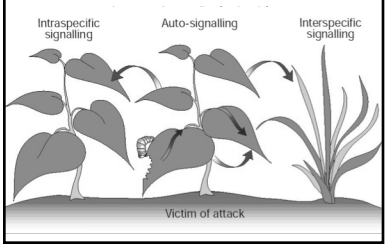
- Leave a lip (about 1")
- Fill the lip with >1/2" of un-composted, clean rice hulls for weed control.
- Rice hulls
  - Reduce weed seed germination.
  - Likely add silicon which increases plant disease suppression.
  - Reduces herbicide costs.
  - Reduces herbicide slowing of growth.

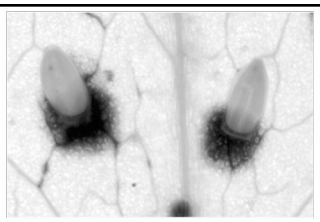
Wood Fiber

- Early indications are that this material (primarily made from Loblolly Pine) is a good peat/perlite substitute.
- In general, 30-40% pf the peat and all of the perlite can be replaced with wood fiber.
- Although we would expect that significantly more nitrogen may be needed with wood – it is not the case. In general, as media decomposes, only an addition 50 ppm N is required.
- The bottom line is that wood fiber is a great peat alternative that can reduce media costs.



Plant Defense Mechanisms





Elicitors from insect eggs activate the SA pathway in Arabidopsis at the site of oviposition. As a result, JA-induced defense responses are supressed surrounding the egg allowing hatched larvae to feed on 'undefended tissue'

Bruessow et al., 2010. Plant J., 62:876-885.

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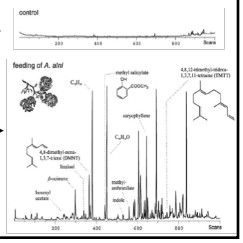
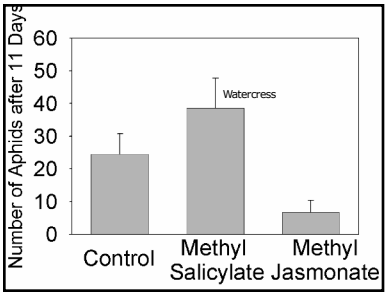
Other Airborne Signals?

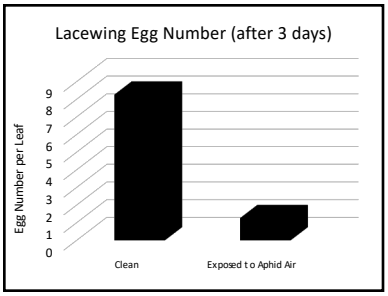
volatile profile from undamaged *Alnus* →

volatile profile from beetle-infested *Alnus* →



From Tscharntke et al. 2001. Biochem. Syst. Ecol. 1025–1047.



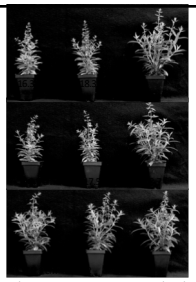


Angelonia 'Serena Purple'
After 4 Weeks (fresh weight)

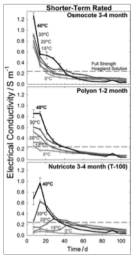
Sunshine (LC8)

MetroMix

Bert's Blend
(Incorporated Controlled Release Fertilizer)



Clear Water Osmocote Liquid Feed



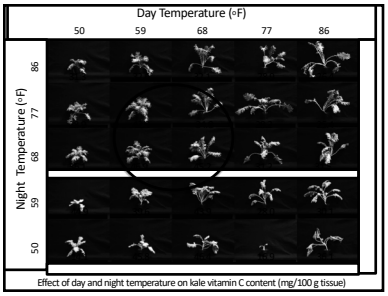
"Nutirents most affected by temperature were typically N, K, B, Cu and Zn, while the least affected were P, Mg, and Fe."

"Osmocote fertilizers released faster than specified at both high and low temperature. Nutricote had relatively steady release rates over time and a nonlinear response to temperature. Polygon released more slowly than specified but replicate samples were highly uniform."

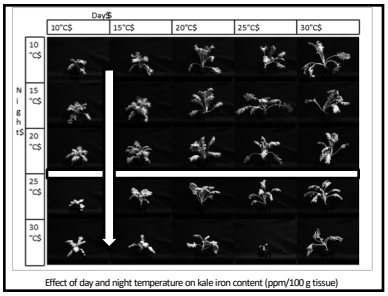
Adams et al., 2013. Macro- and micronutrient-release characteristics of three polymer-coated fertilizers: Theory and measurements. J. Plant Nutr. Soil Sci., 176:76-88.

Reducing Inputs to Increase Profitability

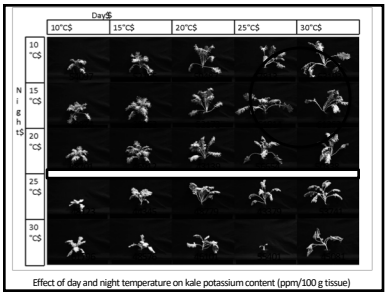
- Reducing Labor
- Reducing Losses
- Reducing Reducing Energy Costs
- Reducing Chemical and Fertilizer Costs
- **New Directions!**



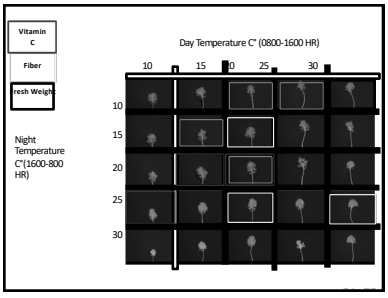
Effect of day and night temperature on kale vitamin C content (mg/100 g tissue)

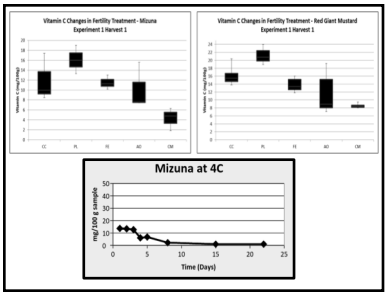


Effect of day and night temperature on kale iron content (ppm/100 g tissue)



Effect of day and night temperature on kale potassium content (ppm/100 g tissue)

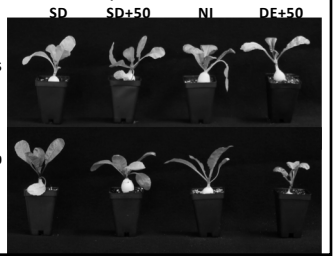




Burpee White

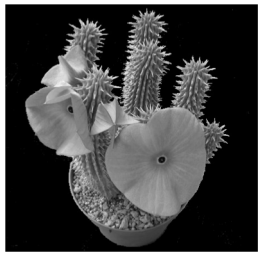
SD SD+50 NI DE+50

- 20/15
- 15/10



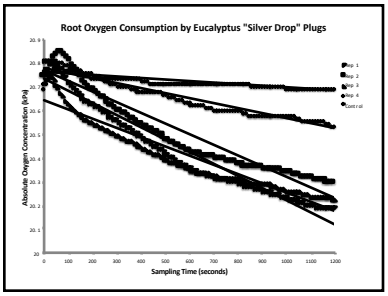
Hoodia is used by the African Bushman to reduce appetite AND it can be ornamental!

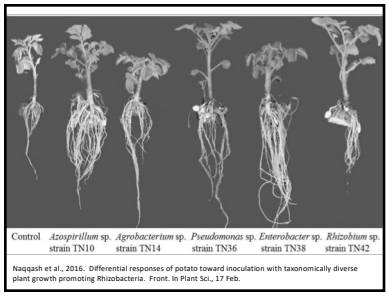
It is photoperiodic (SDP)– i.e. programmable.



Mammillaria painteri forma mostruosa: A) grafted on Opuntia compressa B) grafted on Trichocereus C) On its own roots

Green Roofs

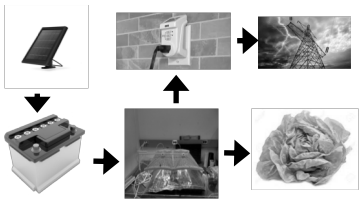


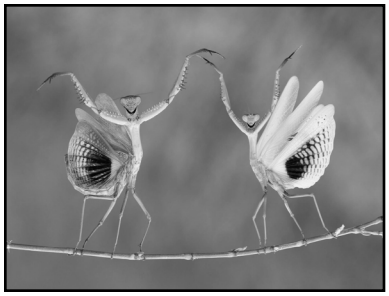


Naqqash et al., 2016. Differential responses of potato toward inoculation with taxonomically diverse plant growth promoting Rhizobacteria. Front. In Plant Sci., 17 Feb.

New LED lighting technologies will revolutionize integration of photosynthetic lighting into building designs.

Example Modular Indoor Home Food and Energy Production System Being Developed



Industry Acknowledgements

- Minnesota Flower Growers and the Minnesota Agriculture Experiment Station
- Floriculture Research Alliance
- USDA-ARS (FNRI – supported by SAF)
- U of MN Partners:
  - Altman Plants, Inc.
  - Rocket Farms, Inc.
  - Smith Greenhouses, Inc.
  - Green Circle Growers, Inc
  - Wagner's Greenhouse