Young Plant Research Center

POST-HARVEST CONDITIONS FOR ROOTED CUTTINGS

By Erika Williams, University of New Hampshire; Paul Fisher, University of Florida; and Susan Han, University of Massachusetts.

These lantana rooted cuttings received Florel applications 1 day (left), 1 week (middle), or 2 weeks (right) before storage for 3 days at 67°F.
The difference in plant health results from ethylene damage to the plant at left.

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Liners placed in Mason jars to collect ethylene gas samples

Executive Summary

Potential damage that may occur to rooted cuttings during shipping includes high temperature (which leads to increased respiration and dehydration), freezing or chilling injury, bruising, disease (especially botrytis), and ethylene exposure. This report summarizes results from several experiments related to effects of ethylene and storage temperature on quality of vegetatively-propagated cuttings. Initial experiments screened a range of cultivars, and later experiments focused on known ethylene-sensitive species (Begonia, Lantana, and Portulaca). Our goals were to assist growers to reduce losses in shipping and to evaluate the overall importance of ethylene for shipping of vegetatively-propagated cuttings.

- **Ethylene-sensitivity as rooted vegetative cuttings**
  - **Insensitive.** Argyranthemum 'Artist Blue', Bracteantha 'Sundaze Golden Yellow', Calibrachoa 'Superbells Red' and 'Superbells Blue', Diascia 'Flying Colors Coral', Gypsophila 'Festival Star', Lobelia 'Compact Blue with Eye', Nierembergia 'Blue Eyes', Petunia 'Supertunia Red', Scaevola 'New Wonder' and 'Whirlwind Blue', and Verbena 'Superbena Burgundy'.
  - **Somewhat sensitive.** Temporary epinasty (downward-bending of leaf petioles): Ageratum 'Artist Blue', Cuphea 'Tiny Mice', Nemesia 'Bluebird', Phlox 'Intensia Lavender Glow', *Sagina subulata* 'Aurea', Sutera 'Bacopa Giant Snowflake', and Torenia 'Summer Wave Blue'. *Salvia greggii* 'Wild Thing' showed epinasty and a 10-12 day flower delay in flowering. *Diascia integerrima* 'Coral Canyon' and Osteospermum 'Soprano Light Purple' showed a slight increase in necrosis.
  - **Very sensitive.** Begonia 'Nonstop Yellow', lantana 'Patriot Dove Wings', lantana 'Tropical Fruit', and portulaca 'Yubi Red' showed symptoms of leaf drop and epinasty, with subsequent delayed flowering and stunted growth.
- Many floricultural species have been shown in other studies to drop flowers in response to ethylene exposure. Therefore, if a grower is producing liners that already have flower buds, especially if you are manipulating flower initiation with lighting or vernalization, ethylene exposure during shipping should definitely be avoided so that flowers are not aborted.
- Our treatments were mainly based on only 1-2 cultivars per species, and cultivars may differ in ethylene sensitivity.
- Florel (ethephon) at 500 ppm applied 1 day - and in some treatments 1 week – applied before shipping caused elevated ethylene and subsequent plant damage in begonia, lantana, and portulaca. Florel applications should occur no later than 2 weeks before shipping in flowering or sensitive species. Florel applications to insensitive species may also lead to ethylene production that would affect sensitive species in the same box.
- In most commercially-produced rooted cuttings that were shipped to UNH, ethylene level inside carboard shipping containers was not elevated. However, in a few cases gas samples showed 0.5 ppm ethylene which is enough to cause quality problems in sensitive cultivars.
- 1-MCP eliminated ethylene sensitivity of rooted lantana liners, in terms of both initial leaf drop, and also post-transplant flowering and growth.
- 1-MCP also eliminated leaf drop symptoms in unrooted lantana cuttings, although we did not evaluate the effect of 1-MCP on subsequent rooting.
- Another factor that affects post-shipping quality is shipping temperature. At warm temperatures, plants respire and use energy more rapidly during shipping. Bacopa showed delayed flowering after exposure to storage temperatures of 69°F for 2 days, compared with storage at 34 or 40°F or no storage. Maintaining cool (40-45F) temperatures is probably optimal for shipping most species.

Introduction

Damage may occur to rooted cuttings during shipping from high temperature (which leads to increased respiration and dehydration), freezing or chilling injury, physical damage, disease (especially botrytis), and ethylene exposure. We ran a series of experiments to evaluate effects of storage temperature, ethylene, and bruising on cuttings.

An overview of ethylene

All higher plant parts produce trace amounts of ethylene that interact with other plant hormones to control development and growth. "Generally, meristematic tissue and nodal regions are the most vigorous sites of ethylene synthesis" (Wilkins, 1984).

Ethylene is a gas at room temperature that can become elevated during shipping in response to plant stress or damage. Plants that produce ethylene, such as ripening fruit, can elevate ethylene exposure forn adjacent plants. Another source of ethylene gas in the greenhouse is incomplete combustion of fuel. Florel is a spray that produces ethylene for several days following application, which can potentially carry over into ethylene production during shipping.

Producers should avoid elevated ethylene during transit because of undesirable plant responses, which can include growth inhibition, growth promotion, tissue proliferation, formative growth, chlorophyll destruction, anthocyanin synthesis, flower initiation, flower sex shifts, fruit growth stimulation, fruit degreening, fruit ripening, respiratory changes, storage product hydrolysis, protein synthesis promotion, seed and bud dormancy release, and apical dominance release (Wilkins, 1984).

Ethylene is physiologically active at very low concentrations (0.1 to 10 ppm). Ethylene can be sampled from a shipping box by inserting a hypodermic syringe into the closed container. For larger storage rooms or greenhouses, a test-tube-sized sample is collected from the air. Ethylene level in a gas sample can be measured with a gas chromatograph, which is a sensitive piece of lab equipment that needs calibration and use by a trained technician.

Several products are available to scrub ethylene from shipping containers, mainly based on potassium permanganate which oxidizes ethylene. Ethylene is bound on certain sites within the plant, and ethylene-binding inhibitors are available that reduce sensitivity of plants to ethylene exposure. Silver thiosulphate (STS) has been used to bind to internal ethylene receptors, but is limited by problems with silver disposal and also the need to pulse cut stems in the STS solution (http://ucce.ucdavis.edu/files/datastore/234-79.pdf#search=%22ethylene%20gas%20sts%22). 1-MCP (1-methylcyclopropene, also known as Ethyl Bloc) as an ethylene-binding inhibitor, where plant material is placed in an enclosed space for several hours and is exposed to the 1-MCP as a gas. Increasing temperature reduces the required exposure time. Over a period of several days, the effects of 1-MCP may wear off as the plant produces new ethylene binding sites.

Literature cited: Wilkins, Malcom B. 1984. *Ethylene*. Ch. 5, pp111-124. In: *Advanced Plant Physiology*. University of Glasgow. Pitman Publishing Inc., Marshfield, MA.

Research Experiments

A. Sensitivity of multiple cultivars to ethylene January 2006

A. Objective To observe the ethylene sensitivity of several cultivars of rooted cuttings.

A. Research Methods Liner trays, containing a mix of 84-count rooted cuttings randomly placed in each tray, were inserted into sealed chambers that contained specific rates of ethylene between 0 and 1 ppm. These vegetatively-propagated liners were exposed to ethylene in tanks at the University of Massachusetts, and were subsequently grown on in 4.5-in pots in a glass greenhouse at the University of New Hampshire.

Figure A1. Transportation from the University of Massachusetts Amherst to the University of New Hampshire.

Rooted cuttings were transported to UNH from Pleasant View Gardens, Loudon, N.H. by van in open boxes (45 mins. transit). On arrival at UNH, the liners were removed from trays and cultivars were randomly placed throughout each of sixteen 84-count trays. Three plants of each species were placed on each tray so that each individual tray had 19 different species totaling 57 plants per tray. The sixteen trays were then transported to the University of Massachusetts in open boxes (Figure A1). The trays were placed in a glass greenhouse for one week to acclimate in the greenhouse prior to ethylene exposure treatments. Twelve of the trays were exposed to ethylene in tanks (Figure A2) and four trays remained unexposed in the greenhouse.

Figure A2. Ethylene gassing chambers. In trial one, cultivars were exposed to ethylene concentrations of 0, 0.1, and 1ppm for one day. In trial two cultivars were exposed to ethylene concentrations of 0, 0.5, and 1.0ppm for a period of two days.

We ran two trials. In the first trial, plants were exposed to 0, 0.1, or 1 ppm ethylene for one day. These plants were placed into their specified chambers beginning on January 9th.

Because we did not see major growth responses, we ran a second trial with 0, 0.5 or 1.0 ppm ethylene for two days (a higher exposure rate and time) in which these liners were placed into their specified chambers beginning on January 30th.

One tray was placed into each chamber for ethylene exposure. Plants were photographed and observations were recorded during the first week after exposure. One week after exposure, the plant material was transported to the University of New Hampshire for secondary evaluations.

For trial one three SPAD measurements were taken per plant per data collection time. Data were collected on January 17th, 19th, and the 20th. There were three collection times. SPAD data were collected one week after ethylene exposure. There were no other data collected for this trial because of the lack of observed response after transplanting most cultivars.

The data collected for trial 2 consisted of average necrotic leaf, shoot length, number of shoots, and initial flowering dates. The data for trial 2 were collected on March 8th through March 10th.

A. Results for ethylene sensitivity of multiple cultivars

Figure A3. Lantana cuttings exposted to zero, 0.5 ppm, or 1.0 ppm ethylene for two days in Trial 2. Note the leaf drop in response to ethylene, and also the down-turning leaves (epinasty).

Figure A4. Ageratum liner showing temporary epinasty (down-turning of leaves). After 48 hours in the greenhouse, leaf orientation returned to normal.

Table A. 1 Summary of cultivar sensitivity to ethylene based on two trials.

Cultivar	Included in Trials	Comments on ethylene sensitivity
Ageratum 'Artist Blue'	1, 2	Temporary epinasty (down-turning of leaves) at 0.1 to 1 ppm.
Argyranthemum 'Butterfly'	1, 2	Not sensitive
Bracteantha 'Sundaze Golden Yellow'	1, 2	Not sensitive
Calibrachoa 'Superbells Red'	1, 2	Not sensitive
Calibrachoa 'Superbells Blue'	1	Not sensitive
Cuphea 'Tiny Mice'	1	Temporary epinasty at 0.1 to 1 ppm.
Diascia 'Flying Colors Coral'	1, 2	Not sensitive
Diascia integerrima 'Coral Canyon'	2	Slight increase in leaf necrosis at 1 ppm in trial 2.
Gypsophila 'Festival Star'	1	Not sensitive
Lantana 'Tropical Fruit'	2	Severe leaf drop at 0.5 and 1 ppm. Epinasty. Flower delay by 10 days at 0.5 or 1 ppm. Most sensitive cultivar tested.
Lobelia 'Compact Blue with Eye'	1, 2	Not sensitive
Nemesia 'Bluebird'	1, 2	Temporary epinasty at 0.5 to 1 ppm in trial 2.
Nierembergia 'Blue Eyes'	1	Not sensitive
Osteospermum 'Soprano Light Purple'	1, 2	Slight increase in leaf necrosis at 0.5 and 1 ppm in trial 2.
Petunia 'Supertunia Red'	1, 2	Not sensitive
Phlox 'Intensia Lavender Glow'	1, 2	Temporary epinasty at 0.1 to 1 ppm.
Sagina subulata 'Aurea'	2	Not sensitive
Salvia greggii 'Wild Thing'	2	10-12 day flower delay at 0.5 and 1 ppm in trial 2. Temporary epinasty at 0.5 to 1 ppm in trial 2.
Scaevola 'New Wonder'	1, 2	Not sensitive
Scaevola 'Whirlwind Blue'	1	Not sensitive
Sutera 'Bacopa Giant Snowflake'	1, 2	Temporary epinasty at 0.5 to 1 ppm in trial 2.
Torenia 'Summer Wave Blue'	1, 2	Temporary epinasty at 0.1 to 1 ppm in both trials.
Verbena 'Superbena Burgundy'	1, 2	Not sensitive

In trial 2, by far the most sensitive variety was lantana 'Tropical Fruit' (Figure A3). At ethylene exposure of 0.5ppm this cultivar dropped half of its leaves (0ppm 14 leaves and 0.5ppm 7 leaves). At ethylene exposure of 1ppm this cultivar dropped two thirds of its leaves (0ppm 14 and 1ppm 4 leaves).

Most cultivars did not show a lasting response to ethylene at 0.1 or 1.0 ppm for one day, or 0.5 or 1.0 ppm for two days. The most common response to ethylene was epinasty (Figure A4), and plants recovered within 2 days in the greenhouse. Lantana was an exception exhibiting permanent epinasty. *Diascia integerrima* 'Coral Canyon' and Osteospermum 'Soprano Light Purple' showed a slight increase in leaf necrosis at 1 ppm ethylene.

Flowering of Lantana 'Tropical Fruit' and *Salvia greggii* 'Wild Thing' were both delayed by approx. ten days in response to ethylene exposure at 0.5 or 1.0 ppm. The stage of flower bud development is important on liners – previous research has shown that a broad range of floricultural species will abort flowers in response to ethylene (consider, for example, responses to Florel). Therefore, plants that already have flower buds at the liner stage for a wide range of species would probably be more affected by ethylene than plants that are in a vegetative state.

B. Experiment (b) Exposure of Bacopa to different storage conditions [Feb 2006]

B. Objective: Observe effects of different storage temperature, Florel, and physical damage treatments on the quality of Bacopa rooted cuttings.

B. Research Methods

Bacopa 'Snowstorm' cuttings were grown from unrooted cuttings at UNH, followed by simulated storage treatments:

1) Bruising followed by 54F for three days. In this treatment, liners were placed in bags and then shaken orbitally on a machine for 5 mins until they are slightly damaged.
2) 33F for three days
3) 40F for three days
4) 54F for three days
5) 69F for three days
6) 92f for three days
7) Florel applied at 300 ppm in the greenhouse two weeks prior to storage at 54F
8) Florel applied at 300 ppm in the greenhouse one week prior to storage at 54F
9) Florel applied at 300 ppm in the greenhouse one day prior to storage at 54F
10) No storage
11) Media without plants (as a standard to check for the tray media as a potential ethylene source)

Figure B1. Lantana and Bacopa liners were placed into paper and plastic bags throughout the duration of the storage treatments.

Plant leaf greenness (SPAD chlorophyll index), flower, and leaf necrosis data were collected before and after storage treatments as well as after having been potted and grown on in the greenhouse.

The Bacopa cuttings were planted into 105-cell trays using Greenway propagation media. The trays of cuttings were separated into storage groups on the greenhouse benches. Bacopa plants had an average of 7 flower buds or open flowers before storage.

Before the liners were sealed into paper bags and divided into storage groups, Florel sprays were applied to some trays 1 day, 1 week, or 2 weeks before storage. Trays were then placed into their specified storage areas on Jan 6 2006 for three days until Jan 9 2006.

Three air samples per treatment were treatment were taken with a hypodermic needle from the sealed paper bags for ethylene analysis, but there were no significant differences between treatments, probably because of porosity of the bags.

Trays were removed from the bags and one cutting from each bag was potted into a 4.5-in pot for growing on in the greenhouse for the following 4 weeks. Data were taken on SPAD, height, and number of necrotic leaves per plant. There was no effect of treatments on SPAD chlorophyll index, and these results are not reported.

B. Results

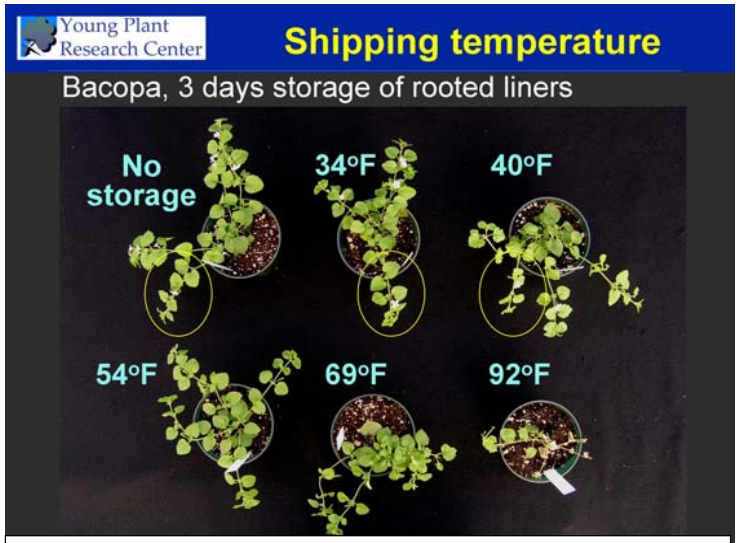


Figure B3. Increasing storage temperature led to decreased flower number on Bacopa. In this photograph, taken 9 days after removal from storage, flower buds were only visible on plants stored at 33 or 40°F, or plants that had not been stored.

Increasing storage temperature decreased flower bud number (Table B1). Plants were not wilted after storage, and nor was there evidence of botrytis, yellowing, or immediate leaf damage after removal from bags even after storage at 92°F.

By 9 days after removal from storage, plants stored at the highest temperature (92°F) were severely stressed, with reduced size and no flower buds, and several of these 92°F-treated plants died later in the trial. There was no effect from storage temperature between 34 and 69°F on shoot elongation.

Figure B4. Although Bacopa liners looked fine when removed from storage, several days later leaf damage was observed on plants stored at 69°F or 92°F.

However, plants at both the 69°F and 92°F treatments showed leaf damage (Figure B4). The highest number of flower buds, Table B1) occurred on plants that had been stored at 33F-40°F, or plants had not been stored. Warm temperatures and florel treatments reduced flowering in Bacopa.

Florel applied 1 day, 1 week, or 2 weeks before storage caused more compact growth and eliminated almost all flowers (Figure B5, Table B1).

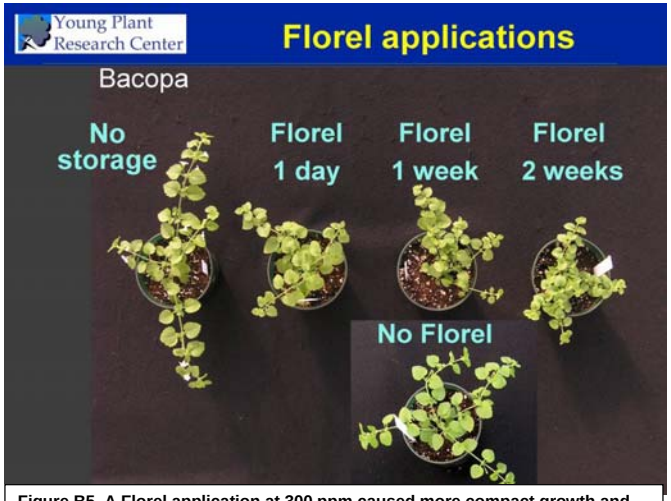


Figure B5. A Florel application at 300 ppm caused more compact growth and fewer flower numbers. The Florel was applied 1 day, 1 week, or 2 weeks before storage at 54°F for 3 days. The "No Florel" treatment was also stored at 54°F for 3 days. The "No Storage" liners remained in the greenhouse.

Table B1. Effects of storage temperature on growth and flowering of Bacopa, measured 9 days after storage. Across a row, numbers that share the same letter are not significantly different at the p=0.05 level using Tukey's HSD test.

Storage duration:	None	3 days	3 days	3 days	3 days	3 days
Details of storage conditions	Greenhouse			Growth rooms		
Storage temperature	68F	34F	40F	54F	69F	92F
Variable						
Number of flower buds	7.2A	6.3AB	4.8ABC	4.0BC	2.3CDE	0.0E
Shoot length (inches)	6.14A	5.46A	5.79A	5.7A	5.56A	1.94C

Table B2. Effects of bruising and Florel on growth and flowering of Bacopa measured 9 days after storage. "Bruising" means that liners were placed into a machine that shook liners until they are slightly damaged. Florel treatments were administered 2 weeks, 1 week, or 1 day before storage. Across a row, numbers that share the same letter are not significantly different at the p=0.05 level using Tukey's HSD test.

Storage duration:	None	3 days	3 days	3 days	3 days	3 days
Details of storage conditions	Greenhouse		Bruising	Florel 2 weeks	Florel 1 week	Florel 1 day
Storage temperature	68F	54F	54F	54F	54F	54F
Variable						
Number of flower buds	7.2A	4.0BC	3.2CD	0.8DE	0.5E	0.3E
Shoot length (inches)	6.14A	5.7A	4.93A	3.63B	4.98A	4.9A

C. Experiment (c) Exposure of Begonia, Lantana, and Portulaca to different storage conditions June 2006

Previous research by North Carolina State University had found the begonia, lantana and portulaca were sensitive to ethylene in storage as unrooted cuttings.

Our objective was (a) to quantify the plant health response of Begonia 'Nonstop Yellow', Lantana 'Patriot Dove Wings', and Portulaca 'Yubi Red' as rooted liners to a range of storage temperatures, bruising, and Florel applications, and (b) to quantify ethylene release with these different cultivars following these storage conditions.

Figure C1. Begonia, Lantana, and Portulaca liners before storage in brown paper bags.

C. Research Methods

Cultivars utilized throughout these trials were Begonia 'Nonstop Yellow' (3x72-count trays), Lantana 'Patriot Dove Wings' (3x84-count trays), and Portulaca 'Yubi Red' (3x84-count trays), sourced from Pleasant View Gardens located in Loudon, New Hampshire.

On receipt at UNH on May 24 2006, Begonia trays were pinched to two nodes and the trays of Portulaca and Lantana were pinched to a height of about five cm so that these plants would not outgrow their trays over the period of treatment.

The trays of Begonia were cut into strips of six cells and the trays of Lantana and Portulaca were cut into strips of seven cells. All of the trays were double spaced in preparation for storage treatments. As shown in Figure C1, plants had flower buds before storage.

Liners were placed into brown paper bags and moved to temperature controlled rooms to be stored for two days.

The experiment was repeated three times, with 1 week between each experimental run, on June 9, 16, and 23 2006.

Figure C2. Florel (ethephon) was to strips of Portulaca, Lantana, and Begonia at 500 ppm, either 1 day, 1 week, or 2 weeks before storage.

Storage Treatments:

1.) Bruising before storage @ 67°F for three days
2.) 33°F for three days
3.) 41°F for three days
4.) 51°F for three days
5.) 67°F for three days
6.) Florel (500 ppm) applied two weeks before storage @ 67°F
7.) Florel (500 ppm) applied one week before storage @ 67°F
8.) Florel (500 ppm) applied one day before storage @ 67°F
9.) Media without plants (67°F for three days)
10.) No storage (remains in greenhouse)

Liner weight before and after storage was measured as an indicator of dehydration at different temperatures.

After storage, leaf drop was immediately tallied from the paper bags that the individual treatments had been previously stored in.

Figure C3. Post storage treatments Begonia, Lantana, and Portulaca liners are removed from paper bags and placed into mason jars for 4 hours.

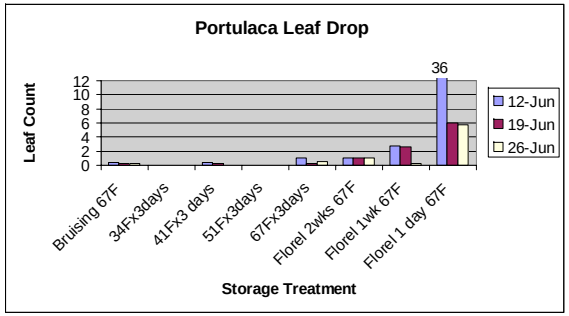
Figure C4. After liners were in the Mason jars for 2.5 hours, ethylene samples were taken using syringes. Syringes were then placed into a stopper and carefully packaged to be sent to Floralife for ethylene analysis.

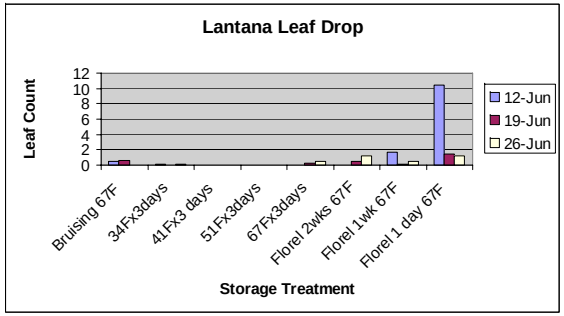
Plants were then placed into 480 cm^3 mason jars for 4 hours while they were still in the storage rooms, with a single plant per jar and one replicate jar per treatment for each of three separate experimental runs (Figure C4). After 4 hours, ethylene levels were then measured using syringes that pierced the rubber septum in the lid of the Mason jar. Air samples were also collected from the growth chambers to check for unintended ethylene sources.

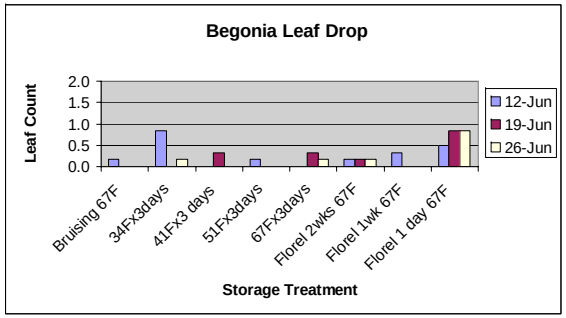
Four plants that had not been placed in the mason jars for each treatment and experimental run were potted into 4.5-inch standard pots to be grown on for the following four weeks in a glass greenhouse (photo at right). 50% shade was placed above the begonias, and the greenhouse was white-washed. Over the duration of four weeks physical differences are noted and critical data is taken such as SPAD, height, the amount of abscised leaves per pot, necrotic leaves per pot, and number of flowers per pot.

C. Results for storage of begonia, lantana, and portulaca.

Figure C5. Number of leaves abscised per plant from three trials, June 12, June 19, and June 26, where (a) Portulaca, (b) Lantana, and (c) Begonia liners were stored for three days in simulated shipping conditions.



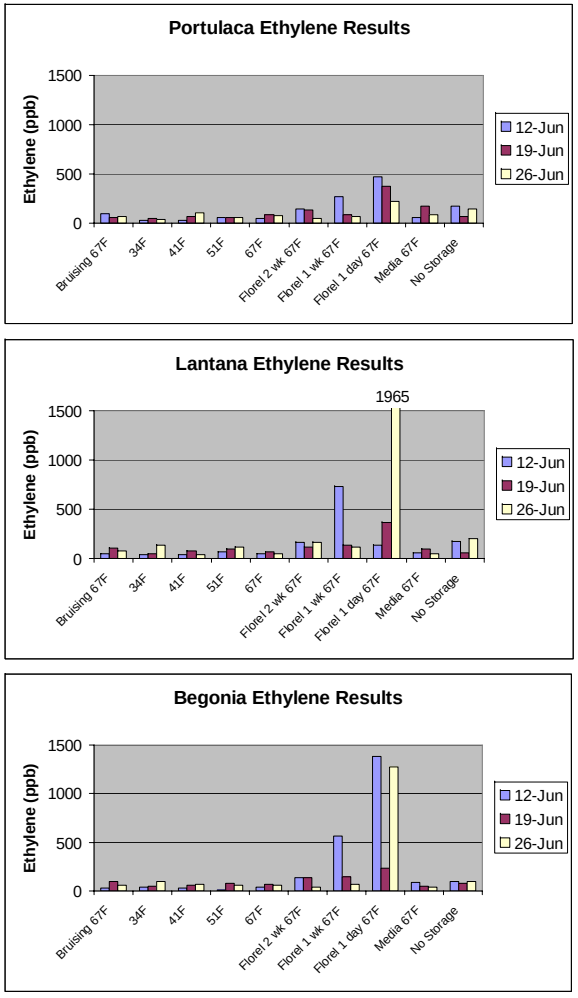




- Leaf drop was increased when Florel was applied one day before storage, in all species.
- There were some differences from one experimental run to the next, but portulaca and lantana also had a higher average amount of leaf drop with Florel application one week before storage.
- Because of their growth form, begonia had fewer leaves total, and also had fewer dropped leaves, than lantana or portulaca.

C. Results continued… Ethylene Sample Data Collection

Figure C6. This chart shows the amount of ethylene produced in 4 hours after 3 days in different storage conditions, with 1 liner per 480cc container. Ethylene samples were analyzed by FloraLife.



- Ethylene levels were elevated with Florel treatments 1 day before storage.
- There was a smaller increase in ethylene from liners sprayed with Florel 1 week and 2 weeks before storage.
- The "Media 67F" sample showed low levels of ethylene production, indicating that the growing medium was not an important source of ethylene.
- Bruising or temperature treatments alone did not increase ethylene production.
- Air samples from the growth rooms and greenhouse were less than 100 ppb indicating that there was no unintended ethylene contamination (data not shown).

C. Results continued... Plant Health After Transplant (evaluated at day 8 and 28).

- Compared with the height of plants stored at 67F…
  - Begonia that received Florel 1 day or 1 week before storage were 65 and 55% of the 67F plants after 28 days; plants that were sprayed with Florel 2 weeks before storage had similar growth; and bruising decreased height by 29%. Plants stored at cooler temperatures had decreased growth and flowering.
  - Height of lantana receiving Florel applications 1 day or 1 week before spraying was also decreased by 20%. Lantana receiving Florel 1 day before storage or bruising had 9 or 4 more necrotic leaves per plant. 4 of 4 plants that received the Florel 1 day and 3 of 4 plants receiving the Bruising treatment in the first experimental run died after transplant. There was little effect of storage temperature on subsequent growth.
- Height of Portulaca receiving Florel 1 day before storage was 67% of 67F plants. There was little effect of storage temperature on subsequent growth.
- There were no clear differences between storage temperatures. We did quantify dehydration, and the weight of media and plants stored at 67F ("Bruising", "Florel", and "67F") dried down more (20-40% less than pre-storage weight) than liners stored at cooler temperatures (5-15% decrease in weight).

Flower buds on lantana died following physical damage during shipping.

Portulaca showing purpling of lower leaves following physical damage during shipping.

Begonia, 1 day after storage.
Top left to right: Greenhouse (no storage) and storage at 67F.
Bottom left to right: Florel 1 day, Florel 1 week, and Florel 2 weeks before storage.

Portulaca (top) and Lantana (bottom) one day after storage.
From left to right: Greenhouse (no storage), Florel 1 day before storage, Florel 1 week before storage, and Florel 2 weeks before storage.

D. Measuring Ethylene Levels in Commercial Shipments

Research Methods A hypodermic needle was inserted into unopened boxes, and a gas sample was drawn out and sent to FloraLife for ethylene analysis. Samples were taken in 2005 from boxes of Pleasant View Gardens cuttings and rooted liners and 2006 from several growers.

Sample #	Sample Description	Date Boxed	Date Opened	Date Sampled	Ethylene Level (ppb)	Ethylene Level (ppm)
Warehouse 1	Pleasant View Gardens shipping area	N/A	N/A	2-Jun	11	0.011
Warehouse 2	Pleasant View Gardens shipping area	N/A	N/A	2-Jun	11	0.011
Sample 1	Single layer box containing 4 liner trays. Top to bottom: Bacopa, Bacopa, Argyranthemum Vanilla Butterfly, Argyranthemum Vanilla Butterfly.	31-May	2-Jun	2-Jun	244	0.244
Sample 2	Single layer box containing 2 liner trays, order from top to bottom (No tray, Euporbia, No Tray, Euphorbia)	31-May	2-Jun	2-Jun	234	0.234
Sample 3	Single layer box containing 2 liner trays, order from top to bottom (No tray, No Tray, Lantana Gold, Lantana Gold)	31-May	2-Jun	2-Jun	508	0.508
Cuttings 1	Euphorbia Cuttings from Costa Rica: ethylene samples taken from individual internal (1 of 6) cardboard boxes w/in shipping box immediately after opening.	Arrived (5/31) then in cooler	2-Jun	2-Jun	541	0.541
Cuttings 2	Euphorbia Cuttings from Costa Rica: ethylene samples taken from individual internal (1 of 6) cardboard boxes w/in shipping box immediately after opening.	Arrived (5/31) then in cooler	2-Jun	2-Jun	285	0.285
Cuttings 3	Euphorbia Cuttings from Costa Rica: ethylene samples taken from individual internal (1 of 6) cardboard boxes w/in shipping box immediately after opening.	Arrived (5/31) then in cooler	2-Jun	2-Jun	309	0.309

2006: An additional six boxes containing Calibrachoa cuttings from Center Greenhouses, D.S. Cole Growers, Glass Corner, Kube Pak, and Welby Gardens were analyzed on May 24 2006. Ethylene levels ranged from 44 to 136 ppb (0.044 to 0.136 ppm).

Conclusion: Elevated ethylene levels (above 0.1 ppm) clearly can occur sometimes in commercial shipping boxes with both unrooted and rooted cuttings.

E. Experiment (d) Lantana responses to ethylene and Ethylbloc™ (Active ingredient 1-MCP) June 2006

E. Protocol

Four trays of Lantana were transported in open racks from Pleasant View Gardens to the University of Massachusetts, Amherst. Twenty rooted liners placed into 5-gallon containers at 68°F overnight and treated with 1-MCP (Ethylbloc™) gas at label rate or no 1-MCP. The Lantana liners were then divided into four equal groups of five plants, and were placed into ethylene exposure tanks at 0, 0.5, or 1 ppm ethylene for two days, or directly into the greenhouse, representing the no storage treatment.

The eight treatment combinations, with five liners per treatment, were therefore: 1-MCP greenhouse, 1-MCP air, 1-MCP 0.5 ppm, 1-MCP 1.0 ppm, no 1-MCP greenhouse, no 1-MCP air, no 1-MCP 0.5 ppm, and no 1-MCP 1.0 ppm.

This experiment was repeated four times over the course of 8 days from June 8 to June 16.

In addition to the rooted liners, unrooted cuttings were harvested from extra lantana liners, and on the same day were treated with 1-MCP and ethylene along with the rooted liners. After each treatment the number of abscised leaves per rooted liner and per unrooted cutting was recorded.

The treated Lantana liners were then transported to the University of New Hampshire to be grown on for the following four weeks. Once these plants were received at UNH they were potted into four and half inch pots and placed into the research greenhouses for further observation. On July 26, 2006 (40 days after treatment) flower number, shoot length, shoot number, and fresh weight data was collected.

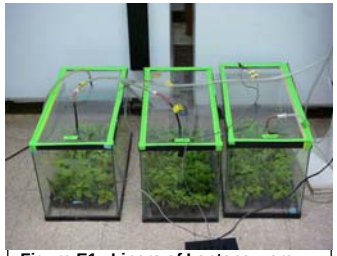


Figure E1. Liners of Lantana were placed into these three tanks with ethylene exposures of 0ppm (air), 0.5ppm and 1ppm.

Figure E2. Lantana exposed to 1ppm with no 1-MCP (Ethylbloc) for two days.

E. Results

The Lantana cuttings and liners that were exposed to ethylene and were not treated with 1-MCP had a high occurrence of leaf abscission.

After ethylene exposure at 1 ppm with no 1-MCP, all leaves dropped, and 40% of plants died. Lantana exposed to 0.5ppm with no 1-MCP dropped half their leaves.

Treatment with 1-MCP prevented leaf abscission in Lantana cuttings and liners.

After transplant, all rooted liners treated with 1-MCP grew the same as plants that did not receive ethylene exposure at 0.5 or 1 ppm.

Figure E3. Growth of plants 19 days after ethylene exposure as rooted liners.
Top three plants: No 1-MCP. Bottom three plants: 1-MCP.
Left to right: 0, 0.5, and 1 ppm ethylene exposure for 2 days.

Figure E4. Growth of plants 32 days after ethylene exposure as rooted liners.
Top three plants: No 1-MCP. Bottom three plants: 1-MCP.
Left to right: 0, 0.5, and 1 ppm ethylene exposure for 2 days.

Table E1. Effects of ethylene and 1-MCP on rooted lantana liners.

		Liners		Transplanted 4.5-inch pots			
		# leaves abscised (5 liners)	% dead	flower number	shoot length (cm)	fresh weight (g)	side shoot number
Air	1-MCP	0	0	11	37	254	10
Air	no 1-MCP	0	0	10	38	296	8
500ppb	1- MCP	0	0	13	39	336	7
500ppb	no 1-MCP	115	0	6	29	372	6
1000ppb	1-MCP	0	0	11	42	284	8
1000ppb	no 1-MCP	166	40%	2	28	270	4

Table E2. Summary of number of leaves abscised from five unrooted lantana cuttings

Treatment	# leaves
Air MCP	0
Air NO MCP	0
0.5ppm MCP	0
0.5ppm NO MCP	11
1.0ppm MCP	0
1.0ppm NO MCP	21