Grow a Better Liner

Ball FloraPlant®

BEST PRACTICES THROUGH EVERY STAGE

Grow the best liner every time you stick a cutting.

This piece is all about how you can grow the BEST liner every time you stick a cutting. Vegetative propagation is one of the most challenging phases of plant production — and it takes a level of detail and consistent focus for any grower. Our hope is that this supplement can help both large and small growers propagate more effectively and better ensure the success of your vegetative crops. We've divided this piece chronologically into the four phases or parts of propagation to help you grow a better liner.

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Planning

The goal of planning is to reduce the time from when you receive the cuttings to when they're stuck – **to shorten the time from the box to the bench**. To help this move as smoothly as possible, you need to plan ahead.

What your plan should include:

- How many cuttings are coming each week?
- How many trays will you need?
- How much bench space will you need?
- What days will the shipments arrive? You can check with your Ball Seed® Sales Rep or on WebTrack® to find out the exact day your cuttings will arrive.
- Do you have enough employees ready and available to stick the cuttings once they arrive?

Preparing

Before your cuttings arrive, it's important to check that everything is functioning properly. Start with your heating system – is everything in working order? If not, now is the time to correct any issues.

Next, check that your misting systems are ready to go and there are no surprises once the cuttings arrive in the propagation zone. Clean filters and nozzles, test your booms or misting systems, solenoids, temperature and humidity sensors.

Another important factor to consider when preparing for your cuttings to arrive is sanitation. Be sure to clean the walkways and floors under the benches, clean the tops of benches and remove any weeds. It's important to make sure everything is sanitary before your cuttings arrive. Furthermore, it's equally important to continue your **sanitation protocols** throughout the season.

Preparing your employees is another important step you should take before your cuttings arrive. Instruct them how deep they should stick cuttings. Should they be using rooting hormone? Make sure they are trained to properly tag liners so there's no confusion down the road. By planning how many cuttings are coming on what days, you can ensure that you have enough employees to stick efficiently and timely.

Storing and handling upon arrival

The ideal temperature to store your unrooted cuttings (URCs) is between 50 to 55°F (10 to 13°C) for the vast majority of the unrooted cuttings you'll propagate. There are a few outliers from this temperature range, like geraniums and chrysanthemums, which you can store at temperatures closer to 40°F (4°C). In addition, crops like portulaca, basil and sweet potato vine prefer warmer temperatures, between 55 to 60°F (13 to 16°C).

You also want a **high relative humidity** to maintain strong, turgid cuttings until you're able to get them stuck: Dry fog systems are a great method to increase humidity. For smaller growers who don't have computerized systems, you can raise relative humidity by wetting down the floors and by covering your cuttings with wet newspaper. Your cooler can actually be a very dry environment, so it's important to maintain high humidity to ensure turgid cuttings.

Arrival

After 24 hours in a cooler with a fog chamber, the cuttings look better

RECOMMENDED URC STORAGE TEMPERATURES

COOL TEMP STORAGE

45-50ºF (7-10ºC)

- Argyranthemum
- Bacopa
- Bidens
- Brachyscome
- Bracteantha
- Calibrachoa
- Cuphea
- Lobelia
- Nemesia
- Osteospermum
- Petunia
- Plectranthus
- Salvia
- Scaevola
- Verbena

MEDIUM TEMP STORAGE

50-55ºF (10-13ºC)

- Angelonia
- Coleus
- Dahlia
- Erysimum
- Heliotrope
- Impatiens, Double
- Impatiens, Interspecific
- Impatiens, New Guinea
- Impatiens *walleriana*
- Iresine
- Perilla
- Poinsettia
- Strobilanthes
- Thunbergia

COLD SENSITIVE STORAGE

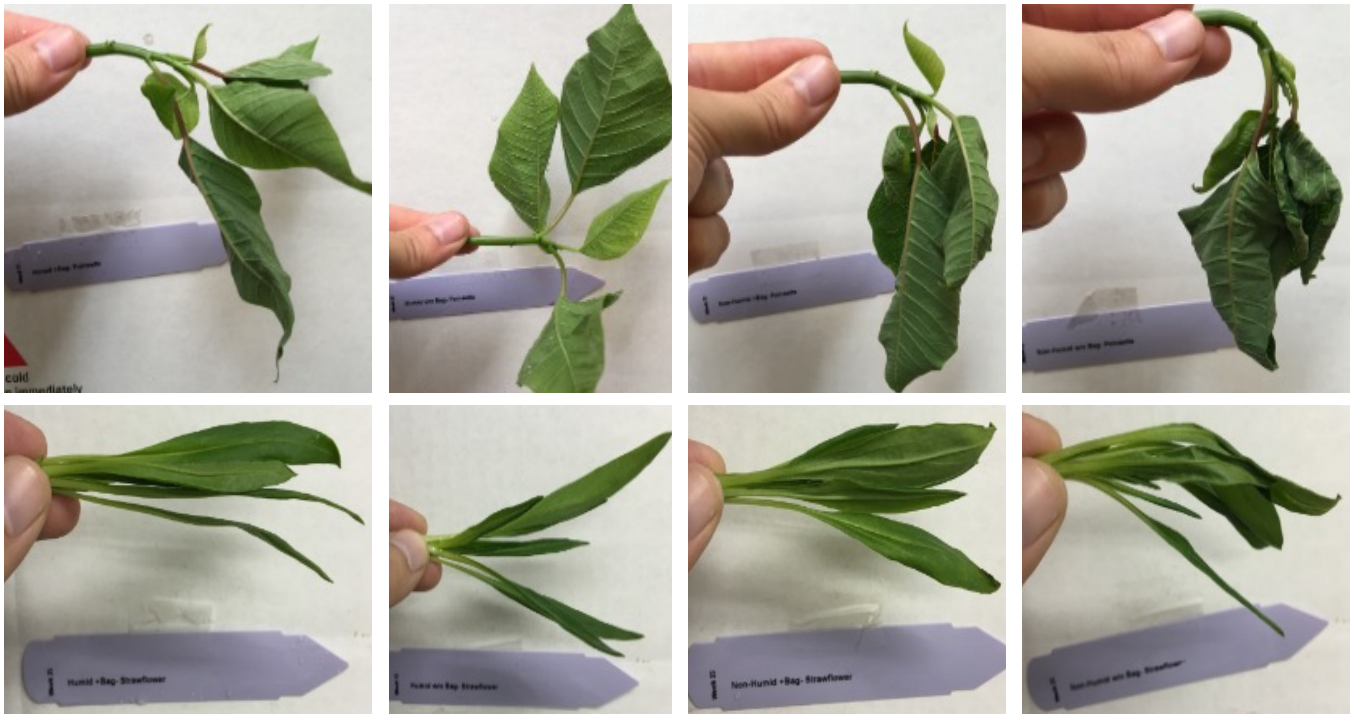
55-60ºF (13-16ºC)

- Basil
- Ipomoea
- Purslane

CARE AND STORAGE OF URCS

The difference in turgidity between treatments after 24 hours is drastic. Coolers naturally dehydrate cuttings, and bags limit water absorption. Add humidity with something like a dry fog system and remove or open URC bags when possible to maximize hydration in the cooler.

Humid + Bag | Humid - Bag | Cooler + Bag | Cooler - Bag



Planning, preparing and receiving your cuttings

Sanitation Protocols

Sanitation protocols for handling and growing vegetative annuals start as soon as you unpack your cuttings, so be sure your team knows what your sanitation program entails. When handling and storing unrooted cuttings, there are two important factors to consider: **barriers, such as gloves or aprons, and sanitizing agents**. Be sure every employee is wearing aprons and gloves when handling cuttings, even in the cooler. Provide a sanitizer – for example, a quaternary ammonium product – for employees handling cuttings to use periodically to sanitize their hands. Ideally, employees sanitize hands between opening boxes. Additionally, be sure to sanitize carts, trays and any other equipment or resources used to handle and store cuttings. This should be done in between each use.

Sanitation checklist

- Written and posted sanitation protocols for handling and sorting URCs
- Barriers – Do you have aprons and gloves available for employees handling and sorting the cuttings?
- Sanitizing agents – Mixed, ready to go and applied using the labeled rates and instructions

Sticking Priority

Certain crops are more sensitive to the stresses that are incurred during transit from the stock farm to your dock. It's important that you have a priority list of crops to **determine the order of sticking** (see chart on page 5) when they arrive. Crops like geraniums, euphorbia, lantana, thunbergia and purslane are very sensitive to transportation stress and tend to perform best if they're stuck the same day they arrive. If you cannot stick them the same day, be sure they're unpacked and stored appropriately to minimize the stress.

Not all crops have the same temperature, humidity, light and mist requirements, and because of this, it helps to **group cuttings in your propagation house** so you can better deliver the right environment. We've developed a list you can use as a starting point and then tweak to fit your location and facility (see page 5). Factors to consider when creating groups are the length of time under mist, soil and air temp, light levels and mist frequency. Certain crops like osteospermum and bracteantha need more frequent mist to remain turgid. Geraniums should have their own misting regime. Lantana need very little mist, so they would also have their own misting group.

All of this grouping and planning will help improve your chances of success once the cuttings get into the prop house.

BIGGEST MISTAKES

- **A failure to plan is a plan to fail**
- **Storing cuttings in the wrong environment (temperature, humidity)**
- **Not prioritizing or sorting for success in the propagation house**
- **Poor sanitation practices**

STICKING PRIORITY LIST

Prioritizing and grouping your cuttings for success

FIRST PRIORITY

- Dahlia
- Euphorbia
- Geranium, Ivy
- Geranium, Zonal
- Heliotrope
- Ipomoea
- Lantana
- Lobelia
- Purslane
- Thunbergia

SECOND PRIORITY

- Arctotis
- Artemisia
- Bacopa/Sutera
- Begonia *boliviensis*
- Calibrachoa
- Coleus
- Diascia
- Erysimum
- Evolvulus
- Fuchsia
- Impatiens, Double
- Impatiens, Exotic
- Impatiens, Mini
- Lobularia
- Nemesia
- Osteospermum
- Perilla
- Petchoa
- Petunia
- Plectranthus
- Salvia
- Strobilanthes
- Verbena
- Viola

THIRD PRIORITY

- Multi-liners
- Ageratum
- Alternanthera
- Angelonia
- Argyranthemum
- Bidens
- Brachyscome
- Bracteantha
- Chrysocephalum
- Cuphea
- Felicia
- Helichrysum
- Impatiens, Interspecific
- Impatiens, New Guinea
- Iresine
- Lamium
- Nierembergia
- Phlox (all)
- Scaevola
- Torenia

FOURTH PRIORITY

- Celosia
- Gaura
- Hedera
- Lophospermum
- Lysimachia
- Sanvitalia
- Streptocarpella
- Vinca major

Media choice, tray manufacturing and proper fill

Uniform, high-quality liner production starts before the cuttings get into the propagation house, so be sure to put the proper **emphasis on the manufacturing processes** included when sticking your cuttings.

Tray Quality

We want to highlight the important factors to consider when you stick your unrooted cuttings. Things to consider: uniform soil levels in propagation trays, appropriate soil moisture at the time of stick, proper dibbling and utilizing rooting hormone.

There are many media options to choose from – paper pots, peat, peat perlite, foam plugs and stabilized media. Things to consider are: Will you fill your own trays or order pre-made trays? Do you prefer loose fill, media bound with paper or a stabilized media like Preforma? You should make your decision of what media to use by considering your operation and environment and the cost versus the benefit of each.

The quality of the liner depends on many different things. First, the media – be sure to check pH and EC weekly or biweekly. The pH should be between 5.5 and 6.0 and EC should be between 0.5 and 0.75. You want to ensure uniform filling of the trays and to eliminate cells being filled at different levels. Be aware of soil compaction in your trays. **If soil is too wet and compact, it can delay rooting time and quality.** If you're using media bound with paper, be sure that the paper isn't higher than the plug or it will wick away the water.

Moisture Management

Soil moisture management starts before you stick your cuttings.

It's important to consider the soil moisture both before and after the cuttings are stuck. Soil that's too dry will quickly pull away moisture from the cutting and

The soil level needs to be uniform in your propagation trays.

The moisture level scale is shown in this tray, with 5 being completely saturated on the left and 1 as extremely dry on the right.

MOISTURE MANAGEMENT					
	Level 5	Level 4	Level 3	Level 2	Level 1
Soil Color	Black	Dark brown	Brown	Light brown	Tan
Moisture Content	Water freely drips from soil	Drips when squeezed	Single drip when squeezed	No dripping	No dripping
Soil Adhesion	Forms ball like tofu or pudding	Soil ball sticks together	Soil ball cracks apart	Soil ball crumbles	Soil ball won't form

result in unnecessary stress on the plant. On the other hand, soil that starts too wet will make it harder to achieve the ideal soil moisture level during callus formation and root initiation.

A lot of this depends on what trays you use for propagation and when they're prepared. If you're preparing trays in advance or purchasing pre-made trays, you'll need to be sure that the soil moisture is correct before sticking your cuttings. If the soil has become too dry, it will be difficult to rewet and may take several irrigations and considerable time to get to the correct soil moisture. If this is the case, it's important to start this process a day or more in advance of the cuttings arriving at your facility.

One of the first things you should do is determine what the proper moisture looks and feels like in your trays. At Ball, we work with a 1-to-5 moisture scale where 1 = bone dry and 5 = completely saturated. You may have developed your own scale already or you can use this one, but it's important to have everyone involved in irrigating your crops speak the same language with regards to moisture management. Once your cuttings are stuck, **it's ideal to have the soil moisture at approximately a level 4**. This would mean that water could be readily squeezed from the soil, but there's not any freestanding water on the surface. A great way to put a value on the correct moisture is to weigh a few trays that you feel are at the ideal Level 4 moisture. The average of those measurements will give you and your team a target to hit and an expectation for what the right soil moisture looks and feels like.

Achieving the Perfect Dibble

Proper dibbling is about more than just making a hole in the soil for the cutting to be stuck into. **The dibble offers a target for your sticking crew, as well as a safe place for the cutting to go without risk of breaking the stem or damaging the base of the cutting.** The location, depth and size of the dibble are all important details to discuss when training your sticking crew on proper dibbling.

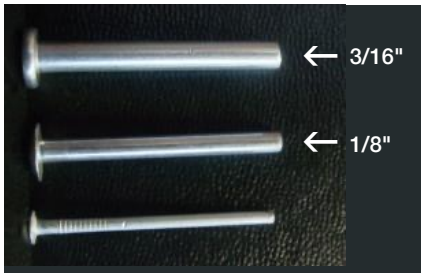
Location is pretty easy – the center of the cell.

Depth of the dibble depends not only on the size of cuttings being stuck, but it can also depend on what crop you're sticking. Obviously, larger, longer cuttings will need a deeper dibble than smaller cuttings. In our experience, certain crops like calibrachoa and lobelia will root more quickly and uniformly when they have good contact between the base of the cutting and the soil. Dibble too deep and this contact won't occur. We've seen many employees dibble through the bottom of the cell and leave the base of the cutting dangling in the air. Dibble too shallow and the cutting won't go in far enough to be secure, and the risk of breaking or damaging the cutting is greater.

And lastly, the size or diameter of the dibble is also important. A lobelia or calibrachoa cutting doesn't need the same size dibble as a zonal geranium. You may need two different sized dibble pins for your sticking crew based on what they're sticking.

Dibble Correctly

Managing dibble size and depth



One size does not fit all crops, so use a properly sized dibble pin.

Improper dibbling can lead to a lack of uniformity.

Media choice, tray manufacturing and proper fill

Rooting Hormone

A great way to **improve the uniformity and speed of root initiation** in vegetative propagation is to use a rooting hormone (see chart on page 9). Not all crops need hormone for fast rooting, but many will benefit from an application, and the harder-to-root items and those crops that take longer to root are the best candidates for using hormones.

IBA is the most common and widely used rooting hormone for vegetative propagation, and we're sure many of you are familiar with some of these products. IBA can come in a powder form, in a soluble salt form and in a liquid form. IBA powder is available in several concentrations, usually between 0.1% to 0.3%, and is applied to the base of the stem prior to sticking.

The most popular soluble salt form is KIBA, which can be applied to the base of the stem or as an overhead application as a coarse spray. When applied to the base of the stem, KIBA can be used in concentrations from 150 to 500 ppm. As an overhead application, KIBA rates are normally in the 50 to 250 ppm range. This method of applying your rooting hormone can be more cost effective and sanitary when compared to treating the base of the stem. Remember that the overhead applications need to be coarse enough to get the solution down the stem toward the base of the cutting. One warning regarding the overhead application: it will cause a leaf and/or stem curl in some crops, but they'll normally grow out of this distortion within a few weeks. Because of this potential reaction, it's always good to trial the overhead applications first before using as a broad treatment.

Liquid rooting hormone is also available, and Dip 'n Grow is a widely used product that falls into this category. Same as the KIBA water-soluble salts, this product will be applied to the base of the stem prior to sticking the cuttings. As a best practice on sanitation, it's best to apply this with a hand sprayer and avoid getting the solution on the leaves.

Rooting hormones are a great tool that every propagator should utilize to ensure a good start on harder-to-root crops.

Be sure to visit BallFloraPlant.com to reference more detailed information on culture and on which crops benefit from rooting hormones.

Rooting Hormones Basal End Applications

Powder Applications

- Powdered hormone such as Rhizopon AA Dry Powder can be applied to the basal end of the cutting.
- Use a duster to apply to the stem only.
- Avoid getting powdered hormone on the leaves.
- Do not dip the stem into a container of hormone...this is a sanitation risk.
- Do not coat the stem with a solid layer of powder.

Liquid Applications

- IBA can be applied as a liquid basal application with typical rates of 500 to 1,000 ppm.
- Dip 'n Grow and Rhizopon AA are two commonly used hormones for this type of application.
- Apply to the basal end with a hand-held spray bottle.
- Do not allow solution to get on the stems or leaves of the cutting.
- Do not dip stems directly into the solution...this is a sanitation risk.

Rooting Hormones
Spray Application After Sticking

- IBA can also be applied directly over the top of the crop after sticking.
- This method requires a coarse spray that allows some of the solution to run down the stem toward the base of the cutting.
- Hortus IBA Water Soluble Salts are the most commonly used product, with rates from 50 to 300 ppm.
- Some leaf curl response can occur, but the plants will normally grow out of it prior to shipping.

Argyranthemum showing leaf curl after IBA spray

ROOTING HORMONE CHART

Trade Name	Source	Formulation	Ingredient
Chryzopon	ACF Chemiefarma	Powder (talc)	0.1% to 8% IBA
C-mone	Coor Farm Supply Services, Inc.	Liquid (isopropyl alcohol)	1% and 2% IBA
C-mone K	Coor Farm Supply Services, Inc.	Liquid (isopropyl alcohol)	1% KIBA
C-mone K+	Coor Farm Supply Services, Inc.	Liquid (isopropyl alcohol)	1% KIBA + 0.5% NAA
Dip 'n Grow	Astoria-Pacifica, Inc.	Liquid (alcohol)	1% IBA + 0.5% NAA + boron
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
Woods Rooting Compound	Earth Science Products Corp.	Liquid (ethanol)	1.03% IBA + 0.56% NAA

BIGGEST MISTAKES

- Not emphasizing correct tray manufacturing process
- Incorrect soil moisture at time of stick
- Improper dibbling (right depth and size)
- Not utilizing a rooting hormone

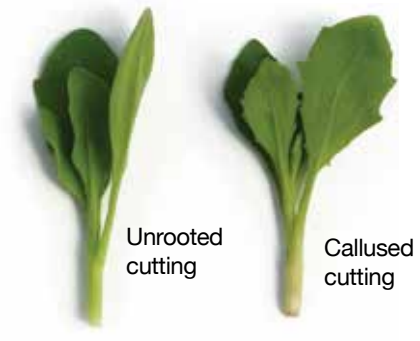
Stages 1 & 2: From unrooted to rooted cuttings

Stage 1 of propagation (from stuck cutting to callus)

The first step is to decide if you're going to use a surfactant. A surfactant works by breaking the surface tension on the leaf, which allows the cutting to rehydrate quicker. This allows every mist cycle through the duration of Stage 1 to be more effective. Most importantly, surfactants help to minimize stress on the cutting.

Planning a proper mist strategy for the first stage of propagation is important to ensure success. After sticking the cutting, it can take anywhere from three to 10 days for the callus to develop, depending on the crop. The goal is to rehydrate the cuttings as quickly as possible. Maintaining a high humidity during this stage helps the cuttings stay turgid. You don't want cuttings to dry down or wilt during the first three to five days.

The ideal propagation zone should feel warm like a sauna. Soil temperature in the liners should be between 70 to 74°F (20 to 24°C), depending on the crop and location. More importantly, the soil temperature should remain above 68°F (20°C) throughout the night. The daytime temperatures should range between 68 to 80°F (20 to 27°C). You should increase humidity to maintain turgid cuttings, but not too high as to cause breakdown or botrytis. Light intensity should range between 1,300 to 1,500 foot-candles.



Remember – minimizing the stress on the cutting and rehydrating are crucial in the first few days of propagation.

Fertility

Initially, cuttings don't require fertilizer because they don't have developed roots uptaking nutrients. Start with low nitrogen levels around 50 ppm. If you're using an overhead mist system, you could potentially leach out nutrients. If this occurs, increase nitrogen levels to 75 ppm. If nutrients are leached from the cuttings, they develop into soft, weak liners. Once the callus is formed, you can increase nitrogen levels to 75 to 100 ppm.

Stage 2 of Propagation (from callus to rooting)

Once the callus has started to form, we're at Stage 2. For some crops, this can be just a few days after sticking, and for others, it could be six to eight days, so it's important to understand when this occurs for the crops that you're propagating because there's action to be taken in this stage. In order to force the cutting to initiate roots, we must make it work a bit to survive, which means we start to **cut back both the mist frequency and the soil moisture**.

BIGGEST MISTAKES

STAGE 1

- Allowing cuttings to dry down in the first three to five days
- Over-misting
- Allowing soil temperatures to drop below 68°F (20°C)
- Not having the right environment (too high of light levels, too much air movement)
- Not minimizing stress on the cuttings

So where does Stage 2 end? Once roots have emerged and are starting to elongate (just reaching the edge of the cell), we're at the end of Stage 2 and misting is likely finished.

Mist Strategy

Stage 2 is where most crops are **receiving minimal or no night mist and the daytime mist has been reduced greatly** from the first few days of propagation. If you don't reduce the mist during Stage 2, will your cuttings still root? Sure, many of the cuttings will start to root, but the uniformity and speed of rooting will be reduced, and disease and insect pressure can increase quickly. Because we want to get them off mist as quickly as possible, this **weaning process is crucial,** and propagators should know when to begin this process and have a strategy in place. You should always have an end date in mind for when Stage 2 will be complete and the mist will be off so that you're working toward that throughout the Stage 2 timeline. If you feel that Stage 2 ends on day 12 after stick, then gradually reduce your misting/humidity each day until you get to the goal.

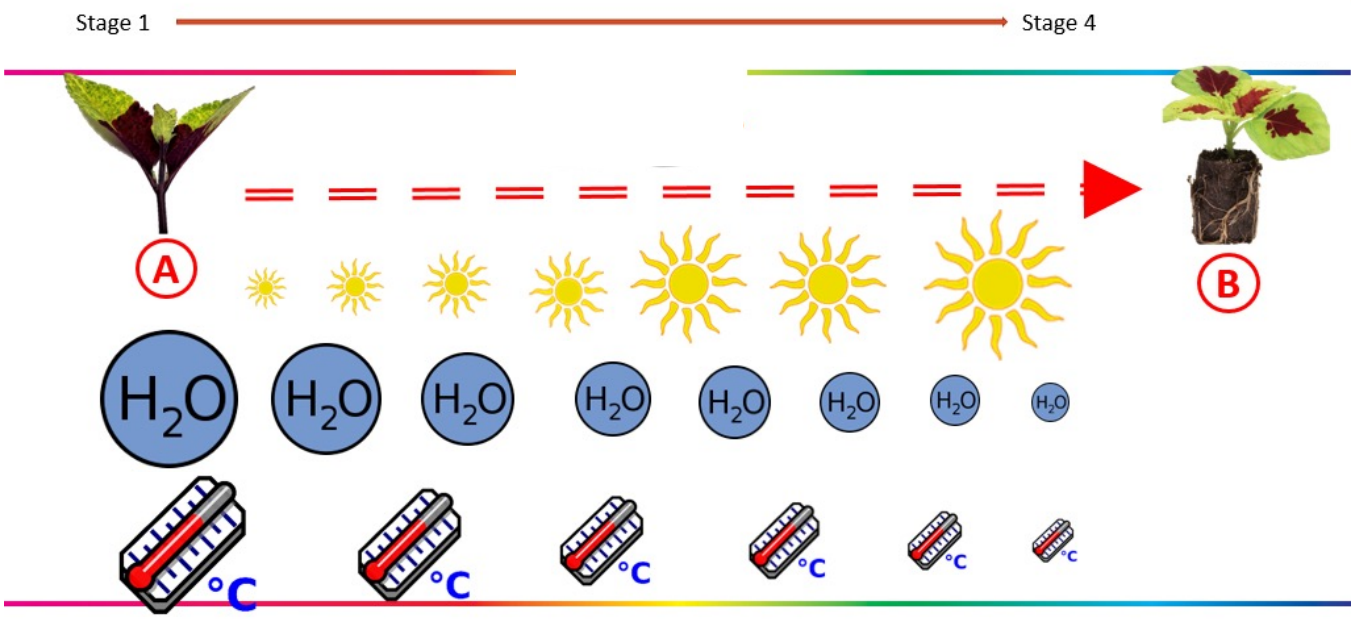
Some of the problems that are caused by over-misting or not weaning cuttings off mist in Stage 2:

- Increased instance of fungal diseases like botrytis
- Increased algae growth and more fungus gnat and shorefly pressure
- Reduced fertility in the cutting, as well as low EC in the propagation media
- Saturated soil that slows root initiation and rapid root growth, and decreases the uniformity of root initiation

STAGE 2: Mist Strategy

- Cuttings should be aggressively weaned off mist during this stage
- Night mist should be off during Stage 2!

Day	Stage	Morning	Day	Evening	Overnight
1-3	1	Mist	Mist	Mist	Mist
4-5	1	Mist Reduced	Mist	Mist Reduced	Mist Off
6	1	As Needed	Mist	Mist Reduced/Off	Mist Off
7	2	As Needed	Mist Reduced	Mist Reduced/Off	Mist Off
8	2	As Needed	Mist Reduced	Mist Off	Mist Off
9	2	Mist Off	As Needed	Mist Off	Mist Off
10	2	Mist Off	As Needed	Mist Off	Mist Off



As a URC roots, the light, water and temperature requirements change. A good VPD system and appropriate curve will make the moisture management easy.

Stages 1 & 2: From unrooted to rooted cuttings

Moisture Management

Saturated, or Level 5 soil moisture, will decrease the uniformity and speed of rooting for most crops, so it's important to emphasize the proper soil moisture during Stage 2. Ideally you can maintain a Level 4 soil moisture during root initiation and then start drying down to a Level 3 as the roots start to elongate. Dry soil below a Level 3 during Stage 2 can stall the root initiation process, so too dry can be a problem as well.

Fertility

The cutting has been losing nutrients ever since it was severed from the stock plant and this is our first real chance to start to replace this lost nutrition. Ideally, you can provide some fertility in mist during Stage 1 of propagation. The biggest benefit of this will come from the increased EC of the soil, as the water makes it to the propagation media. This is ideal because, as the cutting strikes a root, we want to have some nutrients there for it to start taking up immediately. Regardless of whether you foliar fertilize or not, you should start fertilizing the soil in this stage to bring up the soil EC – 75 to 100 ppm N of a balanced fertilizer like 17-5-17 is a great place to start. As your soil starts to dry down and the roots begin to elongate, you can recharge the soil EC at each irrigation, but be careful not to push too hard. This is a great environment to promote stretched internodes and rapid growth, so try to balance the fertility at this point until you can get your liners into a better environment for toned growth.

PGRs – Controlled Growth Management

This is likely the **first stage in which a grower will start to treat liners with growth regulators**. Not all crops will need treatments in this stage, but because of the need for controlled and compact growth, combined with an environment that provides conditions that aren't favorable to this type of growth, we may need to begin PGR treatments.

HIGHER Mist Frequency Crops	Average Days to Root*
Argyranthemum	5 to 7
Thunbergia	7 to 9
Angelonia	8 to 10
Bracteantha	8 to 10
Osteospermum	9 to 12 (URC)
Scaevola	9 to 12 (URC)

LOWER Mist Frequency Crops	Average Days to Root*
Purslane	5 to 7
Streptocarpella	6 to 8
Helichrysum	7 to 9

GERANIUM Group	Average Days to Root*
Zonal Geranium	7 to 10
Ivy Geranium	7 to 10

AVERAGE Mist Frequency Crops	Average Days to Root*
Coleus	4 to 6
Ipomoea	4 to 6
Perilla	4 to 6
Impatiens, Double	5 to 7
Impatiens *walleriana*	5 to 7
Iresine	5 to 7
Verbena	5 to 7
Alternanthera	6 to 8
Bacopa	6 to 8
Bidens	6 to 8
Brachyscome	6 to 8
Cuphea	6 to 8
Diascia	6 to 8
Euphorbia	6 to 8
Gaura	6 to 8
Heliotrope	6 to 8
Impatiens, New Guinea	6 to 8
Impatiens, Interspecific	6 to 8
Lamium	6 to 8
Lysimachia	6 to 8
Nemesia	6 to 8
Petchoa	6 to 8
Petunia	6 to 8
Plectranthus	6 to 8
Rudbeckia	6 to 8
Salvia	6 to 8
Basil	7 to 10
Calibrachoa	7 to 10
Dahlia	7 to 10
Erysimum	7 to 10
Evolvulus	7 to 10
Lantana	7 to 10
Lobelia	7 to 10
Strobilanthes	7 to 10

*These are average days to root for URC, depending on environment and location

For vigorous and fast-rooting crops, we need to be prepared to tone the crop well before we've moved it out of the propagation zone or changed its environment. We often talk about stacking nodes on certain crops, especially those that we want to pinch, and this is the stage when those stems often stretch and they're "unstacked." Some crops will even stretch before they've started to root and could need a PGR treatment right at the beginning of Stage 2. Others could need it at the end of this stage, and many won't need any PGRs until the third stage of liner production.

Utilize growth regulators with lower activity like daminozide and chlormequat whenever possible. Be sure to know the vigor of the crops you're producing so you can stay ahead of the growth and maintain a toned liner coming out of Stage 2.

Pest and Disease Control

In Stage 2, the primary pest concerns will be fungus gnats and shoreflies. **Sticky cards and population monitoring should be a big part of your weekly routine,** and good algae control and sanitation will help with controlling populations as well. There are quite a few good biological options for controlling fungus gnats and several effective insect growth regulators that will control the larvae in the soil. *continued on p.14*

Liner at end of Stage 2

No fertilizer

Feed (14-4-14, 150 ppm with 1.5 g·100 gal STEM) at stick and following

Stages 1 & 2: From unrooted to rooted cuttings

Pest and Disease Control, continued

These options are best employed as preventative measures and should be used on a regular basis during propagation, but it's usually best to use either biological or chemical control. You can use both in some instances, but if you're using biological controls, be sure to check on the toxicity of any chemical control you may want to use.

Also important is to keep up with disease control in Stage 2, especially for botrytis. Even though we're reducing humidity and slowly eliminating the mist, these cuttings are still in an environment that favors disease. This is why we must stay on top of preventative treatments to help eliminate shrink that can quickly occur in this stage. Utilizing a multi-site, broad-spectrum fungicide like chlorothalonil as a preventative treatment is a good practice.

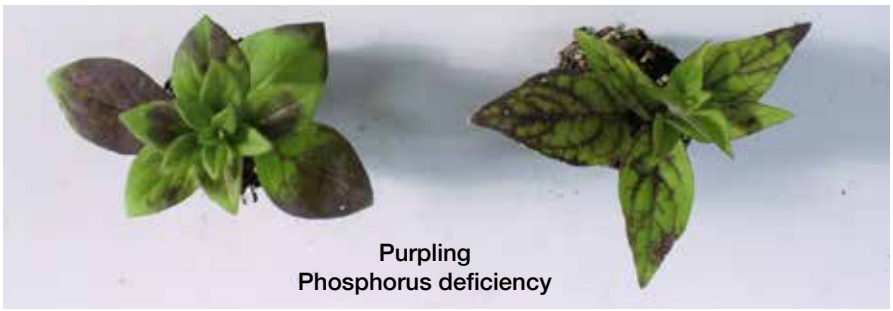
Nutrient Deficiencies

- Slow rooting
- Poor branching and vigor

Green
Low fertility asymptomatic

Yellow
Nitrogen, Sulfur, Fe: Mn

ENVIRONMENT / CHARACTERISTIC	
✓	Soil Temperature
✓	Air Temperature
✓	Humidity or VPD
✓	Light Intensity
✓	Light Duration
✓	Soil Moisture
✓	Air Movement
✓	Nutrition/Fertility
✓	PGRs
✓	Pinching
✓	Pest Management



Purpling
Phosphorus deficiency

BIGGEST MISTAKES

STAGE 2

- Over-misting or not weaning cuttings off mist quickly enough
- Saturated soil moisture – this will lead to slow and uneven rooting in most crops
- Not reducing and eliminating night mist – most cuttings will be off night mist during this stage
- Not fertilizing in this stage
- Neglecting IPM and disease control
- Not using PGRs in this stage

Stages 3 & 4: Building, bulking, toning and pinching

Stage 3: The building and bulking stage

So now that Stage 2 is complete and the roots have started to elongate and hit the edge of the cell, we've entered **Stage 3 of vegetative propagation and the first part of finishing your liner.** We like to call this the Building and Bulking Stage, and these are the primary focal points:

1. Changing the environment
2. Building the root mass and bulking the top
3. Fertility
4. Pinching
5. PGRs and controlled growth

Changing the environment – to move or not to move

Once your cuttings have started pushing roots out and the mist is off, we can start to call them liners. Now that they're liners, they no longer belong in your propagation house environment. To give your liners the best conditions for quality growth, you must either move them out of your propagation house or leave them there and change the environment. Either way, **a change in environment is the best management practice for this stage.**

So what's the ideal environment? We want to push moisture through the plant but have temperatures that promote controlled growth while providing the highest light levels the plant will accept. All of the factors that stimulate quality, controlled growth should be considered, including **reduced humidity and temperatures, increased air movement and high light levels.** These conditions aren't always easy to create in the late Winter months, but we must do the best we can with the resources we have. Liners grown too dark, too warm, too humid, etc., won't present you with the best opportunity for a successful finished crop. Conversely, liners grown too cold will likely not be ready for their target plant date. Balance the environment for the highest quality growth while keeping in mind your crop time. All of the other focal points of this stage will be directly linked to this topic, and that makes it the single biggest key for successfully *finishing* a good liner.

Building and Bulking

In Stage 3, we must be sure we're getting our liner ready for transplanting into the finished container. This stage starts with a small plant that's pushing out roots and ends with a transplantable liner that meets your specifications, so **be sure to have a target or an expectation in mind as to what your finished liner will look like.** In the building part of this phase, we like to focus on building the root mass so we can have a strong start after transplanting our liner.

As we all know, it's important to have a well-defined root system so the liners are easy for your transplant crews to handle and so they quickly take off in their new soil. **Soil moisture management is key in the building of root mass**, so take great care in maintaining good wet/dry cycles and avoid saturated soil for more than a day. Also, avoid hard dry-downs or wilting your liners, as this can damage and reduce root mass or slow take-off after transplant. The soil moisture management goal should be to stay in the "middle of the road" and ideally to alternate between Level 2 and Level 4 soil moisture. The environment will play a key role in your ability to achieve the ideal soil moisture and overall root mass development. An "active" environment with lower humidity, higher light levels, increased air movement and appropriate temps for plant growth is the goal.

The bulking part of this phase is about the green part of the liner. We need to **bulk up our plant in order to meet our specifications** of what the liner should look like at time of transplanting. Leaves should be unfolding and breaks emerging in this stage as you build the structure of the liner that you want. Again, the environment will play a key role, so be sure to match up temperatures that will keep the liner moving and developing but won't promote soft growth or poor quality. High light and cool temperatures have repeatedly been shown to produce the best plants, so, when possible, match those two factors with the proper amount of plant

growth to achieve our finished liner spec so we'll produce the best product at this stage. The hardest part of providing the best environment is that not all plants have the same needs, so you'll have to hit the middle of the road for what you're producing and you may need **separate zones for the warmest crops** (think angelonia, lantana, sweet potato vine) and a different zone for the rest of your liners.

Fertility in Stage 3

This is the first opportunity to fully recharge our liners with the nutrients they've lost since being removed from the stock plants. Again, the environment will play a key role, so we need to make sure our plants are "active" so we can push nutrients into the soil and into our liners.

Stage 3 is often only two to three weeks long, so there isn't much time to recharge our plants and **a good fertility plan is necessary.** Choosing the best formulation of fertilizer is important in this stage, especially because of the high density of the plants in your liner tray. A well-balanced fertilizer with calcium and magnesium, along with a higher percentage of nitrate to ammoniacal nitrogen, is best. This will help to promote controlled growth but provide the plants with everything they need. In this instance, a 14-4-14 is superior to a 20-10-20.

Many growers will use a constant fertilizer strategy in this stage, but will keep their ppm N lower, like 75 to 150 ppm N, in an effort to better control the growth. Remember that most complete fertilizers will deliver 1 ppm Fe at a 200 ppm N rate, so if you're using a lower ppm N, then it's advisable to increase your micronutrient package to deliver a 1 ppm Fe constantly to your liners. If you feel that your liners are behind schedule, don't be afraid to push them with higher rates – they can take it. If you need to hold them, you can irrigate with clear water or reduce the ppm N. Remember the goal of producing controlled growth that meets your specs at time of transplant.


Pinched liner

Pinching

Stage 3 is where most crops that need a pinch in the liner will get their pinch. As with all aspects of liner production, **start this with the end in mind** – in other words, what should the finished liner look like when it's time to transplant? Do we want four, six or eight breaks on the liner? How many leaves or nodes should remain on the plant after pinching to achieve that? How tall should the plant be after pinching? How much space do we want between nodes or leaves when we pinch? These are all important questions to answer before you stick your cuttings and should be a part of your finished liner specifications. Once you know how many breaks you need and how developed you want the breaks at the time of transplant, you can **put a date on the pinch.** This date will then become your target date for the plant to be ready for a pinch. You should have a size and number of leaves as part of the expectation or spec of your plant on this pinch date. Ideally, your pinched liner has breaks emerging and starting to develop, and unfolded leaves so your finished liner is ready to quickly fill out the finished container after transplant. This means timing it correctly before the transplant date.

Sanitation is a big part of any pinching process and shouldn't be taken lightly. Build this into your pinching process and be sure to communicate it properly to your crews; it should be a priority. Whether we pinch liners with scissors or shear them with a machine, there's always the opportunity to rapidly transmit disease, and we want to minimize this risk with the correct sanitation protocols. **Pick a sanitizer that provides control of fungi and bacteria as well as viruses.** This is especially important for solanaceous crops like petunia and calibrachoa. Choose an appropriate concentration of sanitizer and be sure to give your cutting tools the appropriate contact time before reusing. Many growers will give their pinching crews two pairs of scissors, and they'll have one soaking in the sanitizer while using the other pair to trim a tray. Once the tray is finished, they'll switch scissors. Please don't skip this step of the pinching process!

PGRs and Controlled Growth

Stage 3 is the phase of liner production where tone and controlled growth is most often lost, so having a plan or controlled growth strategy is important. Ideally, we can use environmental factors, moisture management and proper fertility to produce a toned liner that meets our specs, but sometimes that's not enough. As all propagators know, growth regulators are one of the most useful tools in your toolbox; however, over-regulation is one of the fastest ways to ruin a finished crop and should always be on your mind when formulating your controlled growth strategy. Know the genetic potential of the plants

in your production plan so you can formulate the best possible controlled growth strategy. For example, we regularly breed and select plants for specific uses like smaller pot sizes or, alternatively, big vigor and fast growth for larger containers.

Having a PGR plan is important, including a list of regulators that you're comfortable using on the crops you're propagating. When it comes to choosing chemistry to use, we recommend using regulators with lower activity whenever possible when finishing your liner. Growth regulators with lower activity, like daminozide, chlormequat, ethephon and ancymidol, are preferred options. Often a tank mix of two, like daminozide/chlormequat or daminozide/ethephon, is a popular choice with propagators. **Lower rates and more frequent applications are ideal** to ensure that the risk of overregulation is minimal.

If you're comfortable with more reactive or stronger growth regulators like paclobutrazol or uniconazole, you can utilize them on your more vigorous genetics, but again, lower rates and more frequent applications are better. One thing to remember is that paclobutrazol and uniconazole can be taken up by roots, so unless you're intentionally drenching them, it's best to avoid soil contact. Always take a careful approach to PGRs in Stage 3, but they should be seen as a tool that's often necessary to achieving the best finished liner.

Stage 4: Toning your liner

This is the stage of liner production that's most often overlooked, but it can be a very valuable part of growing the best liner possible. **A toned liner will be better prepared for the stress of transplanting** and the new environment that it's often placed in once it's in its new container. Providing a liner with higher light levels and cooler temps will increase your chances of success post-transplant. Soft or untoned plants will be slower to take off and may even be lost after undergoing the stress of transplanting. For small growers, there are other options, like using a hallway or outside hoops.


Toned liner

The toning process is driven by lower temperatures and higher light levels. Be sure to visit **BallFloraPlant.com** for more culture information.

BIGGEST MISTAKES

- Not changing the environment to promote controlled growth
- Insufficient moisture management that results in poor root system and soft growth
- Incorrect fertilizer choices – both formulation and rates
- No controlled growth strategy
- Overregulation with PGRs
- Pinching or shearing plants without a plan – plants are often too big at time of pinch or too small and cannot be pinched until after transplant
- Not toning your liners

LINER PGR TANK MIXES TO TRY… TRIAL 1ST!

Tank Mix	Genera	Timing	Comments
Daminozide (2,500 ppm) + ethephon (350-500 ppm)	Petunia, Salvia, Diascia, Nemesia, Heliotrope, Bacopa, Coleus, Torenia, SuperCal	~2wks after stick	
Daminozide (2,500 ppm) + ethephon (350-500 ppm)	Lantana, Calibrachoa, Lobelia, Bidens, Helichrysum, Artemisia, Dorzoo	~2-3wks after stick	
Benzyladenine (150 ppm) + ethephon (350-500 ppm)	Portulaca, Verbena, Angelonia	~2wks after stick	
Paclobutrazol (0.5-1 ppm) drench	Portulaca, Verbena	~2wks after stick	ONLY Apply to counter yellowing and loose branching growth after benzyladenine application. Can be applied same day or 1-2 days after benzyladenine application.
Benzyladenine (100 ppm)	Begonia *hiemalis, boliviensis*		Sandwich with soft removal of growing tip or harder pinch if liner has gotten tall.
Ethephon (350-500 ppm)	Vinca Vine, Impatiens	~2-3wks after stick	
Ethephon (250 ppm)	Ipomoea/sweet potato vine, Lysimachia, Lamium	~2wks after stick	

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