POINSETTIA HEIGHT CONTROL

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Height control is critical for the production of a high quality poinsettia crop. Breeding programs have been active in producing cultivars which are naturally shorter growing. However, management of height artificially is still critical to produce a saleable crop. Traditionally, height control has been achieved through the use of chemical growth retardants. Increasing social concerns over the use of chemicals has lead to a renewed interest in non-chemical methods of height control. One non-chemical method which has proven to be economical and easily applied in the floriculture industry is to manipulate temperatures daily to limit stem elongation.

This chapter will concentrate on how to control poinsettia stem elongation and growth through crop management and the use of daily temperature manipulations within a greenhouse to produce a saleable plant at a desired height. Scheduling mother cutting management, pinching technique and specific effects of temperature manipulation will be discussed.

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What Determines Plant Height?

Every plant has a potential for growth. There are both short and tall growing plants and/or cultivars. The ability of a plant to reach its potential height is modified by the environment in which it grows. Management of plant structure also affects plant height. Poinsettia plant height is composed of 1) the height of the 'mother' stem on pinched plants, 2) the number on internodes on a lateral shoot and 3) the length of each of the internodes on a lateral shoot.

Basic Concepts Of Plant Growth:

The rate at which leaves or nodes unfold on a poinsettia is determined by the average daily temperature which plants are grown under.

Node Number: The rate at which leaves or nodes unfold on a poinsettia is determined by the average daily temperature which plants are grown under. Poinsettia node unfolding rate, as with all plants, responds to temperature in a similar fashion. There is a base temperature where little or no leaf unfolding occurs. There is a linear range where leaf unfolding increases proportionally to an increase in temperature. There is an optimal temperature where leaf unfolding is at its most rapid rate possible. As temperature increases above the optimal temperature, leaf unfolding rate decreases. The base temperature for poinsettia leaf unfolding is approximately 45°F. Leaf unfolding increases as average daily temperatures increase from 45°F to 76-80°F. Leaf unfolding does not increase as temperatures increase greatly above 76°F and will, in fact, decrease if temperatures exceed 90°F. Death occurs when poinsettias are grown at constant 100°F.

Table 1. *The number of days needed from planting until pinching to produce plants with various break numbers at various average daily temperatures. To generate this table it was assumed that cuttings had 4 leaves when planted, that pinching resulted in the removal of 2 leaves, that 80% of the axillary buds developed into breaks and that flower initiation occurs on September 20. Times are based on leaf unfolding rate functions published in the following reference: Berghage, R., R.D. Heins and J.E. Erwin, Quantifying leaf unfolding in the poinsettia. Acta. Hort., 272:243-247.*

Final Estimated Inflorescence Number	Average Daily Temperature (°F)				
	60	63	65	68	71
4 Inflor.	21	18	16	15	14
5 Inflor.	28	24	22	20	19
6 Inflor.	35	30	27	25	23
7 Inflor.	42	35	33	30	28
8 Inflor.	49	41	38	35	33

Internode Length: Poinsettia internode length or elongation is affected by the way in which temperature is delivered to a plant during a day/night cycle and the actual temperatures plants are grown under.

Internode length increases as day temperature increases relative to night temperature (Figure 1). The greater the difference between day and night temperature, the greater the stem elongation. One way to describe this relationship is to simply say that poinsettia stem elongation increases as the difference (DIF) between day and night temperature increases when day and night temperatures range from 50 to 86°F.

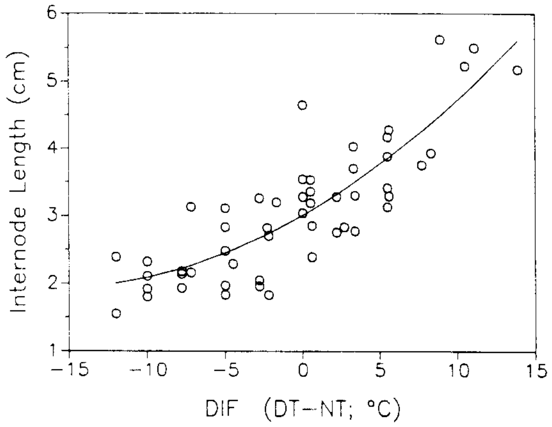

Figure 1. *Relationship between DIF and length of internodes on the second lateral shoot of poinsettia 'Annette Hegg Dark Red' grown with 36 DT/NT combinations. Data shown are for all nodes after the first with a VBI of 0 for each of the temperature treatments. From: Berghage, R.D. and R.D. Heins. 1991. Quantification of temperature effects on stem elongation in poinsettia. J. Amer. Soc. Hort. Sci. 116(1):14-18.*

Poinsettia stem elongation is most sensitive to cool and/or warm temperatures at the beginning of the morning. Dropping temperatures during the last hour of the night and the first 4-5 hours of the morning will dramatically reduce internode elongation. In contrast, allowing temperatures to increase rapidly in the morning will stimulate elongation.

Poinsettias have an optimal temperature for stem elongation. The optimal temperature for poinsettia stem elongation is 76°F. Elongation is reduced if either day/night temperature deviates from 76°F.

Height Management:

The importance of leaf number and/or internode elongation varies at different times during the development of a poinsettia. For instance, leaf number and internode length may be of primary concern prior to flower initiation, whereas internode elongation only is usually of concern after initiation, since leaf number is set. Bract expansion and color may be more important than internode elongation late in development. It is critical that you, as a grower, understand how you can manage temperature effectively to promote what type of growth you desire at different times in the development of the poinsettia.

An effective way to break down environmental management of a 'pinched' poinsettia crop is to simply discuss each stage of poinsettia development and what factors are critical during each stage to produce a quality poinsettia. Factors which determine mother shoot height and leaf number will be discussed first. Second, timing of pinching and how pinching technique affect plant height will be discussed. Lastly, management of the environment following flower initiation to control stem elongation and promote bract expansion will be discussed.

Cutting and Mother Shoot Management:

The mother shoot is of importance because it determines the potential break number following a pinch and establishes the plant height from which the lateral shoots develop. Few leaves on the mother shoot will result in few breaks. In contrast, high leaf numbers on a mother shoot often result in higher break or lateral shoot numbers. Therefore, it is important to manage the cutting after potting but prior to pinching to promote leaf unfolding to achieve the desired leaf number.

It is also important to control internode elongation on the mother shoot to result in a short compact plant. This is often difficult to do since

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Table 2. *Days required to produce a 3 leaf shoot after pinching when 'Dark Red Annette Hegg' plants are grown in a variety of average daily temperature environments. Times are based on published in the following reference: Berghage, R., R.D. Heins and J.E. Erwin, Quantifying leaf unfolding in the poinsettia. Acta. Hort., 272:243-247.*

	Average Daily Temperature				
	60	63	65	68	71
Number of Days	20	18	17	15	14

crops grown at different average daily temperatures prior to pinching and which vary in the final desired break number. This data was calculated from information collected on the cultivar 'Dark Red Annette Hegg'. Leaf unfolding rates may vary between cultivars (personal communication, Royal Heins).

Remember, the higher the day temperature relative to the night temperature, the greater the internode elongation.

mother shoot or cutting growth often occurs in August (one of the warmest months of the year). Because temperature manipulation is difficult during the summer, growers frequently depend on growth retardant applications to control mother shoot height. Experience has shown that frequent lower concentration applications of growth retardants result in better height control than infrequent higher concentration applications.

Planting and pinching dates should be managed to result in the desired leaf number on a cutting at the desired pinch date.

Frequently, mother shoot height control is ignored and, as a result, cutting height is too tall. When this occurs you will find yourself in the difficult situation of deciding whether you will accept a taller final plant, or reducing potential break number by 'hard' pinching the cutting.

If temperature manipulation is possible, attempt to reduce the day temperature as much as possible the remainder of the day. Remember, the higher the day temperature relative to the night temperature, the greater the internode elongation. If you cannot control day temperatures all day, drop morning temperatures to below the night temperature, if possible, starting 1 hour prior to dawn until 3 hours after sunrise to get some reduction of stem elongation using temperature. Temperature control of stem elongation is preferable to chemical control of stem elongation since repeated growth retardant applications may affect subsequent lateral shoot breaking after pinching.

Breakage of lateral shoots during sleeving and/or shipping is a common problem.

Planting and pinching dates should be managed to result in the desired leaf number on a cutting at the desired pinch date. In addition, enough time needs to be allocated to allow lateral breaks to develop after pinching but prior to flower initiation to produce strong growth, large leaves and high bract quality. Table 1 shows the predicted pinch and planting dates for poinsettia

Table 2 shows the length of time required for plants, after pinching, when grown under a variety of different average daily temperatures to produce lateral breaks with 3 leaves. A shoot should have at least 3 leaves on it at the time of flower initiation if it is to be sold as a 5 inch or greater pinched plant.

To figure out your schedule simply back up from September 20th. For instance, if you would like to grow a 5 break crop at 68°F average daily temperature prior to flower initiation, you will need to pinch your crop on September 5 and plant a cutting on August 17th. Remember, failure to maintain the desired average daily temperatures in the tables means that your schedule will need to be altered.

Remember that newer cultivars such as 'Freedom' will initiate flowers earlier than the older cultivars. Anticipate that 'Freedom' plants will probably initiate flowers one week earlier on September 13.

Break Joint Strength

Breakage of lateral shoots during sleeving and/or shipping is a common problem. The problem seems to arise from two situations:

1) weak joints - the union of the mother and lateral shoot
2) breaks which are perpendicular to he mother shoot

Weak joints can occur when breaks form rapidly and/or breaking occurs under low light. Weak break joints can also occur when plants are crowded. Crowding results in higher amounts of far red colored light hitting the axillary buds. High far red light inhibits breaking and stimulates rapid elongation of the first internode. Solutions to the weak joint problem include:

1) Maintain temperatures at constant 68-70°F. Do not 'heat up' the crop to stimulate rapid development!

2) Space plants to allow adequate light.

3) Do not allow leaves to shade axillary buds on adjacent plants.

4) Do not grow plants with a high +DIF as this will stimulate rapid elongation.

Horizontal branching occurs when plants are grown with too much space. Lots of space is fine if the plants are not going to be sleeved. However, horizontal branching resulting from lots of space (light) frequently results in breakage during sleeving. The solution is to simply delay spacing to encourage an upright branch orientation early in shoot development. Early spacing can often result in problems.

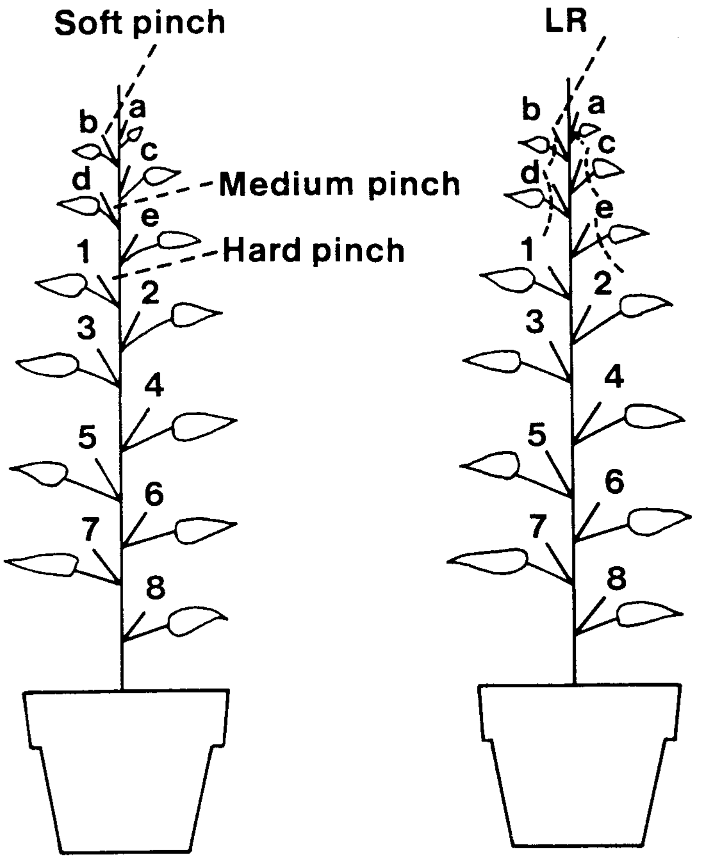

Figure 2. *Effect of pinching technique on average lateral shoot growth rate of shoots 1 to 8 and analysis of variance for 'Annette Hegg Dark Red' in 1987, from pinching to anthesis. Lateral shoot 1 is one subtended by the uppermost fully expanded leaf at pinching. Shoots 2 through 8 were the lateral shoots subtended by the 2nd through the 8th fully expanded leaf at pinching. Pinching treatments were: soft (removal of the apical meristem plus stem and leaf tissue associated with leaves ≤2 cm long); hard (removal of the apical meristem plus stem and leaf tissue associated with all immature leaves); and leaf removal (LR) (soft pinch as defined above plus removal of all immature leaves but not the associated stem tissue). From: Berghage, R.D., R.D. Heins, M. Karlsson, J. Erwin and W. Carlson. 1989. Pinching technique influences lateral shoot development in poinsettia. J. Amer. Soc. Hort. Sci. 114(6):909-914.*

Pinching Techniques:

Pinching technique can influence total plant height. The way in which you pinch influences the number of lateral shoots which develop, the way the axillary buds develop and the final plant architecture and height (Table 3).

We pinch a poinsettia to release the plant from apical dominance. Apical dominance is defined as the inhibition of the lateral bud growth by the growing apex. Traditionally, growers pinch plants based on the size and leaf number on a cutting at the time of pinching. Pinches are either hard (>1" removed), medium (1/2-1" removed) or soft (<1/2" removed).

The objective when pinching a poinsettia is to promote rapid uniform lateral shoot development. In order to do this we need to remove all tissues which cause apical dominance. Recent research has shown that the young, immature expanding leaves also contribute to apical dominance in poinsettias. Therefore, the

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Table 3. *The influence of pinching technique on days to flower (DTF), height to width ratio, primary stem length and inflorescences in the bract canopy. Primary stem length is the length of the uppermost lateral shoot on the mother shoot. A high height to width ratio denotes an upright plant whereas a low height to width ratio denotes a broad plant. Data contained in this table was extracted from a table from: Berghage, R., R.D. Heins, M. Karlsson, J. Erwin and W. Carlson. 1989. Pinching technique influences lateral shoot development in poinsettia. J. Amer. Soc. Hort. Sci., 114(6):909-914.*

Cultivar	Pinch Type	DTF	Height:Width	StemLength (cm)	Inflorescence # in flow. canopy
Annette Hegg Dark Red	soft	48	.85	19.9	6.3
	hard	51	.85	10.9	5.5
	soft + leaf removal	56	.74	16.7	8.2
Annette Hegg Brilliant	soft	48	.79	17.3	6.3
	hard	53	.68	10.4	5.7
	soft + leaf removal	54	.67	14.3	8.7
V-14 Glory	soft	66	.74	15.4	7.6
	hard	78	.59	9.9	6.3
	soft + leaf removal	80	.55	11.3	8.9

Removal of the immature leaves results in uniform breaking, maximizes total break number, greater plant width, reduction in total plant height and more inflorescences contributing to the overall flowering canopy.

presence of immature leaves on a 'soft-pinched' plant will influence subsequent lateral shoot development on a mother cutting. A new technique has been proposed by R. Berghage and R. Heins where young leaves are removed following a soft pinch. Removal of the immature leaves results in uniform breaking, maximizes total break number, greater plant width, reduction in total plant height and more inflorescences contributing to the overall flowering canopy (Table 3). The benefits and disadvantages of each pinching technique are shown below (Figure 2).

Hard Pinch

Advantages: Easy, fast, and generally results in uniform axillary bud breaking.

Disadvantages: Can only be used on plants which have attained a desired leaf number. Occasionally one of the upper 2 shoots will be excessively tall resulting in an uneven flowering canopy.

Medium Pinch

Advantages: More nodes are left on the plant than on a hard pinch which can ultimately result in more breaks.

Disadvantages: Immature leaves left on the mother shoot inhibit the growth of lateral shoots below. This results in the tendency for the uppermost lateral shoots to be longer, sticking out above the plant flower canopy giving the plant an uneven appearance.

Soft Pinch

Advantages: More nodes are left on the mother shoot. Plants which receive a soft pinch will often grow tall and narrow which may be an advantage with limited bench space.

Disadvantages: Plants are tall and narrow with more lateral shoots appearing below the flower canopy. A smaller percentage of the lateral shoots develop into flowering shoots.

Soft Pinch + Leaf Removal

Advantages: Release of lateral shoots occurs quickly and uniformly. Number of potential lateral breaks is maximized. More of the lateral shoots contribute to the flower canopy compared to medium or soft pinched plants. A more uniform flower canopy with respect to height.

Disadvantages: Labor intensive. Flowering is delayed on plants on which leaf removal has been used compared to plants which are soft, medium, or hard pinched. The delay is usually no longer than 2-3 days.

Clearly one way to help manage total plant height is to pinch using a hard or soft pinch plus leaf removal. From the data presented above, we can see that a hard pinch reduces final plant height 40-45% and soft pinch plus leaf removal reduces plant height 12-27% relative to the soft pinch with no leaf removal.

Flower Initiation:

The poinsettia is a short day plant. In other words, poinsettias will flower when the night length exceeds some critical length. Flower initiation occurs under natural photoperiodic conditions throughout the United States for most cultivars between September 10 and 25th. Each cultivar varies with respect to its critical photoperiod.

The optimal temperature for flower initiation of poinsettia is 68°F. It is critical that you, as a grower, maintain night temperatures during the flower initiation period below 74°F. Failure to do this will delay flowering, increase node number and will increase overall plant height in most cases.

Lateral Shoot Height Management:

After flower initiation, the primary concern for most growers is control of stem elongation of the lateral shoots. This is the period where plant height can get 'out of control'. This period typically occurs between September It is critical to control stem elongation during this period as growth regulators cannot be used after October 15 because they reduce bract size. In addition, use of temperature late in development (after October 15), when the plants are not elongating as rapidly, will not have as great an impact on total plant height.

Graphical Tracking: The elongation pattern of the lateral shoots of all determinant crops is similar. First, there is a lag period. Second, there is a period of rapid elongation. Lastly, elongation slows and finally stops as the inflorescence develops. A 'model' curve can be developed which can help you follow the elongation of your crop graphically to determine whether your crop is elongating more rapidly than may be desired, or not enough. This technique was developed by Royal Heins at Michigan State University and is referred to as 'graphical tracking'. The procedure for developing a graphical track for your poinsettia crop is shown in the following article, 'Making a graphical track'.

A more in depth article on graphical tracking of a variety of poinsettias will appear in the next issue of the MCFGA bulletin.

Plants are entering the rapid elongation phase in the beginning of October if they are pinched prior to flower initiation and are initiated under natural photoperiodic conditions. With older cultivars both temperature manipulation and growth retardant application will be necessary to control stem elongation during the rapid elongation phase. However, in northern climates many growers are finding that height control can be achieved solely with temperature manipulation when newer-shorter growing cultivars such as 'Freedom' are grown.

DIF: Control of day and night temperature during the rapid elongation phase is critical. Traditional temperature regimes suggested that day temperatures should be maintained 7°F higher than night temperatures. The estimated internode length on 'Annette Hegg Dark Red' plants grown with this regime is 3.75 cm. In contrast, if you drop your day temperature so that day and night temperature are equal, the estimated internode length is reduced to 3.0 cm. This translates into a 20% reduction in height! The reduction in internode length is greater when day/night temperatures are changed from a higher day than night temperature to equal day/night temperatures than when the temperature regime is changed from equal day/night temperatures to cooler day than night temperatures.

Table 4. *The influence of dropping the temperature during the first 2 hours of the morning on total plant height at flower of poinsettia cvs 'Starlight'(SL) and 'Lilo'(L). Data presented was extracted from a table presented in: Moe, R., N. Glomsrud, I. Bratberg and S. Valso. 1992. Control of plant height in poinsettia by temperature drop and graphical tracking. Acta Hort., 327:41-48.*

Temperature Treatment	Plant Height (cm)		Plant Diameter (cm)	
	SL	L	SL	L
Constant 66°F	20.3	16.5	28.5	29.1
Drop to 55°F for first 2 hours of morning	15.7	12.7	27.4	27.1
Increase to 77°F for first 2 hours of morning	21.1	18.9	28.3	30.5

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After flower initiation, the primary concern for most growers is control of stem elongation of the lateral shoots.

Plants are entering the rapid elongation phase in the beginning of October if they are pinched prior to flower initiation and are initiated under natural photoperiodic conditions.

Control of day and night temperature during the rapid elongation phase is critical.

Monitor effectiveness of growth retardant applications using graphical tracking.

Chemical Control: Control of internode elongation can be achieved by applying cycocel. Recommended rates for cycocel application range from 750-2500 ppm.

B-Nine application alone is not effective in controlling stem elongation. However, when B-Nine is combined with cycocel, they are together more effective in controlling elongation than either chemical separately. Combining B-Nine and cycocel together is referred to as 'tank mixing'. If you 'tank mix' B-Nine and cycocel together, do not mix more than 750 ppm of each as a single application.

To limit stem elongation, it is critical that temperatures are cool when light first hits the plants.

Monitor effectiveness of growth retardant applications using graphical tracking. Plants will 'grow out' of a growth regulator application more quickly when grown under a +DIF temperature regime compared to a 0DIF temperature regime. Do not apply growth regulators after October 15.

Cool Mornings: As stated before, stem elongation responses to temperature are greatest in the morning. Cool morning drops in temperature can greatly reduce plant stem elongation. Conversely, increases in temperature during the early hours of the morning can greatly increase stem elongation.

The response to day and night temperature and/or the morning drop in temperature is greatest when light intensity during the day is high.

To limit stem elongation, it is critical that temperatures are cool when light first hits the plants. Do not wait until the sun has already risen. The rapidity of the change in temperature also seems to influence the stem elongation response to the temperature shift. The more rapid the change in temperature, the greater the response.

Table 4 clearly shows that final plant height can be reduced markedly by dropping the temperature for only 2 hours in the beginning of the morning. It is important to realize that the reduction in height is due to a reduction in stem elongation and that node number, plant width and bract size are not greatly affected (Table 4). If you cannot cool plants using air, cool plants by watering plants overhead using cool water.

Interaction Between DIF And Other Environmental Factors:

It is important to realize, however, that bract and inflorescence size have an optimal temperature for development.

The response to day and night temperature and/or the morning drop in temperature is greatest when light intensity during the day is high. Under cloudy conditions, temperature control of stem elongation is not as great, and growth retardant applications may be necessary.

The response of stem elongation to day/night temperature is also affected by photoperiod. Stem elongation response to DIF increases as photoperiod length decreases. Therefore, you will probably get a greater response to DIF during October than you would in September.

Bract Expansion and Development:

When many cultivars are initiated using natural photoperiodic conditions, bract expansion usually occurs during the last 1-2 weeks of October. Growth retardants should not be applied during the bract expansion period, i.e. after October 15. Application of growth retardants during bract expansion will, in general, reduce bract size and inflorescence width. Temperature manipulation to control stem elongation will, in general, not reduce bract or inflorescence size, and can be used after October 15.

It is important to realize, however, that bract and inflorescence size have an optimal temperature for development. In general, the warmer day and night temperatures (up to 76°F) are during the bract expansion period, the greater individual bract and inflorescence size is. For this reason you should try to grow a crop at constant 68-72°F when bracts are expanding. After bract expansion is complete, temperatures can be dropped to 55-60°F to intensify the color of the bracts.

References

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