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GROWTH CONTROL WITHOUT CHEMICALS

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Control of excess stem elongation is essential to successfully produce bedding plants, especially to the grower who must ship product to market. Many bedding plants are shipped to market on racks whose shelves are 8 inches apart. With a 2.5-inch-high flat, maximum plant height is 5.5 inches. Keeping many plants shorter than that is a challenge.

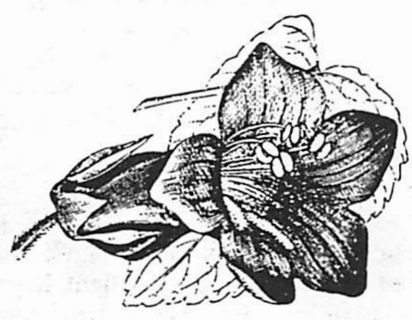
Stem elongation can be controlled by several different methods, including applying growth retardants, selecting cultivars, limiting media volume, spacing of plants, mechanical stress, limiting nutrient availability, manipulating seedling maturity at transplant, water stress and manipulating day and night temperature. Discussion throughout this chapter will be limited to non-chemical methods of height control.

Factors associated with tall plants

Growing a tall plant requires selecting a genetically tall species and cultivar. Once a seed germinates, maximum plant height is achieved with an optimal environment, which means water and nutrients are freely available and the root system is not restricted by a small container. Height is further promoted when plants are grown close together and with a warmer day temperature than night temperature.

Selecting Cultivars

When producing bedding plants, the grower normally does not have the option of only selecting short-growing species and cultivars. The market dictates that some tall growing plants be produced. Therefore, height control must be achieved through methods other than genetic selection.



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Limiting media volume

The fact that limiting root development with a small container dwarfs plants is well documented. One only need look at old bonsai plants to see the effects of the container size on plant height. A more relevant example is the restriction of growth achieved in plug production, even when adequate water and nutrients are provided. It is obvious that a 300-foot redwood will not develop in a 512-size plug!

The bedding-plant grower normally has a limited selection of container sizes. While the containers (cells) most bedding plants grow in will limit final plant size, the volume of soil available to a bedding plant is usually large enough that the plant growing in it can still get too tall. Therefore, cell size is not a strategy for height control of bedding plants. However, it is important to realize that the potential for plant growth and expansion is greater as the soil mass increases; e.g., a 4-inch pot versus a cell in a 72-cell tray.

Spacing of Plants

Most bedding plants are classified as "sun" plants. "Sun" plants are sensitive to crowding. A survival mechanism of plants growing in a canopy is to elongate so the upper leaves are exposed to direct sunlight. A plant that does not elongate in response to high plant density would be shaded by its neighbors and unable to efficiently harvest light for flowering and seed production.

Plants detect density by sensing changes in light quality or color, specifically the red to far-red light ratio. Red light is absorbed by leaves more efficiently than far-red light; most far-red light is either reflected from or transmitted through a leaf. As plant density increases, the relative proportion of far-red light increases relative to red light within the canopy. Most plants respond to this change in red to far-red light by increased stem elongation.

One feature of bedding-plant production is high plant density. Therefore, the natural response of plants in bedding-plant flats is to elongate.

Light Quantity

Elongation of all plants is suppressed by the presence of light. In general, elongation of plants increases as light intensity decreases. Light intensity in all greenhouses is lower than that outside because of shading from the glazing material and the greenhouse structure. Most growers are quite aware of the increased plant height that occurs under gutters or near dark side walls.

The presence of overhead hanging baskets decreases light intensity and alters light quality (higher far-red light). Both changes cause stems to elongate in comparison to those of plants in greenhouses without hanging baskets.

Mechanical Conditioning

A plant growing outside a greenhouse is normally shorter than the same kind of plant growing inside. Similarly, plants growing on the edge of a field or stand of plants are shorter than those in the middle. Part of the reason for this height difference is the mechanical stress placed on plants by the wind.

Mechanical stress or conditioning induced by wind or physical contact, such as brushing, reduces stem elongation. The magnitude of response depends on both the duration and frequency. For the conditioning to be useful, plants must be treated for a minimum of one to two minutes at least once or twice a day.

The biggest challenge in using mechanical conditioning of greenhouse crops is delivery of the stimulus to the plant. The Japanese have used manual brushing of seedlings with a small broom for years; however, their transplant production units are generally small. Systems such as dusting brushes, suspended aluminum bars, steel bars suspended in a cloth sling, wooden poles, water sprays, and wind from fans have also been tested. All are difficult to implement on bedding plants that are different ages and heights and are growing in a single greenhouse. Also, materials such as PVC or painted pipes can cause mechanical damage to the leaves that adhere to them.

Mechanical conditioning can be an effective method of controlling plant height, but the lack of good delivery systems continues to limit its commercial usefulness.

Nutrition manipulation

Growth of plants requires energy from photosynthesis and mineral nutrients. While each of the 16 essential nutrients is truly essential, the nutrient that has the greatest impact on plant size is nitrogen; which is required in greater quantities than any other mineral nutrient. Although similar percentages of nitrogen and potassium are often in plants, they actually require about three times more nitrogen than potassium because of differences in the weight of their ions.

Nitrogen, then, is one of the major tools available for height control of bedding plants. Growth will be restricted irrespective of cultivar, cell size, light and water availability if nitrogen is limiting. While this statement is also true for the other essential nutrients, nitrogen management is normally easiest.

Media formulations often include a base fertilizer charge; e.g., one pound calcium nitrate and one pound potassium nitrate per cubic yard. There is enough nitrogen in this charge to supply 40 to 60% of all the nitrogen necessary to produce a bedding-plant flat from plugs in about five weeks. If the media contains a base charge like this and growth control is desired, plants should not be fertilized again until they begin to show slowed growth associated with nitrogen deficiency. The plants should not require more than two 200 ppm N and K applications between this time and finish. Higher concentrations of N or more frequent applications will provide more than enough nutrients (nitrogen) for most plants to outgrow the space allotted in flat culture.

If no charge of N and K is added to the media, fertilization with 200 ppm N and K will be necessary within the first few days after transplanting. However, no more than five applications of 200 ppm N and K should be needed to finish the crop. Fertilizer should be applied no more than once per week under ordinary production conditions, and only if growth is not "lush."

If these strategies of growing "lean" are used during most of the production phase to control plant size and height, the plants may look somewhat chlorotic near market date. An application of 200 to 300 ppm N and K a few days prior to marketing will quickly "green up" the plants. Guaranteed sales are important with this strategy since the plants will grow very rapidly. Shipping delays because of poor weather rapidly result in overgrown plants.

The optimal base charge in a bedding-plant medium depends in part on the maturity of the plug transplanted into it. A "good" base charge (one pound each of potassium and calcium nitrate) is very desirable if the plug is "mature" and flower buds have been set; e.g., visible flower buds on impatiens. In this situation, the goal is to grow enough plant so the flat is saleable when the plant flowers. However, when the plug is immature and is transplanted into a medium with a "good" base charge, vegetative growth may be difficult to control prior to flowering. In this case, a medium with little or no base charge is preferable so that there is little vegetative growth while flower initiation and development occur.

Manipulating plug maturity at transplant

The interaction of plug seedling maturity and nutrition was discussed above. The topic of plug maturity, however, deserves further discussion. Two advantages are associated with plugs which are more mature and have initiated flower buds. First, production of short plants in a bedding plant flat is much easier because the plant can be rapidly grown to fill in around the flower buds. If the plant is not mature when transplanted, growth retardants and/or the methods discussed in this section often must be used to hold back plant size until the plant flowers. A second advantage of a more mature plug is that less time is required to flower from transplant. A shorter time to flower is very valuable during peak ship weeks in the spring. Sometimes the difference of only a few days in flowering means the difference between shipping or not shipping a flat to market.

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Water Stress

Growth of any plant is associated with increased cell number and size. Enlargement of an immature cell is similar to inflation of a balloon. Immature cells have elastic walls. High water pressure (turgor pressure) in the cell promotes stretching and increased size. The latter results in larger leaves when leaf cells expand and taller plants when stem cells elongate. The amount of turgor pressure in the cell is determined by many factors, but the most important is the availability of water to the plant.

Water, therefore, is one of the most powerful non-chemical tools a grower has to manage the height of bedding plants. Water stress limits cell expansion and plant growth. Plants can be water stressed by limiting quantity or availability of water.

The duration plants can be allowed to wilt without sustaining permanent damage such as leaf burn or death depends on climatic conditions.

Two techniques can be used when growing "dry." The first is irrigating the flat thoroughly and then allowing the flat to dry to the point of wilting before watering thoroughly again. Growth is restricted during the period when the medium is very dry, but once the plants are watered and the stress is relieved, they rapidly resume elongation with a minimal effect on plant size. The second method of growing "dry" is to continuously limit the quantity of water available to the plant by means of frequent, light waterings. Plants are irrigated lightly only after they show some signs of water stress, such as wilting. Only the plant shoot and the top half inch or so of the medium is wetted during irrigation. This technique is very effective under climatic conditions that foster slow drying. The system requires intensive grower management, but is very effective in regulating growth. It is not possible to use this technique with a subirrigation watering system because the growing medium cannot be partially wetted.

The duration plants can be allowed to wilt without sustaining permanent damage such as leaf burn or death depends on climatic conditions. Plants may be stressed for one or more days prior to irrigation under cloudy, humid conditions. In contrast, plants exposed to high light and windy, dry air may require irrigation within minutes once they show water stress to avoid severe stress injury.

Plant height can be managed by temperature in two different ways; average daily temperature and DIF.

Uniform plant growth requires uniform water delivery when using water stress for height control. Anything that results in nonuniform water delivery will result in nonuniform plant development.

Hanging baskets over flats can also cause problems when water stress is used for height management. Watering hanging baskets without having any dripping is very difficult. Some water is invariably going to splash on the flats below when baskets are hand irrigated, and some dripping is likely when plants are watered with an automated dripper system. Plants that receive this extra water (and often nutrients) grow significantly larger than surrounding ones.

Temperature Manipulation

Plant height can be managed by temperature in two different ways; average daily temperature and DIF. This is because plant height is a function of internode number and internode length. The rate at which a plant matures or forms internodes is largely controlled by the average daily temperature, increasing as temperature increases. Internode length, in contrast, is largely controlled by the difference between day and night temperature (DIF).

Assuming there is no photoperiod requirement, the time it takes a bedding plant to flower is primarily a function of average temperature. The goal is to have the plants in flower just when they are needed for market. If they are in flower earlier than the market date, they continue to grow. So in an indirect manner, average temperature is a mechanism to control plant height.

Plant height is the combined length of each internode formed as a plant grows. Internode length is affected by the way temperature is delivered during a 24-hour period. Internode length and plant height increase as DIF increases. Plants growing with lower day than night temperatures will be shorter than those growing with warmer day than night temperature. Plants respond to DIF whether they are widely or closely spaced.

Plant height response to DIF will depend on the magnitude of the DIF; i.e., how warm or cool the day is compared to the night and how the temperature is changed from night to day. Negative DIF is most effective in controlling stem elongation when the day temperature is lowered in synchrony with the transition from dark to light. Most growers find it most efficient to start lowering the day temperature 30 to 60 minutes prior to sunrise.

The longer that cool day temperatures can be maintained during the light, the greater the effect of DIF on stem elongation. However, the most important hours for height control during the day are the first two to three. For many species, lowering the temperature during the first two to three hours will reduce height 50 to 70% as much as lowering the temperature throughout the entire day.

Because temperature often cannot be controlled during late morning and the afternoon, abruptly dropping the temperature at sunrise is an effective way to use DIF for height control. An example DIF regime may be to maintain a constant day temperature of 60°F with a night temperature of 65°F when day temperatures can be controlled. When day temperature cannot be controlled later in the day and will rise above the night temperature, an example strategy may be to drop the temperature at sunrise to 45 or 50°F.

A secondary response to negative DIF is reduced leaf chlorophyll. As DIF becomes more negative, leaf chlorophyll content decreases and plants appear progressively more chlorotic or yellow. Certain species such as salvia show severe chlorosis when they are exposed to large negative DIFs, especially for plug seedlings. One of the advantages of the temperature dip at sunrise followed by warmer temperatures later in the day is less yellowing compared to that found with low temperatures all day long.

While there are many, many possible temperature strategies, an excellent compromise is to maintain zero DIF (day and night temperature the same) with a 10 to 15°F temperature dip at sunrise for two to three hours.

Growers who rolled plants outside a heated greenhouse in the morning usually grew very short, stocky plants, a result of high light, mechanical conditioning from the wind, and negative DIF temperatures.

One must be careful that crop maturity is not adversely affected by cooler average daily temperatures when using negative DIF for height control for the first time. Growers traditionally have used warm day temperatures to help maintain an average daily temperature. Average daily temperature is lower and crop development (flowering) will be slowed if the night temperature is kept the same and the day temperature is lowered. Conversely, raising the night temperature while maintaining a constant day temperature will increase average temperature and hasten flowering. Final height at flower will be shorter whether the day temperature is lowered or the night temperature is raised.

The magnitude of plant responses to DIF is influenced by the photoperiod. Response to DIF is greater under short-day than long-day conditions. In other words, DIF will be more effective in February and March than in April and May, even if day temperature can be equally controlled, which is unlikely. Plants under supplemental HID lights at night will likewise respond less to DIF, although they may still be short because of the higher light intensity. Conversely, plant response to negative DIF is less under very low than under high light conditions. Control of stem elongation with negative DIF is reduced during periods (five to seven days) of continuous heavy overcast.

Light from incandescent lamps is high in far-red light and will negate the effects of negative DIF.

Plant response to a change in DIF is rapid and is evident on some species within 24 hours. Therefore, DIF is an excellent tool to speed or slow stem elongation as desired. While rapid response to negative DIF is desirable, loss of daytime temperature control, resulting in positive DIF, also means instant loss of stem elongation control. Compact bedding plants being held in check by negative DIF can increase in height significantly with a few days of high day temperatures when negative DIF can no longer be maintained.

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