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Cutting Production Is Affected by Pinch Number during Scaffold Development of Stock Plants

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Abstract. **Stock plants of four vegetatively propagated annual species (*Argyranthemum frutescens* 'Comet Pink', *Nemesia fruticans* 'Plum Sachet' Venten., *Osteospermum fruticosum* 'Zulu' L., and *Verbena ×hybrida* 'Lanai Bright Pink' L.) were grown with one (P), two (PP), or three (PPP) pinches during the scaffold development phase. The number of pinches applied to all four species affected the yield and distribution of cuttings produced over time. P began to produce cuttings first; however, the rate (number of cuttings per week) of cutting production was relatively low resulting in the fewest total cuttings produced by the end of the experiment. Cutting harvest from PPP started 3 to 6 weeks after cuttings were initially harvested from P. However, the rate of increase in cutting production was greater in PPP than P for all species, except *Osteospermum*, so the total cutting yield of PPP equaled P after 3 to 5 weeks of cutting production. The final cutting yield for PPP was 38%, 38%, 20%, and 8% higher than P for *Argyranthemum*, *Nemesia*, *Osteospermum,* and *Verbena*, respectively. PP produced 24%, 17%, and 21% more total cuttings than P for *Argyranthemum*, *Nemesia*, and *Osteospermum*, respectively, while *Verbena* displayed no significant difference. At the termination of the experiment, the weekly rate of cutting production increased 66.3%, 84.0%, and 30.5% as pinch number increased from P to PPP for *Argyranthemum*, *Nemesia*, and *Verbena*, respectively. This study demonstrates that the number of pinches performed on stock plants during scaffold development can have a significant impact on the timing, the weekly production rate, and cumulative yield of cuttings harvested.**

The vegetatively propagated annuals market continues to grow rapidly in the United States. Historically, several important floriculture crops have been propagated vegetatively, such as geranium (*Pelargonium ×hortorum* L.H. Bailey) (O'Donovan, 1993), poinsettia (*Euphorbia pulcherrima* Willd. ex Klotzsch) (Grueber, 1985) and chrysanthemum (*Chrysanthemum ×morifolium* Ramat.) (Eng et al., 1983), but little work has been done on recently introduced species. Previous research performed on stock plants has focused on the effect of supplemental lighting (Donnelly and Fisher, 2002), spectral light quality (Read, 1988), photoperiod (Pallez and Dole, 2001), temperature (Kresten-Jensen, 1997), carbon dioxide (Molitor and von Hentig, 1987), and nitrogen concentration and form (Ganmore-Neumann and Hagiladi, 1992) on cutting yield and performance. Canopy management techniques have been studied on poinsettia stock plants, for example, leaf removal (Wilkins, 1988) and node position following pinching (Grueber, 1985) have been shown to affect cutting production.

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Although, stock plant research examining the effect of pinch number has not been reported in the scientific literature, pinch number is commonly manipulated on commercial poinsettia stock plants. Poinsettias require 4 to 5 weeks following a pinch to produce a shoot that has the proper maturity to be pinched and 6 to 7 weeks are required following a pinch to develop a cutting; therefore, the number of pinches affects the duration of the stock plant schedule. For example, single-pinch stock plants require 12 weeks to produce 21 cuttings per stock plant (Ecke et al., 1990). Two-pinch stock plants require 16 weeks to produce 39 cuttings, three-pinch stock plants require 20 weeks to produce 54 cuttings, and four-pinch stock plants require 25 weeks to produce 80 cuttings. Therefore, higher pinch numbers applied to poinsettia stock plants results in an increase in the total number of cuttings harvested per stock plant, but at the cost of a considerable increase in production time.

A stock plant starts from a single shoot-tip cutting. After propagation, the rooted cutting is transplanted to a container or bed. Then, the primary shoot is pinched, i.e., apex removal, to promote lateral shoot development. The stems and nodes remaining on the stock plant below the pinch are referred to as the scaffold. The developing lateral shoots are then harvested as cuttings or pinched to produce further lateral shoot development. The grower must make the decision as to the potential benefit or detriment to harvesting a cutting versus pinching to allow for more nodes on the stock plant scaffold for further cutting harvest. We hypothesize that harvesting cuttings results in higher cutting yield initially, but potentially sacrifices future cutting production, since fewer nodes remain on the scaffold. In contrast, pinching lateral shoots sacrifices early cutting production and invests in future production, since more leaves remain on the stock plant to intercept solar radiation and more axillary buds remain on the stock plant to produce future shoots.

The objective of this study was to determine the effect of different scaffold building approaches on cutting production over time. The results will provide propagators with an improved understanding of how to manage stock plants to match cutting production with market demand and to improve total cutting yields.

Materials and Methods

Eighteen rooted cuttings of each of four species [*Argyranthemum frutescens* 'Comet Pink', *Nemesia fruticans* 'Plum Sachet' Venten., *Osteospermum fruticosum* 'Zulu' L., and *Verbena ×hybrida* 'Lanai Bright Pink' L.] were transplanted into a peat-based growing medium (Fafard 3B, Fafard Inc., Anderson, S.C.) in 16.5-cm-diameter containers (2.2 L) at the start of experiment in 2003. One cutting was transplanted in each container. Each plant represents an experimental unit. Containers were placed at 30 × 30-cm spacing, so that the canopy of neighboring plants did not overlap during the experiment. Each species had unique transplant dates, pinch dates, node numbers left below each pinch, and cutting length (Table 1). One node pair or two nodes, depending on the leaf arrangement for each species, remained on the stock plant stems following cutting removal. Six plants for each species were randomly treated with one of the three following pinch treatments:

1) One pinch (P). The primary shoot was pinched. Cuttings were harvested on all the subsequent lateral shoots.
2) Two pinches (PP). The primary shoot was pinched. The secondary shoots that emerged after the first pinch were also pinched. Cuttings were harvested from all the subsequent lateral shoots.
3) Three pinches (PPP). The primary shoot was pinched. The secondary and tertiary shoots that emerged after the first and second pinches, respectively, were also pinched. Cuttings were harvested from all the subsequent lateral shoots.

The number of cuttings harvested per stock plant was recorded weekly. The mean daily light integral during the experiment was 8.7 $mol \cdot m^{-2} \cdot d^{-1}$ for *Argyranthemum*, *Nemesia* and *Verbena*, and 9.9 $mol \cdot m^{-2} \cdot d^{-1}$ for *Osteospermum*. The experiment was conducted in Clemson, South Carolina under ambient daylengths, and the greenhouse average daily air temperature during the experiment was 19.8 °C. Plants were fertilized twice weekly with 20N–8.6P–16.6K Peat-Lite Special (O.M. Scott, Marysville, Ohio) at 250 $mg \cdot L^{-1}$ N.

Table 1. Materials and methods for each of the four species used in this study. The transplant date is for unpinched, rooted cuttings. Each species had plants that were pinched 1, 2, or 3 times. For example, the one-pinch treatment (P) for *Argyranthemum* was pinched 22 d after transplant (DAT), the two-pinch treatment (PP) was pinched on 22 and 35 DAT, and the three-pinch treatment (PPP) was pinched 22, 35, and 48 DAT.

		Pinch date(s) (days after transplant)			Nodes remaining on stem below pinch (no.)			
Species	Transplant date	First pinch	Second pinch	Third pinch	First pinch	Second pinch	Third pinch	Cutting length (cm)
Argyranthemum	11 Nov.	22	35	48	9	4	4	2.5
Nemesia	6 Dec.	3	21	37	5	3	3	3.8
Osteospermum	27 Nov.	10	38	66	6	4	4	2.5
Verbena	6 Dec.	3	21	38	3	3	3	2.5

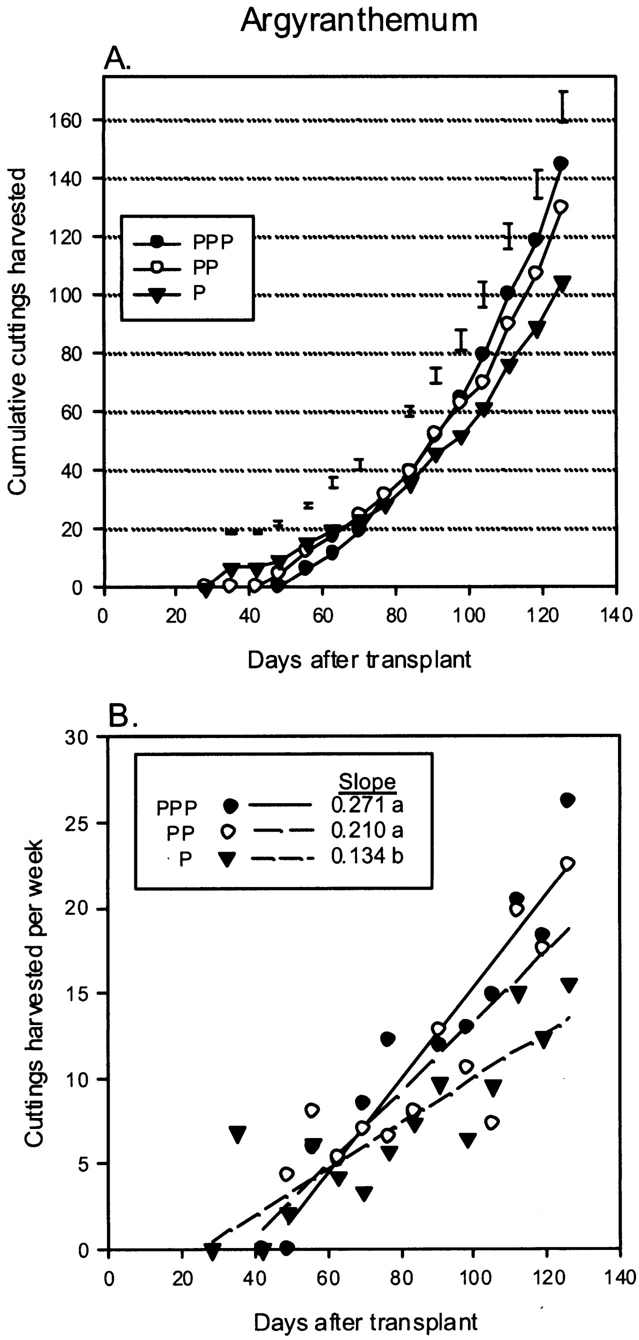

Fig. 1. The effect of pinching on (**A**) the cumulative number of cuttings harvested per plant and (**B**) the weekly rate of cuttings harvested per plant from *Argyranthemum* 'Comet Pink' stock plants. Stock plants were pinched once (P), twice (PP), or three (PPP) times before the weekly harvest of cuttings. Symbols represent the mean of six plants. $LSD_{0.05}$ bars display the differences between the pinch treatments at each week for the cumulative harvest data (no bars are shown where no significant effects occurred), while letters represent statistical differences between the slopes of the regression lines for the harvest rate data.

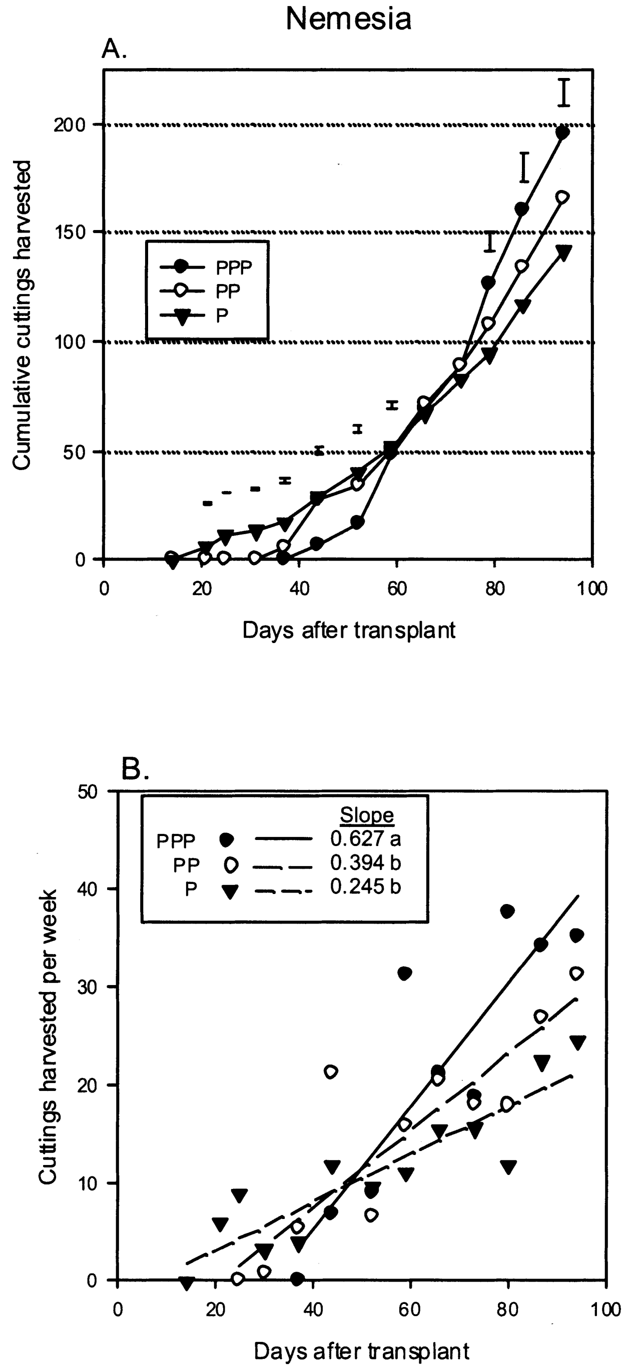

Fig. 2. The effect of pinching on (**A**) the cumulative number of cuttings harvested per plant and (**B**) the weekly rate of cuttings harvested per plant from *Nemesia* 'Plum Sachet' stock plants. Stock plants were pinched once (P), twice (PP) or three (PPP) times before the weekly harvest of cuttings. Symbols represent the mean of six plants. $LSD_{0.05}$ bars display the differences between the pinch treatments at each week for the cumulative harvest data (no bars are shown where no significant effects occurred), while letters represent statistical differences between the slopes of the regression lines for the harvest rate data.

Tap-water was applied as needed the remainder of the week.

The pinch treatments were applied in a completely randomized design. ANOVA were performed for each species and cumulative harvest date using PROC GLM (SAS Institute, Cary, N.C.). Means were separated by least significant differences (LSD) $P \leq 0.05$ to determine differences at each harvest. Linear regression was performed on the cutting yield rate data, and linear contrasts were performed to determine the differences between the slopes of the regression lines.

Results

Argyranthemum. The first harvest of cuttings from P, PP, and PPP were on days after transplant (DAT) 35, 49, and 56, respectively (Fig. 1A). The rate (number of cuttings per week) of increase in cutting production was lowest for P (Fig. 1B), so the cumulative cuttings harvested in PP and PPP equaled P on DAT 63 and DAT 70, respectively (Fig. 1A). Cumulative cutting yield of PP exceeded P on DAT 91 through the end of the experiment (DAT 126). Cutting yield of PPP exceeded P

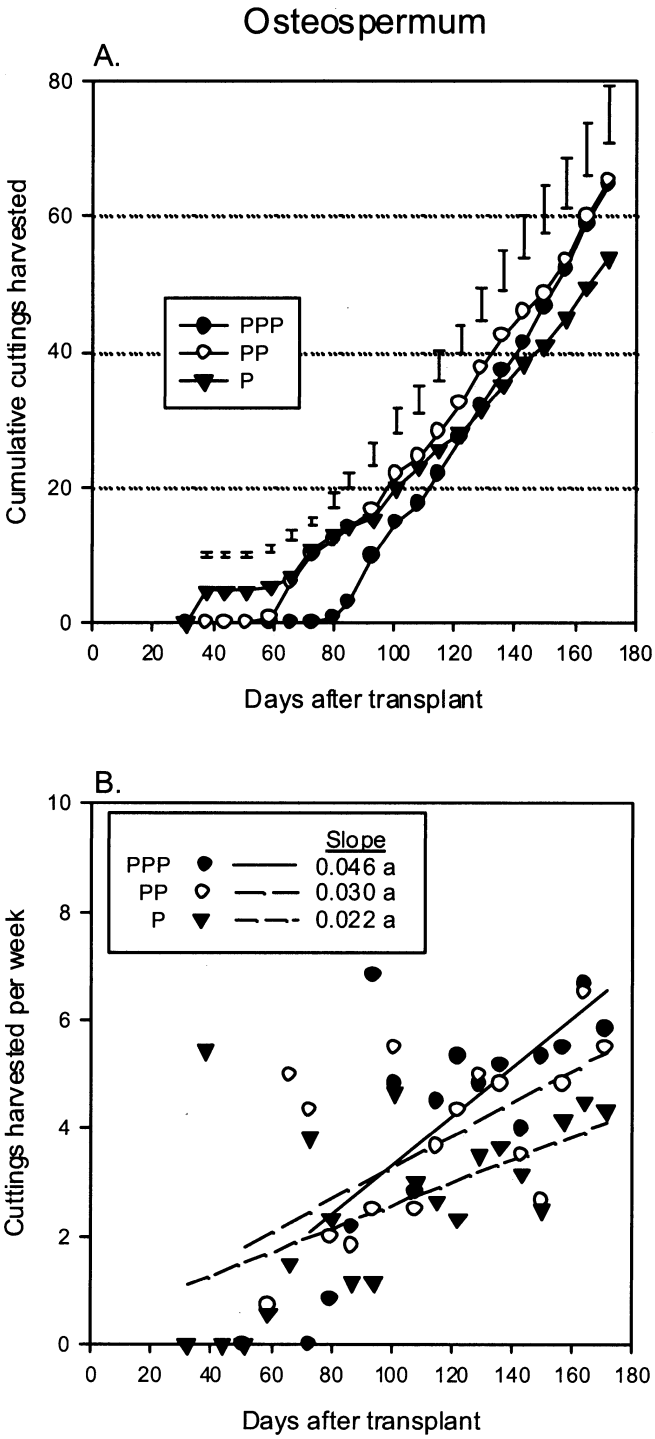

Fig. 3. The effect of pinch on (**A**) the cumulative number of cuttings harvested per plant and (**B**) the weekly rate of cuttings harvested per plant from *Osteospermum* 'Zulu' stock plants. Stock plants were pinched once (P), twice (PP), or three (PPP) times before the weekly harvest of cuttings. Symbols represent the mean of six plants. $LSD_{0.05}$ bars display the differences between the pinch treatments at each week for the cumulative harvest data (no bars are shown where no significant effects occurred), while letters represent statistical differences between the slopes of the regression lines for the harvest rate data.

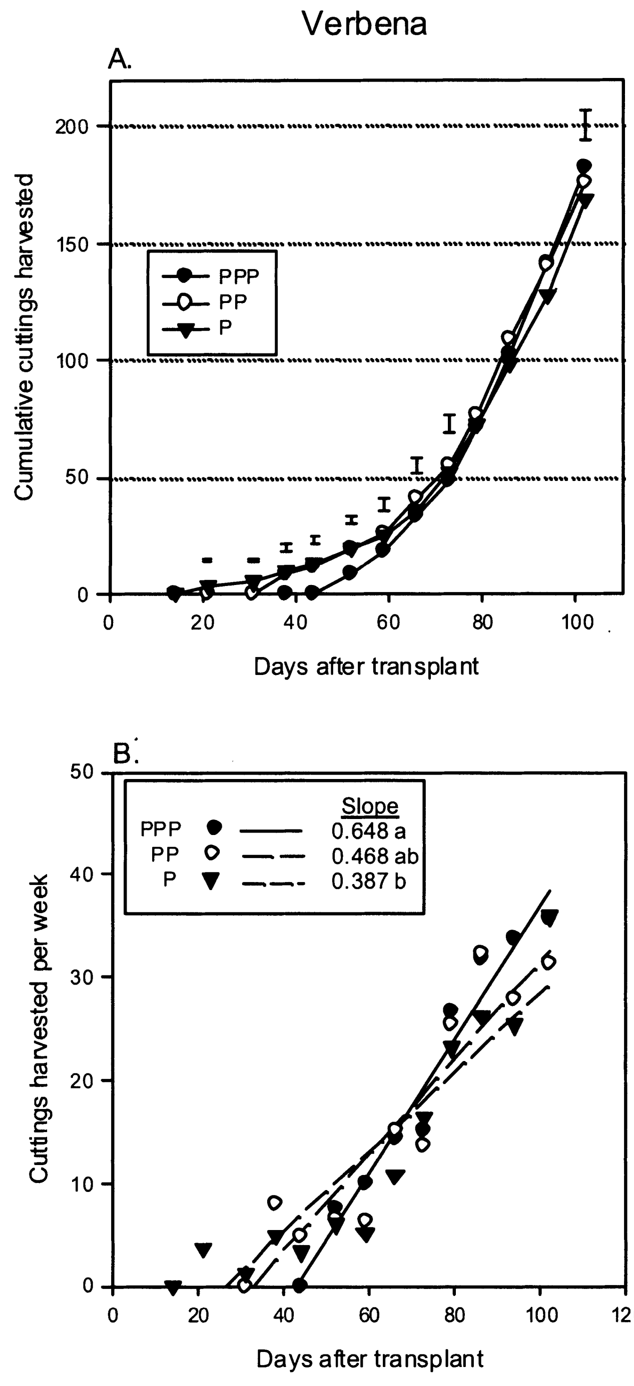

Fig. 4. The effect of pinching on (**A**) the cumulative number of cuttings harvested per plant and (**B**) the weekly rate of cuttings harvested per plant from *Verbena* 'Lanai Bright Pink' stock plants. Stock plants were pinched once (P), twice (PP), or three (PPP) times before the weekly harvest of cuttings. Symbols represent the mean of six plants. $LSD_{0.05}$ bars display the differences between the pinch treatments at each week for the cumulative harvest data (no bars are shown where no significant effects occurred), while letters represent statistical differences between the slopes of the regression lines for the harvest rate data.

on DAT 84 to 126, and PPP exceeded PP on DAT 104 to 126.

The final cutting yield for P, PP, and PPP was 104, 130, and 144 cuttings per stock plant, respectively (Fig. 1A). The rate of cutting production at the termination of the experiment was 13.5, 18.8, and 22.4 cuttings per week for P, PP, and PPP, respectively (Fig. 1B).

Nemesia. Cutting production for P, PP, and PPP began on DAT 21, 31, and 44, respectively (Fig. 2A). By DAT 37, P had yielded 29.3 cuttings per plant and PP yielded 6.0 cuttings per plant, while no cuttings were yet removed from PPP. The rate of increase of cutting production per week was greatest in PPP (Fig. 2B), so the cumulative yield of PPP equaled P and PP by DAT 60 and exceeded P and PP by DAT 79. Cutting yield of PP exceeded P on DAT 73.

The final cutting yield for P, PP, and PPP was 142, 166, and 196 cuttings per stock plant, respectively (Fig. 2A). The rate of cutting production at the termination of the experiment was 21.3, 28.8, and 39.3 cuttings per week for P, PP, and PPP, respectively (Fig. 2B).

Osteospermum. The first cuttings were harvested from P on DAT 38, while PP and PPP began to produce cuttings on DAT 59 and 80, respectively (Fig. 3A). No significant difference in cumulative cutting production between P and PP occurred from DAT 66 to 115. Total cutting production in PP was greater than P from DAT 122 to the end of the experiment (DAT 171). Total cutting production in PPP was greater than P on DAT 164 and 171, while no yield difference was observed between PP and PPP at the end of the experiment.

The final cutting yield for P, PP, and PPP was 54, 65, and 65 cuttings per stock plant, respectively. The rate of cutting production at the termination of the experiment was not statistically different for the three pinch treatments.

Verbena. One-pinch stock plants produced more cuttings than PP and PPP plants during the first 31 and 59 DAT, respectively (Fig. 4A). The rate of increase in cutting production for PP and PPP was sufficiently high from 31 to 59 DAT (Fig. 4B) that no significant differences were observed between any of the pinch treatments by DAT 73 (Fig. 4A). The total cutting yield of PPP was statistically higher than P on the last day of the experiment (DAT 102); however, the difference was relatively small.

The final cutting yield for P, PP, and PPP was 168, 176, and 182 cuttings per stock plant, respectively (Fig. 4A). The rate of cutting production at the termination of the experiment was 29.4, 32.5, and 38.3 cuttings per week for P, PP, and PPP, respectively (Fig. 4B).

Discussion

The number of pinches applied to a stock plant affected the timing of the first cuttings to be harvested for all four species. Single pinch stock plants began to produce cuttings earlier than the multiple pinch (PP and PPP) stock plants. The weekly rate of cutting production varied considerably from week to week, so there are fewer statistical differences for the rate data compared to the cumulative yield data. However, the rate of cutting production increased as the number of pinches increased due to the increased number of nodes per stock plant. Three pinch stock plants (PPP) had a higher rate of increase in cutting production than P for all species, except *Osteospermum*. As a result, P produced cuttings earlier, but produced fewer cuttings over time resulting in a lower weekly yield, while PPP had a higher rate of cutting production over a shorter period of time.

Multiple-pinch treatments produce higher cutting yields over time for two reasons. First, the scaffold has more nodes from which to develop lateral shoots. Second, the extra nodes result in a larger leaf area and greater interception of solar radiation, which promotes photosynthesis and growth. Visual observations indicated that the multiple-pinch treatments produced the largest stock plants, while P produced the smallest stock plants. In commercial production, we would expect that the multiple-pinch treatments would reach canopy closure first. So, multiple-pinch treatments would reach the maximum cutting production rate per unit area more quickly than P.

In this study, stock plants were grown individually, not as multiple plants in a crop as done in commercial production. If we attempt to extrapolate our data to commercial production, we would expect pinch treatment differences to occur only to the point in time when the canopy of neighboring plants begins to overlap. The increase in the rate of cutting production over time would only occur until canopy closure occurs. At canopy closure, the maximum cutting production rate would be reached, so cutting production would become relatively constant. We hypothesize that before canopy closure, the number of developing shoots is limited by the number of nodes on the scaffold and the solar radiation intercepted. The number of developing shoots is not node-limited once the canopy of multiple stock plants has closed together, so solar radiation would become the primary limiting factor. Therefore, the magnitude of the effect of pinching during the scaffold phase will increase as plant spacing increases or will decrease as plant spacing decreases.

This study demonstrates that scaffold management during the early stages of stock plant production can significantly impact cutting production. The general results of this study are not surprising; however, the magnitude of the treatment differences is particularly interesting. Increasing cutting production by 17% to 38% simply by altering the number of pinches applied to a stock plant scaffold is substantial. It is also interesting to observe that at the termination of the study, the weekly rate of cutting production increased 66.3%, 84.0%, and 30.5% as pinch number increased from P to PPP for *Argyranthemum*, *Nemesia*, and *Verbena*, respectively. The result is that pinch number during scaffold development provides a very useful tool for stock plant growers to manipulate the timing, the weekly production rate, and the cumulative yield of cuttings.

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