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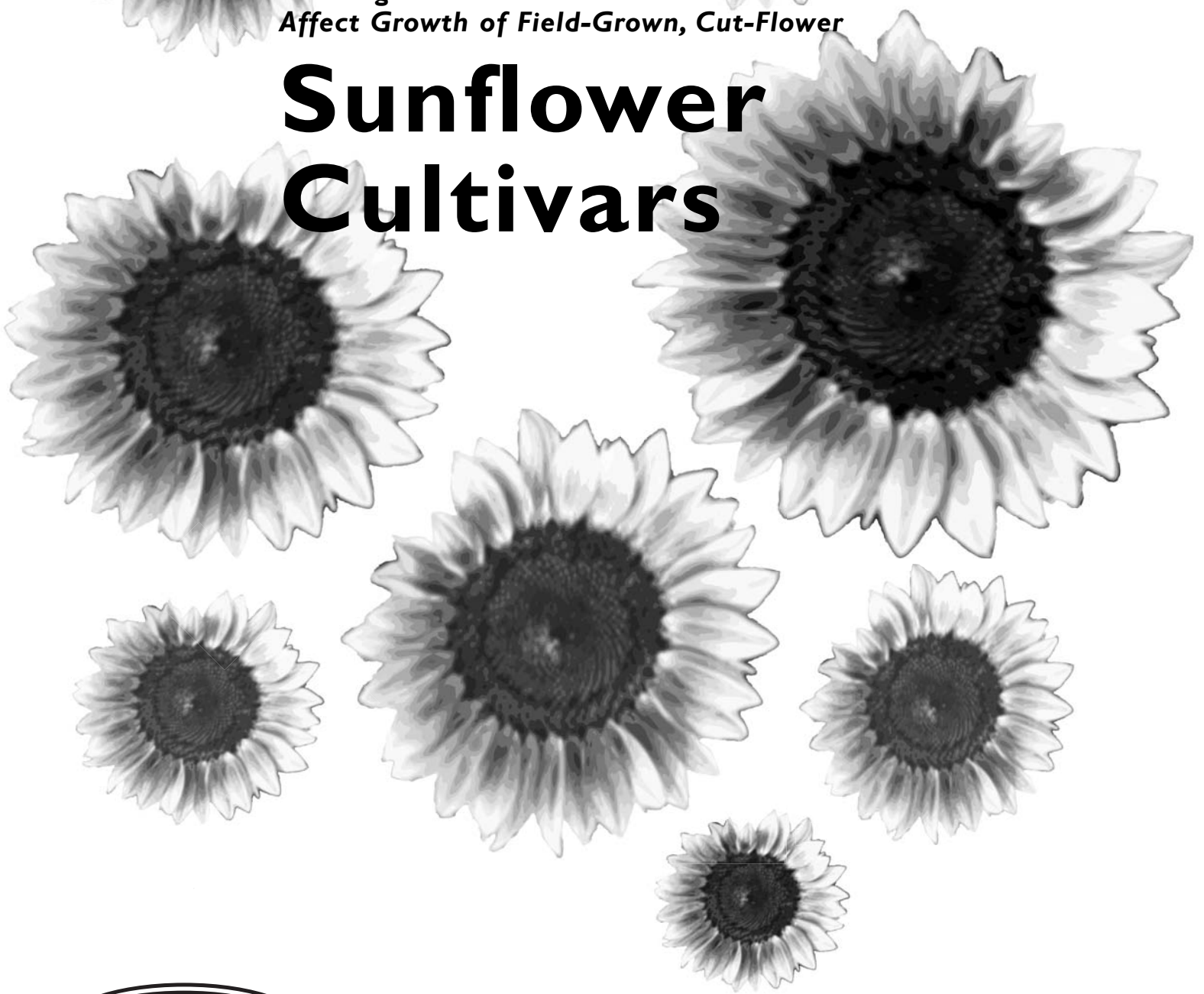

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Planting Date and Pinch Treatments Affect Growth of Field-Grown, Cut-Flower Sunflower Cultivars

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ABSTRACT

The objectives of this experiment were to evaluate the effects of terminal bud removal, planting date, and cultivar on the number of days to harvest, number of stems per plant, stem size, and flower size of representative branching and upright cut-flower sunflower cultivars. For the branching cultivars, the number of days to first harvest, number of stems per plant, and stem diameter were not affected by cultivar. Cultivar did affect stem length and flower diameter. Planting date did not affect the number of stems of the branching cultivars, but it did produce differences in stem and flower size. Branching sunflower cultivars in this experiment required a longer time to mature to first harvest for the May and June planting dates compared with the July and August dates. For the upright cultivars, there was a treatment effect interaction between cultivar and planting date for all growth responses. In addition, there was an interaction between planting date and pinch treatment for stems produced per plant and stem length. Plants of the upright cultivars took longer to grow to first harvest from the May planting date compared with the other dates. The May planting date produced larger stems and flowers for the upright cultivars. The results of this research suggest that pinching branching cultivars in the 6- to 10-node stages in the May–June planting period, and then pinching at the 4- to 8-node stage later in the growing season (July–August), will produce 4–7 stems ranging from 83–95 cm long and 1.0–1.1 cm in diameter. Furthermore, results indicate that pinching upright cultivars in the 4- to 10-node growth stage will result in the production of 3–7 stems that are 64–131 cm long and 1.0–1.8 cm in diameter. All of these stems were within established, acceptable size ranges for florist usage.

Helianthus annuus; sunflower; cut flower; field production; pinch; size reduction

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Introduction

Ornamental sunflowers, *Helianthus annuus*, are relatively easy to grow, and consumers like them, which make them attractive for commercial growers and farmer's market growers to include in their production schedules. Sunflowers were not listed in the top 20 most valuable cut-flower species grown in the U.S. in 1998, but the wholesale value of sunflowers produced in the U.S. that year was $4,423,000 (U.S. Department of Agriculture, 1998).

Participants in Association of Specialty Cut Flower Growers on-farm evaluations reported that some upright sunflower cultivars were too large for florist usage, while other cultivars branched too freely and produced stems and flowers that were unacceptably small (Dole, 2002, 2003). In another trial, many upright sunflower cultivars grown in Mississippi field beds produced stems and flowers that were too large for general florist use (Sloan and Harkness, 2006). Emino and Hamilton (2004) attempted to reduce stem and flower size of sunflowers by removing the terminal bud. They reported that pinching 'Sunbright' 3 weeks after planting produced a uniform crop of 91-cm-long stems, while the nonpinched stems grew to 152 cm. Another trial reported that spacing 'Superior Sunset' plants 7.6 cm within the row, compared with 15 cm or 23 cm was necessary to reduce stem size (Sloan et al., 2004). Florists in Tupelo, Mississippi, indicated that the desirable sunflower stem size for general floral arrangements would be 60–90 cm long and 0.5–1.5 cm wide; the ideal flower would be 8–15 cm in diameter (Sloan, unpublished). The objective of this experiment was to determine the effect of pinch severity, cultivar, and planting date on days to harvest, stems produced per plant, and flower and stem size of upright and branching sunflower cultivars.

Materials and Methods

Seven sunflower cultivars, four upright and three branching, were transplanted into field beds on a Savannah sandy clay loam soil at the North Mississippi Research and Extension Center in Verona, Mississippi (lat. 34.2° N, long. 88.8° W), on four dates: May 3, June 3, July 1, and August 4, 2005. The upright cultivars in this trial were 'Full Sun Improved,' 'Sunbright,' 'Superior Gold,' and 'Superior Sunset.' The branching cultivars were 'Infrared,' 'Moulin Rouge,' and 'Strawberry Blonde.' Seeds were planted in 1204 cells (3.8 x 6 x 6 cm) and grown in a greenhouse until the seedlings were large enough to transplant to the field. Seedlings were fertilized with 100 mg of nitrogen (N) per liter using Peter's Peat Lite Special 20-10-20 (20N-4.3P-16.7K; The Scotts Company, Marysville, Ohio) water-soluble fertilizer until the first leaves emerged. Then, they were fertilized weekly with 250 mg of N per liter from 20-10-20 water-soluble fertilizer. To reduce root rot problems, the seedlings were drenched with Banrot (15% etridiazole plus 25% thiophanate methyl; Scotts-Sierra Crop Protection Co, Marysville, Ohio) at a rate of 59 ml per 3.8 L before transplanting to the field beds.

Preplant fertilizer 8-8-8 (8N-3.5P-6.6K) (IMC Rainbow Agribusiness, Florence, Alabama) was applied to the field at a rate of 495 kg per hectare. Raised beds were formed with a three-point hitch bed shaper and covered with plastic mulch. The beds were

76 cm across the top and were spaced on 1.5 m centers. A single drip tape was placed in the center of the bed and buried 2.5 cm below the bed surface. Beds were fertigated weekly with Peter's 20-20-20 (20N-8.8P-16.5K) at a rate of 27.2 kg per hectare during the growing season. Irrigation was supplied in the absence of rain through the drip tape to provide 473 L per 30.5 m of row once per week until harvest.

A hard pinch was made on the sunflower plants, removing the terminal bud and the top of the stem to leave the sunflower plants with 4, 6, 8, and 10 nodes. Experimental units consisted of four plants of each cultivar that were planted in pairs, two plants on each of two parallel rows that were spaced 0.3 m apart on the raised beds. Sunflower stems were harvested as soon as the ray flowers were parallel to the flower head. Variables measured in this trial were stem length, stem basal diameter (measured at the cut end of the stem), flower diameter (measured across the expanded ray flowers), the number of days from transplanting to harvest, and the number of stems produced per plant.

The experimental design was a split-split plot with the planting date being the whole-plot factor, the cultivar being the subplot factor, and the pinch treatment being the sub-subplot factor. The upright and the branching cultivars were analyzed separately. Data collected during the experiment were analyzed by SAS PROC Mixed (SAS Institute Inc, Cary, North Carolina). Mean separation was conducted with Fisher's protected least significant difference (LSD) at the 0.05 significance level.

Results and Discussion

The 2005 growing season was relatively cool with the average high temperatures for June and July below the 30-year averages, while August was slightly hotter than average. The average high/low temperatures for the 2005 growing season were May, 78.5–53.1°F; June, 85.3–68.0°F; July, 88.2–70.1°F; and August, 92.1–70.2°F. (Mississippi State University, 2006). The precipitation for May and June was below normal, while July and August's precipitation was above normal. The average monthly day lengths for May–August were 13.9, 14.6, 14.4, and 13.3 hours, respectively (U.S. Naval Observatory, 2005).

Branching Cultivars

There were no significant interactions between the effects of planting date, cultivar, and pinch treatment in the analysis of the growth responses of the branching cultivars, so the main effects could be examined separately. Cultivar did not affect the number of days required for the branching cultivars to produce the first mature flower stem for harvest, the number of stems produced per plant, and stem diameter (Table 1). The stem length and flower diameter of 'Strawberry Blonde' was significantly less than the other cultivars. Planting date had a significant effect on days to harvest, stem length, stem diameter, and flower diameter, but not on number of stems per plant. Plants from the May planting date took longer than those from the other dates to produce the first flower; likewise, plants from the June planting required a longer time to harvest than plants from the July and August planting. Previous research indicated that sunflowers grown in the controlled climate of a greenhouse under long days required longer to grow from germination to anthesis (Blacquire et al., 2002; Yanez et al., 2005). This growth delay was not observed in this experiment where the longer day lengths occurred in June and July compared with May. There was a decrease in stem length — 110.1 > 94.9 > 82.9 > 70.7 cm — due to planting date from May–August. These results disagree with previous research where sunflowers grown in short days had shorter stems than those grown in long-day conditions (Blanquire et al., 2002; Yanez et al., 2004). Stem diameter was greater for plants from the May and June plantings than for plants from the July and August dates. Likewise, May- and June-planted branching sunflowers produced the largest flower diameter, while the July planting yielded flowers larger than those in the August planting. Yanez et al. (2005) reported that photoperiod did not affect sunflower stem and flower diameter, so the differences in stem length and diameter and flower diameter observed in this experiment could be due to increasing air temperatures from May to August. Vince-Prue (1975) reported that sunflowers could be quantitative short-day or day-neutral plants and that temperature affected flowering in day-neutral plants. Pinch treatment affected neither days to first harvest nor flower diameter. Pinching at the 8- and 10-

Table 1. Effect of cultivar, planting date, and pinch treatment on the days to first harvest, stems produced per plant, stem length, stem diameter, and flower diameter of branching sunflower cultivars in 2005.

Cultivar	Days to first harvest	Stems per plant	Stem length	Stem diameter	Flower diameter
	no.	*no.*	*cm*[1]	*cm*	*cm*
Infrared	60.8 a[2]	5.8 a	93.5 a	1.1 a	12.4 a
Moulin Rouge	60.5 a	6.2 a	92.2 a	1.1 a	12.2 a
Strawberry Blonde	60.7 a	5.7 a	83.3 b	1.0 a	11.5 b
LSD	NS	NS	7.3	NS	0.5
Planting date					
May	67.7 a	5.9 a	110.1 a	1.2 a	13.3 a
June	61.1 b	5.8 a	94.9 b	1.2 a	13.3 a
July	56.9 c	5.8 a	82.9 c	0.9 b	11.3 b
August	56.9 c	6.29 a	70.7 d	0.9 b	10.3 c
LSD	1.5	NS	6.4	0.1	0.6
Pinch treatment					
4	61.3 a	4.2 b	90.5 a	1.1 a	11.9 a
6	60.4 a	5.2 b	94.8 a	1.1 a	11.9 a
8	60.5 a	6.7 a	89.9 a	1.0 ab	12.3 a
10	50.5 a	7.6 a	83.4 b	1.0 b	11.9 a
LSD	NS	1.1	5.7	0.1	NS

[1]1 cm = 0.3937 inch.
[2]Means compared by Fisher's Protected LSD at *P*=0.05. Means followed by the same letter in a column do not differ at the 5% significance level.

node stage of development produced more stems per plant compared with pinching at the 4- and 6-node stages. This finding was expected since there were more potential buds on the 8- and 10-node plants. The 4- and 6-node pinching treatments imposed on the branching cultivars produced fewer, but larger stems per plant compared with the 10-node treatment. The number of stems produced by the branching cultivars in this experiment was not affected by planting date, but the stem length and diameter and flower diameter were affected by planting date. The May and June plantings produced larger branching sunflower stems than the July and August plantings.

Upright Cultivars

There was an interaction between the cultivar and planting date effects on all growth responses of the upright sunflower cultivars in this trial (Table 2). The number of days required from planting to first flower was greater for all cultivars in the May planting compared with the other planting dates. This response was also seen with the branching cultivars and agrees with the conclusion of Young et al. (2003), who reported that sunflowers planted earlier in the growing season required a longer time to harvest compared with those planted later in the season. Aiken (2005) reported that the sunflower development depended on temperature and photoperiod. The observed response could be due to increased air temperatures from May to August. The May planting produced more stems per plant compared with the July and August plantings for three of the four cultivars, but there was no difference in the number of stems per plant between July and August plantings. The May planting date produced longer stems than the other planting dates, while stems from the August planting were the shortest for three of four cultivars. Cultivar did not affect stem diameter within the July and August planting dates. Photoperiod varied less than one hour per day from May to June, July, or August and probably did not account for the differences in stem length and diameter and flower diameter. The responses of days to harvest and stem length do not agree with previous research that showed that short day length produced shorter stems in a shorter period of time compared with long days (Blacquire et al., 2002; Hasata and Imaizumi, 2000; Pallez et al., 2002; Yanez et al., 2004; Yanez et al., 2005). There was an increase in the daily average air temperature from May to August that could have contributed to the decrease in days to harvest, stem length, stem diameter, and flower diameter from May to August. Aiken (2005) reported that the growth of oilseed sunflower cultivars

responded to both photoperiod and temperature, and Vince-Prue (1975) reported that flowering of day-neutral sunflowers was affected by temperature. The ornamental sunflower cultivars in this experiment appear to have responded to temperature.

There was an interaction between pinch treatment and planting date on the number of stems per plant and stem length (Table 3). Plants from the May planting date that were pinched at the 6- and 8-node stages produced more stems per plant than plants pinched at the 10-node stage. The pinch treatment had no effect on plants from the June planting date with respect to the number of stems per plant. Among plants from the August planting, the 8-node treatment produced more stems than the 4- and 6-node treatments. Plants from the July planting date produced more stems from the 8- and 10-node pinch treatments compared with the 4- and 6-node treatments. Differences due to pinch treatments across the planting dates were not straightforward for the 4- and 6-node treatments, but the 8- and 10-node treatments from the July and August planting dates produced more stems than the May and June planting dates. Within all pinch treatments, stem length decreased due to planting date from the May to the August planting dates. This was also observed in the branching cultivars and could be due to increasing air temperatures from May to August as noted by Aiken (2005) and Vince-Prue (1975). The 4-node treatment produced longer stems than the 8- and 10-node treatments in the May and June plantings while the 8-node treatment produced longer stems than the 4- and 10-node treatments in the July planting. Stem length was not affected by pinch

Table 2. Effect of cultivar and planting date on the number of days to first harvest, stems per plant, stem length, stem diameter, and flower diameter of upright sunflower cultivars in 2005.[1]

Cultivar	Planting date				
	May	June	July	August	
			Days to first harvest		
Full Sun Improved	67.9 a B[2]	58.5 c C	57.2 c C	65.1 b A	LSD = 2.2783[3]
Sunbright	74.5 a A	64.2 c A	63.6 c A	66.9 b A	
Superior Gold	70.2 a B	62.3 b B	59.9 c B	60.8 bc B	
Superior Sunset	69.9 a B	63.5 b A	59.4 c BC	62.3 b B	
LSD = 2.2910[4]					
			Stems per plant		
Full Sun Improved	4.1 a A	3.9 a AB	4.7 a B	4.7 a C	LSD = 1.1162[3]
Sunbright	4.3 b A	3.2 b B	5.8 a AB	5.9 a AB	
Superior Gold	3.4 b A	4.7 ab A	5.3 a AB	5.2 a BC	
Superior Sunset	3.5 b A	4.0 b AB	6.2 a A	6.4 a A	
LSD = 1.1402[4]					
			Stem length (cm)[5]		
Full Sun Improved	104.0 a B	87.5 b B	85.9 bc B	65.1 c AB	LSD = 9.0193[3]
Sunbright	110.5 a B	95.4 b B	84.5 c B	58.3 d B	
Superior Gold	131.1 a A	120.5 b A	91.3 c AB	71.1 d A	
Superior Sunset	134.9 a A	125.7 b A	95.1 c A	70.9 d A	
LSD = 8.6407[4]					
			Stem diameter (cm)[5]		
Full Sun Improved	1.5 a B	1.3 b B	1.3 b A	1.2 b A	LSD = 0.1912[3]
Sunbright	1.3 a B	1.3 ab B	1.1 bc A	1.0 c A	
Superior Gold	1.8 a A	1.6 a A	1.2 b A	1.0 b A	
Superior Sunset	1.8 a A	1.6 a A	1.2 b A	1.0 b A	
LSD = 0.2050[4]					
			Flower diameter (cm)[5]		
Full Sun Improved	13.8 a B	12.2 b B	11.5 c B	10.8 c AB	LSD = 1.0651[3]
Sunbright	12.4 a C	11.5 ab B	11.3 b B	9.9 c B	
Superior Gold	15.4 a A	15.1 a A	11.5 b B	10.3 c B	
Superior Sunset	15.5 a A	14.9 a A	12.7 b A	11.4 c A	
LSD = 1.041[4]					

[1]There was an interaction between cultivar and planting date in the number of days required to first harvest (P=0.0002), stems produced per plant (P=0.0263), stem length (P<0.0001), stem diameter (P=0.0097), and flower diameter (P=0.0001) of upright cultivars in 2005. Two comparisons were needed for the analysis: (1) within the cultivar and across planting dates, and (2) within planting date and across cultivars.
[2]Means compared by Fisher's Protected LSD at P=0.05. Means with the same lower-case letter in a row do not differ at the 5% significance level. Means with the same uppercase letter in a column do not differ at the 5% significance level.
[3]LSD within cultivar and across planting dates.
[4]LSD within planting date and across cultivars.
[5]1 cm = 0.3937 inch.

treatment in plants of the August planting date. Stem length and diameter and flower diameter were greater for sunflowers planted early in the growing season (May and June) compared with later-planted sunflowers. The later planting dates produced more stems per plant compared with the early planting dates for the upright cultivars in this trial. The number of stems resulting from pinching treatments imposed on upright sunflower cultivars in the May and June planting period did not significantly differ among the 4-, 6-, 8-node treatments. Stem length was greater in the May and June plantings in plants pinched at the 4-node stage, but this was not observed in July, where the 8-node treatment produced longer stems than the 4-node treatment. Even the shortest stem lengths of the pinch treatments within the August planting date were within the acceptable range of 60–90 cm established by Sloan (unpublished). The production of stems longer than 90 cm is not a problem. As long as the stem diameter is not too large, they can be cut to the desirable length.

Table 3. Effect of pinch treatment and planting date on the number of stems produced per plant and the length of upright sunflower stems in 2005.[1]

Pinch treatment	Planting date				
	May	June	July	August	
			Stems per plant		
4	3.9 ab AB[2]	3.6 ab A	3.3 b C	4.6 a C	LSD = 1.0881[3]
6	4.1 b A	4.4 ab A	5.1 ab B	5.3 a BC	
8	4.2 b A	4.1 b A	6.5 a A	6.7 a A	
10	3.0 c B	3.7 c A	7.0 a A	5.7 b AB	
LSD = 1.0780[4]					
			Stem length (cm)[5]		
4	131.3 a A[4]	117.1 b A	84.5 c B	64.2 d A	LSD = 9.0552
6	122.6 a B	111.5 b AB	92.8 b AB	66.6 c A	
8	119.2 a B	104.1 b BC	94.4 c A	68.1 d A	
10	108.5 a C	97.9 b C	85.4 c B	66.3 d A	
LSD = 8.4819					

[1]There was an interaction between pinch treatment and planting date (P=0.0002) in analyzing the number of stems produced per plant (P=0.0002) and stem length (P=0.0010) in 2005. Two comparisons were needed for the analysis: (1) within pinch treatment and across planting dates, and (2) within planting date and across pinch treatments.
[2]Means compared by Fisher's Protected LSD at P=0.05. Means with the same lower-case letter in a row do not differ at the 5% significance level. Means with the same uppercase letter in a column do not differ at the 5% significance level.
[3]LSD within pinch treatment and across planting dates.
[4]LSD within planting date and across pinch treatments.
[5]1 cm = 0.3937 inch.

Conclusions

This research suggests that pinching the branching cultivars in the 6- to 10-node stage in the May to June planting period, and then pinching at the 4- to 8-node stage later in the growing season (July to August) will produce 4–7 stems ranging from 83–95 cm long and 1.0–1.1 cm in diameter. These dimensions are within the suitable size range for sunflower stems. Planting date has a greater effect on stem length and diameter of upright cultivars than the choice between 4-, 6-, 8-, or 10-node pinch treatments, possibly due to increasing temperatures from May to August in Mississippi. This research indicates that removal of the terminal bud of upright sunflowers in the 4- to 10-node stage of growth results in the production of 3–7 stems that were 64–131 cm long and 1.0–1.8 cm in diameter, which are within established, acceptable size ranges.

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