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Using Photoperiod to Manipulate Flowering and Tuberous Root Formation in Seed Dahlias

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Introduction

Tuberous root development and flower induction of Dahlia are controlled by photoperiod; however, photoperiod manipulation is generally not used in their production. Plug production of seed propagated typically takes place under the short days of late autumn and early winter. The critical day-length for tuberous root formation is approximately 11 to 12 hours (Moser and Hess, 1969). When the day-length is shorter than this critical period it signals the plant to store energy in tuberous roots, at the expense of shoot growth. Many growers may have experienced difficulty when extracting plugs using mechanical trans-planters because the tuberous roots have outgrown the plug tray.

Growers may have also experienced delays in flowering. Short days also induce flowering in dahlia. This effect may be quantitative or qualitative depending on the cultivar; however, longer day-lengths are required for proper flower development. Konishi and Inaba (1964 and 1966) found the optimum day-length for flower induction to be 10 hours or less; however, they determined that a day-length of 12 hours or greater was required for proper flower development. They observed that plants grown under continuous 10-hour photoperiods had a high percentage of aborted flower buds. Halburton and Payne (1978) showed that while long days delayed bud set and flowering, the flowering percentage and overall flower and foliage quality of Dahlia 'Redskin' actually improved with long days. Plants grown under short day-lengths were shorter than those grown under longer day-lengths, suggesting that photoperiod could be used as a method of height control. Durso and De Hertogh (1977) observed that natural springtime photoperiods increasing from 10 to 14 hours were optimal for forcing of tuberous rooted cultivars 'Kolchelsee' and 'Park Princess'. Brondum and Heins (1993) determined that the optimum photoperiodic conditions for the production of 'Royal Dahlietta Yellow' were 12-14 hours at approximately 20 C.

In this article, we present the results of two studies we've conducted involving the use of photoperiod manipulation during plug and pot production of Dahlia 'Sunny Rose' and 'Sunny Yellow'. The first study demonstrates how night interruption lighting can be used to inhibit tuberous root formation during 288 plug production (Legnani and Miller, 2000). The second study investigates the use of photoperiod manipulation for optimal flowering and height of plugs after transplanting into 5” standard pots.

Experiment 1
Night interruption lighting inhibits tuberous root formation in Dahlia ‘Sunny Rose’ plugs.

Materials and Methods
Dahlia ‘Sunny Rose’ seeds (donated by Ball Seed Co.) were sown 7 Feb. (two seeds per cell) in 288 plug trays filled with Fafard Superfine Germinating Mix. The flats were covered with clear plastic wrap, and placed in a growth chamber with 24-h fluorescent lighting at 18 ˚C. Germination occurred in approximately 4 to 5 days. Seven days after sowing, flats were thinned to one seedling per cell and moved to a glass greenhouse for photoperiod treatments. Greenhouse night temperatures were maintained at 17 ˚C, with maximum day temperatures reaching 27 ˚C. During the second week of production, flats were sub-irrigated and fertilized by immersion in a tray containing 50 ppm N and K. Following the second week of production, as seedlings became established enough for overhead watering, they were fertilized at each watering with 150 ppm N and K. Weekly sprays (to runoff) of 33 ppm A-Rest were applied beginning on 28 Feb. for height control.

On day 7 in the greenhouse five flats were placed under LD (9-h natural daylight + night interruption lighting with two 60-watt incandescent lamps between 10 PM and 2 AM) while the other five received SD (9-h natural daylight from 9:00 AM to 6:00 PM). Seedlings were randomly harvested 2, 4, and 6 weeks following the start of photoperiod treatments, and growth measurements made

Results
Although photoperiod treatments had no effect on total plant dry weight, SD increased tuberous root development at the expense of shoot growth (Table 1). These differences in dry weight of shoots and roots were first observed at week 4 (Table 1). By week 6, LD plugs showed a 63% increase in shoot dry weight over SD plugs, but the dry weight of their tuberous root was less than half that of SD plugs.

No tuberous root formation was evident at week 2. By week 4 there was noticeable swelling at the stem bases on both LD and SD plugs, although this swelling was greater on the SD plugs. Adventitious tuberous roots originated from the swollen base of the stems independent of fibrous roots and were greater in diameter than the latter. These tuberous roots were noticeably larger on SD than on LD plugs. At week 6, SD plugs had developed large, rounded, tuberous roots while LD plugs had produced slender, elongated structures. Tuberous root dry weight was 2.4-fold as great in SD than in LD plugs at week 6. In contrast, LD plugs had a more extensive fibrous root system; dry weight of the roots was 2-fold as great in LD as in SD plugs (Table 1, Fig. 1)

Week 4 plants had greater leaf area under LD than under SD without a substantial increase in the average number of leaf pairs. At week 6, LD plugs showed a 55% increase in leaf area over SD plugs and had approximately one more pair of leaves (Table 2, Fig. 1). Leaf number may affect the time when the plug is capable of responding to photoperiod for flower induction and thus the time to flower. Barrett and De Hertogh (1978) found that non-pinched, tuberous-rooted cultivars 'Miramar' and 'Park Princess' became reproductive following the unfolding of four to six true-leaf pairs under inductive photoperiods.

Shoots were shorter under LD than under SD at week 2 (Table 2). Long-day plugs continued to grow taller while growth in height of SD plugs ceased at week 4. By week 6, LD plugs were 50% taller than SD plugs. We suspect that this increase was attributable to both increased partitioning to the shoot and increased exposure to far-red light during the night interruption.

In summary, LD promoted shoot growth, foliar development, and fibrous root growth in plugs, but reduced growth of tuberous roots. Long-day plugs were of salable size and quality at week 5 (6 weeks after sowing) but SD plugs were not salable until week 6 (7 weeks after sowing).

Experiment 2
Using photoperiod manipulation for optimal flowering and height of Dahlia 'Sunny Yellow' plugs after transplanting into 5" standard pots.

Materials and Methods
Dahlia 'Sunny Yellow' seeds were sown 7 Feb. in 288 plug trays and moved to a glass greenhouse (Ithaca, NY) on 14 Feb. for photoperiod treatment. Greenhouse temperatures were maintained at 21 C day/night. Both LD and SD plugs received 9 hours of natural daylight from 8:00 AM to 5:00 PM, with LD plugs receiving a night interruption between 10:00 PM and 2:00 AM. Weekly sprays of 33 ppm A-Rest were made beginning on 20 Feb.. Fertilization was as previously described. On 7 April, plugs were transplanted to 5" standard pots (Metro-Mix 360) and moved to another greenhouse were temperatures were maintained at 17 C day/night with maximum daily temperatures reaching 25 C. Fertilizer rates were increased to 200 ppm N and K. Both LD and SD plugs were each subjected to 6 different photoperiod schedules over a production period of 10 weeks:

1) Long days (as described above) for 10 weeks
2) 1 week of short days (as described above) followed by 9 weeks of long days
3) 2 weeks of short days followed by 8 weeks of long days
4) 3 weeks of short days followed by 7 weeks of long days
5) 5 weeks of short days followed by 5 weeks of long days
6) Short days for 10 weeks

Data collected included days to visible bud, days to first flower, percent flowering diameter of first flower, height at flowering, and dry weight of shoots after 10 weeks.

Results

Following transplanting to 5" pots, LD plugs grew faster than SD plugs (Fig. 2). Long day plugs reached visible bud and flowered earlier than SD plugs and providing just 1 week of SD (followed by LD) after transplanting accelerated flowering in LD plugs by 10 days (Table 3). Two weeks of SD following transplanting accelerated flowering in SD plugs; however, 5 or more weeks of SD after transplanting greatly decreased the flowering percentage (Table 3). Short days slightly decreased flower size and resulted in shorter more compact plants when compared to plugs receiving only LD after transplanting. Plugs receiving 5 or more weeks of SD following transplanting were stunted, showing poor foliar and shoot development (Table 3).

The data show that LD or SD plugs benefited from 1 to 2 weeks of short days (followed by LD) after transplanting. These benefits include faster flowering (7 to 10 days), slightly larger flowers and shorter more compact plants. In our study, the highest quality plants were produced by growing plugs in LD, giving 2 weeks of SD immediately after transplanting, then finishing the pots under LD (Figs. 3 and 4).

Conclusions

Night interruption lighting during dahlia plug production can shorten crop time and inhibit tuberous root growth. It is important to keep in mind the critical day-length for tuberous root formation is 11 to 12 hours. If the natural day-length is greater than this critical period, then night interruption light will likely provide little benefit; however, crops sown in the short days of late Fall and early Winter should benefit greatly. It should be stressed that visible effects on inhibiting tuberous root growth were not observed until 4 weeks after beginning photoperiod manipulation. This means that real benefits will be observed on plugs with a production time of 4 weeks or longer.

Following plug transplanting, 1 to 2 weeks of SD will promote flower induction. Growing on in LD will accelerate flower development and flowering. Short days also result in a shorter more compact plant. When the natural day-length is shorter than the critical periods for flower induction (10 hours) or tuberous root formation and flower development (12 hours), we suggest the following photoperiod schedule for producing 288 plugs and then growing on in 5" pots:

- Use night interruption lighting during plug production.
- After transplanting, provide 2 weeks of natural SD to induce flowering
- Then provide a night interruption to promote shoot growth and flower development.

If the natural day-length is longer than these critical day-lengths, then grow plugs under natural long days (> 12 hours). After transplanting to 5” pots, provide 2 weeks of short days using black cloth and finish the crop under natural LD. In either situation, up to 4 weeks of short days can be used after transplant for additional height control.

Table 1. Effects of photoperiod on dry weight of roots and shoots of *Dahlia sp*. 'Sunny Rose' plugs following 2, 4, and 6 weeks of photoperiod treatment. SD is 9-h natural irradiance; LD is identical photoperiod with a 4-h incandescent night interruption. *Expt. 1*

		Dry wt. (g) of:				
Week	Photoperiod	Shoot	Root	Tuberous root	Fibrous root	Total plant
2	LD	0.11	0.04	0.00	0.04	0.15
	SD	0.10	0.04	0.00	0.04	0.14
4	LD	0.51	0.17	0.06	0.11	0.68
	SD	0.41	0.24	0.17	0.07	0.65
6	LD	1.02	0.45	0.28	0.18	1.46
	SD	0.59	0.76	0.67	0.09	1.35

Table 2. Effects of photoperiod on leaf area, shoot length and number of leaf pairs in *Dahlia sp*. 'Sunny Rose' plugs following 2, 4, and 6 weeks of photoperiod treatment. SD is 9-h natural irradiance; LD is identical photoperiod with a 4-h incandescent night interruption. *Expt. 1*

Week	Photoperiod	Leaf area (cm^2)	Shoot length (cm)	No. leaf pairs
2	LD	35.5	4.1	2.0
	SD	35.6	3.7	2.0
4	LD	101.4	5.7	3.0
	SD	84.3	4.8	3.2
6	LD	169.0	7.2	5.2
	SD	109.4	5.0	4.5

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Table 3. Effects of different photoperiod regimes following transplanting of *Dahlia sp*. 'Sunny Yellow' plugs to 5" pots. SD is 9-h natural irradiance; LD is identical photoperiod with a 4-h incandescent night interruption. *Expt. 2*

SD (Weeks)	LD (Weeks)	Visible Bud (Days)	First Flower (Days)	Percent Flowering	Flower diameter (cm)	Flowering Height (cm)	Shoot Dry Weight (g)
Plugs Grown Under Long Days (LD)							
0	10	25.4	53.3	90	7.4	30.3	36.4
1	9	18.2	43.7	100	7.0	25.4	39.0
2	8	15.6	41.0	100	7.1	21.9	30.9
3	7	17.7	40.9	100	6.5	19.6	20.4
5	5	16.4	38.0	90	6.4	18.1	5.2
10	0	17.6	38.4	80	6.6	18.0	5.0
Plugs Grown Under Short Days (SD)							
0	10	23.2	58.3	100	7.1	30.1	31.0
1	9	17.8	60.9	90	6.2	26.8	21.0
2	8	20.0	50.1	90	5.9	19.8	17.9
3	7	25.2	56.5	80	5.9	19.9	14.1
5	5	22.5	54.8	60	6.6	20.5	8.0
10	0	25.2	52.7	30	5.5	13.3	3.2

Figure 1. Dahlia 'Sunny Yellow' plugs grown under 6 weeks of LD (left) or SD (right).

Figure 2. Dahlia 'Sunny Yellow' plants 14 days following transplanting of plugs to 5" standard pots and growing under LD. LD plugs (left) and SD plugs (right).

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Figure 3. Dahlia 'Sunny Yellow' plants 48 days following transplanting of plugs to 5" standard pots. Top row: all LD plugs. (L to R): 0 weeks of SD after transplanting then LD; 1 week of SD then LD; 2 weeks of SD then LD; 3 weeks of SD then LD; 5 weeks of SD then LD. Bottom row: all SD plugs. (L to R): 0 weeks of SD after transplanting, then LD; 1 week of SD then LD; 2 weeks of SD then LD; 3 weeks of SD then LD; 5 weeks of SD then LD.

Figure 4. Dahlia ‘Sunny Yellow’ plant (5” pot) produced from a LD plug that was given 2 weeks of SD after transplanting then finished under LD.