USE OF SHORT AND LONG DAYS TO ENHANCE STANDARD CARNATION PRODUCTION IN THE WINTER — PRELIMINARY REPORT

Joe J. Hanan[1]

Forty-five short days, followed by three weeks of dusk-to-dawn lighting, increased flower production of 'White #1', standard carnations two-and-a-half to three flowers per square foot on the first year, single pinched, crop planted June 13 and July 1.

Introduction

Common practices in photoperiodic control of flowering in standard carnations was reviewed by Hanan in 1983 (CGGA Bul. 392, Supplement). During previous years, Wilkins, Healy and Heins, at the University of Minnesota, explored interactions of alternating short and long days. They showed that short days promoted break formation, as contrasted to the stem elongation of long days, which also inhibited break formation. Graper (CGGA Bul. 412) undertook a test of 30, 45, and 90 short days on first year, single pinched carnations, followed by three weeks of long days, in order to determine if responses under Minnesota conditions could be duplicated in Colorado. Unfortunately, the mechanics of the experimentation were undesirable, and although there appeared to be a trend toward greater winter production, plot variability prevented adequate results. We felt there might still be a benefit to appropriate cultural modifications if we could show on a sufficiently large scale, a significant effect of actual short days. In this preliminary report, it is shown that 45 short days (9 hrs/24 hrs) will increase side break production on single pinched plants by nearly one break per plant, resulting in approximately three additional flowers per square foot over a 51 week growing period. Additional studies are continuing in 1986-87 on the second year, with the idea to duplicate experimentation in the third and fourth years in order to overcome objections to statistical confounding in the experimental design.

Methods

Linear benches, as found by Graper, do not lend themselves to small plot investigations of photoperiodism. It is practically impossible to prevent light leaks between adjacent plots, especially if the neighboring plot is being given long days. On the other hand, lacking sufficient resources to renovate the experimental area to adequately take into account position effect and other mechanics of photoperiodic experimentation, we decided to use each 36 foot bench in the greenhouse as a single treatment, permitting six treatments, combing various pinching, short and long day treatments. Although we know that there is a distinct position effect across the house, i.e. south bench produces the highest, followed by the north bench with the inside north bench producing the least, the experiment could be replicated in the third and fourth years by changing bench position of the treatments. This might be sufficient to adequately prove or disprove the possible commercial practicality of treating standard carnations to short days.

Each of the six benches was divided into four plots of 72 plants each at about 2.6 plants per square foot density (6 × 8 in.), with two rows of buffers at each end. The substrate was soil, 6 in. deep, irrigated by 7 rows of trickle tube, into which the standard carnation nutrient solution was injected at each watering. Preplant additions included ground limestone and superphosphate. The variety was 'White #1'. Treatments were:

1. Bench A (north bench): Benched June 13, 1985
   Single pinched July 1, 1985
2. Bench B: Benched July 1, 1985
   Single pinched July 15, 1985
3. Bench C: Benched June 13, 1985
   Single pinched July 1, 1985
   Black cloth pulled between 1800 and 0900 hours for 45 days beginning July 16, 1985
   Dusk-to-dawn, incandescent lighting for three weeks, beginning August 29, 1985
4. Bench D: Benched July 1, 1985
   Single pinched July 15, 1985
   Black cloth pulled between 1800 and 0900 hours for 45 days, beginning August 13, 1985
   Dusk-to-dawn incandescent lighting for three weeks, beginning September 27, 1985
5. Bench E: Benched June 13, 1985
   Single pinched July 1, 1985
   One-half pinch July 24, 1985
6. Bench F (south bench): Benched July 1, 1985
   Single pinched July 15, 1985
   One-half pinched August 29, 1985 (carried out over a one week period)

As a consequence of the study published by Hanan and Baker (CGGA Bul. 398), it is now a standard procedure at Colorado State University to drench carnations with Truban® at six month intervals, beginning the second week after planting. CO_2 was injected to maintain a range between 500 and 1000 ppm with the night temperatures set to 53 F, heating to 62 F during the day. In the winter months, the ventilation temperatures were adjusted upward (CGGA Bul. 392) to begin cooling at 70 F, as contrasted to the usual 64 F during the warmer months. Beginning in March, 1986, carnations on all treatments were deliberately cut into hard wood, below breaks, in order to reduce height and open the canopy.

Results

Shortly after stopping the short day treatment on Benches C and D, one row from each plot in benches A through D was randomly selected, and the number of breaks on the inside four plants, originating on the side shoots from the single pinches, was counted. These breaks were the potential second crop. The length of the top break on the same four plants in each plot was also measured. There was a significant effect of the short days on both breaks and stem

length (Table 1). There were more than an additional two breaks per four plants on the shoots which would eventually provide the first crop, resulting from the single pinch. However, the average length of these second crop side breaks was reduced by four centimeters for both planting dates. As would be expected the number of breaks was greater for those plants benched on June 13, as compared to those benched on July 1. But, plant date had no significant effect on shoot length, even though the measurements for the July 1 planting were taken 18 days after those obtained on the June 13 planting.

This potential indication of yield continued in the final results (Table 2, Fig. 1) after 51 weeks in the bench (records terminated June 8, 1986). The general summary showed an average of one more flower per plant produced by those carnations subjected to 45 short days, or, roughly, three more flowers per square foot. Both yield and aver-

Table 1: Average number of breaks per row of 'White #1' on lateral side shoots from a single pinch on two different planting dates and subjected to 45 short days, including the length of the top side shoot, originating from the breaks of a single pinch. Measurements taken on September 10 (Benches A, C) and September 28 (Benches B, D), 1985. Outside rows excluded (6 across), 4 plants counted per row.

Measurement date	Natural days		Short days		Average per planting date	
	Breaks	Length	Breaks	Length	Breaks	Length
Sept. 10 Benched June 13, 1985	12.1	19.6 cm	13.9	13.5 cm	13.0	16.5 cm
Sept. 28 Benched July 1, 1985	8.1	16.2 cm	11.1	14.1 cm	9.6	15.2 cm
Average per Treatment	10.1	17.9 cm	12.5	13.8 cm		

Honestly significant difference (HSD) at the 5% probability level = 1.9 for number of side breaks as a function of the main effect treatment and planting date, and 0.5 cm for shoot length as affected by treatment. Planting date had no significant effect on shoot length.

Table 2: Yield and grade of 'White #1', standard carnations benched on two dates, given single and 1½ pinches, and subjected to 45 short days (9 hrs light/24 hrs), and 21 long days (dusk-to-dawn incandescent) immediately thereafter. Records terminated June 8, 1986.

Treatment	Total yield	Yield per sq.ft.[1]	Yield per plant	Average weekly yield per plot[2]	Mean grade[3]	Percent grade distribution			
						Fancy	Standard	Short	Design
Bench A (north) Benched June 13, 1985 Single pinched July 1, 1985	4663	42.7	16.2	28.8	3.72	14	57	24	5
Bench B Benched July 1, 1985 Single pinched July 15, 1985	3614	33.0	12.5	22.6	3.28	12	59	24	5
Bench C Benched June 13, 1985 Single pinched July 1, 1985 Short days July 16, 1985 Long days August 29, 1985	4995	45.7	17.3	31.2	3.54	9	53	31	6
Bench D Benched July 1, 1985 Single pinched July 15, 1985 Short days August 13, 1985 Long days September 27, 1985	3994	36.5	13.9	25.0	3.03	9	52	28	9
Bench E Benched June 13, 1985 Single pinched July 1, 1985 Half pinch July 24, 1985	4923	45.0	17.1	30.1	3.57	13	56	25	6
Bench F (south) Benched July 1, 1985 Single pinched July 15, 1985 Half pinch August 29, 1985	5151	47.1	17.9	32.3	3.00	11	52	28	10

[1]Plants in bench 51 weeks for June 13, 1985 planting.
[2]Seventy-two plants per plot, 2.6 plants per square foot.
[3]Number of fancies multiplied by 5, standards by 4, shorts by 3, and designs by 2, the accumulated total divided by the total yield.

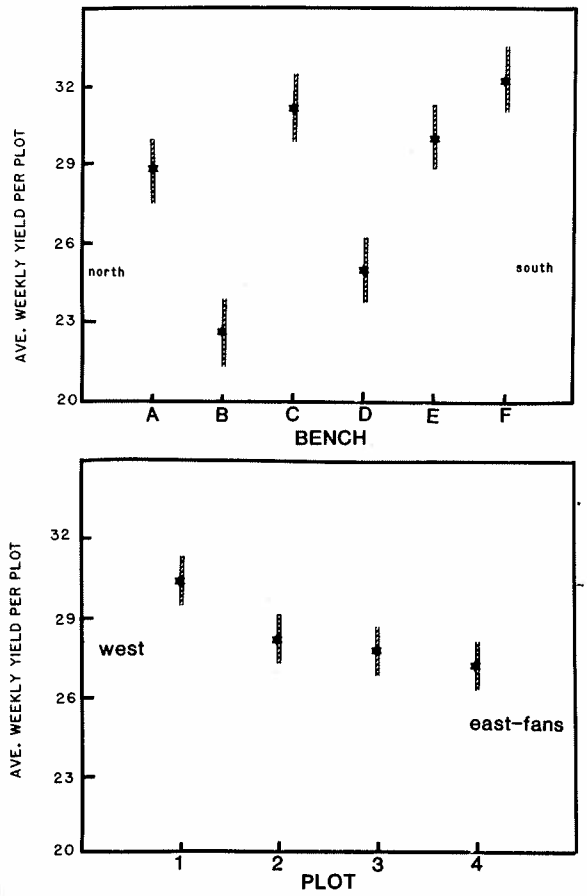

Figure 1: Average weekly yield per plot-treatment (upper) and per plot, all treatments (lower), of 'White #1', standard carnations, planted on two dates, subjected to single (A-D) and 1½ pinches (E,F), and 45 short days (9 hrs/24 hrs), followed immediately by three weeks of long days (dusk-to-dawn) (C,D). Vertical bars indicate the difference required between means for statistical significance. Plants grown in soil, irrigated by trickle system with Colorado State University carnation solution, using basic water with less than 100 micromhos/cm total salinity.

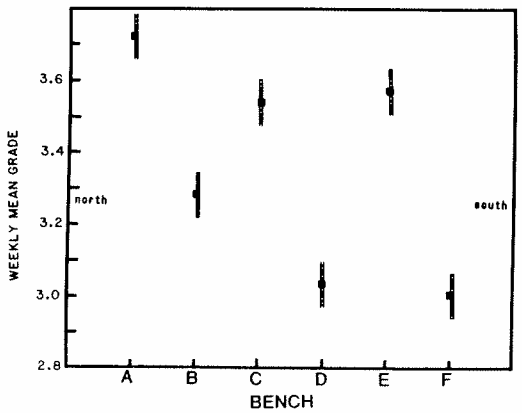

Figure 2: Average mean grade for 'White #1', standard carnations planted on two dates, subjected to single (A-D) and 1½ pinches (E,F), and 45 short days (9 hrs/24 hrs) followed immediately by three weeks of long days dusk-to-dawn (C,D). Plants grown in soil, irrigated by trickle system with Colorado State University carnation solution, using basic water with less than 100 micromhos/cm total salinity. Vertical bars indicate difference required between means for statistically significant differences.

age grade varied significantly between treatments, with differences large enough to exclude the possibility of the difference being due solely to a position effect. There was a position effect among plots (Fig. 1) with highest yields produced in those plots closest to the evaporative pads, gradually decreasing toward the fan end of the greenhouse — a distance less than 36 feet. There was no effect of plot position on mean grade of cut carnations, but cut flower quality varied markedly among treatments (Fig. 2). Bench A (north) produced the highest quality cut flowers, whereas benches D and F (south) produced the lowest quality. There did not appear to be a consistent effect of treatment on grade. For all treatments, at least 60 percent of all flowers cut graded into the fancy and standard classification (Table 2).

The effect of short days, followed by three weeks of dusk-to-dawn lighting, on timing was remarkable (Fig. 3). For both planting dates, the first crop was reduced and delayed, which would probably be expected. But, the second crop was advanced by two to three weeks, with a definite

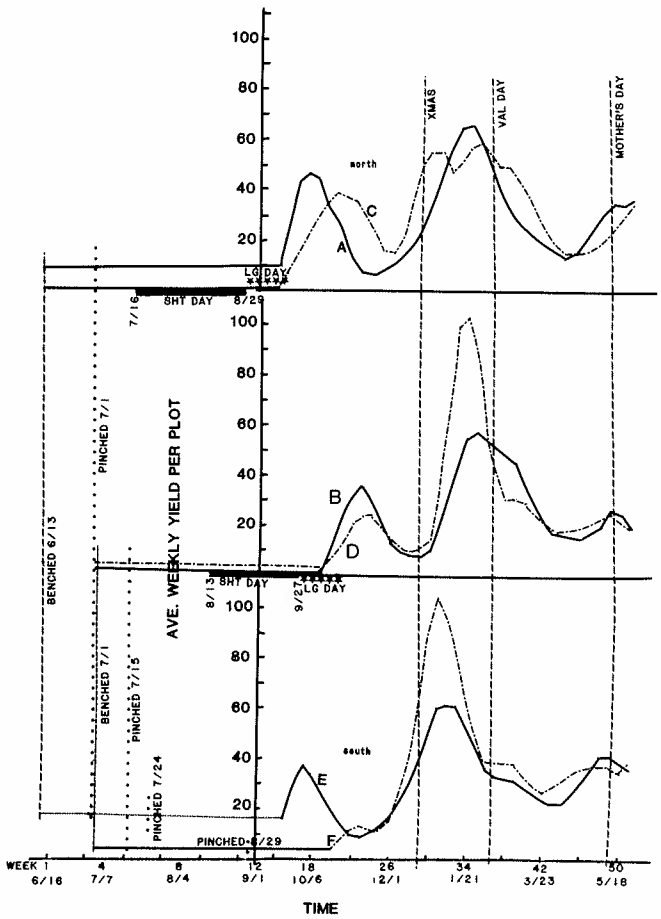

Figure 3: Smoothed production curves of 'White #1', standard carnations, grown in soil, planted on two dates, subjected to single (A-D) and 1½ pinches (E,F), and 45 short days (9 hrs), followed immediately by three weeks of long days (dusk-to-dawn) (C,D). The smoothing process causes the loss of the first and last weeks of production. Seventy-two plants per lot, 288 plants per treatment, 2.6 plants per square-foot. Irrigated with Colorado State University standard carnation solution, using a raw water supply with less than 10 micromhos/cm total salinity. Water applied through a trickle system.

increase in the number of flowers produced between Christmas and Valentine's Day. For the June 13 planting, the effect was to broaden the peak from Christmas to Valentine's Day, and on the July 1 planting, Christmas was entirely missed, with a very high peak occurring two to three weeks before Valentine's. Carnations given 1½ pinches peaked about the same time for both planting dates (June 13 and July 1) around the first of January. The June 13 planting had an initial peak the end of September, but the second crop did not produce as heavily as the July 1 planting.

Summary

Despite confounding of the experiment with bench position in the greenhouse, there appeared to be a definite, beneficial, effect of short days used in conjunction with long days, as suggested by the Minnesota group. The study is being continued on the second year crop, with benches A and B subjected to natural days, C and E treated with 45 short days, followed by three weeks of long days, and benches D and F given only long days at the same time. If funds are sufficient, the house will be re-planted Spring, 1987, and the treatments re-randomized in order to compare the effect better statistically. The cost of shading a carnation house is formidable, but if the grower has installed thermal screens for energy conservation, the way may be open to extend the usefulness of such curtains in providing short days. Of course, care must be taken to avoid very high temperatures when shading in the late summer and early fall, which is the reason we pulled cloth at 6:00 p.m. and allowed it to remain until 9:00 a.m. the following morning. Timing was probably not the most desirable, but would vary with the individual operation[2].

[1]*Professor. Research supported by the CO Agric. Experiment Station and the CO Greenhouse Growers' Association.*

[2]*Thanks to Cheryl Fechner and Paul Zimmerman, undergraduates, for their assistance in keeping records.*

FORT COLLINS GREENHOUSE CLIMATOLOGICAL SUMMARY FOR FOUR WEEKS BEGINNING OCTOBER 5, 1986 (See Bulletin 426 for details.)

	Week beginning							
	10/5/86		10/12/86		10/19/86		10/26/86	
	Day	Night	Day	Night	Day	Night	Day	Night
Average outside temperature (°F)	56	45	56	40	54	45	52	44
Maximum outside temperature (°F)	77	65	73	59	64	54	69	64
Minimum outside temperature (°F)	28	28	26	25	45	35	29	29
Degree-days of heating	32	70	32	88	39	70	46	76
Average hours in the period	10	14	10	14	11	13	9	15
Accumulated total solar radiation (MJ/sq.m.)	78	—	100	—	100	—	143	—
Average relative humidity (%)	55	80	34	59	65	84	55	65
Maximum relative humidity (%)	98	100	74	89	98	100	100	100
Minimum relative humidity (%)	20	36	13	18	27	17	18	25
Average absolute vapor pressure (mb)	8	8	5	5	9	9	7	6
Average wind speed (mph)	3	2	3	1	4	1	2	2
Maximum wind speed (mph)	27	20	33	15	25	13	15	36
Average CO_2 concentration (Pascal)	24	—	24	—	23	—	24	—
Maximum CO_2 concentration (Pascal)	34	—	45	—	29	—	46	—
Accumulated gas consumption (cu.ft./sq.ft.)	14	40	7	54	11	33	7	38

Dick Kingman, Executive Vice President
2785 N. Speer Blvd., Suite 230
Denver, Colorado 80211
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