SPLIT-NIGHT TEMPERATURES ARE THEY COMMERCIAL?[1]

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Increased energy costs have spurred research to decrease energy costs by 1) using cheaper or alternative energy sources, 2) reducing greenhouse heat loss, 3) selection of plants which grow under cooler conditions, 4) increasing greenhouse efficiency, 5) growing more plants per unit area per time, and 6) evaluating the possibility of growing plants at relatively low temperatures at various stages of their development (Zieslin and Kohl, 1978).

As word was spread to commercial greenhouse operators about the possible use of split night temperatures to further save on fuel consumption and cost of production, more and more interest and questions have been generated. The authors have frequently been asked what our opinions are by various operators. Thus, a brief review of the literature and a brief article pertaining to split night temperatures (SNT) we felt was in order. SNT is the concept of growing plants under "normal" night temperatures for part of the night and under very low temperatures during the remainder of the night. Most of the research into this technique has been conducted on chrysanthemums.

The English have been working on the concept of lowering night temperatures since the early 1970's (Butters, 1974, 1977). Based on his research, he recommends to the British grower the following night temperature settings during the year on chrysanthemums.

September-October	13°C (55°F)
November	16°C (61°F)
December-January	17°C (63°F)
February	16°C (61°F)
March-August	13°C (55°F)

This information was reported in the American literature (Florist's Review) by H. White in 1979. These British recommended temperatures contrast with the traditional year-round 60-62°F night temperatures recommended for chrysanthemums in the U.S. The English find this temperature regime gives an average 10% fuel savings under their conditions of, we strongly suspect, lower light intensities and shorter durations in the winter, and cool summers with very long photoperiods.

A second approach of Butters (1977) has been to lower the night temperature to 4°C (40°F) one night a week. Fuel savings were about 10% with an average delay in flowering of 0.6 days per crop from December to June and a maximum delay of 1.6 days in March. This practice has been recommended to the growers in Britain.

Actual split night temperature experiments have met with mixed results. Significant fuel savings occurred when temperatures were lowered to 50°F after either 8 or 10 hours of normal night temperatures but crop delays of 2 to 7.5 days or 0 to 7.6 days occurred, respectively, for both treatments. Plant growth under split night temperatures which averaged 55° was, however, superior to a constant night temperature of 55°F (Butters, 1977).

Research conducted at the University of Connecticut and reported by Thorne and Jaynes (1977) discussed the work of Bill Loefstedt, a greenhouse grower. His findings were that both chrysanthemums and lilies developed normally in plant growth and timing when grown under SNT of 60°F until 11:00 p.m. and 45°F till 6:00 a.m. Plants were watered with 70-75°F water at 6:00 a.m. Fuel savings were 6% for the month of February.

On work by Gent, Thorne and Aylor (1979), 20% fuel savings were realized from January to April using this same temperature regime. They reported little difference in time to flower of lily plants between the SNT and control plants under 60°F night temperatures. The results may be suspect, however. The author's report, "The growth and flowering of Easter lilies were affected little by the temperature at night. The cooling near the lilies, however, was not as great as in other parts of the split-night greenhouse because they were closest to the steam

[1]Reprinted from Minnesota State Florists Bulletin, Vol. 29, No. 6, December, 1980.
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heating pipes." Perhaps temperatures on the lilies never did drop to the 45°F used in the house from 10:00 p.m. to 6:00 a.m. and may have been higher than the rest of the house while heating in the morning.

Koths and Schneider (1980) report little or no delay on chrysanthemums, marigold and petunia seedlings. Mixed results, incomplete results or delays were reported on Rieger begonia, carnation, snapdragon, Easter lily, azalea, poinsettia, gloxinia and kalanchoe.

Zieslin and Kohl (1978) grew chrysanthemum plants for 0-9 weeks at either 42°F or 62°F night temperatures and then switched them to the other temperature (62° or 42°) until they flowered. Starting plants at 42°F for one week delayed flowering only 4 days but two weeks delayed 11 days — a day for day delay. Starting plants off at 62°F for one week accelerated flowering 14 days over plants grown continually at 42°. Further time at 62° only accelerated flowering time by one day per day of 62°, not the 2 days experienced during the first week of growth under long days.

Parups in Canada reported in 1978 on the growth of twenty-six chrysanthemum cultivars under split night temperatures of 60°F from 8:00 p.m. to 12:00 p.m. and 50°F from 12:00 p.m. till 8:00 a.m. Good growth was observed on all cultivars with an average delay in flowering of only 3 days. Plants averaged 1½" taller when grown under the SNT. The number and size of flowers was not affected.

Kohl and Thigpen (1979) evaluated chrysanthemum dry weight accumulation under 60°F night temperatures and 42°F night temperatures. When the leaf area index (ratio of total leaf area to ground area) was greater than approximately 3.0, no differences in dry weight accumulation per unit bench area per day occurred. Flowering, however, was delayed. A key observation of this was that plant growth during the first 21 days after the start of SD determined the growth efficiency of plants throughout the balance of the cultural cycle.

Now, for the question from greenhouse growers, "What conclusions can be drawn from this research conducted to date?" It is obvious that conflicting results exist. We feel that the use of SNT should be approached with caution. The greatest possibility of its use appears to be with the chrysanthemum. However, *all* research results to date indicate some flowering delay, though minimal as it is in some cases.

The fuel saved by the use of SNT must be weighed against the added costs of bench time or the possibility of missing a holiday crop. If one assumes an average cost of 20¢ to 25¢/ft²/week of bench spaces and a chrysanthemum pot at a 12" × 12" spacing, a delay of 3 days increases the cost of that chrysanthemum plant by 7.7¢ to 8.5¢. This must be weighed against any fuel savings.

The time period where floral initiation and early differentiation occurs is an especially critical time period in the development of a flowering plant. Therefore, we also feel that recommended night temperatures should be maintained during this period of flower initiation and early differentiation. In the case of the chrysanthemum, this period would be under long days and including the first 3-4 weeks after the start of short days.

Recent work of ours on the Easter lily (Wilkins, Pemberton and Heins, 1980) and work by Armitage and Carlson (1980a, b) on the seed geranium have shown that light intensity has no influence of rate of flower development from visible bud to flower at any one temperature. The present authors have also found that the number of degree days for a 2 inch lily bud to flower is similar regardless if forced from 60°F to 75°F. These data imply that any combination of temperatures and times that result in the same number of degree days will result in flowering of the lily bud from the 2 inch size in the same amount of time. Roh and Wilkins (1973) have shown that any temperature (day/night, i.e., 60°F/80°F or 50°F/90°F) combination which averaged 70°F is as efficient as a constant 70° in opening lily buds from the visible bud stage. This concept of degree days may also be valid for many of our other floricultural plants or crops from approximately visible bud to flower.

Conclusions

1) SNT shows some promise but should be trialed on small production areas first.
2) Delay in flowering should be expected.
3) Cost of bench time should be weighed against fuel savings.
4) Proper temperatures should be maintained during flower initiation and early differentiation.
5) SNT appears to be most feasible after floral initiation has occurred and during later developmental stages.

Future

We feel that the concept of degree days must be developed in floriculture. This concept is actively used in the canning industry to accurately predict when fields of vegetables are to peak in quality and hence when to harvest.

Too, we feel little is understood in the "compensation" of low temperature periods by a higher than "normal", temperature time period.

Hence, if a greenhouse temperature is lowered by 10° for 4 hours (say 12:00 midnight to 4:00 a.m.) can we compensate for this by increasing the "normal" day temperature by 10° for 4 hours during the day from 12:00 noon to 4:00 p.m. or be 5° for 8 hours when temperatures are normally warmer and "trap" the natural solar heat. This we don't know yet but the concept is certainly worth researching. Nevertheless, plant quality must be maintained. Savings must be greater than any increased cost of production or quality loss.

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Published by
Colorado Greenhouse Growers Association, Inc.
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Denver, Colorado 80211

Bulletin 367

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