COLORADO FLOWER GROWERS ASSOCIATION

Bulletin 330 | Edited by David E. Hartley | December 1977

GREENHOUSE HEAT CONSERVATION: PART I[1]

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Introduction

During the winters from 1972 to 1975, the greenhouse industry was faced with the problems of esculating fuel costs and potential reductions in fuel allocations. In 1972, the Department of Horticulture at Colorado State University undertook a long range program of evaluating the facets of heat requirements, conserving fuel and maintaining temperatures in greenhouse structures. The Pennsylvania State University and other universities across the nation also started similar projects.

Most greenhouse operators are aware of the value of double glazing and it has been a common practice by many to line the inside of their greenhouses with transparent plastic films to conserve heat. Such an installation has reduced heat loss from 20-50 percent, depending on the weather conditions (4, 6).

The double layed, air-inflated, polyethylene covered structures have provided a 20 to 40 percent reduction in heat loss when compared to a single layer covering (1, 3, 8). In Great Britain, internal insulating blinds were used in greenhouses at night, resulting in an annual fuel reduction of 20 percent (7).

Studies in this phase of heat conservation were undertaken to determine the efficiency of a laminated aluminum foil reflectant fabric, installed in a greenhouse as an eave height ceiling with side curtains during nocturnal periods.

It should be noted that fuel costs are still increasing and several natural gas suppliers are requesting that greenhouse operators decrease their fuel consumption by 10 to 20 percent for the 1977-78 season.

Methods & Materials

The thermal transmission values of ten potential curtain materials were evaluated using a system modeled after the "hot box" apparatus designed by Liu et al (5). Foylon 2001 P, a product manufactured by the Duracote Corporation, was chosen because it had the greatest efficiency in limiting heat transfer.

The experimental greenhouse used in the study was an east-west oriented steel frame structure, 32 ft wide by 41.6 ft long with a 5 oz. fiberglass reinforced plastic roof and three exterior side walls of glass. The west end was attached to a second greenhouse structure and both were cooled with a common fan and pad cooling system during daylight hours. The structure had an individual heating system consisting of pneumatically controlled steam pipes. The heating thermostat within the experimental house was set to maintain 11°C at night and 15°C during daylight hours. An insulation curtain was used, every night, between the

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[1] *A portion of the research accomplished by John Tristan while fulfilling the requirements for a master of science degree at Colorado State University.*

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experimental and adjacent house. Due to gaps at truss intersections and gable ends (Figure 1), approximately five percent of the experimental house was not lined.

A semi automatic suspension system designed by the Simtrac Corporation was used to hold the ceiling and side curtains in position during treatment periods (Fig. 1). The insulation material, aluminum side in, was applied on alternate nights at 5:00 p.m. and withdrawn the next morning at 8:00 a.m. from December 1, 1974 to March 1, 1975. The nights when the ceiling and side curtains were not applied was considered the control.

Condensate formed in the steam lines was collected and measured with a low volume General Station tripping meter, installed in the condensate return line serving the experimental house. Each complete revolution of the tripping bucket represented the flow of five pounds (one unit) of condensate. The number of "condensate units" produced during the 86 days of the evaluation were considered to be directly related to the amount of heat required to maintain the desired night temperatures in the greenhouse.

Results

Outside temperature effects — Significantly more condensate was produced on nights when no curtain treatment was applied, than the nights when it was used. The night time, outdoor, "low" temperature ranged from -23°C to 4°C during the 86 day evaluation period. The temperatures were divided into three classes and the effects of applying curtains determined (Table 1). On a monthly basis, it was noted that 19.9, 22.5 and 27.4 percent less condensate formed with the treatment application in December, January and February respectively, than when it was not used.

Table 1. Data and categories used to determine the percent heat saved by applying internal curtains from December 1, 1974 to March 1, 1975 in an experimental greenhouse.

Temp Class	Cover Treatment	Number of Nights	Mean Condensate	Percent Saved
-23 to -12°C	+	7	309	
	0	12	381	19
-12.1 to -6°C	+	21	268	
	0	16	312	14
> -6°C	+	15	171	
	0	15	237	28
Wind Speed				
0-2 mph	+	7	249	
	0	5	307	19
2-4 mph	+	18	254	
	0	22	298	15
4 mph	+	18	214	
	0	16	324	34
Overall				
	+	43	239*	
	0	43	310*	23

*Significant at .05 level

Wind effects — During the 86 nights of the evaluation, the wind data was divided into classes by velocity and correlated with the amount of condensate produced due to the application of the treatment (Table 1). The wind velocity ranged from .8 to 13 mph with gusts to 47 mph. High wind velocities in the Fort Collins geographical area are associated with warmer air temperatures, which contribute to less heat loss. The application of the internal curtain was effective throughout the evaluation, but did provide more positive benefits at some outside temperature and wind velocity ranges, than at others. (Fig. 2).

The overall reduction for the three month period was 23.0 percent. (Table 1). It can therefore be assumed that the application of a totally enclosed ceiling and side curtains, with Foylon 2001P, would have reduced the heat loss, at least, 24 percent for the heating season.

Night Heat loss

Condensate formed during several 24 hour periods throughout the evaluation was divided into day and night categories (Table 2). During the three month period, the data indicated that 77 percent of the heat lost from the greenhouse occurred during the night. The data substantiated the results obtained by Barnard of Great Britain (2).

Discussion

The use of an internal suspended insulation material at night during the winter season reduced the condensate produced in the steam pipes by 23 percent when compared to the nights when it was not used. A steam piping system is considered to be a thermodynamically closed, therefore, it is valid to equate directly a reduction in condensate with a comparable decrease in BTU/thermal consumption. Thus, the results obtained can be interpreted as a quantative measure of the value of the cover in conserving greenhouse heat and reducing expenditures on fuel supplies.

Table 2. Day and night condensate values for 24 hour periods when no curtains were applied.

	MONTHS		
	December	January	February
Day Condensate (8 a.m. to 5 p.m.)	1250	1414	1012
Night Condensate (5 p.m. to 8 a.m.)	4450	3996	3824
Number of 24-hour periods	15	13	12

$$\text{Per cent night heat loss} = \frac{\text{night condensate}}{\text{total condensate}} = \frac{12{,}270}{15{,}946}$$

$$= 76.9$$

Even though the seasonal heat savings proved to be 23 percent by using an internal suspended insulation system, data on specific nights indicated that a 50 to 55 percent reduction was achieved, depending on the outside weather conditions.

It was practically impossible to eliminate all the gap areas in the ceiling and side wall covers due to the interference of the greenhouse structural members. Such a condition may be more prevalent in commercial greenhouses and more than five percent of the cover area be exposed. The effects of using a suspended insulation system in a house heated with

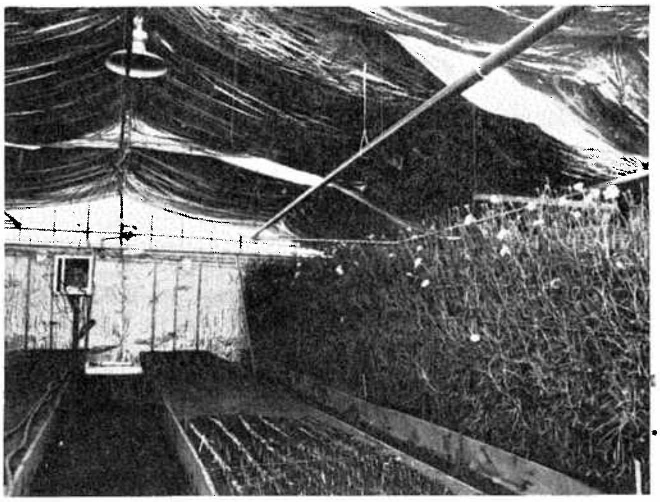

Fig. 1. Insulation cover in closed night position. Small area in east gable end was exposed.

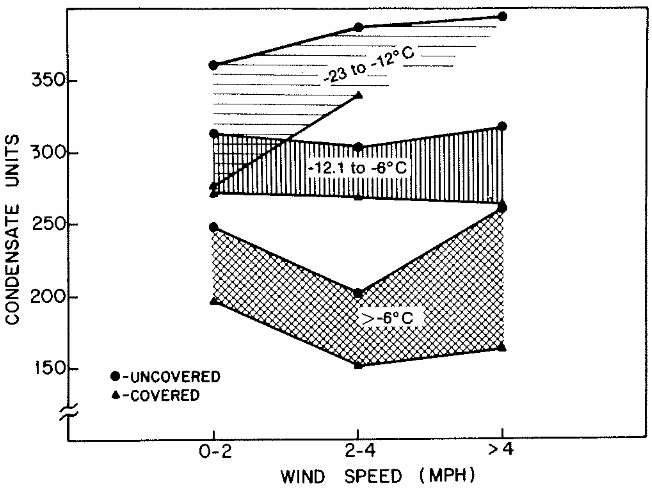

Fig. 2. The inter-relationships of outside wind speed and air temperature based on the mean condensate produced in a steam heated greenhouse when interior insulating curtains were used on alternate nights from December 1, 1974 to March 1, 1975. No wind velocities greater than 4 mph were recorded when outside air temperatures ranged from -23 to -12°C.

gas fired unit heaters remains to be seen. The air movement created by the fan distribution system could increase the heat loss through the cover and gaps, reducing the overall efficiency. The Foylon fabric used in the evaluation started wearing within a relatively short time. The folding or "bunching" of the material during periods when it was not in use caused cracking and eventual peeling of the aluminum laminate. A material that has a high fatigue factor and light weight should be considered.

A grower should consider a material for dual usage, one that could be used for photoperiod requirements. Dual usage may also be justified to include the criteria for winter insulation and summer reduction of light intensity. Such a cover will no doubt have to be cleaned periodically.

It is apparent that growers contemplating new construction should design their facility "around" the crop. They must consider new methods of supporting plants, suspending steam lines or heaters and the economics of installing internal heat saving materials.

BIBLIOGRAPHY

1. Ball staff writers; "Living with the fuel pinch," in *Grower Talks*, Supplement Dec. 1973, p. 1-11.
2. Barnard, G. K.; "Panel method of thermal insulation," in *Comm. Gr.*, 1954, #3031, p. 180.
3. Editors of Grower Magazine; "Heat retention is main benefit of twinskin inflated plastic house," in *The Grower*, Nov. 10, 1973, p. 933.
4. ———; "Conserving fuel in greenhouse heating," in *Under Glass*, March-April, 1974, p. 12-14.
5. Liu, R. C., Bailey, W. A., Klueter, H. H. and Krinzek, D. T.; "Problems in measuring heat losses through greenhouse covering materials," in a paper presented at the *9th Nat. Agric. Plastics Conf.*, Oct. 1969, p. 198-212.
6. ———; "Thermal insulation and glasshouses," in *Comm. Grower*, No. 3384, 1960, p. 1037-9.
7. National Instit. of Agric. Eng.; "Reducing glasshouse fuel costs," in *Annual Report*, April 1972-March 1973, p. 38.
8. Sheldrake R. and Langhans, R. W.; "Heating plastic greenhouses" in *N.Y. State Flower Growers*, Bull. #166, Oct. 1959, p. 1-2.

Appreciation is expressed to the following companies for supplying materials and equipment:
Public Service Company of Colorado,
Duracote Corporation, Ravenna, Ohio and
Simtrac Corporation, Skokie, Illinois

Sandwell, Ian. 1977. Warm-rooted tomatoes crop satisfactorily at 5 C night. The Grower. 88(13):605-611. (British)

Fairfield Experiment Station has been growing tomatoes at 56.3 F as contrasted to the recommended temperature of 61.7 F. With only slight reductions in yield and cropping pattern, the question was asked how much can night temperatures be reduced without drastically affecting yield?

Fairfield decided to look critically at the effect of soil warming coupled with very low night temperatures. A preliminary trial in 1975 showed that tomatoes would at least grow at 44.6 F where roots were maintained at 77.9 F. At the end of work in 1976, the results showed yield no less than the standard treatment of 56.3 without soil warming.

The results in 1977 with various air and soil temperatures showed complex interactions in terms of growth habit, cropping pattern and yields. Differences were also found in regard to variety. The trial has demonstrated that the tomato will grow and set fruit at night temperatures of 41 F with soil warming, and still produce 70 tons of fruit in the first 12 weeks.

(NOTE: Is it possible that some of this may be applicable to Colorado conditions?)

8th Annual Bedding and Pot Plant Short Course

Marriott Hotel, I-25 & Hampden Ave.,
Denver, Colorado 80222
303/758-7000

Wednesday, January 4

6:00 p.m. Mini Trade Fair, open until 8:30 p.m. with reception (come and visit with your friends and see what's new for you in the industry.) FREE!

Thursday, January 5

Morning Moderator: Mike Paulino

8:00 a.m. Mini Trade Fair opens
Registration

9:00 a.m. Welcome - Al Gerace, President, Colorado Bedding and Pot Plant Association

9:15 a.m. Cutting your costs of production - Jay Koths

10:05 a.m. New ideas for pot plant production from Europe - Ken Goldsberry

10:55 a.m. Plant materials for you from Texas - Larry Irwin

12:00 Annual BPP Association Membership Luncheon and election - Al Gerace presiding

Afternoon Moderator: Bud Novotny

1:30 p.m. Making your employees and customers aware — what should they know about insecticides - Dick Lindquist

2:30 p.m. Education programs for your employees and customers - Larry Watson

3:10 p.m. Mini Trade Fair and Coffee Break

3:40 p.m. On the other side of the fence — a panel of growers, industry related, garden center operators, retailers — making each other aware. Bob Briggs, moderator
Growers: Larry Irwin, Herb Ventker
Industry Related: Clyne Dutson, Glenn Montague
Retailers: Rick Riggs, Jack Ewald

4:40-6:00 p.m. Mini Trade Fair

6:30 p.m. Happy half hour

7:00 p.m. Annual Awards Banquet and Dance

Friday, January 6

8:00 a.m. Bus Tour of greenhouses - Departs east door

- 8:20- 9:10 City Floral (Eddie and Donna Kornfield) 1440 Kearney Street
- 9:20- 9:45 Wenkheimer Greenhouse (Cecil Wenkheimer) 357 Harrison
- 9:45-10:00 Third Avenue Flower Shop (Bruce Callbeck) 301 Harrison Street
- 10:00-11:00 Newberry Brothers (Weldon & Harold Newberry) 201 Garfield Street
- 11:15-12:15 Country Fair (Charlie & Marie Watenpaugh) 840 S. Havana
  Lunch here

12:30 p.m. Depart for Marriott

Afternoon Moderator: John Shelton

1:00 p.m. Potpourri around the greenhouse - Jay Koths

1:50 p.m. How can you really control "them insects"? - Dick Lindquist

2:40 p.m. CSU Research to Date
- Zeolite for slow release fertilizer - Joe Hanan
- What's in the prepackaged potting soils - Dave Hartley
- How much light does your greenhouse cover transmit? - Ken Goldsberry

3:30 p.m. How are yard and garden plants really merchandized: - Chuck Greenridge

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

Bulletin 330

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