INFLUENCE OF CONTAINER CONFIGURATION ON MEDIUM TEMPERATURES IN OVERWINTERING STRUCTURES

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Abstract. Medium temperatures and between pot air temperatures were measured within blocks of closely packed round and hexagonal #1 nursery containers inside of a white polyethylene covered, unheated overwintering storage house at John Vermeulen & Son, Inc. Nursery in Neshanic Station, NJ. Temperatures were recorded every 2 hours from November, 1984 through June, 1985. During the period of November, 1984 through March, 1985, little consistent difference was seen among pot types along the wall of the house and along the aisle. In the center of the block, however, hex pots showed average temperatures and minimum temperatures that tended to be in the range of 0.5 to 1.5°F warmer than round pots in similar locations. Within each pot type, there were differences associated with pot location within the block and with thermocouple location within the pots at the various locations.

J. P. Vermeulen: Plant culture in special containers at our nursery has been a practice for over 25 years. We have run the gamut of available containers from the original punched, crimped, and asphalted reclaimed fruit and vegetable cans to the present abundance of specially manufactured styles, sizes, and configurations.

In 1983 we started testing a No. 1 (formerly industry 1 gal) 6 sided container that measures 6 in. across and 6 in. deep. Our standard at that time was the regular round 1 gallon that is 6 in. in diameter and 7 in. deep. The containers were potted at various times during the growing season and placed in quonset style growing houses. The houses are covered with 49% shade polypropylene netting from approximately June 1 through October 1 and with white polyfilm sheeting from approximately November 1 to April 1. This is not a fixed time frame and actually fluctuates with weather conditions. The houses are not heated and are 15 ft wide by 120 and 140 ft long, and 7 ft and 9 ft high at center. They are oriented east/west.

Our climatic Zone is USDA 6A, but we experience a microclimate of 5A. Our temperatures range from extremes of −23 to 101°F with a mean of just about 50°F. We average 190 growing days, with the first fall frost as early as mid-September (this year we dipped to 32°F on the morning of August 29) and our last spring frost in mid-May, the latest being June 10.

Because of our microclimate we are much concerned with medium temperatures in our growing containers. Our usual checks seemed to indicate 5 to 10°F higher winter medium temperatures in the new 6-sided container than in the regular round No. 1. This prompted a desire for more accurate data and the research you are about to hear reported. The research was conducted at our nursery by Dr. Arthur Vrecenak, Assistant Research Professor at Cook College, Rutgers University. We are much impressed with Art's data and analysis. Since he is so much more conversant with and qualified to report the data and findings than I am, I sought and have permission to have him do so. At this time I am pleased to introduce him to you, Arthur Vrecenak.

Arthur Vrecenak: Thank you, Pete, for the kind introduction. It is a pleasure for me to be here today to speak to you. My colleague, Dr. Elwin Orton, has always spoken very highly of this organization, and I welcomed the opportunity to present my work when it was offered.

INTRODUCTION

The use of containers in the production of woody plant materials has added many benefits to the nursery industry, including ease of handling, an expanded marketing and planting season, greater production per unit area, and faster production cycles. It has also added some of its own unique problems to nursery management in the U.S. Northeast. One of these problems involves the overwintering of this plant material. The fact that root tissues do not develop the same degree of cold hardiness as do stem tissues (1, 2) and that young roots differ from mature roots in their ability to develop cold hardiness (2) presents another set of circumstances that must be managed at the nursery.

There are plant species and/or cultivars that can be difficult to overwinter successfully in the standard unheated polyethylene quonset storage house. The reasons for this are not always obvious, but often are related to the root cold hardiness characteristics of the plant material. When grown in the field, root tissues are well buffered against the temperature variation experienced by the stem tissues. The roots of container-grown plants are not so well protected and the more tender roots are exposed to greater temperature extremes and fluctuations than they would encounter in the field. In order to enhance survival and growth of these materials in this artificial environment, it is important both to understand and to properly manage that environment toward those ends.

OBJECTIVES

The objectives of this work were:

1) To determine the validity of the assumption that closely packed hexagonal nursery containers would be better able to utilize the thermal buffering effects of the soil beneath

them to moderate temperature extremes than would closely packed round containers of similar size.

2) To compare temperature responses within the medium at the edge and center of each pot.
3) To compare the temperature responses of pots at three location within each block.
4) To compare the temperature responses within the air spaces between pots for each pot type.

MATERIALS AND METHODS

As mentioned, the measurements were taken at John Vermeulen & Son, Inc. Measurements were taken every 2 hours, except during a 2-hour period bracketing sunrise and sunset, when 20 min intervals were used. The thermocouples were placed in pots on the north side of the house. For each pot type, one pot was located on the aisle, one was in the center of the block, and one was along the wall. Within each pot, one thermocouple was placed 2-in. deep in the center of the pot and one was placed 4-in. deep and 0.5 in. in from the north edge of the pot. Inside and outside air temperature measurements were taken using shielded thermocouples on wooden stakes at a height of 4 ft. Between pot air temperatures were measured by suspending a thermocouple between pots at a depth of 4 in. from the rim of the pot. All data was recorded on a Campbell Scientific 21X microprocessor-based datalogger.

RESULTS

Table 1 is a summary of the data for a randomly selected day (January 24, 1985). For each location within the block, no substantial difference in average temperature was seen between the two pot types. On this particular day, a slight difference of 0.6°F was seen between pot types in the middle of the block, but this was not a consistent trend. Minimum temperatures, however, tended to be approximately 0.5 to 1.0°F higher in hex pots than in round pots over the course of a day.

Table 1. Averages, minima and ranges of temperatures (°F) for the various thermocouple locations on day 24.

	Wall		Middle		Aisle		Between
	Edge	Center	Edge	Center	Edge	Center	Pots
Hex avg.[1]	28.8	28.6	30.8	30.3	29.3	29.4	31.4
Hex min.	25.5	24.5	29.5	28.3	25.4	25.7	30.7
Range	5.8	7.2	2.1	3.4	6.3	5.9	1.2
Rnd avg.	28.6	28.4	30.2	29.7	29.5	29.1	30.3
Rnd min.	24.9	24.2	28.7	27.1	26.5	25.3	28.4
Range	6.5	7.4	2.8	4.6	5.0	6.3	3.2

[1] Hex = 6 sided pot, Rnd = round pot.

For the mid-winter to early spring period, when outside temperatures were low, average pot temperatures were lowest along the wall for both pot types. Medium temperatures in the center of the block tended to be higher and to fluctuate less than those of either the wall or the aisle location. The data in Table 1 are representative of the period in this respect.

Within each individual pot, edge temperatures tended to vary less than the center temperatures, except in the hex pots along the aisle, where edge and center temperatures consistently showed very similar responses.

The air temperature between hex pots in the center of the block tended to be less responsive to fluctuations of inside air temperature compared to round pots. This comparison was not made on the aisle or along the wall due to equipment limitations.

Table 2 lists the minimum temperatures reached and its date of occurrence for each measurement location during the entire study period. Those pots located along the wall showed the most extreme minima, and the center location in the pot reached a lower temperature than did the edge. The pots along the aisle tended to show slightly less extreme minima, and the pots in the center of the block were least affected by extreme minimum tempteratures. .Once again, with the exception of the hex pots on the aisle, the center locations reached lower minima than did the edge locations.

Table 2. Seasonal minima for the various thermocouple locations.

Location	Date	Temperature (°F)
Hex wall,E[1]	Jan 21	18.7
Hex wall,C	Jan 21	16.9
Rnd wall,E	Jan 21	18.4
Rnd wall,C	Jan 21	17.0
Hex mid,E	Jan 22	28.4
Hex mid,C	Jan 22	26.8
Rnd mid,E	Jan 22	27.5
Rnd mid,C	Jan 22	25.4
Hex aisle,E	Jan 21	19.2
Hex aisle,C	Jan 21	19.9
Rnd aisle,E	Jan 21	21.8
Rnd aisle,C	Jan 22	21.4
Hex air	Jan 22	30.0
Rnd air	Jan 28	27.3
Outside	Feb 4	− 6.2
Inside	Jan 21	15.2

[1]*Hex = 6 sided pot, Rnd = round pot.*

DISCUSSION

There may be a thermal benefit to the use of hexagonal pots if one considers the effect of pot configuration on the minimum temperature reached by the medium in the pots. The fact that hex pots tended to have higher minima than did round pots might be justificaton for their use in some cases. Further work needs to be done to assess the potential benefits of this phenomenon.

Temperatures in the center of a pot tended to fluctuate more than temperatures along the edge, probably due to the relative stability of the between pot air temperatures compared to the ambient house temperatures. Figures 1, 2, and 3 show the temperature responses of the various thermocouple placements within the pots to an increase in outside and inside air temperatures from approximately 0700 to 1400 hours on 24 January 1985. For all locations within the block, temperatures in the pot centers responded more readily to a change in ambient air temperature than did the temperatures along the pot edges, as evidenced by the steeper slopes of the lines corresponding to the center thermocouples in all three figures. The differences are most pronounced in the mid-block location, since the edges of the pots would be most thermally buffered from the effects of lateral intrusion of ambient air. The edges of these pots are responding primarily to the fluctuations of the between-pot air temperatures, which Figure 4 shows to be quite negligible. The primary location of heat exchange in the mid-block location is from the surface of the medium, which is exposed to the ambient air within the house. Over the course of this day, the ambient air showed a range of approximately 17°F, while the between pot air temperatures fluctuated approximately 1 and 3°F for the hex and round pots, respectively.

This is the difference between the hex and round pots that led to this study. The air temperatures between hex pots fluctuated less than did those between round pots. Whether the corresponding medium temperature responses shown in the data of this study differ significantly is a question that needs to be answered by a controlled study. And even if a statistically significant difference can be demonstrated, is the difference significant to winter survival? These questions cannot be answered here, but we do have some information that suggests the merit of additional work.

It is worth noting in Figures 1, 2, and 3 that the mid-block pots showed less response to ambient temperature fluctuations than did the other two pot locations. The elimination of these extremes might be beneficial to winter survival, since plants respond to temperatures as they move through the various levels of hardiness during the cold season. It seems reasonable to assume that the closer we come to simulating the natural temperature conditions in the field, the better our chances of increasing winter survival of container plant material.

This would lead me to guess that the tests being conducted by the previous speaker should show that complete coverage of the block of plants by some sort of mulch material would be most advantageous. The reduction in the lateral exchange of heat would

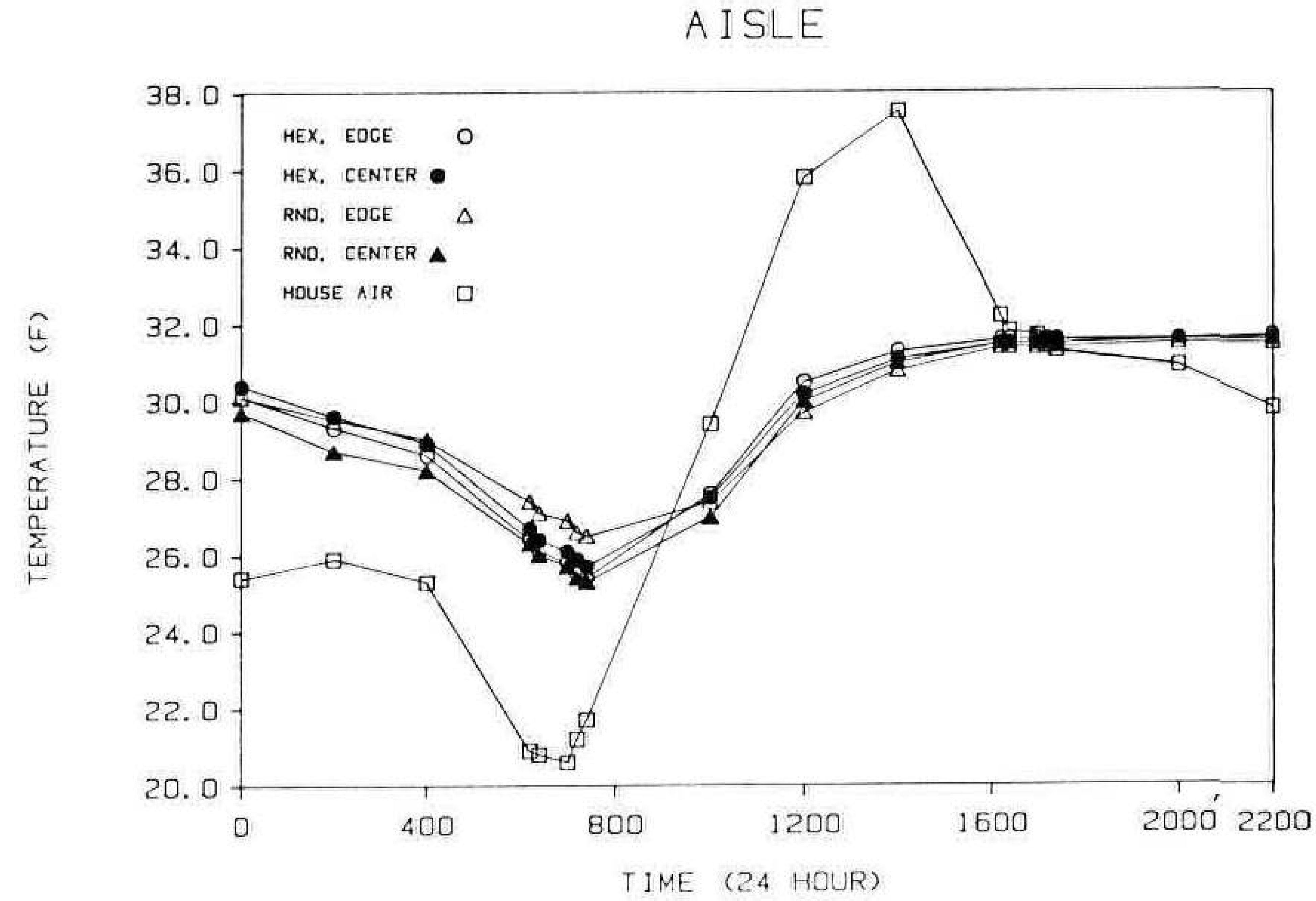

Figure 1. Medium temperature responses of the two locations within the two pot types to the ambient air temperature in the aisle location on day 24 (24 January 1985). Hex = 6 sided pot, Rnd = round pot.

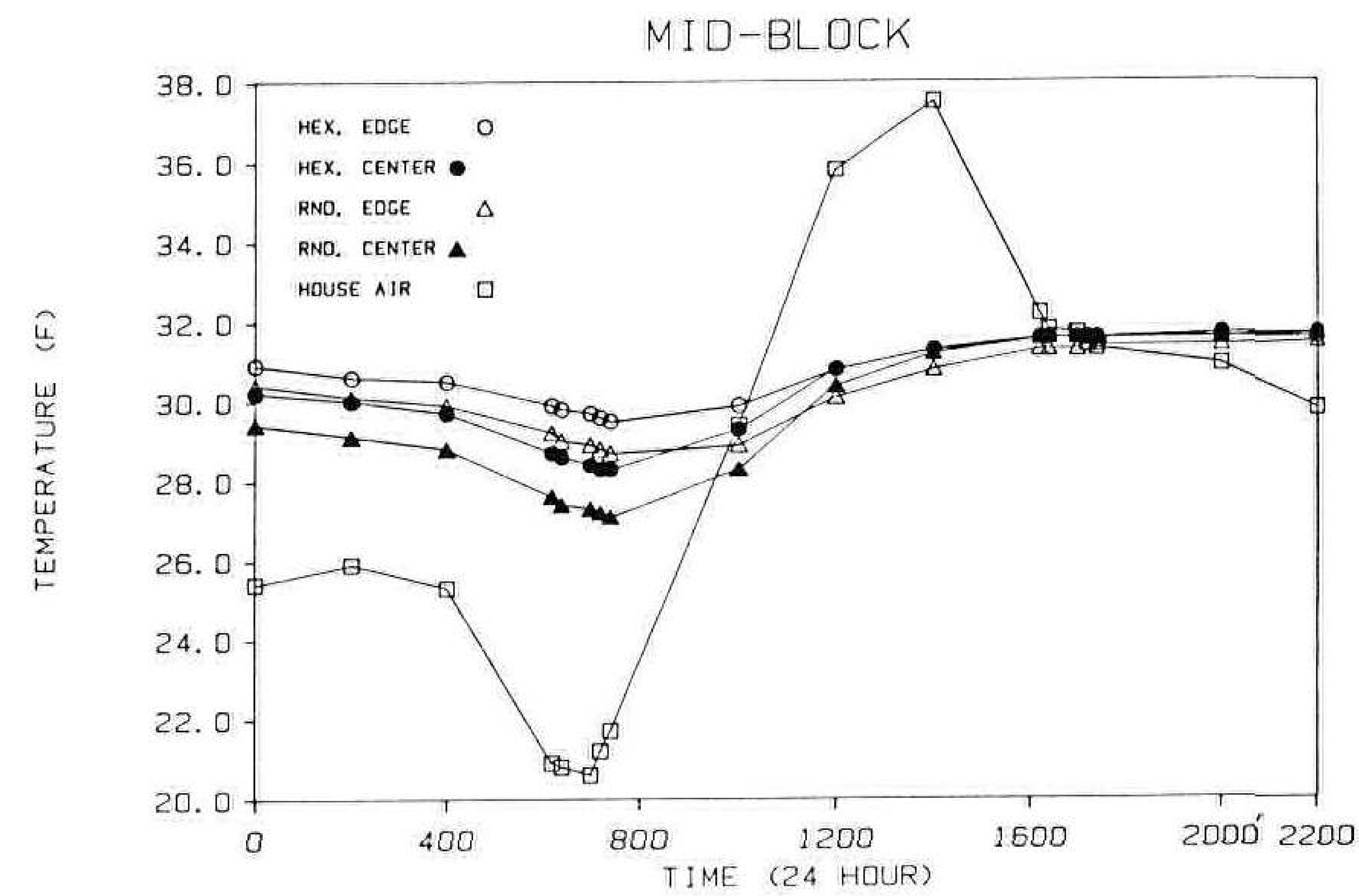

Figure 2. Medium temperature responses of the two locations within the two pot types to the ambient air temperature in the mid-block location on day 24 (24 January 1985). Hex = 6 sided, Rnd = round pot.

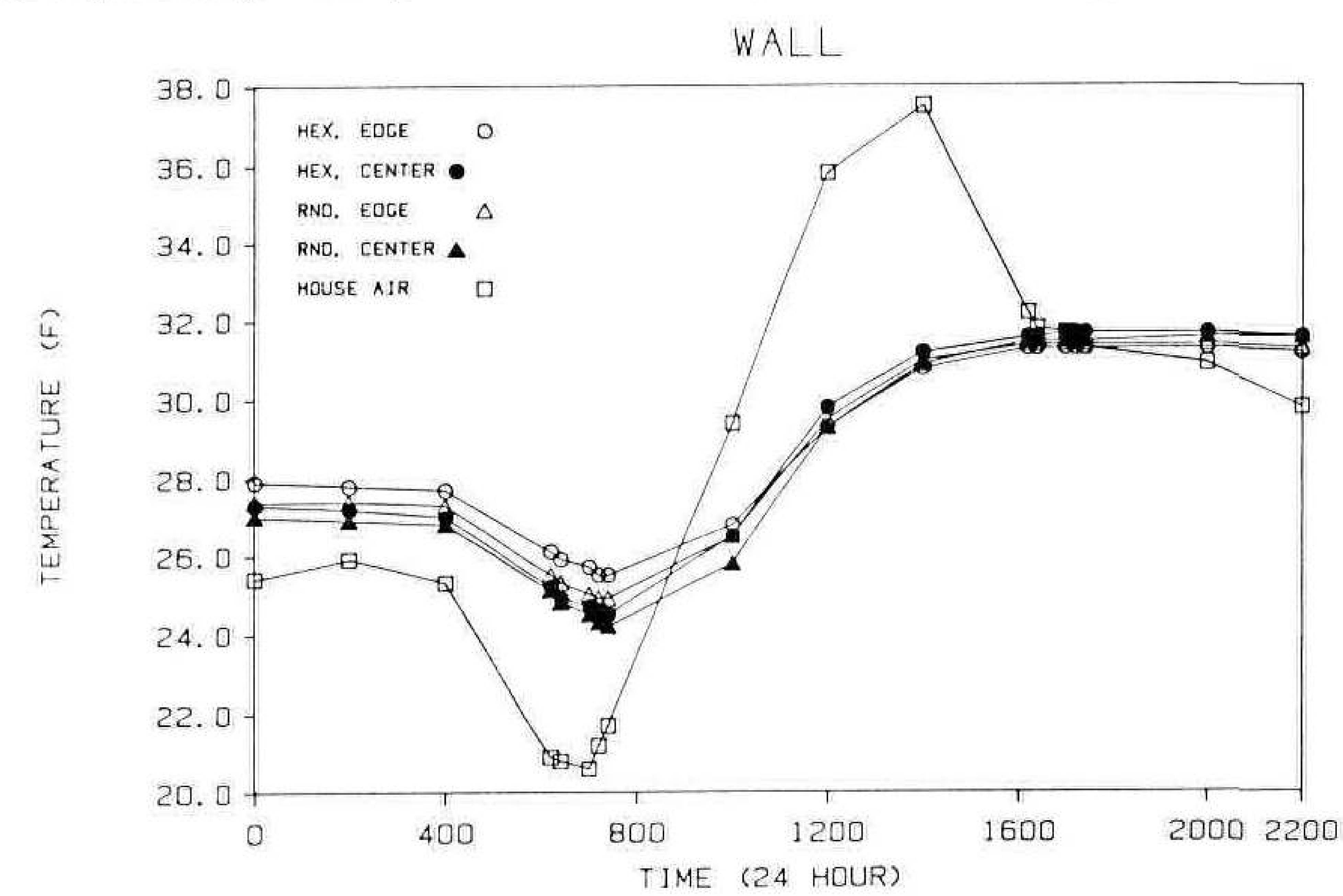

Figure 3. Medium temperature responses of the two locations within the two pot types to the ambient air temperature in the wall location on day 24 (24 January 1985). Hex = 6 sided pot, Rnd = round pot.

allow more of the block to respond like the pots in the mid-block location of this study. Covering the surface of the pots would reduce the exchange of heat from the surface of the soil medium, allowing a greater proportion of the volume of the pot to respond like edges of the pots in this study.

More work needs to be done and will be done to study the responses of containers to cold temperatures. We hope that further tests under controlled conditions can lead to more answers about how to successfully overwinter container plant material.

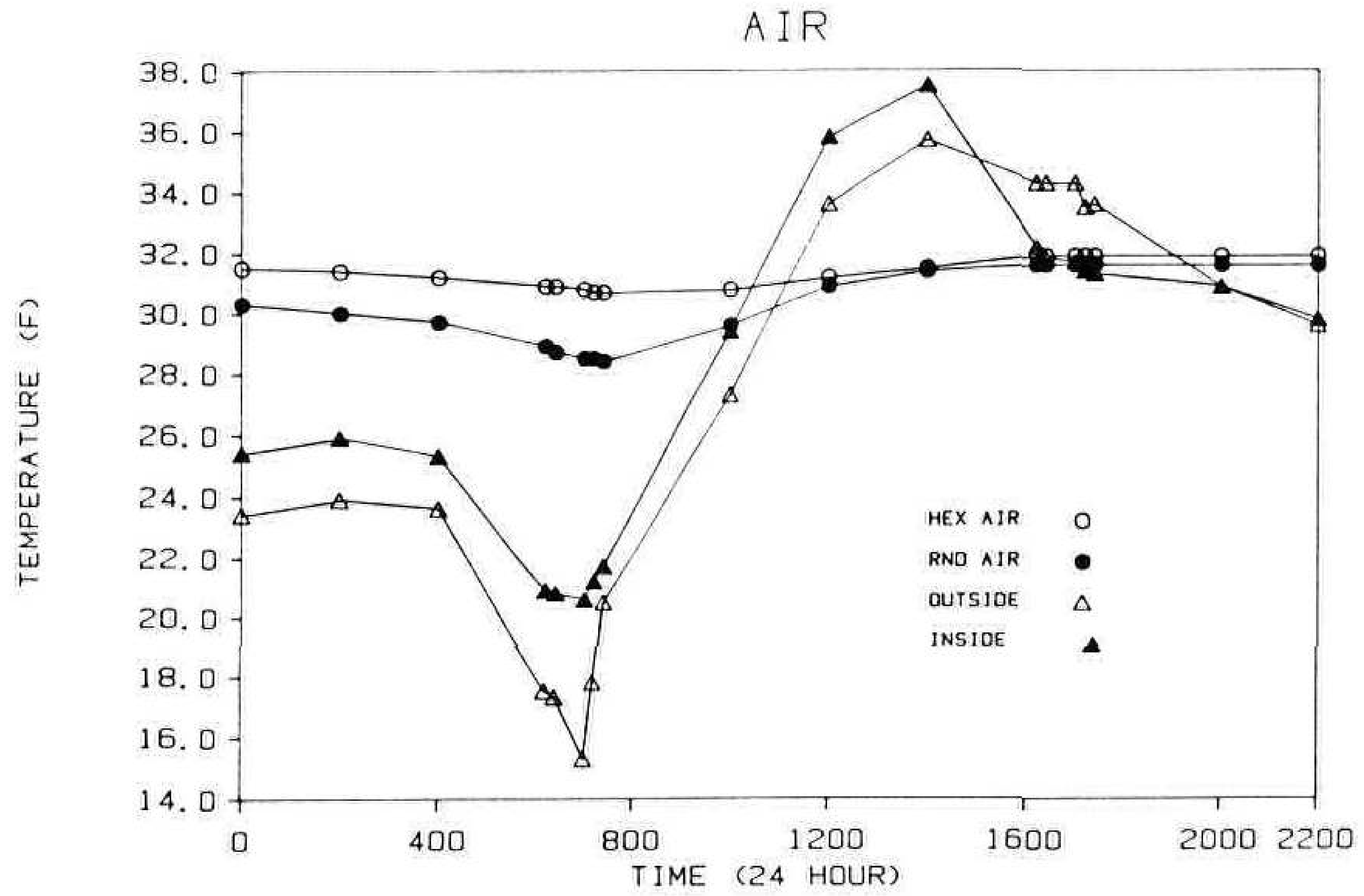

Figure 4. Response of the between pot air temperatures for the two pot types to the ambient air temperature in the mid-block location on day 24 (24 January 1985). Hex = 6 sided pot, Rnd = round pot.

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