This Journal of Environmental Horticulture article is reproduced with the consent of the Horticultural Research Institute (HRI – www.hriresearch.org), which was established in 1962 as the research and development affiliate of the American Nursery & Landscape Association (ANLA – http://www.anla.org).

HRI's Mission:

To direct, fund, promote and communicate horticultural research, which increases the quality and value of ornamental plants, improves the productivity and profitability of the nursery and landscape industry, and protects and enhances the environment.

The use of any trade name in this article does not imply an endorsement of the equipment, product or process named, nor any criticism of any similar products that are not mentioned.

Copyright, All Rights Reserved

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-07-18 via free access

Overwintering Container-grown Nursery Crops: Plant, Air and Medium Thermal Response to Porous Row Covers[1]

Stuart L. Warren, Katharine B. Perry, and Richard E. Bir[2]
Department of Horticultural Science
North Carolina State University
Raleigh, NC 27695-7609

Abstract

Three structureless row covers (white, spunbonded polyester and two weights of white, spunbonded polypropylene) were evaluated for winter protection of container grown 'Helleri' holly (*Ilex crenata* 'Helleri'), 'Atropurpurea Nana' nandina (*Nandina domestica* 'Atropurpurea Nana'), Fraser photinia (*Photinia* × *fraseri*), and 'Mohave' pyracantha (*Pyracantha Koidzumii* × *coccinea* 'Mohave') relative to white copolymer film and white copolymer backed thermoblanket over quonset-shaped structures and an unprotected control. Air and rooting medium temperatures were monitored during the deployment period. Visual foliar injury ratings were taken immediately after treatments were removed and again four months later. Visual shoot injury ratings were correlated with the mean daily average and the mean daily minimum temperature of air and rooting medium within each treatment. Both polypropylene covers provided protection for plants in the interior of a consolidated group equivalent to white poly and the thermoblanket for all species except *Pyracantha*. Porous row covers are a feasible alternative to standard protection systems.

Index words: winter protection, row covers

Species used in this study: 'Helleri' holly (*Ilex crenata* 'Helleri'); 'Atropurpurea Nana' nandina (*Nandina domestica* 'Atropurpurea Nana'); Fraser photinia (*Photinia* × *fraseri*); 'Mohave' pyracantha (*Pyracantha Koidzumii* × *coccinea* 'Mohave')

Significance to the Nursery Industry

Structureless Kimberly Farms and Typar covers can provide overwintering protection equivalent to while poly structured systems for some container-grown nursery crops. The plants most likely to be damaged in structureless systems are those positioned next to the cover. Damage could be avoided by providing additional insulating material, by using fallow containers or containers of more tolerant plants around the exterior. The degree of protection required and the value of the species should be considered relative to the cost of the winter protection material before choosing the appropriate system.

[1]Received for publication October 23, 1989; in revised form June 1, 1990. Technical assistance of Joe Conner and Everett Whitman is gratefully acknowledged. This research was supported, in part, by grants from the Horticultural Research Institute; C.I.L., Inc; Kimberly Farms; The Lutravil Co.; Ametek, Inc.; and Reemay, Inc.

[2]Assistant Professor, Associate Professor, and Extension Specialist, resp.

Copyright 1990
Horticultural Research Institute
1250 I Street, N.W., Suite 500
Washington, D.C. 20005

Reprints and quotations of portions of this publication are permitted on condition that full credit be given to both the HRI *Journal* and the author(s), and that the date of publication be stated. The Horticultural Research Institute is not responsible for statements and opinions printed in the *Journal of Environmental Horticulture;* they represent the views of the authors or persons to whom they are credited and are not binding on the Institute as a whole.

Where trade names, proprietary products, or specific equipment is mentioned, no discrimination is intended, nor is any endorsement, guarantee or warranty implied by the researcher(s) or their respective employer or the Horticultural Research Institute.

The *Journal of Environmental Horticulture* (USPS Publication No. 698-330) is published quarterly in March, June, September, and December by the Horticultural Research Institute. Subscription rate is $45.00 per year in USA; $60.00 per year for others. Second-class postage paid at Washington, D.C. and at additional mailing office. Send address changes to HRI, 1250 I Street, N.W., Suite 500, Washington, D.C. 20005.

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-07-18 via free access

Introduction

Container production of landscape plants represents over one-half of all landscape plants sold in the United States (3). Winter protection of container-grown nursery crops is one of the principal cultural problems (3). A winter protection system must provide adequate thermal protection for roots, which are significantly less hardy than shoots (9), and allow management of water to prevent desiccation of evergreens.

Although there are no standards accepted by industry for overwintering container-grown nursery crops, there are several commonly used systems in USDA hardiness zones 6 and 7 (1), e.g., quonset-shaped structures covered with a single or double layer of polyethylene film or thermal blanket, structureless polyethylene film or thermal blanket covers, or combinations of these (2). Previous research documented the effectiveness of these systems in providing winter protection (2, 5, 6, 8, 10, 13). Structureless systems are two to three times less expensive than those requiring structures (2, 3); thus, alternative structureless covers would be beneficial. Porous row covers developed for agronomic crops might provide an alternative structureless winter protection system.

The objectives of this study were to compare three structureless row covers for winter protection of container-grown nursery crops, relative to white copolymer and white copolymer backed thermoblanket covered structures and to quantify the air and medium thermal environment created by each winter protection system.

Materials and Methods

Uniform rooted cuttings of 'Helleri' holly, 'Atropurpurea Nana' nandina, Fraser photinia, and 'Mohave' pyracantha were potted into 2.8 l (#1) containers in a medium of milled pine bark : sand (4:1 by vol) in the spring of 1987. The plants were grown by local nurserymen following North Carolina container production recommendations (4). These species have the following root killing temperatures: 'Helleri' holly, −6.7°C (20°F); 'Atropurpurea Nana' nandina, −6.6°C (20°F); Fraser photinia, (−11.1°C 12°F); and 'Mohave' pyracantha, −7.8°C (18°F) (7, 12).

In November 1987, 15 plants of each species were randomly selected for each treatment in each block and consolidated 5 containers wide in a north-south orientation. The order of the species was randomly determined for each plot. Containers filled with the same medium were placed on the north and south ends of all plots, so every species had 6 and 9 containers on the exterior and interior of the consolidated group, respectively.

The following winter protection treatments began Dec. 1, 1987 and continued until March 1, 1988:

1) One layer of 0.1 mm-thick (4 mil) white copolymer film (C.I.L. Inc., Brampton, Ontario, Canada) supported by quonset-shaped 2.5 cm (1 in) PVC pipe, 75 cm (29.5 in) tall; hereafter called 'white poly'.

2) One layer of 0.1 mm-thick (4 mil) white copolymer backed thermoblanket, 0.6 cm (0.25 in) thick, (Trade name Microfoam, Ametek, Atlanta, GA), supported in the same manner as the white poly; hereafter called 'thermoblanket'.

3) One layer of white, spunbonded polypropylene, 51 g/m^2 (1.5 oz/yd^2), (Kimberly Farms, Roswell, GA) pulled tight over plants; hereafter called 'Kimberly Farms'.

4) One layer of white, spunbonded polyester, 68 g/m^2 (2 oz/yd^2) (Lutradur LD 7270, The Lutravil Co., Durham, NC) pulled tight over plants; hereafter called 'Lutradur'.

5) One layer of white, spunbonded polypropylene, 64 g/m^2 (1.9 oz/yd^2) (Typar, 3201 Natural, Reemay, Inc., Old Hickory, TN) pulled tight over plants; hereafter called 'Typar'.

(6) No protection provided; hereafter called 'control'.

All covers were held in place with gravel. To prevent shading, treatments were spaced 2.5 m (8.2 ft) apart within blocks, 3 m (9.8 ft) between blocks.

Air temperature was measured in the center of the consolidated containers 20 cm (8 in) above the container medium in each treatment in each block by shielded 30 gauge copper-constantan thermocouples. The rooting medium temperature was measured at a depth of 8 cm (3 in), 5 cm (2 in) from the north wall of the container in two locations: the exterior of the north facing side (hereafter called 'exterior'); and at plot center (hereafter called 'interior'), in each treatment in each block. Temperatures were measured every 2 minutes; average, maximum, and minimum temperatures were recorded every two hours by a CR-21X micrologger (Campbell Scientific, Inc., Logan, UT). Ambient air temperature was measured at 1.5 m (5 ft) within a ventilated instrument shelter located 30 m (98 ft) from the test site. The container medium was checked every 30 days for moisture. No irrigation was required.

On March 1 and June 16, 1988, two people estimated foliar injury visually for every plant in each plot, using the following scale: 1 = dead, 2 = >75% foliar necrosis, 3 = 25 to 75% foliar necrosis, 4 = <25% foliar necrosis, and 5 = no foliar necrosis. Fourteen grams (0.5 oz) of Osmocote 18N-2.6P-10K (18-6-12) (Sierra Chemical Co., Milpitas, CA) was applied to each container on April 27, 1988. The plants received 1.3 cm (1/2 in) of water every other day via overhead irrigation until April 27, 1988; afterward water was applied daily.

The experiment, a split-split-plot design with four replications, was conducted on a gravel pad at the Mountain Horticultural Crops Experiment Station [35°26'N, 82°34'W, elev. 631m (2051 ft)], Fletcher, NC. Fletcher is located in USDA hardiness zone 7A. The main plots were winter protection treatments. Subplots were species and location within subplots (exterior and interior) were sub-subplots.

Analysis of variance was performed on the plant injury ratings; the minimum rooting medium temperature recorded on the coldest day, February 7; the maximum air temperature recorded on the warmest day, February 1; and the following air and rooting medium (at each location) temperature means calculated from Dec 1 to March 1: daily average, daily maximum, and daily minimum. Rooting medium temperature had a significant location (exterior, interior) by winter protection treatment interaction. Therefore, rooting medium temperatures were analyzed by location and treatment. There was no significant difference between the two evaluators' foliar injury ratings at either evaluation date, so the foliar injury ratings were pooled on each date. Treatment means were separated using Fisher's lsd, 5% level (SAS Institute, Cary, NC).

Results and Discussion

Air temperatures during the study period deviated from normal. The average air temperature in December, 1987 was 2.1 C (3.7 F) warmer than normal. However, January and February, 1988 were colder than normal by 2.7 C (4.9 F) and 0.55 C (1.0 F), respectively. Therefore, these rêsults can be considered in the context of extreme cold for zone 7A.

The coldest ambient air temperature, −17.5°C (0.5°F), was recorded on the morning of February 7. Exterior rooting medium temperature in the control treatment was within 1 degree of this temperature (Table 1). Consolidating containers provided 6°C (10.8°F) degrees of protection, compared to the ambient air temperature, as illustrated by the interior rooting medium temperature in the control. During this period, white poly and thermoblanket performed similarly providing about 16°C (29°F) degrees of protection for exterior containers (Table 1). Other research indicates that white poly and thermoblanket provide about 5°C (9°F) (6, 13) and 23°C (41°F) of protection (10), respectively. The degree of protection is dependent upon the duration of cold temperatures, so care must be taken when comparing similar materials evaluated in dissimilar environments. Kimberly Farms, Lutradur, and Typar provided 12.3°C (22.1°F), 4.8°C (8.6°F), and 6.8°C (12.2°F) degrees of protection, respectively, for the exterior containers. Interior medium temperatures of these three row covers were not significantly different from white poly and thermoblanket, providing about 11°C degrees of protection. (Table 1).

On the warmest day of the test period (Feb. 1), a maximum air temperature of 20°C (68°F) was recorded. Air temperatures in each treatment ranged from 1°C (1.8°F) to 11°C (19.8°F) higher than this ambient air temperature (20°C) (Table 1). High temperatures are undesirable because they promote deacclimation of the plants and contribute to desiccation injury. Heat buildup was most severe under the white poly and Kimberly Farms materials with maximum air temperatures of 8.9°C (16°F) and 11.1°C (20°F), respectively, higher than the ambient air temperature maximum (Table 1). The maximum air temperatures recorded in thermoblanket, Lutradur, and Typar treatments were not significantly different. Heat buildup is influenced by light transmission (11). Among the covers, Kimberly Farms had the highest light transmission (65%) and thermoblanket the lowest (35%).

Mean interior daily average rooting medium temperature, for all treatments, was significantly higher than the control (Table 2). White poly, thermoblanket, and Kimberly Farms were not significantly different. Lutradur and Typar temperatures were similar. Similar differences were found in the mean exterior daily average rooting medium temperature, except: i) Lutradur and Typar were not significantly different from the control, and ii) Kimberly Farms was significantly lower than white poly and thermoblanket. None of the row covers maintained similar rooting medium temperatures in the exterior position, compared to white poly and thermoblanket.

For all treatments, mean daily maximum and daily minimum temperatures of the rooting medium were 0.3°C (0.5°F) to 2.8°C (5.0°F) higher in the interior compared to exterior (Table 2). The exception was the mean daily maximum rooting medium temperature of the interior control which was 0.7°C (1.3°F) lower than the exterior. Increased container surface exposure to incoming solar radiation at the exterior location likely increased the medium temperature during the day, resulting in a higher daily maximum.

All treatments significantly increased interior mean daily maximum temperature of the rooting medium (Table 2). White poly, thermoblanket, and Kimberly Farms were significantly higher than Lutradur and Typar (Table 2). However, in the exterior location, Lutradur, Typar, and Kimberly Farms were similar to the control.

All treatments increased average daily minimum temperature of the rooting medium by 0.3°C (0.5°F) to 1.9°C (3.4°F) in the exterior compared to the interior (Table 2). Similar results were reported for white poly by Young et al. (1987).

All treatments, regardless of location, significantly increased mean daily minimum temperature of the rooting medium, compared to the control (Table 2). Thermoblanket maintained the highest mean daily minimum medium temperature, regardless of location, but it was not significantly greater than Kimberly Farms in the interior location (Table 2). For mean daily minimum, Kimberly Farms was equivalent to white poly and was significantly higher than Lutradur and Typar, in both locations.

The mean daily air temperature of all treatments was significantly higher than the control (Table 3). Kimberly Farms had the highest mean daily average; however, it was not significantly greater than white poly. Among the covers, Lutradur and Typar had the lowest temperatures and did not

Table 1. Minimum temperature of the rooting medium recorded on February 7, 1988 and maximum air temperature recorded on February 1, 1988 under five winter protection treatments and a control.

Winter Protection Treatment	Minimum medium temp Location[z] Exterior		Interior		Maximum air temp[y]	
	°C	°F	°C	°F	°C	°F
Control	−16.5	(2.3) e[x]	−11.4	(11.5) c	21.1	(70.0) c
White poly	−1.0	(30.2) a	−0.7	(30.7) ab	28.9	(84.0) a
Thermoblanket	−0.5	(31.1) a	−0.5	(31.1) ab	24.0	(75.2) b
Kimberly Farms	−4.2	(24.4) b	−0.3	(31.5) a	31.1	(88.0) a
Lutradur	−11.7	(10.9) d	−1.0	(30.2) b	26.2	(79.2) b
Typar	−9.7	(14.5) c	−0.6	(30.9) ab	25.4	(77.7) b

[z]Measured 8 cm (3 in) deep and 5 cm (2 in) horizontally from the north wall of the container in two locations: exterior of the north facing side and at plot center (interior).

[y]Measured at plot center 20 cm (8 in) above the container medium.

[x]Means followed by the same letter within a column are not significantly different using Fisher's lsd, 5% level.

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-07-18 via free access

Table 2. Mean of daily average, daily maximum, and daily minimum temperature of the rooting medium in two locations for five winter protection treatments and a control from December 1, 1987 to March 1, 1988.

Winter Protection Treatment	Daily average				Daily maximum				Daily minimum			
	Location[z]											
	Inter[y]		Exter		Inter		Exter		Inter		Exter	
	°C	°F		°F	°C	°F	°C	°F	°C	°F	°C	°F
Control	1.0	(33.8) c[x]	0.7	(33.3) c	3.4	(38.1) c	4.1	(39.4) b	−1.2	(29.8) e	−2.7	(27.1) d
White poly	4.1	(39.4) a	3.3	(37.9) a	8.3	(46.9) a	7.2	(45.0) a	1.1	(34.0) bc	0.6	(33.1) b
Thermoblanket	4.4	(39.9) a	3.9	(39.0) a	7.7	(45.9) a	7.0	(44.6) a	2.0	(35.6) a	1.7	(35.1) a
Kimberly Farms	4.1	(39.4) a	2.1	(35.8) b	7.6	(45.7) a	4.8	(40.6) b	1.7	(35.1) ab	0.2	(32.4) b
Lutradur	2.7	(36.9) b	1.3	(34.3) c	5.4	(41.7) b	4.2	(39.6) b	0.2	(32.4) d	−1.6	(29.1) c
Typar	3.0	(37.4) b	1.3	(34.3) c	5.8	(42.4) b	4.0	(39.2) b	0.8	(33.4) cd	−1.1	(30.0) c

[z]Measured 8 cm (3 in) deep and 5 cm (2 in) horizontally from the north wall of the container in two locations: exterior of the north facing side and at plot center (interior).

[y]Exter = exterior; inter = interior.

[x]Means followed by the same letter within a column are not significantly different using Fisher's lsd, 5% level.

Table 3. Mean of daily average, daily maximum, and daily minimum air temperature for 5 winter protection treatments and a control from December 1, 1987 to March 1, 1988.[z]

Winter Protection Treatment	Air temperature					
	Daily average		Daily maximum		Daily minimum	
	°C	°F	°C	°F	°C	°F
Control	1.6	(34.9) d[y]	11.2	(52.2) d	−4.9	(23.2) c
White poly	6.0	(42.8) ab	20.5	(68.9) b	−1.5	(29.3) b
Thermoblanket	5.9	(42.6) b	16.7	(62.1) c	0.1	(32.2) a
Kimberly Farms	6.9	(44.4) a	25.8	(78.4) a	−1.3	(29.7) b
Lutradur	4.6	(40.3) c	19.0	(66.2) b	−2.0	(28.4) b
Typar	4.9	(40.8) c	19.8	(67.6) b	−1.7	(28.9) b

[z]Measured at plot center 20 cm (8 in) above the container medium.

[y]Means followed by the same letter within a column are not significantly different using Fisher's lsd, 5% level.

differ significantly. Similarly, Kimberly Farms had the highest mean daily maximum air temperature, averaging 14.6°C (26.3°F) higher than the control. Of all the covers, thermoblanket had the lowest mean daily maximum air temperature, averaging 5.5°C (9.9°F) greater than the control. In contrast, thermoblanket's mean daily minimum air temperature was significantly higher than all treatments. The mean daily minimum air temperature of white poly, Kimberly Farms, Lutradur, and Typar were not significantly different from each other but were different from the control.

The foliar injury ratings had a significant interaction between location (exterior, interior) and treatment, indicating that the plants responded differently depending upon location in the consolidated group. Thus, the injury data are presented by treatment and location. In most cases where differences existed between positions, plants in the exterior position had more injury than plants in the interior (Table 4). The June 16, 1988 foliar injury ratings are more indicative of the plant response so they are the only ratings presented.

Table 4. Mean visual shoot injury rating of *Ilex crenata* 'Helleri', *Nandina domestica* 'Atropurpurea Nana', *Photinia × fraseri*, and *Pyracantha Koidzumii × coccinea* 'Mohave' on June 16, 1988.[z]

Winter Protection Treatment	Species							
	Ilex		Nandina		Photinia		Pyracantha	
	Exter[y]	Inter	Exter	Inter	Exter	Inter	Exter	Inter
Control	1.1 d[x]	1.0 c	1.0 c	1.0 c	1.0 c	1.0 c	1.3 c	1.4 d
White poly	4.4 a	4.4 a	4.2 a	4.8 a	4.8 a	4.9 a	3.0 b	3.2 c
Thermoblanket	4.6 a	4.4 a	4.0 a	4.2 a	4.9 a	5.0 a	4.7 a	4.7 a
Kimberly Farms	4.3 ab	4.3 ab	4.4 a	4.6 a	4.9 a	4.9 a	3.4 b	3.6 bc
Lutradur	3.3 c	3.5 b	1.7 c	3.7 b	3.8 b	4.8 a	3.3 b	3.9 b
Typar	3.9 b	4.1 ab	2.9 b	4.6 a	4.5 a	4.8 a	4.0 b	3.5 bc

[z]Injury rating: 1 = dead, 2 = >75% foliar necrosis, 3 = 25% to 75% foliar necrosis, 4 = <25% foliar necrosis and 5 = no foliar necrosis.

[y]Exter = exterior; Inter = interior.

[x]Means followed by the same letter within a column are not significantly different using Fisher's lsd, 5% level.

All covers reduced foliar injury, except exterior 'Atropurpurea Nana' nandina under Lutradur (Table 4). Most of the control plants were dead by June 16. The thermoblanket was the only treatment which resulted in less than 25% foliar necrosis for all four species, regardless of location. This was followed by white poly and Kimberly Farms which maintained less than 25% foliar necrosis, regardless of location, for all species, except 'Mohave' pyracantha. Since 'Mohave' pyracantha has a lower root killing temperature than 'Helleri' holly and 'Atropurpurea Nana' nandina, it might have incurred more injury due to the greater heat buildup under white poly and Kimberly Farms.

Kimberly Farms and Typar protected interior 'Helleri' holly and 'Atropurpurea Nana' nandina as well as white poly and thermoblanket. However, for the exterior plants, only Kimberly Farms was equivalent to white poly and thermoblanket. All covers protected interior Fraser photinia equally well. However, only Kimberly Farms and Typar protected exterior Fraser photinia as well as white poly and thermoblanket. For 'Mohave' pyracantha, the three row covers were equivalent or better than the white poly but did not perform as well as the thermoblanket at either location.

Visual shoot injury ratings of all species were highly correlated with the mean daily maximum air temperature and the mean daily average and daily minimum air and interior and exterior medium temperature (Table 5). The correlation with mean daily maximum temperature of the rooting medium, regardless of location, was not significant. These correlations emphasize that the minimum medium temperature is a critical factor in determining plant response to winter protection treatments. Maximum medium temperature did not affect plant response in this study. The positive correlation with daily maximum air temperature suggests that air temperature was not high enough to cause plant damage; however, this may not apply to 'Mohave' pyracantha.

Table 5. The range of linear correlation coefficients between the June 16, 1988 foliar injury ratings of 'Helleri' holly, 'Atropurpurea Nana' nandina, Fraser photinia, and 'Mohave' pyracantha and the means of the daily average, daily maximum, and daily minimum for air and rooting medium (interior and exterior locations) temperature from December 1, 1987 to March 1, 1988.

Location	Daily average	Daily maximum	Daily minimum
Air temp			
r value	0.70–0.91[z]	0.44–0.61	0.76–0.96
Medium temp			
Interior			
r value	0.74–0.93	NS	0.73–0.98
Exterior			
r value	0.51–0.75	NS	0.63–0.88

[z]Significant at the 0.01 level or NS = nonsignificant.

Literature Cited

1. Anonymous. 1990. USDA Plant Hardiness Zone Map. U.S. Dept. Agric., Misc. Pub. 1475.

2. Badenhop, M.B. and J.W. Day. 1985. Costs of overwintering plants in Tennessee nurseries differentiated by system. Agric. Exp. Sta. Bull. 636, University of Tennessee, Knoxville.

3. Beattie, D.J. (Ed.). 1986. Principles, practices, and comparative costs of overwintering container-grown landscape plants. Southern Cooperative Series Bull. 313, Pennsylvania Agric. Exp. Sta., University Park.

4. Bonaminio, V.P. (Ed.). 1986. Nursery crops production manual. N. C. Agric. Ext. Serv., Raleigh.

5. Davidson, H. and R. Mecklenburg. 1974. Overwintering of evergreens in plastic structures. HortScience 95:479–480.

6. Gouin, F.R. and C.B. Link. 1979. Temperature measurements, survival, and growth of container-grown ornamentals, overwintered unprotected, in nursery shelters and under microfoam thermo-blankets. J. Amer. Soc. Hort. Sci. 104:655–658.

7. Havis, J.R. 1976. Root hardiness of woody ornamentals. HortScience 11:385–386.

8. Hicklenton, P.R. 1982. Effectiveness of 4 coverings for overwintering container grown ornamentals in different plant hardiness zones. HortScience 17:205–207.

9. Pellett, H. 1971. Comparison of cold hardiness levels of root and stem tissues. Can. J. Plant Sci. 51:193–195.

10. Pellett, N.E., D. Dippre, and A. Hazelrigg. 1985. Coverings for overwintering container grown plants in northern regions. J. Environ. Hort. 3:4–7.

11. Rizzo, C.F., T.A. Fretz, and E.M. Smith. 1981. Evaluation of plastic films used to cover woody-ornamental winter storage structures. Scientia Horti. 14:181–190.

12. Studer, E.J., P.L. Steponkus, G.L. Good, and S.C. Weist. 1978. Root hardiness of container-grown ornamentals. HortScience 13:172–174.

13. Young, R.E., J.L. Dunlap, Jr., D.J. Smith, and S.A. Hale. 1987. Clear and white plastics for freeze protection of landscape plants in the southern to mid-Atlantic region. J. Environ. Hort. 5:166–172.

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-07-18 via free access