Table 2. Effect of planting depth on growth and production of standard 'Delicious' on Malling 7A rootstock.

	Planting Depth[z]	
Treatment	25 cm	5 cm
Bloom rating[x]	2.4a[y]	6.9b**
Number fruit per tree	162.0a	202.0a
Fruit—cross sectional area	2.8a	4.0b*
Degree of lean[w]	23.5a	35.5a
Depth to first root (cm)	1.8a(7")	1.0a(4")
Tree height (m)	4.7a(15.4')	4.10b (13.5')

[z]Deeper than original nursery planting depth.

[x]Rating of 1 (least) to 10 (most bloom)

[w]Degree of lean from vertical

[y]Means in rows followed by the same letter are not significant at the 5% level (*) or the 1% level (**) as determined by Duncan Multiple Range Test.

and research than it is now receiving. If a grower or homeowner is planting with the desire for earlier flowering, above ground rootstock shanks of reasonable length may be part of the answer. The problem of cold injury and burrknots on many rootstocks must still be addressed. We also would not expect all combinations of scion variety and rootstock to react the same and suggest that trials with the more popular rootstock and scion combinations would be warranted in each production area.

Our data does not support the belief that deep planting overcome poor tree anchorage thereby reducing the degree of lean. For this reason we believe that nurseries should maintain a reasonable budding height of not more than 15 cm (6 in) so planting depth can be adjusted without great risk of poor plant performance.

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Consumer Attitudes Toward the Defoliation of American Arborvitae, *Thuja occidentalis*, by Bagworm, *Thyridopteryx ephemeraeformis*[1]

Clifford S. Sadof and Michael J. Raupp[2]

Department of Entomology
University of Maryland
College Park, MD 20742

Abstract

A group of 93 retail nursery customers were surveyed to determine their attitudes toward defoliation of American arborvitae, *Thuja occidentalis* L., caused by the bagworm, *Thyridopteryx ephemeraeformis* (Haworth). More than half of the customers surveyed perceived plants with 4% of the leaf area missing or discolored as damaged. The proportion of customers who refused to buy a plant corresponded closely ($r = 0.98$, $p < .0001$) with the proportion of those who perceived the plant as damaged.

Index words: marketing, economics, aesthetic injury, integrated pest management, bagworm

Introduction

The bagworm is a widespread defoliator of many evergreen and deciduous shrubs in the eastern United States. On American arborvitae, high populations can strip plants of foliage during a single growing season.

Overwintered bagworm eggs hatch during late May and early June. Prior to feeding, each larva spins a silken bag around its body. As the larva begins to feed, bits of foliage are attached to the bag. With its head and legs free, the larva moves along branches or to nearby shrubs in search of food. Bagworms continue their development until they pupate in bags up to 5.1 cm (2 in) long in late summer. After mating the female deposits eggs in her bag and dies. These eggs remain in the bag through the winter until they hatch the following year (1).

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[2]Graduate student and extension professor, resp. Computer support was provided by SEA grant funds and Computer Science Center of the University of Maryland. Special recognition to J.A. Davidson, C.S. Koehler, J.J. Holmes, and K. Reichelderfer and the nursery retailers for their support and assistance. Scientific Article No. A-4678 Contribution No. 7674 of the Maryland Agricultural Experiment Station.

Although bagworm can effectively be controlled during its early larval stages with a well timed insecticide application, larval densities that economically justify the cost of a nursery spray program have not been determined. A first step in determining this density would be to assess the economic impact of defoliation on the value of individual plants. The economic value of American arborvitae is derived from the aesthetic quality of its appearance. Consequently, the value of the plant to a nursery retailer is determined by customers who perceive how well a plant satisfies their aesthetic expectations. Plants that fully satisfy customer expectations are more valuable and command a higher price in the marketplace. The relationship between plant defoliation and the satisfaction of customer expectations is key to determining the economic impact of bagworm injury. Previous work on the relationship between plant injury and aesthetic quality has focused only on the extent that injury alters a consumer's decision to buy a plant (2). This report examines the attitudes retail nursery customers have toward plant defoliation. The relation between bagworm populations, defoliation and the economic considerations for implementing a control tactic are reported elsewhere (3).

Materials and Methods

To determine customer attitudes toward defoliated American arborvitae we photographed a plant with known levels of defoliation. A containerized 1.2 m (4 ft) tall American arborvitae was infested with 500 first instar larvae in early June. The plant was photographed at the time of infestation and at regular intervals until mid-August. The plant was always photographed at the same angle, distance, and lighting. The amount of foliage discolored or missing was quantified by comparing the tracings of the undamaged plant to tracings of the plant showing successive stages of injury. The percent leaf area missing or discolored at a given time was calculated as the percent of the total of foliage found on the plant.

Customers were shown a 76 x 101 cm (30 x 40 in) poster board with color prints 20 x 30 cm (8 x 12 in) of the plant with 0, 2, 4, 8, 15 and 75% defoliation. The prints were randomly placed in one of 6 positions on the poster board. The poster board was then taken to 5 randomly selected retail nurseries in the Washington, D.C. metropolitan area. Approximately 20 people at each site completed the survey.

The response toward defoliated plants was determined by asking each customer "Which plant or plants show damage?" The potential economic impact on a retailer was determined by asking customers "Which plant or plants have damage that would prevent you from purchasing them?"

The analysis of the relationship between defoliation and customer responses focused on the range of defoliations that caused the sharpest changes in customer response. This range is the most critical for determining economic injury levels and was linear. The general linear models procedure of SAS was used to determine the best straight line in this range (4).

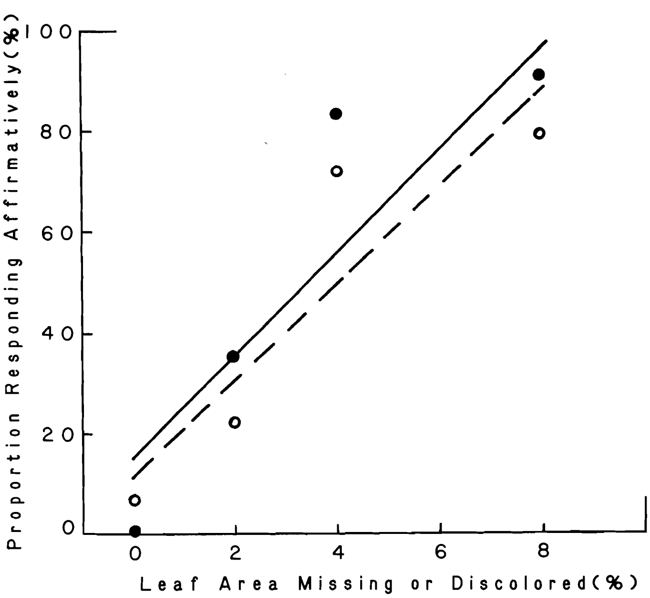

Fig. 1. Relationship between the percent leaf area missing or discolored of American arborvitae and the attitudes of 93 retail nursery customers at 5 retail nurseries in the Washington, D.C. metropolitan area. The solid line and points represent the number of customers that felt the plant with the indicated amount of injury was damaged. The dashed line and open points represent the number of customers that would not buy the plant.

Results and Discussion

Customers had a very low tolerance for defoliation (Fig. 1). At defoliation levels between 0 and 8 percent there was a strong linear relationship between the area discolored or missing (x) and the proportion of individuals who perceived plant damage (y) ($y = 10.21x + 15.43$, $R^2 = 0.84$, $p < 0.05$). The proportions of people perceiving damage and refusing to buy a plant at each nursery were strongly correlated over the entire range of defoliation (Pearson's $r = .98$, $p < 0.0001$, $n = 6$). However, 94% of the customers surveyed would have bought the undamaged plant. There was a strong linear relationship between the percent of customers refusing to buy and the percent leaf area missing or discolored (Where y = percent refusing to buy and x = percent defoliation $y = 9.53\,x + 11.32$, $R^2 = .83$ $p < 0.05$).

These findings suggest that small levels of defoliation on American arborvitae can have a large impact on the value of individual plants for two reasons. Customers are able to perceive small amounts of defoliation which they recognize as plant damage. Specifically, we found that each percent increase in plant defoliation caused a 10% increase in the proportion of customers recognizing a plant as damaged and a 9% increase in the proportion refusing to buy the plant.

These findings are in agreement with the results of previous studies of the relationship between leaf mining injury on the aesthetic quality of chrysanthemums (2). As the percentage of mined leaves on plants increased there was a decrease in the number of consumers who would buy plants. Seventy percent of the consumers participating in this survey refused to buy chrysanthemums with as little as 9% of their leaves mined. Thus, as with our findings, a substantial proportion of potential customers refused to buy plants with low levels of insect injury.

Significance to the Nursery Industry

The low tolerance of retail nursery customers for American arborvitae defoliated by bagworm has strong implications for developing pest management strategies. Retail customers are discriminating shoppers. They will generally not purchase plants they recognize as damaged. A reasonable goal for nurserymen should be to minimize the defoliation on their plants during the period of sale. Prior to the time of sale higher levels of damage may be tolerated provided that the plant can recover before it is marketed.

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Clear and White Plastics for Freeze Protection of Landscape Plants in the Southern to Mid-Atlantic Region[1]

R.E. Young, J.L. Dunlap, Jr., D.J. Smith and S.A. Hale[2]
Agricultural Engineering Department
Clemson University
Clemson, SC 29634

Abstract

Rapid, wide fluctuations in winter temperatures in Mid-Atlantic and Southern states can result in severe damage to container grown landscape plants. Freezes on Christmas Day, 1983 and January 21, 1985 left nurserymen in this region with multi-million dollar losses and an interest in low-cost freeze protection methods. This study examines the cold protection properties of white copolymer and clear poly 6 mil plastics for covering unheated propagation hoop houses and for wrapping container growing beds. Soil, canopy, house ambient and outside temperatures were collected by computer on 15 minute intervals for a 3 month period. Diurnal temperature fluctuations were 1.5 to 2 times greater in clear poly than white copolymer. Double layer plastic coverings maintained minimum soil and canopy temperatures significantly higher than single layer structures. White copolymer wrapping of growing beds afforded root protection to Asian jasmine (*Trachelospermum asiaticum* Lem.) and Burford holly (*Ilex cornuta* Lindl 'Burford Nana') with some border damage; Wiltonii juniper (*Juniperus horizontalis* Moench. 'Wiltonii') did not need covering. White copolymer offers greater freeze protection at a lower cost.

Index words: freeze protection, clear plastic, white plastic, landscape plants, single layer, double layer, plastic coverings, overwintering, cold protection

Introduction

Increasing inventories of container grown nursery stock have occurred because of greater plant densities, lower labor costs per plant, and better control of media composition to optimize plant growth. Weather, however, has proved challenging to producers of container plants, particularly during record cold events like that which occurred January 21-22, 1985 (11, 16, 17). Above-ground roots in nursery containers are vulnerable to freezing, particularly in Southern to Mid-Atlantic climates where cold days may be immediately preceded by relatively warm days during winter months. In response to multi-million dollar losses of plant materials from the 1983 and 1985 freezes (3, 9, 16), Southern and Mid-Atlantic nurserymen are eagerly seeking low-cost freeze protection methods. In cooperation with Carolina Nurseries of Moncks Corner, South Carolina, Clemson University conducted a comparative study of clear and white plastic films as freeze protection devices for container grown plants.

The clear disadvantage of container grown landscape plants over field grown stock, however, is increased susceptibility to root damage from cold weather exposure. Roots of most plants do not develop the same level of root hardiness as the shoots (10). Yet, in containers, roots are also exposed to lower, above-ground temperatures during a freeze.

Havis (7) published a list of minimum safe root temperatures and killing root temperatures for 30 woody species commonly produced in containers. In 1976, Havis (8) extended his list to show root killing tempera-

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[2]Professor, Instrument Supervisor, Meteorologist, Visiting Instructor, resp.