on a variety of ornamentals including boxwood. It is not known whether this formulation of oxamyl will perform as well as Vydate 10G.

To avoid nematode-related losses, production areas should be sampled prior to planting boxwoods to spot populations of *P. vulnus* or other plant parasitic nematodes. If nematodes are detected, nurserymen would then have the option of selecting a nematode free site or making a pre-plant application of a fumigant nematicide. Supplemental applications of labeled non-fumigant nematicides may be needed to maintain effective nematode control following the use of a fumigant nematicide.

(*Ed note:* This paper reports the results of research only, and does not imply registration of a pesticide under amended FIFRA. Before using any of the products mentioned in this research paper, be certain of their registration by appropriate state and/or federal authorities.)

Literature Cited

1. Benson, D.M. and K.R. Barker. 1976. Efficacy of 1, 2 dibromo-3-chloropropane and aldicarb for control of parasitic nematodes in the root zone of American boxwood, and Japanese and Chinese hollies. J. Nematol. 9:263-264.

2. Byrd, D.W., C.J. Nusbaum, and K.R. Barker. 1966. A rapid flotation sieving technique for extracting nematodes from soil. Plant Dis. Rep. 50:954-957.

3. Haasis, F.A., J.C. Wells, and C.J. Nusbaum. 1961. Plant parasitic nematodes associated with decline of woody ornamentals in North Carolina and their control by soil treatment. Plant Dis. Rep. 45:491-496.

4. Skinner, H.T. 1948. Selenium and insect pests of boxwood. Morris Arboretum Bul. 4:73-79.

5. Tarjan, A.C. 1950. Investigations of meadow nematodes attacking boxwood, and the therapeutic value of sodium selenate as a control. Phytopathology 40:1111-1124.

Effect of Time of Spacing on the Growth of Container-Grown *Ilex cornuta* 'Dwarf Burford,' Lindl. and Paxt., and *Pittosporum tobira*, Thumb.[1]

Adolph J. Laiche, Jr.[2]
South Mississippi Branch Experiment Station
Mississippi State University
Poplarville, MS 39470

Abstract

Ilex cornuta 'Dward Burford,' Lindl. and Paxt., and *Pittosporum tobira,* Thumb. liners were transplanted into unspaced (adjacent) black 15.2 cm (6 in) diameter containers and later spaced 30 cm (12 in) apart 0, 30, 61 and 126 days after transplanting. Keeping plants can-to-can (unspaced) significantly reduced growing-media temperatures. Delaying spacing until required by crowding resulted in improved root and shoot growth in *Pittosporum tobira* and to a lesser degree in *Ilex cornuta.*

Index words: temperature, spacing, woody plants, container culture

Introduction

In general, root growth is superior with lower rather than higher soil temperatures (1). Excessive media temperatures often damage plants grown in containers (4, 12, 13). Roots of 5 woody-plant species grown in containers were killed when exposed to 50 °C (122 °F) for 4 hours (15). Daily exposure to 40°-45 °C (133 °F) killed root tips and 35 °C (95 °F) for 6 hours reduced growth of 1 species. Ingram and Buchanan (7) found substantial direct heat injury to roots of woody ornamentals when container media temperatures exceeded 50 °C (122 °F) for 20 minutes, but only minimal injury was observed when temperatures were below 45 °C (113 °F). Woody plants can usually withstand higher media temperatures than citrus (8). Reductions in growing-media temperatures have been attained with light colored containers (2, 3, 5, 13, 14).

Varying media mixtures has had only a slight influence on the media temperature (4, 2). Ingram and Johnson (6) evaluated treatments of row orientation, north-south vs northwest-southeast; plant spacing, 30 and 46 cm (12 and 18 in); and placement pattern, triangular vs rectangular; with azalea in 3 l (#3) black containers. They found that a north-south orientation, 30 cm (12 in) spacing and a triangular placement seemed to be the superior combination for root growth. Ingram and Johnson (9) also found that a growing-media tempera-

[1]Received for publication July 14, 1984; in revised form October 22, 1984. Published with the approval of the Director of the Mississippi Agricultural and Forestry Experiment Station as Scientific Contribution No. 5881.

[2]Horticulturist.

ture of 40 °C (104 °F) for 6 hours daily severely inhibited growth of *Pittosporum tobira*. Brown (3) found that in white containers, which reduced growing-media temperature in full sun, but not in shade, the growth of variegated *Pittosporum tobira* in the sun was comparable to growth obtained in the shade.

The objective of this study was to determine the effects of time of spacing after transplanting in the spring on the subsequent summer and early fall root and shoot growth of *Ilex cornuta* 'Dwarf Burford' and *Pittosporum tobira*.

Materials and Methods

Liners of *Ilex cornuta* 'Dwarf Burford' and *Pittosporum tobira* grown in 7.6 cm (3 in) diameter containers, were transplanted to black 2.8 1 (#3) containers on April 6, 1983 in a growing media pine bark:sand (4:1 v/v) amended with 4.45 kg (7.5 lb) slow release 18N-2.6P-10K (18-6-12), 4.45 kg (7.5 lb) dolomitic limestone, 0.59 kg (1 lb) 0N-9P-0K (0-20-0), 0.59 kg (1 lb) 13N-6P-11K (13-13-13), and 0.07 kg (0.125 lb) Peters trace elements No. 555 per cubic meter. Additional slow release fertilizer was surface-applied on June 23 and on September 23 at the rate of 6.3 g (0.22 oz)/container.

On April 6, 1983 containers were placed as close together as possible (can-to-can in a square pattern) in full sun on a concrete slab. On this same date, control (0 days spaced) plants were spaced in a square pattern in rows oriented north to south 30 cm (12 in) apart. Later the plants placed can-to-can were similarly spaced 30 cm (12 in) apart on May 6, June 6, and August 11. Thus, test plants remained unspaced for 0, 30, 61, and 127 days. An experimental plot consisted of 6 container plants with 2 border rows. Treatments (spacing dates) were replicated 4 times with each specie.

Plants were irrigated as required between 10:30 am and 12:00 noon with an overhead system. Soil thermometers with 20 cm (8 in) stems were inserted to a depth of 11 cm (4.5 in), midway between the liner ball and the south wall of one container/plot in 3 of the 4 replications. Temperatures were recorded hourly from 6:00 am to 6:00 pm on April 15 and from 6:00 am to 7:00 pm on July 26 to ascertain that 7:00 to 7:15 am and 3:45 to 4:00 pm readings would reflect the daily low and high temperature recorded at 4 to 6 week intervals. Overhead irrigation from 10:30 am to 12:00 noon temporarily halted the rise in temperature, but temperature again began to climb at 1:00 pm. Temperatures were recorded at 7:00 to 7:15 am and 3:45 to 4:00 pm Monday through Friday at 4 to 6 week intervals throughout the growing season.

Final data were taken on each plant on November 11, 1983. Plant height was measured from the rim of the container. Plant width was recorded as a mean of 2 width measurements taken perpendicular to one another. Shoot quality and root growth ratings, 10 excellent-0 very poor, are mean ratings of 2 observers. Shoots were cut at the surface of the growing media to obtain fresh weight.

Results and Discussion

Shoot height, width, quality ratings and fresh weight, and root ratings of *Pittosporum tobira* were substantially increased by delaying spacing (Table 1). Shoot and root growth was increased to a lesser degree by delaying spacing of *Ilex cornuta* (Table 1).

Afternoon media temperatures were significantly different between spacing dates in April, May, June and August (Table 2). Morning media temperatures, approximately 3 ° higher than the ambient low temperature, were very similar in both spaced and unspaced plants, although slight statistical differences were obtained in April and June. Afternoon media temperatures of unspaced plants were very similar to ambient high temperatures.

The reduction in media temperature obtained with delayed spacing in the spring resulted in a large increase in shoot height, width, plant quality, shoot fresh weight and root rating in *Pittosporum tobira*—and only a slight increase in *Ilex cornuta* at the end of the growing season in early fall. After spacing, the larger canopy of plants not spaced until August 11 resulted in more shading of the growing media. This resulted in a slight, but nonsignificant, decrease in media temperature.

Laiche (11) found that variegated *Pittosporum* in containers grew well in 55% shade and very poorly in full sun although the cuttings for that test were taken from plants growing in soil in full sun. Delaying spacing

Table 1. Effects of spacing date on the shoot height, width, quality ratings and fresh weight, and root ratings of *Ilex cornuta* and *Pittosporum tobira* in 2.8 liter (#3) containers.

Spacing date	Height (in)	Width (in)	Quality	Fresh wt (g)	Root Eval.[z]
		Ilex cornuta			
April 6	24.0 b	16.8 b	6.4 a	67.0 b	6.0 ab
May 6	23.8 b	19.5 a	6.5 a	68.7 ab	6.3 ab
June 6	23.1 b	19.9 a	6.7 a	72.1 ab	5.9 b
August 11	27.1 a	21.1 a	7.0 a	73.5 a	7.0 a
		Pittosporum tobira			
April 6	19.4 b	19.9 b	5.9 b	84.6 b	5.4 b
May 6	20.7 b	19.5 b	6.1 b	85.9 b	5.6 b
June 6	20.5 b	20.9 b	6.7 b	97.9 b	7.4 a
August 11	24.2 a	25.0 a	7.8 a	127.2 a	8.2 a

[z]Root rating and shoot quality: 10 = excellent, 0 = very poor.

[y]Means of each specie in the same column followed by the same letter or letters are not significantly different at the 5% level using Duncan's Multiple Range Test.

Table 2. Effects of spacing date on container plant growing-medium temperature.

Treatments	Recording period[z]						
Spacing date	4/18-4/22	5/16-5/20	6/13-6/17	7/18-7/22	8/29-9/2	9/26-9/30	10/31-11/4
	degrees fahrenheit						
				7:00-7:15 AM[y]			
April 6	52.0 b[x]	68.7 a	72.7 ab	75.5 a	75.4 a	63.3 a	59.7 a
May 6	*53.5* ab	68.2 a	72.5 ab	75.3 a	74.9 a	62.3 a	59.2 a
June 6	*53.9 a*	*69.4* a	71.9 b	74.7 a	74.9 a	64.3 a	60.6 a
August 11	*53.4 ab*	*69.7 a*	*74.1 a*	*75.9* a	73.7 a	61.7 a	59.1 a
(Ambient low)	(47.1)	(62.4)	(68.5)	(71.2)	(71.1)	(59.0)	(55.8)
				3:45-4:00 PM[y]			
April 6	82.9 a[x]	90.3 a	93.9 a	102.1 a	101.7 a	98.6 a	82.0 a
May 6	*71.0* b	89.1 a	93.3 a	101.2 a	99.5 a	96.3 a	80.2 a
June 6	*71.1 b*	*82.5* b	93.3 a	102.2 a	100.7 a	95.3 a	79.5 a
August 11	*71.1 b*	*82.2 b*	*86.0 b*	*88.5* b	97.9 a	91.9 a	78.0 a
(Ambient high)	(74.1)	(82.0)	(85.8)	(91.6)	(93.2)	(83.1)	(80.8)

[z]Each figure is the mean of the temperatures (°F) recorded for the indicated 5-day period.

[y]Temperatures of *unspaced* containers are in italics for emphasis.

[x]Means in the same column followed by the same letter or letters are not significantly different at the 5% level using Duncan's Multiple Range Test.

resulted in initially cooler container growing media with improved growth of sun-grown *Pittosporum* subsequently spaced 30 cm (12 in) apart. This indicated that with *Pittosporum* the container growing-media temperature requirement rather than light intensity was the primary concern since plants grow well in both sun and shade when the temperature of the media was reduced.

Optimum root growth temperature for most species is 20° to 25 °C (68-77 °F) (10). Holding container plants unspaced results in media temperatures in the range that is more desirable for growth. Spacing, however, becomes necessary when plant canopy begins to overlap, resulting in reduced growth and quality. In this study plant crowding did not occur until early August. Delaying the spacing of liners freshly transplanted in early spring in larger containers for as long as possible resulted in a substantial increase in subsequent summer and early fall root and shoot growth and plant quality with *Pittosporum tobira* and to a lesser extent with *Ilex cornuta* 'Dwarf Burford.'

Significance to the Nursery Industry

Many nurserymen in the South root cuttings of woody landscape plants in the summer and fall, force growth, using a minimum of auxiliary heat, in polyethylene houses during winter to produce liners for spring transplanting into larger containers. In this study holding container plants after transplanting in the spring can-to-can (unspaced) until crowding necessitated spacing, was helpful in obtaining increased growth. The degree of increased growth may vary with species.

Literature Cited

1. Barr, W., and H. Pellett. 1972. Effect of soil temperature on growth and development of some woody plants. J. Amer. Soc. Hort. Sci. 97:632-635.

2. Brown, W.L. 1982. Effects of growing medium composition and container color on temperatures of growing medium and growth of plants. Proc. SNA Res. Conf. 27:75-76.

3. Brown, W.L. 1983. Effects of shading, container color, and growing medium additive on growth of selected plants. Proc. SNA Res. Conf. 28:56-57.

4. Fretz, T.A. 1971. Influence of physical conditions on summer temperatures in nursery containers. HortScience 6:400-401.

5. Ingram, D.L. 1981. Characterization of temperature fluctuations and woody plant growth in white poly bags and conventional black containers. HortScience 16:762-763.

6. Ingram, D.L., and C.R. Johnson. 1981. Influence of orientation, spacing and placement pattern of production containers on 'Formosa' azalea growth. Proc. SNA Res. Conf. 26:20-21.

7. Ingram, D.L., and D.W. Buchanan. 1981. Measurement of direct heat injury of roots of three woody plants. HortScience 16:769-770.

8. Ingram, D.L., and D.W. Buchanan. 1984. Lethal high temperatures for roots of three citrus rootstocks. J. Amer. Soc. Hort. Sci. 109:189-193.

9. Johnson, C.R., and D.L. Ingram. 1983. Influence of container media temperature on growth of *Pittosporum tobira*. Proc. SNA Res. Conf. 28:54-55.

10. Kramer, P.J. 1969. Plant and soil water relationships: a modern synthesis. McGraw-Hill, New York, p. 143.

11. Laiche, A.J. 1979. Effects of light intensity and fertility rate on the growth of variegated *Pittosporum*. Proc. SNA Res. Conf. 28:56-57.

12. Rauch, F.D. 1969. Root zone temperatures studied. Miss. Farm Res. 32(11):7.

13. Self, R.L., and H.S. Ward, Jr. 1956. Effects of high soil temperatures on root growth of loquat seedlings in nursery containers. Plant Dis. Rpt. 40:957-960.

14. Verma, B.P. 1979. Container design for reducing root zone temperature. Proc. SNA Res. Conf. 24:179-182.

15. Wong, T.L., R.W. Harris, and R.E. Fersell. 1971. Influence of high soil temperatures on five woody-plant specie. J. Amer. Soc. Hort. Sci. 96:80-82.