assimilate supply and demand. I. Leaves and roots as limiting regions. J. Expt. Bot. 15:574-583.

Maggs, D.H. 1965. Growth rates in relation to assimilate supply and demand: 11. The effect of particular leaves and growing regions in determining the dry matter distribution in young apple trees. J. Expt. Bot. 16:387-404.

Mullin, R.D. 1966. Root pruning of nursery stock. Forest Chron. 42:256-264.

Randolph, W.S. and C. Wiest. 1981. Relative importance of tractable factors affecting the estab-

lishment of transplanted holly (*Ilex crenata*). J. Amer. Soc. Hort. Sci. 106:207-210.

Richards D. and R.N. Rowe. 1977. Root-shoot interactions in peach: The function of the root. Ann. Bot. 41:1211-1216.

Schupp, J.R. and D.C. Ferree. 1987. Effect of root pruning at different growth stages on growth and fruiting apple trees. HortScience 22(3):387-390.

Schupp, J.R. and D.C. Ferree. 1988. Effects of root pruning at four levels of severity on growth and yield of 'Melrose'/M.26 apple trees. J. Amer.

Soc. Hort. Sci. 113(2):194-198.

Tanaka, Y., J.D. Walsted, and J.E. Borrecco 1976. The effect of wrenching on morphology and field performance of Douglas fir and loblolly pine seedlings. Can. J. For. Res. 6:453-458.

Watson, G.W. and T.D. Sydnor. 1987. The effect of root pruning on the root system of nursery trees. J. Arboricult. 13(5):126-130.

Wilcox, H. 1955. Regeneration of injured root systems of noble fir. Bet. Gaz. 116:221-234.

HORTSCIENCE 25(1):77-79. 1990.

Competitive Effects of Weeds on the Growth of Container-grown Plants

Diana L. Berchielli-Robertson¹, Charles H. Gilliam², and Donna C. Fare³

Department of Horticulture, Alabama Agricultural Experiment Station, Auburn University, AL 36849

Additional index words. *Eclipta alba*, eclipta, *Euphorbia supina*, prostrate spurge, *Oxalis stricta*, yellow wood sorrel, *Rhododendron eriocarpum* 'Gumpo White Sport', gumpo azalea, *R. x 'Fashion'* azalea, *Berberis thunbergii* var. *atropurpurea* 'Crimson Pigmy', crimson pigmy barberry

Abstract. A 2-year study evaluated the effects of three weed species: eclipta [*Eclipta alba* (L.) Hasskarl], prostrate spurge (*Euphorbia supina* Raf.), and wood sorrel (*Oxalis stricta* L.) on growth of container-grown 'Gumpo White Sport' azalea (*Rhododendron eriocarpum*), *R. x 'Fashion'*, and *Berberis thunbergii* DC. var. *atropurpurea* 'Crimson Pigmy'. Competitiveness among weed species as ranked from greatest to least was eclipta, prostrate spurge, and wood sorrel. Greater populations of eclipta and prostrate spurge resulted in decreased shoot dry weight of 'Fashion' and 'Gumpo White Sport' azalea. Prostrate spurge had a similar effect on 'Crimson Pigmy' barberry in both small (3.8-liter) and large (15.2-liter) containers, while eclipta reduced shoot dry weight of barberry only in large containers. Wood sorrel had little effect on shoot dry weight of 'Fashion' and 'Gumpo White Sport' azalea.

Weed competition in agronomic crops is well-documented (Buchanan et al., 1980; Dawson, 1965; Hill and Santlemann, 1969; and Lawson, 1974). Limited research has been done in the area of weed competition in container-grown nursery stock (Fretz, 1972). Wilbourn and Rauch (1972) showed that coffeeweed suppressed growth of pyracantha, Andorra juniper, and Japanese holly, while cocklebur suppressed the two former species. Bittercress had no significant effect on any of the plants. Walker and Williams (1989) reported that *Potentilla fruticosa* L. 'Gold Drop' is very sensitive to weed interference and the grassy weed economic threshold density in these container-grown plants may be < 1. Fretz (1972) reported that one redroot, pigweed or large crabgrass plant

per container reduced the growth of Japanese holly grown in 2.4-liter nursery containers by 47% and 60%, respectively. His data reflect the detrimental effects of weeds in container-grown ornamental production. Limited information is available on weed suppression from troublesome weeds currently infesting container-grown ornamental nurseries. The objective of this study was to evaluate the interference of three pernicious weed species in container-grown ornamental in the southern United States.

On 5-8 Apr. 1985, uniform rooted cuttings of 'Fashion' azalea, 'Gumpo White Sport' azalea, and 'Crimson Pigmy' barberry were planted in 3.8-liter plastic containers (1-year-old plants, small containers) containing a 6 pine bark :1 sand medium (v/v) amended with (all in kg·m⁻³) 3.5 dolomitic limestone, 1.2 gypsum, 1.2 superphosphate, 0.6 AquaGro, 8.3 Osmocote "fast start" (18N-2.5P-10K), and 0.9 Micromax (micronutrients). Seeds of yellow wood sorrel, eclipta, and prostrate spurge were sown on 19 Apr. 1985 into flats containing 1 peat : 1 perlite (v/v) and were placed under a mist system. Weed seed had been collected the

previous season and stored at 4C during the winter. On 2-7 May 1985, weed seedlings were transplanted at the four to eight true-leaf stage (≈ 3.5 cm tall) into the containers with the woody plants. Each weed species was evaluated individually with each ornamental species. Twelve single-pot replicates per treatment were used in a complete randomized block design within each ornamental species. Treatments included weed densities of 0, 1, 3, 6, and 9 weeds per pot for each species. Plants were maintained in a 47% shadehouse (9.74 × 10³ μmol·s⁻¹·m⁻² at 1100 AM), with the exception of 'Crimson Pigmy' barberry, which were in full sun (19.62 × 10³ μmol·s⁻¹·m⁻² at 11:00 AM). Plants were maintained with normal nursery cultural practices. Uniform weed populations within treatments were maintained by hand-weeding. Weeds and ornamental were harvested after 90 days from one-half of the pots within each ornamental species and shoot dry weights were obtained. Growth indices (height + width + width/3) were taken on the remaining plants.

In 1986, the experiment was continued with experimental methods similar to those previously mentioned, with the following exceptions: 7 Apr. 1986, ornamental species were transplanted from the 3.8-liter containers into 15.2-liter containers (2-year-old plants, large containers). Weed seedlings were transplanted 3 weeks later and all plants were maintained in a 47% shadehouse.

Due to similar results with 'Gumpo White Sport' azalea and 'Fashion' azalea, only results from the latter are presented.

Shoot dry weights of 'Fashion' azalea grown in both small (3.8-liter) and large containers (15.2-liter) were significantly suppressed by weed densities of one through nine eclipta per container relative to the weed-free containers (Table 1). A 43% reduction in 'Fashion' azalea shoot growth with one eclipta per pot is similar to the growth reduction reported by Fretz (1972) for one redroot pigweed in Japanese holly. Growth indices of 'Fashion' azalea in small containers demonstrated similar results to those observed with shoot dry weight evaluations (Table 2); however, results for growth indices and shoot dry weights were dissimilar for large containers. In these, plants in high competition situations lacked vigor and were spindly in appearance.

In small containers, shoot dry weight of

Received for publication 2 Sept. 1988. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked advertisement solely to indicate this fact.

¹Graduate Research Assistant.

²Professor.

³Research Associate.

Table 1. Shoot dry weight of 'Fashion' azalea and 'Crimson Pigmy' barberry in 3.8-liter (small) and 15.2-liter (large) containers as influenced by various densities of three weed species.

Weeds/pot	Dry wt											
	Fashion azalea						Crimson Pigmy barberry					
	Eclipta		Prostrate spurge		Wood sorrel		Eclipta		Prostrate spurge		Wood sorrel	
	Small		Large		Small		Large		Small		Large	
0	16.6	90.6	13.8	88.2	20.3	87.5	11.5	85.1	17.1	87.7	12.8	81.3
1	9.5	45.9	18.9	64.1	13.1	75.7	13.9	71.6	13.2	77.9	12.7	80.9
3	7.6	61.7	11.7	72.5	16.7	79.3	12.7	53.4	13.7	59.5	12.1	92.1
6	7.2	57.9	10.9	66.3	14.6	77.1	13.7	46.8	10.1	69.7	13.9	83.5
9	3.7	42.4	9.6	66.7	17.2	73.9	13.7	59.6	10.2	41.3	12.4	78.2
Level of significance												
Linear	**	**	**	NS	NS	NS	NS	*	**	**	NS	NS
Quadratic	NS	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS

NS, *, **Nonsignificant or significant at $P = 0.05$ or 0.01 , respectively.

Table 2. Growth indices of 'Fashion' azalea and 'Crimson Pigmy' barberry in 3.8-liter (small) and 15.2-liter (large) containers as influenced by various densities of three weed species.

Weeds/pot	Growth index (GI)*											
	Fashion azalea						Crimson Pigmy barberry					
	Eclipta		Prostrate spurge		Wood sorrel		Eclipta		Prostrate spurge		Wood sorrel	
	Small		Large		Small		Large		Small		Large	
0	30.9	50.9	30.9	52.8	31.9	54.4	41.8	63.9	40.3	65.9	37.1	67.3
1	23.4	46.6	28.6	52.4	29.2	55.6	36.2	60.5	35.6	63.8	38.5	62.9
3	22.7	47.6	26.2	52.4	29.8	52.4	40.9	53.9	33.6	52.8	41.5	65.7
6	20.3	45.1	25.6	50.3	29.9	55.4	37.4	56.1	33.2	62.2	38.7	64.4
9	19.1	45.5	25.4	48.6	28.7	53.9	36.9	58.1	32.7	53.9	36.1	66.5
Level of significance												
Linear	**	NS	NS	NS	NS	NS	NS	NS	**	*	NS	NS
Quadratic	**	NS	NS	NS	NS	NS	NS	NS	*	NS	*	NS

*GI = growth index as determined by $\text{height} + \text{width}^1 + \text{width}^2 \div 3$. Width¹ is measured at the widest point and width² is measured perpendicular to width¹.

NS, *, **Nonsignificant or significant at $P = 0.05$ or 0.01 , respectively.

Table 3. Weed interference, expressed as shoot dry weight, of 'Fashion' azalea and 'Crimson Pigmy' barberry with various densities of three weed species in 3.8-liter (small) and 15.2-liter (large) containers.

Weeds/pot	Eclipta dry wt (g)				Prostrate spurge dry wt (g)				Wood sorrel dry wt (g)			
	Fashion azalea		Crimson Pigmy barberry		Fashion azalea		Crimson Pigmy barberry		Fashion azalea		Crimson Pigmy barberry	
	Small		Large		Small		Large		Small		Large	
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	28.1	65.8	17.8	29.3	16.4	7.3	11.0	5.6	0.4	0.5	0.9	0.6
3	44.1	96.2	15.1	283.6	31.4	6.4	11.6	43.3	3.2	2.1	2.5	1.5
6	41.3	126.0	11.0	79.1	33.0	36.2	14.0	34.3	2.3	1.5	3.9	1.2
9	43.2	167.9	8.2	39.9	31.7	21.2	15.9	32.3	3.7	3.6	2.6	4.8
Level of significance												
Linear	**	**	NS	NS	**	**	**	**	**	**	**	**
Quadratic	**	NS	NS	**	**	*	**	**	**	NS	**	NS

NS, *, **Nonsignificant or significant at $P = 0.05$ or 0.01 , respectively.

'Fashion' azaleas decreased linearly with increased prostrate spurge populations. When prostrate spurge was allowed to compete with the 'Fashion' azalea plants in large containers, azalea dry weights were unaffected, indicating that increasing container volume diminished the competitive effects of prostrate spurge. This result suggests that weed control in small containers with small plants may be more critical than in larger containers with larger plants. Growth indices for 'Fashion' azalea competing with prostrate spurge correspond with the shoot dry weight data in both small and large containers.

Shoot dry weights of 'Fashion' azalea were

similar among wood sorrel densities in both small and large containers, indicating that wood sorrel is not a strong competitor with 'Fashion' azalea. 'Fashion' azalea growth indices in both small and large containers resulted in trends similar to shoot dry weight evaluations with respect to wood sorrel weed densities.

'Crimson Pigmy' barberry shoot dry weights and growth indices in large containers were not suppressed by eclipta plants (Tables 1 and 2). In contrast, barberry shoot dry weights generally decreased with increasing densities of eclipta in large containers. Growth indices were similar among

varying eclipta densities in both container sizes (Table 2).

In small and large containers, barberry shoot dry weight decreased linearly with increased prostrate spurge numbers (Table 1). Barberry growth indices generally decreased with increasing levels of prostrate spurge in both container sizes (Table 2), corresponding to the shoot dry weight data.

Wood sorrel did not reduce 'Crimson Pigmy' barberry shoot dry weight or growth indices in either year.

This research demonstrated that weeds compete with each other. In small containers, maximum weed dry weights oc-

curred with three eclipta plants per pot, indicating the competitive nature of eclipta (Table 3). Although not compared statistically, eclipta dry weights were higher in large than in small containers, indicating that the size of the 3.8-liter containers may have limited eclipta growth. Consistent weed weights at the three, six, and nine density levels in year 1 support this observation.

Maximum prostrate spurge shoot dry weights occurred with six or nine weeds per pot. Only with 'Crimson Pigmy' in 15.2-liter containers did three spurge per pot result in maximum weed weights. These data suggest that prostrate spurge is not as competitive as eclipta, where maximum weed weights occurred with three weeds per pot.

Maximum wood sorrel shoot dry weights generally occurred with nine weeds per pot (Table 3). These data, coupled with limited

suppression of ornamental growth, demonstrate that wood sorrel is relatively non-competitive. Previous research had also shown bittercress (*Cardamine*) to have limited effects on woody plant growth (Wilbourn and Rauch, 1972).

Weeds and ornamental plants vary in their competitiveness. The results of this study indicate that competition from some weeds, but not all, significantly reduces plant growth of woody plants during container production. With two of the problem weed species in the southeastern United States container nurseries, one weed per container limits woody plant growth.

Literature Cited

Buchanan, G. A., J.E. Street, and R.H. Crowley. 1980. Influence of time of planting and distance

from the cotton row of pitted morningglory, prickly sida, and redroot pigweed on competitiveness with cotton. *Weed Sci.* 28:568-572.

Dawson, J.G. 1965. Competition between irrigated sugar beets and annual weeds. *Weeds* 13:245-249.

Fretz, T.A. 1972. Weed competition in container grown Japanese holly. *HortScience* 7:485-486.

Hill, L.V. and P.W. Santlemann. 1969. Competitive effects of annual weeds in Spanish peanuts. *Weed Sci.* 17:1-2.

Lawson, H.M. 1974. The effects of weeds on fruit and ornamental crops. *Scottish Hort. Res. Inst., Invergowrie, Dundee U.K.* p. 1159-1169.

Walker, K.L. and David J. Williams. 1989. Annual grass interference in container-grown bush cinquefoil (*Potentilla fruticosa*). *Weed Sci.* 37:73-75.

Wilbourn, T.A. and F.D. Rauch. 1972. Weed competition in container grown nursery stock. *HortScience* 7:341. (Abstr.)

HORTSCIENCE 25(1):79-81. 1990.

Growth Regulators Combined with Grafting Increase Flower Number and Seed Production in Sweet Potato

Ricard D. Lardizabal and Paul G. Thompson

Department of Horticulture, P. O. Drawer T, Mississippi State, MS 39762

Additional index words. *Ipomoea batatas*, *Ipomoea carnea* spp. *fistulosa*, BA, 2,4-D, ethephon, GA₃.

Abstract. Four sweet potato [*Ipomoea batatas* (L.) Lam.] cultivars responded differently to growth regulator application for number of flowers produced, percentage capsule set, and number of seeds produced. Gibberellic acid, 2,4-D, and BA application resulted in the highest number of flowers by 'Jewel', 'Shore Gold', and 'Vardaman' plants, respectively. Application of GA₃ to 'Jewel', 2,4-D or ethephon to 'Shore Gold', and BA to 'Vardaman' produced the highest number of seeds. Grafting to rootstock of *Z. carnea* Jacq. spp. *fistulosa* (Mart. ex Choisy) D. Austin increased flower numbers, percentage capsule set, and number of seeds in all cultivars. The effects of growth regulators and grafting were additive for flower numbers, percentage capsule set, and number of seeds. Chemical names used: N-(phenylmethyl)-1H-purin-6-amine (BA), (2,4-dichlorophenoxy) acetic acid (2,4-D), (2-chloroethyl) phosphoric acid (ethephon), and (1 α , 2 β , 4 α , 4 β , 10)-2,4a,7-trihydroxy-1-methyl-8-methylenegibb-3-ene-1,10-dicarboxylic acid 1,4a-lactone (gibberellic acid; GA₃).

Some sweet potato cultivars with desirable characteristics produce few flowers and fruit set is low. 'Jewel' and 'Shore Gold' are two high-performing cultivars that flower sparsely or not at all when grown at Starkville, Miss., but should be valuable parents if hybridizations were possible.

Application of the growth regulators 2,4-D and GA₃ to sweet potato plants has been

reported to increase flower numbers (Howell and Wittwer, 1954, 1955; Suge, 1977). In a preliminary glasshouse study, which included the application of four growth regulators to two cultivars, GA₃ application resulted in the highest flower production by 'Shore Gold' plants (Lardizabal and Thompson, 1988). Flower numbers following ethephon application were lower than with GA₃, but higher than for the control.

Little is known regarding the effect of growth regulators on capsule set in sweet potato. Set was improved in a West Indian breeding line by applying 2,4-D in lanolin to flower pedicels following self-incompatible and cross-incompatible pollinations (Charles et al., 1974); that result indicates

the possibility of increasing capsule set by growth regulator applications.

Flower numbers were also increased by grafting sweet potato to rootstock of different *Ipomoea* spp. (Dukes and Jones, 1981; Folquer, 1961; Folquer and Roncedo, 1974; Kehr et al., 1955; Lam and Cordner, 1955; Lam et al., 1959; Lardizabal and Thompson, 1988; Zobel and Hanna, 1953). *I. carnea* rootstock was considered optimal for flower induction in sweet potato scions because of increased flower numbers, vigor, ease of handling, and disease tolerance (Dukes and Jones, 1981; Folquer, 1961; Folquer and Roncedo, 1974; Kehr et al., 1955). To the best of our knowledge, the effect of grafting on capsule set has not been reported.

We have grafted to *I. carnea* and obtained limited flowering in the low-flowering cultivars Jewel and Shore Gold. However, because of few flowers and low capsule set, few crosses have been possible. This study was the final part of a two-stage experiment to determine methods of increasing flower numbers, capsule set, and seed production. Preliminary glasshouse trials were conducted during the spring season (March-June). Among factors investigated, GA₃ and ethephon in one experiment and grafting to *I. carnea* in a separate experiment increased the number of flowers produced by 'Shore Gold' (Lardizabal and Thompson, 1988). The final part of the study, reported here, was conducted "to compare flowering response to growth regulator application and grafting among seasons and additional cultivars. The specific objectives of the study were to: a) evaluate further the effectiveness of four growth regulators in combination with grafting for increasing flower production, percentage capsule set, and number of seeds produced during the summer; and b) determine if the effects of growth regulator application and grafting to *I. carnea* on flower number, capsule set, and seed production were additive.

Plants were transplanted to field plots at

Received for publication 20 Sept. 1988. Mississippi Agricultural and Forestry Experiment Station Article no. J-7018. The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper therefore must be hereby marked *advertisement* solely to indicate this fact.