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.

Moisture Stress: An Alternative Method of Height Control to B-nine (daminozide)[1]

David R. Brown,[2] D. Joseph Eakes,[3] Bridget K. Behe,[3] and Charles H. Gilliam[4]
Department of Horticulture
Alabama Agricultural Experiment Station
Auburn University, AL 36849

Abstract

Moisture stress was compared to B-nine (daminozide) as a method of height control for annual bedding plant transplants. Three plant species, 'Big Boy' tomato, 'California Wonder' pepper and 'Janie Gold' marigold, were grown in 132 cm^3 (8.05 in^3) cell packs containing one of 2 commercial media, Fafard #3 or Pro-Mix BX. Treatments included moisture stress (MS), 2 concentrations of B-nine (2500 ppm applied twice and 5000 ppm once), and an untreated control. Method of height control and medium type had an interactive influence on height for each of the 3 species. Moisture stress tomato and marigold were shorter in the Fafard #3 medium compared to those in the Pro-Mix BX medium. Regardless of medium, MS tomato and marigold transplants were shorter or similar in size to the most effective B-nine treatment, 2500 ppm applied twice. Moisture stress and the B-nine treatments for pepper plants grown in the Fafard #3 medium reduced plant height similarly compared to the controls. However, when pepper plants were grown in the Pro-Mix BX medium, only B-nine treatments reduced plant height compared to the controls. Treatments producing short plants did not reduce node number, hence plants appeared fuller than treatments with tall plants. Shoot dry weights for MS tomato and marigold were less than those of plants receiving the other height control treatments, regardless of medium type. Plants of all 3 species grown in the Fafard #3 medium had less shoot dry weight than Pro-Mix BX plants across the 4 height control treatments.

Index words: growth regulator, bedding plants, moisture stress, plant height

Growth regulators used in this study: B-nine daminozide, (butanedioic acid mono (2, 2-dimethylhydrazide)).

Species used in this study: 'Big Boy' tomato (*Lycopersicon esculentum* Mill. 'Big Boy'); 'California Wonder' pepper (*Capsicum annuum* L. 'California Wonder'); 'Janie Gold' marigold (*Tagetes erecta* L. 'Janie Gold').

Significance to the Nursery Industry

B-nine (daminozide) was the choice of most bedding plant producers for height control of vegetable transplants until label changes in 1989 restricted its use to non-food crops. Moisture stress may be a viable alternative to the use of B-nine for height control. However, the effectiveness of moisture stress for height control in bedding plant transplants is medium and species dependent. Moisture stress was more effective in controlling plant height of plant species with high water requirements grown in a medium with a low water holding capacity. Practical considerations in the effective use of moisture stress without permanent plant injury include being familiar with the water requirements and wilting response of each plant species to be grown, and knowing the general water holding capacity of the growing medium.

Introduction

When producers market vegetable transplants, they prefer short, compact plants. To achieve the ideal plant size, vegetable transplant producers often used chemical growth regulators. B-nine (daminozide) was the first choice until recent label changes prohibited its use on food crops. This change effectively limited choices of growth regulation and increased the need for economical, effective, and environmentally sound alternatives.

Growing annual plants under low moisture regimes results in shorter plants as compared to those grown with high moisture regimes (1, 6, 12). Several popular articles have suggested the use of moisture stress as an alternative to chemical growth regulators for height control in vegetable transplants (5, 9). Use of moisture stress to control plant height involves withholding water until plants are visibly wilted before rehydration. Although articles advocate the use of moisture stress as a viable alternative to chemical height control, little information is available on how moisture stress compares to the application of growth regulating substances such as B-nine.

Varying medium constituents influence medium physical properties such as pore space and water holding capacity, and consequently plant growth (3, 4, 10, 13, 14). The majority of this work has been aimed at determining the medium components and their ratios that produce soil physical properties for maximum plant yield. Fonteno et al. (7) reported that 'Annette Hegg Diva' poinsettia plants grown in a vermiculite:Canadian sphagnum peat moss medium were taller after 13 weeks than those produced in a composted pine bark:Canadian sphagnum peat moss medium. The latter medium was determined to have less easily available water than the former. In contrast, Beardsell et al. (2) reported that plants grown in a sphagnum peat moss medium wilted more often than plants grown in a pine bark medium despite the sphagnum peat moss mix having a higher water holding capacity than the pine bark medium.

The purpose of this work was to compare moisture stress to B-nine (daminozide) as a method of height control for 3 species of bedding plant transplants in 2 commercial media.

[1]Received for publication April 20, 1992; in revised form September 8, 1992.

[2]Graduate Research Assistant.

[3]Assistant Professors.

[4]Professor.

Materials and Methods

Uniform plugs, at the first or first-pair true-leaf stage, of *Lycopersicon esculentum* Mill. 'Big Boy' (tomato) and *Capsicum annuum* L. 'California Wonder' (pepper), and an ornamental *Tagetes erecta* L. 'Janie Gold' (marigold) were transplanted into cell packs (48 cells/tray) with each cell containing a volume of 132 cm^3 (8.05 in^3). Plants were grown in a polyethylene greenhouse with maximum and minimum temperatures of 34°C (93°F) and 19°C (66°F), respectively. A water soluble 20N-4.4P-16.6K (20-10-20) fertilizer was applied at the concentration of 300 mg N/liter when medium solution electrical conductivity dropped below 0.75 dS/sq.m. Cell packs contained one of 2 commercial media: Fafard #3 (Conrad Fafard, Inc. Springfield, MA), a Canadian sphagnum peat:pine bark based mix or Pro-Mix BX (Premier Brands, Inc., Stanford, CT), a Canadian sphagnum peat:perlite based mix. Treatments for each of the 2 media were: moisture stress (MS), 2 rates of B-nine, and an untreated control. All treatments were initiated one week after transplanting when seedlings were at the third, second-pair and second true-leaf stages for tomato, pepper and marigold, respectively.

Plants receiving MS were allowed to visibly wilt until leaf water potentials reached -1.2 ± 0.3 MPa before being rehydrated (irrigated). The actual duration of each wilt cycle varied depending on evapotranspirative water loss due to greenhouse environmental conditions (i.e. bright, sunny days vs. cloudy, overcast days) and plant size. The time between the initial observation of plant wilt until rehydration was a minimum of 8 hours and a maximum of 48 hours. Plants were monitored carefully during the first wilt cycle to prevent foliar damage from excessive moisture stress to the young seedlings. Plants in the remaining treatments received irrigation to maintain a moist medium surface throughout the study. B-nine treatments were applied at concentrations of 2500 and 5000 ppm until drip with a low pressure, hand-held squeeze-type sprayer. The 2500 ppm B-nine treatment was applied again 3 weeks after the first application. Five weeks after height control treatments were initiated, plant height and node number were determined. Shoots were then harvested to determine dry weights.

Chemical analysis of each medium prior to planting was determined using the Spurway Method (15). Medium pH, electrical conductance, P_2O_5, K_2O, Ca and cation exchange capacity were found to be similar for both media (data not shown). Therefore, differences at the end of the study were not due to the initial chemical properties of the 2 commercial media. Physical properties were also determined for the 2 media prior to planting using procedures adopted from work by Gessert (8) and Whitcomb (16).

This experiment was conducted twice with treatments initiated on September 7, 1989 and May 15, 1990. The experimental design for each experiment was a randomized complete block design of 8 treatments (factorial of 4 height control measures $\times$ 2 media) with 6 blocks. In the first experiment there were 3 plants per experimental unit and the number of plants per experimental unit was increased to 6 in the second experiment. Treatment differences for the 2 experiments were similar, so only results from the second experiment are presented. All data were subjected to analysis of variance (ANOVA) and mean separations were by Fisher's Least Significant Difference (LSD, $\alpha = 0.05$) procedure.

Results and Discussion

Moisture stressed tomato plants grown in the Fafard #3 mix were 12 and 28% shorter in height compared to the best B-nine treatment of 2500 ppm applied twice and the untreated control plants, respectively (Table 1). In contrast, when grown in Pro-Mix BX, both MS and B-nine applied twice at the 2500 ppm concentration resulted in shorter plants compared to the 5000 ppm B-nine application and the untreated control plants. Latimer (11) has reported 30% shorter transplants of 'Early Dawn' broccoli and 'Conquest' cabbage when exposed to non-lethal moisture stress compared to well watered controls.

Table 1. Plant height for three species of annual transplants as influenced by height control method and commercial medium type.

Height control method (HC)	Medium type (MT)	Plant height (cm)[z] 'Big Boy' tomato	'California Wonder' pepper	'Janie Gold' marigold
Moisture Stress	Fafard #3	28.7	18.6	17.5
B-nine$_1$[y]	"	32.7	17.5	21.6
B-nine$_2$[x]	"	37.8	18.9	23.1
Control	"	39.7	22.1	25.0
Moisture Stress	Pro-Mix BX	33.6	21.6	20.6
B-nine$_1$	"	33.5	18.3	22.7
B-nine$_2$	"	38.3	20.4	24.0
Control	"	39.6	22.1	25.0
Significance[w]				
LSD ($\alpha = 0.05$)		1.3	1.2	1.8
HC		**	**	**
MT		**	**	**
HC * MT		**	**	*

[z]Plant heights were measured five weeks after initiation of height control treatments. Treatments were initiated when plants were at the third, second pair and second true leaf stages for tomato, pepper and marigold, respectively.

[y]2500 ppm B-nine applied twice; the second application was three weeks after the first.

[x]5000 ppm B-nine applied once.

[w]* and ** represent significant at the 5 and 1% levels by F-test, respectively.

For pepper plants grown in the Fafard #3 mix, no height control treatment was better than the others, but all treatments resulted in shorter plants than the untreated controls (Table 1). Plants in either the MS or 5000 ppm B-nine treatments were about 15% shorter than the controls, while the 2500 ppm B-nine applied twice plants were 21% shorter than the controls. When grown in the Pro-Mix BX medium, the MS treatment had no influence on pepper height in comparison with untreated control plants. Only the B-nine treated pepper plants were shorter than the control plants when grown in Pro-Mix BX.

Moisture stressed marigold plants grown in the Fafard #3 were 19% shorter than plants in the best B-nine treatment of 2500 ppm applied twice (Table 1). Moisture stress resulted in plants 30% shorter than the untreated controls. Moisture stressed marigold plants grown in the Pro-Mix BX medium were 9% shorter than the best B-nine treatment of 2500 ppm applied twice and were 18% shorter when compared to the control plants. Shorter plant heights also have been reported for 2 bedding plants, 'Coral Sea' petunia (1) and 'Bonfire' salvia (6), when plants were exposed to MS compared to well watered controls during production. Marigold was the only plant species in our study that demonstrated more height control with MS compared to chemical height control measures when plants were grown in the Pro-Mix BX medium.

For all 3 species of annual transplants, the number of nodes per plant was not affected by height control method or medium type (data not shown). Therefore, short plants appeared to have fuller canopies than tall plants in treatments that had no effect on plant height. Eakes et al. (6) have also reported a fuller appearance for MS 'Bonfire' salvia plants when compared to well watered control plants during production.

No interactions between height control method and medium type were detected for shoot dry weights of the 3 species in this test (Table 2). Moisture stress plants had the lowest shoot dry weights compared to plants in the other height control methods for tomato and marigold. Shoot dry weights were 22 and 27% less for MS plants compared to untreated controls for tomato and marigold, respectively. Lower shoot dry weights for plants produced using MS compared to well watered controls have also been reported for 'Coral Sea' petunia (1) and 'Bonfire' salvia (6). Regardless of height control treatment, tomato and marigold plants grown in the Fafard #3 medium had shoot dry weights that were 14 and 11% less than plants grown in the Pro-Mix BX medium, respectively (Table 2).

Unlike tomato and marigold in this study, pepper shoot dry weight was not affected by height control treatment (Table 2). Mean shoot dry weight over the 4 height control treatments was 5.2 g per plant. However, as with tomato and marigold, plant dry weight for pepper was influenced by medium type. Pepper plants grown in the Fafard #3 medium produced 13% less shoot dry weight than those grown in the Pro-Mix BX medium.

Differences in how height control treatments influenced plant growth were probably due to the Fafard #3 medium consistently drying out faster than the Pro-Mix BX medium. Approximate water holding capacities for the 2 media were 32 and 61% for the Fafard #3 and Pro-Mix BX mixes, respectively. Consequently, MS plants grown in the Fafard #3 medium wilted sooner than plants grown in Pro-Mix BX for all 3 species. This is in contrast to work by Beardsell et al. (2), who reported plants grown in a sphagnum peat moss medium wilted faster than those grown in a bark based medium. The number of wilt cycles (times the plants wilted) over the 5 week study were recorded for each species in both media, resulting in 7 wilt cycles for tomato and marigold in the Fafard #3 and 6 wilts for each in the Pro-Mix BX. Pepper plants took longer to wilt during MS wilt cycles than did tomatoes or marigolds, regardless of medium type. The number of wilt cycles for pepper during the test resulted in 4 wilt cycles in the Fafard #3 mix and 3 wilt cycles in the Pro-Mix BX medium. This may explain why MS was less effective in reducing plant height of pepper compared to the other plant species used in these studies.

Results from these studies indicate that the use of moisture stress can produce annual transplants of a similar quality to those produced with B-nine. Effectiveness of moisture stress for height control in bedding plants appears to be medium and species dependent. Moisture stress had a greater influence on controlling plant height for plants with high water requirements grown in a medium with a low water holding capacity.

Table 2. Shoot dry weight for three species of annual transplants as influenced by height control method and commercial medium type.

Treatment	Shoot dry weight (g)[z]		
	'Big Boy' tomato	'California Wonder' pepper	'Janie-Gold' marigold
Height control method (HC)			
Moisture stress	8.0	5.1	5.7
B-nine$_1$[y]	9.1	5.2	8.2
B-nine$_2$[x]	9.5	5.2	8.0
Control	10.3	5.4	7.8
LSD (α = 0.05)	1.1	0.6	1.2
Medium type (MT)			
Fafard #3	8.5	4.9	7.0
Pro-Mix BX	9.9	5.6	7.9
Significance[w]			
HC	**	NS	**
MT	**	**	*
HC * MT	NS	NS	NS

[z]Shoot dry weights were determined five weeks after initiation of height control treatments. Treatments were initiated when plants were at the third, second pair and second true leaf stages for tomato, pepper and marigold, respectively.

[y]2500 ppm B-nine applied twice; the second application was three weeks after the first.

[x]5000 ppm B-nine applied once.

[w]NS, * and ** represent nonsignificant and significant at the 5 and 1% levels by F-test, respectively.

Literature Cited

1. Armitage, A.M. and T. Kowalski. 1983. Effect of irrigation frequency during greenhouse production on the postproduction quality of *Petunia hybrida* Vilm. J. Amer. Soc. Hort. Sci. 108:118–121.

2. Beardsell, D.V., D.G. Nichols, and D.L. Jones. 1979. Water relations of nursery potting media. Sci. Hort. 11:9–17.

3. Bilderback, T.E. 1985. Physical properties of pine bark and hardwood bark media and their effects with 4 fertilizers on growth of *Ilex* × 'Nellie R. Stevens' holly. J. Environ. Hort. 3:181–185.

4. Bilderback, T.E., W.C. Fonteno, and D.R. Johnson. 1982. Physical properties of media composed of peanut hulls, pine bark, and peatmoss and their effects on azalea growth. J. Amer. Soc. Hort. Sci. 107:522–525.

5. Carlson, W. 1990. Height control in vegetable transplants. Greenhouse Grower. 8(2):16–17.

6. Eakes, D.J., R.D. Wright, and J.R. Seiler. 1991. Moisture stress conditioning effects on *Salvia splendens* 'Bonfire'. J. Amer. Soc. Hort. Sci. 116:716–719.

7. Fonteno, W.C., D.K. Cassel, and R.A. Larson. 1981. Physical properties of three container media and their effect on poinsettia growth. J. Amer. Soc. Hort. Sci. 106:736–741.

8. Gessert, G. 1976. Measuring air space and water holding capacity. Ornamentals Northwest. 3:59–60.

9. Hammer, P.A. 1990. Do not spray any chemical growth retardants on vegetable transplants this year. GrowerTalks. 53(11):80.

10. Karlovich, P.T. and W.C. Fonteno. 1986. Effect of soil moisture tension and soil water content on the growth of chrysanthemum in 3 container media. J. Amer. Soc. Hort. Sci. 111:191–195.

11. Latimer, J. 1991. Give transplants the brush. Greenhouse Grower. 9(11):68–70.

12. Rasmussen, O.S. 1976. Water stress in plants I. Abscisic acid level in tomato leaves after a long period of wilting. Physiol. Plant. 36:208–212.

13. Spomer, L.A. and R.W. Langhans. 1975. The growth of greenhouse bench *Chrysanthemum morifolium* Ratam. at high soil water contents: effects of soil water and aeration. Comm. Soil Sci. Plant Anal. 6:545–554.

14. Tilt, K.M., T.E. Bilderback, and W.C. Fonteno. 1987. Particle size effects on growth of three ornamental species. J. Amer. Soc. Hort. Sci. 112:981–984.

15. Warncke, D.D. 1986. Analyzing greenhouse growth media by the saturation exraction method. HortScience. 21:223–225.

16. Whitcomb, C.E. 1979. Plants, pots and drainage. Ornamentals South. 1(4):16–19.

Resistance of Selected Rose Cultivars to Variants of *Marssonina rosae* in Mississippi[1]

James A. Spencer and Opal W. Wood[2]
Department of Plant Pathology and Weed Science
Mississippi Agricultural and Forestry Experiment Station
P.O. Drawer PG
Mississippi State, MS 39762

Abstract

Seven isolates of *Marssonina rosae* (imperfect stage of *Diplocarpon rosae*) exhibited differences in colony color on potato-dextrose agar and in conidial measurements. Four of the isolates selected for pathogenicity tests differed in virulence when inoculated to 76 selected rose cultivars. The Chickasaw variant was the least virulent and the Oktibbeha variant was the most virulent. Cultivars 'Brandy', 'Choo Choo Centennial', and 'First Prize', showed resistance to all variants. 'Coral Destiny', 'Golden Masterpiece', 'Goldilocks', 'Jennifer Hart', and 'Spartan' showed resistance to three variants. Forty-two cultivars showed susceptibility to all variants tested.

Index words: *Diplocarpon rosae*, blackspot, Rose

Significance to the Nursery Industry

Blackspot, the most important disease of landscape roses world wide, is caused by *Marssonina rosae* (*Diplocarpon rosae*). Most modern rose cultivars demonstrate little or no resistance to blackspot and many cultivars that are reported to be resistant are in fact susceptible when exposed to different variants of the pathogen under varying environmental conditions. This study describes variations in conidia size, colony color, and pathogenicity, which were found in isolates of *M. rosae* from different counties in Mississippi. Four *M. rosae* isolates were selected for pathogenicity tests on 76 selected landscape rose cultivars.

[1]Received for publication March 16, 1992; in revised form September 14, 1992. Published as Mississippi Agricultural and Forestry Experiment Station Journal Series No. ———.

[2]Professor and Laboratory Assistant, respectively.

Introduction

Blackspot is the most important rose disease worldwide. Previous reports (2, 4, 8) firmly documented differential pathogenicity of *Marssonina rosae* (Lib.) Lind (imperfect stage of *Diplocarpon rosae* Wolf) isolates to various species and cultivars of roses. Other reports (1, 3, 5) report different plant response to a single isolate.

Blackspot is particularly destructive in Mississippi and other regions where favorable temperature and moisture conditions for leaf infection exist for extended periods of the year. This is especially significant in Mississippi, since roses are grown at 75% of the home units (personal communication, Robert Haygood). There is some commercial rose production in the state and many rose fanciers face difficulties effecting blackspot control since it is apparently impossible to purchase modern plants with known resistance. We established a Disease Research Rose Garden (through encouragement by University Patrons) that would