6. Ball, V. 1991. Bedding plants for the 1990's. pp. 348–390. In: Ball Redbook 15th Ed. Geo. J. Ball Publishing, West Chicago, Ill.

7. Burdett, A.N. and P.A. Martin. 1982. Chemical root pruning of coniferous seedlings. HortScience 17:622–624.

8. Case, G.N. and M.A. Arnold. 1992. Cupric hydroxide-treated containers decrease pot-binding of five species of vigorously rooted greenhouse crops. Proc. Southern Nurserymen's Assoc. Res. Conf. 37:94–98.

9. Flanagan, P.C. and W.T. Witte. 1991. Effects of chemical root pruning on root regeneration and cellular structure of viburnum root tips. Proc. Southern Nurserymen's Assoc. Res. Conf. 36:46–59.

10. Latimer, J.G. 1991. Container size and shape influence growth and landscape performance of marigold seedlings. HortScience 26:124–126.

11. McDonald, S.E., R.W. Tinus, and C.P.P. Reid. 1984. Modification of ponderosa pine root systems in containers. J. Environ. Hort. 2:1–5.

12. Preisig, C.L., W.C. Carlson, and L.C. Promnitz. 1979. Comparative root system morphologies of seeded-in-place, bareroot, and containerized douglas-fir seedlings after outplanting. Can. J. For. Res. 9:399–405.

13. Romero, A.E., J. Ryder J.T. Fisher, and J.G. Mexal. 1986. Root system modification of container stock for arid land plantings. For. Ecology and Management. 16:281–290.

14. SAS Institute Inc. 1985. SAS User's Guide: Statistics, Version 5 Edition. SAS Institute Inc., Cary, NC. p. 956.

15. Ticknor, R.L. 1989. Production of forsythia plants for forcing. Proc. Intern. Plant Prop. Soc. 39:115–118.

16. Wenny, D.L., Y. Liu, R.K. Dumroese, and H.L. Osborne. 1988. First year field growth of chemically root pruned containerized seedlings. New Forests 2:111–118.

17. Wenny, D.L. and R.L. Woollen. 1989. Chemical root pruning improves the root system morphology of containerized seedlings. Western J. of Applied Forestry 4:15–17.

Trends in Plant Material Requirements of Landscape Architects[1]

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Abstract

Landscape architects influence the demand for plant material when specifying plants for landscape projects. A survey of landscape architects in Georgia identified the value of plant material specified for nine plant-types: deciduous trees (> 3" caliper), deciduous trees ≤ 3" caliper), evergreen trees, coniferous shrubs, broadleaf shrubs, perennials/groundcovers, native herbaceous, bedding plants, and turf. As a plant category, trees represented the largest proportion of plant material, approximately 50% of the total value for all firms. With the exception of turf, landscape architects are expected to specify the same or greater value of plant material over the next five years, a positive economic sign for the nursery industry. The frequency of plant substitution due to lack of availability was greatest for the five plant-types generally produced as container nursery stock in Georgia; coniferous shrubs, broadleaf shrubs, perennials/ground covers, native herbaceous, and bedding plants. The two trends identified by landscape architects as most likely to affect the type of plants specified over the next five years are water availability and need for low maintenance landscapes.

Index words: market research, ornamentals, landscape trends, nursery crops, xeriscape

Significance to the Nursery Industry

This study was conducted to determine the current and future plant specification plans of landscape architects. The study identifies the current mix of plant material utilized by landscape architects as represented by the value of nine categories of plants. The anticipated demand for each of the nine categories and landscape trends that could affect the type of plants specified are also identified. The information in this study could be utilized by the industry to make business decisions including, (1) the quantity of deciduous trees versus evergreen trees in the product mix, (2) production procedure(s) for supply of trees, (3) decisions on specific plant cultivars to delete or add to the product mix based on the identified trends and projected demand for the nine plant-types and, (4) groupings of plants for garden center display and promotion to consumers that relate to the identified landscape trends.

Introduction

Landscape architects play an important role in selecting plant material for the landscape industry. They influence which plant varieties are used in the landscape and usually initiate demand for plant material since they specify plant types prior to purchase by landscape contractors (1, 2, 3). In addition, approximately 60% of the landscape architectural firms determine or recommend the production nursery where landscape contractors obtain plants (4, 5). The implication is that landscape architects not only influence demand for specific plants but also influence sales of specific nurseries.

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These results suggest that landscape architects are viable targets for marketing programs of plant producers and potentially valuable sources of information on plant material trends.

In this study types of plant material specified by landscape architectural firms of different sizes was analyzed. Predictions of plant material requirements and trends for the next five years were also analyzed. With a relatively long production time for nursery crops, plant producers could benefit from sources of information on future demand, and landscape architects appear to be a good source of information. Information of plant material trends and potential demand in the five-year horizon could put plant producers in a position to either respond with product line changes or to influence the selection of specific cultivars by landscape architects. Such information could also provide guidance for plant introduction programs.

Recent literature in the landscape design field emphasizes natural landscapes which use local or native plants (6, 8, 9). There is an interest to replicate or maintain local vegetative communities. Such trends could affect the quantity and type of plants required in future landscapes.

The specific questions were intended to gather information related to: (1) the relative values of each of nine plant-groupings that encompassed the spectrum of plants used for landscaping, (2) the preferred root containment system for trees, (3) frequency of substitution required in each of the nine plant-groups, because of nonavailability, (4) forecasted need for plant material over the next five years, relative to current levels of use and, (5) trends that could affect the specific plants utilized over the next five years.

Materials and Methods

The survey instrument (Table 1) was mailed to registered landscape architects in Georgia who were members of the American Society of Landscape Architects (ASLA), representing 168 landscape architectural firms. The firms surveyed were listed in the American Society of Landscape Architects, 1991 IN PRACTICE listing of private landscape architectural firms, government agencies, and academic institutions. The survey questionnaire contained a cover letter cosigned by the senior author and the Marketing Manager of ASLA highlighting the goals of the survey. The initial mailing was sent in May, 1991, with a follow-up mailing to nonrespondents in June, 1991. We received completed forms from 62 firms for a 37% response rate. Data were tabulated and analysis of response conducted using PROC FREQ and PROC GLM of SAS (7). For the open-end question, categories of response were developed after a review of all comments. The specific comments were then coded for the appropriate category and frequency of response analyzed by category.

The survey instrument was pre-tested with landscape architects, landscape contractors, growers (container and field production), and university personnel. Particular attention was paid to the nine plant-groups to ensure that they encompassed the spectrum of plants used in commercial landscapes. The five-year horizon was viewed by all groups as appropriate to allow production planning (grower perspective) and an accurate projection of demand and landscape trends (landscape architect perspective). The "final" version was then tested with several landscape architects not involved in development of the survey prior to the survey of all ASLA members. The data were analyzed for all firms, as a group, and by size of firm (small, medium, large). The data for "all firms" provides an analysis for the population of landscape architectural firms in Georgia. The analysis by size of firm segments the market based on the value of plant material specified. Market segmentation provides greater insight into the plans of landscape architects and allows growers to target specific needs for each class of firm. For analysis of question 4, "often" and "very often" were combined as "often". For question 5, "much less" and "little less" were combined as "less" and, "little more" and "much more" were combined as "more".

Results and Discussion

Landscape architects were asked to prorate total expenditures among nine plant-groups encompassing the array of plant material specified for landscape projects (Table 1—questions I and 2). The mean value of plants specified by Georgia landscape architects (Table 2, all firms) ranged from $91,000 for large deciduous trees (19% of all plants specified) to $12, 100 for native herbaceous (3% of all plants specified). The value of plant material specified, within each plant-group, varied significantly with the size of the landscape architectural firm. The value of each of the nine plant-groups specified by large firms was significantly greater than that of small or medium firms (Table 2). The value of plants specified by medium firms was significantly higher than that of small firms for small deciduous trees, evergreen trees, broadleaf shrubs, and perennials/ground covers. The mean percentage of plant value for the three firm sizes, within each plant-group, did not vary significantly (data not shown). This suggests that the mix of plant-groups used in the landscape is constant across all size firms.

The largest category of plants specified by landscape architects, in terms of dollar value, was the landscape trees, constituting approximately 50% of the value of all plants specified (Table 2). The value of deciduous trees was approximately 75% of all trees and equally divided between small and large trees. The large firms accounted for approximately 80% of the value of all trees specified.

The five plant-groups normally grown by container ornamental nurseries in Georgia constituted about 37% of the value of all plants specified. Within these five groups, broadleaf shrubs were about 47% of the value of nursery stock, followed by perennials/ground covers (24%), coniferous shrubs (11%), bedding plants (11%), and native herbaceous (7%). The large firms accounted for 72% of the value of nursery stock specified.

Turf (sod) accounted for 14% of the value of plant material specified. Large firms specified 78% of the turf value. Landscape architects were asked if they had a preference regarding the method used by growers to produce and supply trees (Table l—question 3). If they had a preference, they were requested to select among the three commercial systems for producing and shipping trees, ball-and-burlap, container, and grow-bag. Eighty-seven percent of all firms surveyed had a preference for the method of production, with no differences in the response between size of firms (Table 3). The most preferred method was ball-and-burlap, followed by container and grow-bag. Landscape architects were about as strong in their praise of the ball-and-burlap

Table 1. Survey Questions Discussed in this Study.

(1) Estimated wholesale value of plant material purchased or specified in 1990? _____

(2) For 1990, what percentage of the value of plants purchased or specified were in the following categories?

	$ (should total 100%)
Deciduous Trees (> 3" caliper)	_____
Deciduous Trees (≤ 3" caliper)	_____
Evergreen Trees (broadleaf and coniferous)	_____
Coniferous Shrubs	_____
Broadleaf Shrubs (evergreen and deciduous)	_____
Perennials/Grounds Covers (Hosta, Liriope, Ivy, etc.)	_____
Native Herbaceous (ferns, wildflowers, grasses, etc.)	_____
Bedding Plants (Annuals)	_____
Turf (sod)	_____

(3) When specifying 2"–4" shade trees, do you have any preference as to whether the tree is supplied as ball-and-burlap, grow bag, or container?
Yes ____ No ____ If yes, please rank your preference:
1 = Most Preferred
Ball & Burlap ____ Grow Bag ____ Container ____

(4) For each of the following categories, how often do you have to substitute plants because of availability:

	Very Infrequent/Never	Sometimes	Often	Very Often
Deciduous Trees (> 3" caliper)	1	2	3	4
Deciduous Trees (≤ 3" caliper)	1	2	3	4
Evergreen Trees (broadleaf and coniferous)	1	2	3	4
Coniferous Shrubs	1	2	3	4
Broadleaf Shrubs (evergreen and deciduous)	1	2	3	4
Perennials/Ground Covers (Hosta, Liriope, Ivy, etc.)	1	2	3	4
Native Herbaceous (ferns, wildflowers, grasses, etc.)	1	2	3	4
Bedding Plants (Annuals)	1	2	3	4
Turf (sod)	1	2	3	4

(5) For the following category of plants, please forecast your needs over the next five years:

	Much Less	Little Less	About Same	Little More	Much More
Deciduous Trees (> 3" caliper)	1	2	3	4	5
Deciduous Trees (≤ 3" caliper)	1	2	3	4	5
Evergreen Trees (broadleaf and coniferous)	1	2	3	4	5
Coniferous Shrubs	1	2	3	4	5
Broadleaf Shrubs (evergreen and deciduous)	1	2	3	4	5
Perennials/Ground Covers (Hosta, Liriope, Ivy, etc.)	1	2	3	4	5
Native Herbaceous (ferns, wildflowers, grasses, etc.)	1	2	3	4	5
Bedding Plants (Annuals)	1	2	3	4	5
Turf (sod)	1	2	3	4	5

(6) What do you see as major trends that will change the type of plants you specify over the next 5 years?
(Please list up to 3 in order of importance)
(1) _____
(2) _____
(3) _____

system as their dislike for the grow-bag. Several respondents that rated the ball-and-burlap and container systems, as first and second preference, added written comments indicating they would reverse their preference during the hot dry summer months. They had experienced better survival with container trees during the summer.

Landscape architects have often expressed frustration over the frequency of substitution required due to lack of availability of plants (2). In this survey, landscape architects were asked to indicate the frequency of substitution required for each of the nine plant-types (Table 1—question 4). The frequency of substitution did not differ significantly among size of firms except for the large (> 3" caliper) deciduous trees (Table 4). For this category of plants the large firms indicated a higher degree of substitution than did small and medium firms. The most frequently substituted plants, based on the percent response in the "often" category, were broadleaf shrubs, coniferous shrubs, native herbaceous, bedding plants, and perennials/groundcovers. These plants comprise the "nursery stock" category. Perhaps this segment of the nursery industry could increase their efforts to better inform landscape architects regarding varieties, sizes, and quantities, of available plants. The lowest frequency of substitution was recorded for the turf (sod) category.

To assist plant producers with production planning, landscape architects were asked to project their needs for each of the nine plant-groups, over the next five years (Table 1—question 5). For two types of plants, coniferous shrubs and turf, the predicted need varied significantly with the size of the firm (Table 5). For coniferous shrubs and turf, the large

Table 2. Value of plant material specified by landscape architects (Tabel 1—questions 1 and 2).

	Firm size[z]								
	Small		Medium		Large			All firms	
	Mean ($)	Total (%)	Mean ($)	Total (%)	Mean ($)	Total (%)	Effect	Mean ($)	Total (%)
	$ Value (in $1000)								
Turf	11.7 b[y]	17	52.4 b	13	224.3 a	15	***[x]	68.0	14
Trees									
Deciduous trees (> 3" caliper)	5.6 b	8	61.6 b	15	339.4 a	22	**	91.0	19
Deciduous trees (≤ 3" caliper)	11.5 c	17	60.4 b	15	299.8 a	19	**	85.5	18
Evergreen trees	7.5 c	11	59.2 b	15	177.0 a	11	**	59.7	12
All trees	24.6 c	36	181.3 b	45	816.1 a	52	**	236.2	49
Other Landscape plants									
Coniferous shrubs	6.1 b	9	20.6 b	5	51.3 a	3	**	20.3	4
Broadleaf shrubs	15.7 c	22	76.7 b	19	251.4 a	16	**	84.2	17
Perennials/ground covers	6.0 c	9	43.1 b	11	128.4 a	8	**	43.7	9
Native herbaceous	2.8 b	4	11.0 b	3	35.1 a	2	**	12.1	3
Bedding plants	1.8 b	3	17.2 b	4	58.7 a	4	**	18.6	4
All nursery stock	32.4 c	47	168.6 b	42	524.9 a	33	**	178.9	37
All plants	68.8 c	100	402.4 b	100	1565.3 a	100	**	483.1	100

[z]Based on annual wholesale value of plants specified; small (<$200K), medium ($200K–$999K), large (≥$1M).

[y]Firm size means, within a row, followed by different letters differ ($p < 0.01$).

[x]***$p < 0.01$

Table 3. Preference of landscape architects for the manner in which trees are supplied (Table 1—question 3).

			Preference ranking[y]								
	Preference		Ball and burlap			Container			Grow bag		
Firm Size	Y	N	1	2	3	1	2	3	1	2	3
	Percent response										
Small	88	12	63	32	5	40	50	10	6	11	83
Medium	90	10	84	11	5	19	75	6	0	12	88
Large	83	17	73	18	9	30	70	0	0	10	90
	Chi-square (2 d.f.)[z] = 0.83		Chi-square (4 d.f.) =2.9			Chi-square (4 d.f.) = 3.3			Chi-square (4 d.f.) = 1.5		
All firms	87	13	73	21	6	32	60	8	2	13	85

[y]Preference ranking = 1 most preferred; 3 least preferred.

[z]Chi-square values with 2 or 4 degrees of freedom (d.f.) were not significant ($p > 0.05$).

firms project a lower level of need, compared to small and medium firms. Predicted need for "more" plants was highest for native herbaceous, perennials/ground covers, large deciduous trees, small deciduous trees, and evergreen trees. With the exception of turf use by medium and large firms, use of the "same" or "more" plants over the next five years was indicated by a majority of the firms.

Landscape architects were asked (Table 1—question 5) to identify trends that could change the plants specified over the next five years. The results are summarized in Table 6. This information could help explain the relative difference in projected need for the different plant-types, and help growers select specific cultivars and market current inventory. Landscape architects were asked to identify up to three trends that would affect their selection of plants. They ranked them by order of importance (1 = more important; 3 = less important). The responses did not vary by size of firm and data is shown for all firms combined. The seven trends included water availability, low maintenance landscapes, more color, minimal pesticide use, smaller areas to landscape, concerns of environmental movement, and more/larger trees.

Over 50% of the respondents listed water availability as the most important issue that could affect the type of plants specified. In fact, 91% of the firms listed water availability as first or second in importance. Comments by respondents indicated a strong concern over total water availability and the likelihood of water interruptions. The comments suggest that future landscapes should require less water and be able to survive periods of no water.

The trend toward lower maintenance landscapes was identified by 75% of the respondents, with 18.7% listing it as the most important trend. Specific comments were related to lower costs for replacement of plant material, such as fewer

Table 4. Frequency of plant substitution (% response) required due to lack of availability (Table 1–question 4).

Firm size	Never	Some	Often	Never	Some	Often	Never	Some	Often
	Deciduous trees (> 3" caliper)			Deciduous trees (3" ≤ caliper)			Evergreen trees		
Small	27	61	12	28	69	3	35	55	10
Medium	33	48	19	52	43	5	28	67	5
Large	0	45	55	18	73	9	9	82	9
	Chi-square (4 d.f.) = 10.6[z]			Chi-square (4 d.f.) = 5.4			Chi-square (4 d.f.) = 3.2		
	Coniferous shrubs			Broadleaf shrubs			Perennials/Ground covers		
Small	48	12	40	33	22	44	44	37	18
Medium	45	15	19	24	62	14	57	33	10
Large	64	36	0	33	42	25	58	25	17
	Chi-square (4 d.f.) = 2.1			Chi-square (4 d.f.) = 1.9			Chi-square (4 d.f.) = 1.5		
	Native herbaceous			Bedding plants			Turf		
Small	38	38	23	36	46	18	69	23	7
Medium	40	30	30	45	40	15	86	14	0
Large	42	33	25	42	33	25	83	17	0
	Chi-square (4 d.f.) = 0.5			Chi-square (4 d.f.) = 1.0			Chi-square (4 d.f.) = 3.5		

[z]$P < 0.05$, no other chi-square was significant at the 0.05 probability level.

Table 5. Percent response for predicted need of plant material during the next five years (Table 1—question 5).

Firm size	Less	Same	More	Less	Same	More	Less	Same	More
	Deciduous trees (> 3" caliper)			Deciduous trees (3" ≤ caliper)			Evergreen trees		
Small	24	40	36	8	46	46	4	65	31
Medium	5	57	38	0	67	33	0	71	29
Large	0	42	58	8	50	42	8	58	34
	Chi-square (4 d.f.) = 7.2			Chi-square (4 d.f.) = 3.1			Chi-square (4 d.f.) = 1.8		
	Coniferous shrubs			Broadleaf shrubs			Perennials/Ground covers		
Small	4	75	21	0	76	24	0	40	60
Medium	5	67	28	0	67	33	5	52	43
Large	42	58	0	17	58	25	0	33	67
	Chi-square (4 d.f.) = 14.3			Chi-square (4 d.f.) = 8.4			Chi-square (4 d.f.) = 3.5		
	Native herbaceous			Bedding plants			Turf		
Small	4	32	64	16	52	32	28	44	28
Medium	5	33	62	19	52	39	86	14	9
Large	0	33	67	42	33	25	83	17	9
	Chi-square (4 d.f.) = 0.6			Chi-square (4 d.f.) = 3.4			Chi-square (4 d.f.) = 12.0[z]		

[z]$P < 0.05$, no other chi-square was significant at the 0.05 probability level.

Table 6. Trends affecting plant material specified (Table 1—question 6).

Trend	Importance[z] 1	2	3
	Mean percent response[y]		
Water availability	51.3 a	39.7 a	7.8 bc
Low cost landscape	18.7 b	22.7 b	34.0 a
More color	0 c	2.6 c	17.0 bc
Pesticide use	2.0 c	5.1 c	9.1 bc
Smaller areas to landscape	3.0 bc	0 c	0 c
Environmental movement	12.0 bc	11.6 bc	32.2 ab
More/larger trees	13.0 bc	0 c	0 c

[z]1 = More Important; 3 = Less Important.

[y]Means, within a column, followed by different letters differ ($p < 0.05$).

change-outs of annual beds. Also mentioned were landscapes that require less maintenance, such as pruning, spraying, and mowing.

The use of more color was listed most often as a third priority. Many of the respondents listing this trend indicated that color, in terms of flowers, would increasingly be obtained through the use of perennials. Also more color would come from selection of plants for their foliage color during the growing season as well as during the fall season.

Landscape architects identified the use of pesticides as a trend that could affect the type of plants required in future landscapes. They were concerned that there would be fewer pesticides to apply, and that their clients would prefer land-

scapes that do not require use of pesticides. They expressed interest in disease- and insect-resistant plants.

Smaller areas to landscape was listed as a trend by relatively few firms but was listed as their number 1 concern by all firms listing this trend. In conjunction with smaller areas they expect taller buildings which creates a need for plants with columnar habit.

The "environmental movement" trend was identified by approximately 56% of the respondents as a third choice in importance. The most frequently listed comment for this trend was increased use of native plants. Other comments included wildlife habitat landscaping and more wetland plants.

Several landscape architects identified a trend toward the use of more trees in the landscape and in city planning, citing city ordinances requiring replanting of trees or use of more trees in parking lots. They also predicted use of larger caliper trees. All firms that listed this trend identified it as a prime concern.

This study demonstrates that trees are approximately 50% of the value of all plants specified by landscape architects. The predicted trends provide guidelines for advertising and marketing communications directed to landscape architects. Plant catalogs and plant availability listings could include plants organized by these trends. This format would simplify plant selection by landscape architects. Marketing communications could highlight how specific plants accommodate one or more landscape trends.

Literature Cited

1. Garber, M.P. 1991a. Have you hugged your landscape architect today? Georgia Green Industry Newsletter 2(1): 12–18.

2. Garber, M.P. 199lb. New Alliance to serve needs of landscape architects. Nursery News 6(4):20.

3. Garber, M.P. I991c. National survey on landscape architects plant needs. Georgia/ASLA Newsletter 2(3):4.

4. Garber, M.P. and K. Bondari. 1992a. Landscape architects as related to the landscape/nursery industry: I. Impact on demand for plant material. J. Environ. Hort. 10:69–72.

5. Garber, M.P. and K. Bondari. 1992b. Landscape architects as related to the landscape/nursery industry: II. Selection of the production nursery and plant availability. J. Environ. Hort. 10:73–77.

6. Galstern, J. 1990. Naturalistic design. Garden Design. 9(1):60–64.

7. SAS Institute, Inc. 1989. SAS/STAT User's Guide. Ver. 6, Cary, NC.

8. Tasker, G. 1990. Replanting "wild" areas on residential sites: It can be done. Garden Design 9(1):39–45.

9. Weber, C. 1990. Healing the earth. Garden Design 9(1):30–35.

A Model for Irrigation Scheduling in Container-Grown Nursery Crops Utilizing Management Allowed Deficit (MAD)[1]

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Abstract

Plant growth and water use of container-grown *Photinia* × *fraseri* (Dress) were studied under varying irrigation regimes. Treatments were based on management allowed deficit (MAD) irrigation (including 0, 5, 10, 25, 50, 75 and 95% MAD), which links evapotranspiration (ET) and plant available moisture in determining irrigation schedules. Plant growth was maximized under 25% MAD irrigation. Plant performance and water use were significantly reduced as moisture deficit levels in the growing medium exceeded 50% under MAD irrigation of 50%, 75% and 95%. Plant performance also tended to decrease, but plant water use increased with lower MAD treatments (i.e., 0%, 5%, 10%). The research reported provides a model for nursery managers and researchers to use MAD irrigation in determining optimum irrigation regimes to meet plant water needs and maintain maximum plant performance.

Index words: Irrigation scheduling, nursery production, *Photinia* × *fraseri*, plant water use, media air-filled porosity.

Significance to the Nursery Industry

The research reported here provides a model for nursery managers and researchers to use management allowed deficit (MAD) irrigation in determining optimum plant water needs and maintaining maximum plant performance based on the dynamics of evapotranspiration (ET) and growing medium characteristics. The experiment required only 28 days for significant differences to appear. Plant growth was maximized under 25% MAD irrigation. Plant performance tended to decrease when growing medium exceeded MAD treatments of 50% and when MAD treatments decreased below 10%. The model represents a quick, low-technology, but highly valuable method of irrigation scheduling. By scheduling irrigation with the MAD concept, the nursery

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