Table 9. (Continued) Monthly and season means for turf color of overseeded grasses grown on a 'Tifway' bermudagrass fairway at Gainesville, FL during the winter of 1994-1995.

Turfgrass	Jan.	Feb.	Mar.	Mean
		Rating[z]		
Mix 2	2.8	2.5	2.8	2.68 f
Mix 3	2.8	2.6	2.5	2.65 fg
PT-GH-92	2.6	2.6	2.8	2.64 fg
Darkhorse	2.4	2.4	2.7	2.50 g
Froghair	2.3	2.7	1.9	2.28 h
Danish Common	1.0	1.0	1.0	1.00 i
MSD[x]	0.3	0.3	0.2	0.18

[z]Color rated from 1 to 5 where 1=yellow green and 5=dark green. Fifteen ratings were averaged.
[y]Means followed by the same letter are not significantly different (P=0.05) using Waller-Duncan k-ratio t-test.
[x]MSD = Minimum significant difference (P=0.05) using Waller-Duncan k-ratio t-test.

'Palmer II', 'Pleasure+', 'Sunrise Primo Blend', 'TMI-EXFLP94', and 'Top Hat'. Most were perennial ryegrasses. Although turf quality in this group was seriously affected by bermudagrass competition, plots were relatively uniform throughout the study period (CV=19.8%). None of the creeping bentgrasses produced turf quality which was better than that of the bermudagrass control plots which were not overseeded. Thus, use of the creeping bentgrass for overseeding fairways is a questionable practice.

Turf color on the fairway differed among grasses throughout the study period (Table 9). Grasses with darkest green color were perennial ryegrasses, which had an average score of 4.9 out of 5.0. These included 'Alliance Blend', 'Blend 1', 'Divine', 'Double Eagle Blend', 'J1704', 'Marvelgreen Supreme', 'Medalist 8', 'Palmer II', 'Pleasure+', 'Sunrise Primo Blend', and 'Top Hat'.

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CULTURE OF COMMON ARROWHEAD

DAVID L. SUTTON
University of Florida, IFAS
Fort Lauderdale Research and Education Center
3205 College Avenue
Fort Lauderdale, FL 33314

Additional index words. *Sagittaria latifolia*, ornamental aquatic plants, aquatic gardens, aquascaping, fertilization practices.

Abstract. **Common arrowhead (*Sagittaria latifolia* Willd.), a member of the Alismaceae or water-plantain family, is used as an aquatic ornamental and for aquatic habitat restoration. Indigenous to North America, this plant produces flowers with three white petals and dark green, three-lobed leaves that make an attractive addition to aquatic gardens. The plant may be propagated from seed or rhizomes. Little is known of the fertilization requirements for culture of common arrowhead although the plant grows in a variety of aquatic habitats. In the current study, common arrowhead plants were planted in sand-filled plastic containers placed under an outdoor overhead sprinkler system. Sierra fertilizer (17 N - 6 P_2O_5 - 10 K_2O plus minors) formulated for an 8-9 month release rate was placed in amounts of 2, 4, 8, 16, 32, and 64 g per container as a layer 7 cm below the surface of the sand. Growth during four 16-week culture periods, as measured by number of plants, height of tallest leaf, width of tallest leaf, and plant dry weight, was low for plants in containers at the 2- and 4-g rate. Growth at the 32 and 64-g rate, equivalent to 360 and 720 g per m^2, showed that an estimated 135 and 214 plants per m^2 averaging 12 and 10 g per plant, respectively, could be expected in a 16-week period. Growth at the 8- and 16-g rate was intermediate between the low and high fertilizer rates. Correct fertilization levels in the rooting medium of common arrowhead is required to produce large plants with wide leaves.**

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Plants in the Alismaceae or water-plantain family are rhizomatous perennial herbs found primarily in fresh water in temperate and tropical regions of the Northern Hemisphere. Included in this family is the predominantly North America genus *Sagittaria* with about 20 species (Dahlgren, et al. 1985). Common arrowhead (*Sagittaria latifolia* Willd.), also known as wapato and duck-potato, is probably the best-known of all the *Sagittaria* species.

Common arrowhead is widespread, and occurs from Canada to Mexico, throughout the United States, and in the tropics and subtropics of both hemispheres. The plants grow emersed with separate leaf and flower stalks arising from the rhizome. Glabrous plants are separated as var. *latifolia* Wieg., while the pubescent ones are var. *pubescens* (Muhl.) J. G. Sm. (Godfrey and Wooten 1979).

Leaves of common arrowhead consist of three-lobed blades with a terminal lobe and two sagittate to hastate basal lobes. The leaves are very variable in overall size, size and shape of the three lobes, and orientation of the basal lobes. Leaf blades of plants in South Florida exhibit lobes broadly ovate-triangular in shape (Fig. 1).

The plant spreads by rhizomes or seeds. In colder climates the plant overwinters by corms produced terminally on rhizomes. Seeds float on the surface and may be carried to new sites by wind and flowing water.

Historically, corms of common arrowhead were used as food by American Indians (Kavasch 1979). Presently, some varieties are cultivated for food in China. Common arrowhead plants are used as ornamentals in aquatic gardens and to increase species diversity in lake restorations.

Little is known of the fertilization requirements for growth of common arrowhead. The objective of this study was to evaluate the influence of fertilizer rate on growth of common arrowhead plants cultured outdoors under an overhead sprinkler system.

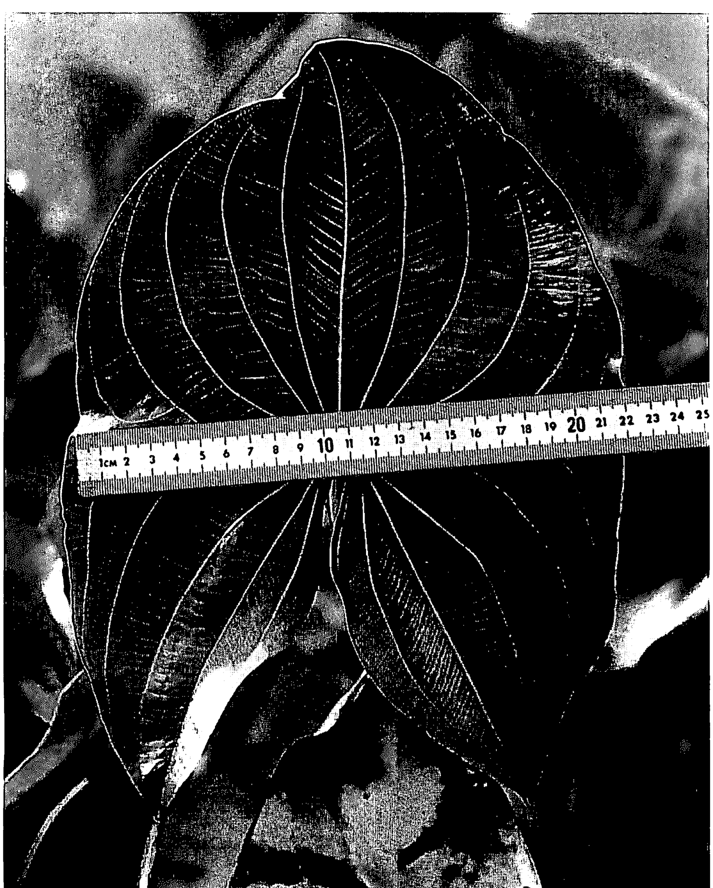

Figure 1. Leaf blade of common arrowhead showing leaf width for a plant cultured at the 64-g rate of fertilizer.

Materials and Methods

Small common arrowhead plants of uniform size (30 ± 1 cm in leaf length and 4 ± 1 g dry weight), originally collected from populations (var. *latifolia*) in Lake Okeechobee and allowed to grow in a drainage ditch at the University of Florida, Fort Lauderdale Research and Education Center, were used for growth studies.

Common arrowhead plants were planted in plastic containers (without drainage holes) with dimensions of 33 cm in length by 27 cm in width (surface area of 0.089 m^2) by 16 cm in depth.

Each container was filled to a depth of 7 cm with coarse builders sand. Then Sierra fertilizer, 17 N - 6 P_2O_5 - 10 K_2O plus minors, (Grace Sierra, Milpitas, CA) formulated for an 8-9 month release rate at 21°C was placed as a layer on top of the sand. An additional layer of sand 7.0 cm in depth was added to cover the fertilizer. Four containers with one plant each were used for each fertilizer rate of 2, 4, 8, 16, 32, and 64 g of fertilizer per container.

Containers were placed in four rows under an overhead sprinkler system on an asphalt surface. Fertilizer rates were randomized within each row. Air temperatures for each culture period were recorded by placing a maximum/minimum thermometer on the surface of the asphalt. Thermometer readings were recorded between 3:30 and 4:00 P.M. 5 days a week (Monday-Friday).

Common arrowhead plants were cultured for four 16-week periods: (1) January 4 to April 22, 1994, (2) May 31 to September 20, 1994, (3) January 13 to May 5, 1995, and (4) June 1 to September 21, 1995. Plant growth was determined by counting the number of plants, measuring height of the tallest leaf from the surface of the sand to the tip of the leaf blade, and determining plant dry weight. Dry weight was determined by washing the plants with pond water to remove sand, fertilizer, and other extraneous material. The washed plants were then dried at 60°C in a forced-air. For the culture period of June 1 to September 21, 1995, additional measurements for growth included measuring width of the leaf blade of the tallest leaf every 4 weeks. Before dry weight determinations, the plants were separated into a shoot portion that included the leaves and petioles, and a root portion that included the rhizomes and roots.

Growth measurements were statistically analyzed using General Linear Models (GLM) procedures of the Statistical Analyses System (SAS Institute Inc., Cary, NC 27511) developed for personal computers. Results are shown as bar graphs with vertical lines to show standard deviations. Values shown for number of plants, leaf height, and dry weight are the means for plants in four culture containers. Values for number of plants, leaf height, or dry weight within each culture period followed by the same letter are not significantly different at the 5% level according to the Duncan-Waller Empirical Bayes LSD procedure (Peterson, 1985). For leaf width, values within each 4-week period followed by the same letter are not significantly different at the 5% level.

Results and Discussion

Air temperatures averaged 26°C with a high of 44°C and a low of 11°C during the culture period of January 4 to April 22, 1994 for common arrowhead plants. During May 31 to September 20, 1994 air temperatures averaged 33°C with a high of 49°C and a low of 21°C. For January 1 to May 5, 1995 the average air temperature was 24°C with a high of 46°C and a low of 4°C. For June 1 to September 21, 1995 the air temperature averaged 31°C with a high of 49°C and a low 20°C. The average air temperatures for all four culture periods were within the formulated release rate of 21°C for the Sierra fertilizer used in this study.

All the common arrowhead survived the transfer from the stock plants to the containers filled with sand and Sierra fertilizer. Growth of common arrowhead responded similarly to growth of pickerelweed (*Pontederia cordata* var. *lancifolia* (Muhl.) Torrey (Sutton 1991), banana-lilies (*Nymphoides aquatica* (S. G. Gmel.) (Sutton 1993), and water snowflake (*Nymphoides indica* (L.) O. Kuntze) using a sand rooting medium amended with controlled release fertilizers (Sutton 1994).

For common arrowhead in this study, lengths of the tallest leaves of after 16 weeks increased with the rate of Sierra fertilizer (Fig. 2). For the first two culture periods however, plants in the 2-g treatment were not longer than the initial ones. Plants for the 64-g treatment were the longest for all four culture periods and was almost three times that of the initial ones.

Widths of the tallest leaves were measured for only the June 1 to September 21, 1995 culture period (Fig. 3). Because of a significant interaction between fertilizer treatments and weeks, a comparison of widths can only be made within each 4-week growth period. After 4 weeks of growth, leaf widths averaged 15 cm for the 16- and 32-g treatment, and were the highest measured for all treatments. The widest leaf blades after 8 weeks of growth were 15 cm for the 32- and 64-g treatments. Leaf blade widths averaged 20 cm for the 64-g treatment after 12 weeks and 16 weeks of growth, and were the widest of all the treatments for both times. One plant after 16 weeks of growth was 23 cm in width.

Overall, the number of common arrowhead plants increased with an increase in fertilizer in the culture containers (Fig. 4). The highest number of plants was associated with the 32- and 64-g treatments; however, for the period of January 1 to May 5, 1995, the 64-g rate was similar to the 8- and 16-g treatments. An average of 20 plants was produced for the 32- and 64-g rate during January 4 to April 22, 1994. This represents a 20-fold increase in plants during the 16 weeks of growth.

Dry weight of plants in the 2-g treatment was not significantly different from the initial weight (Fig. 5). Except for plants in the January 4 to April 22, 1994 culture period, dry weight was higher than the initial weight beginning with the 4-g treatment. Plants cultured for the summer period of May 31 to September 20, 1994 and June 1 to September 21, 1995 at the 64-g Sierra rate produced an average of 250 g and 187 g per container, respectively, and were the highest of each

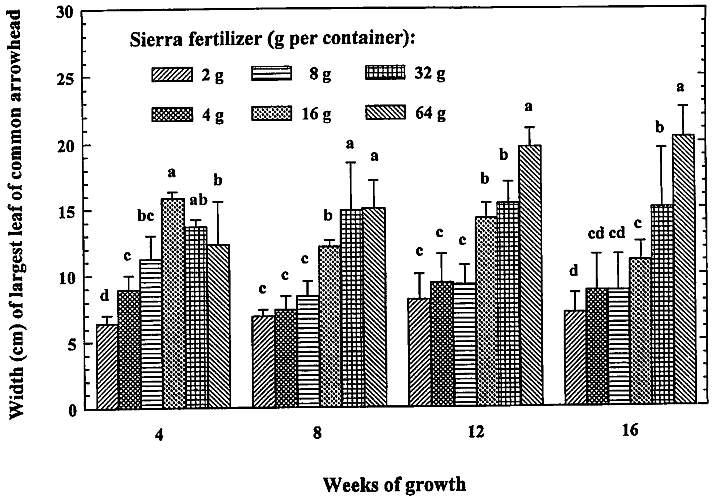

Figure 3. Width of tallest leaf of common arrowhead cultured June 1 to September 21, 1995.

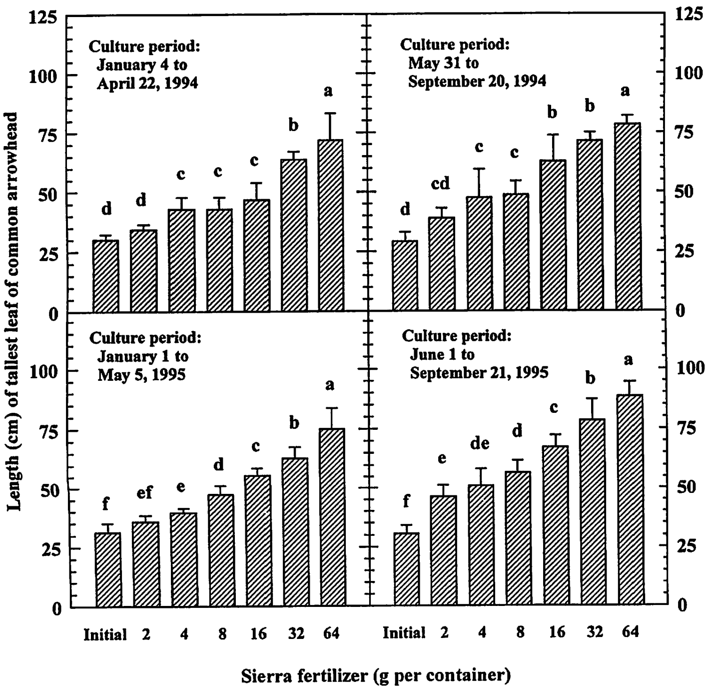

Figure 2. Initial height and height after 16 weeks of growth for the tallest leaf of common arrowhead.

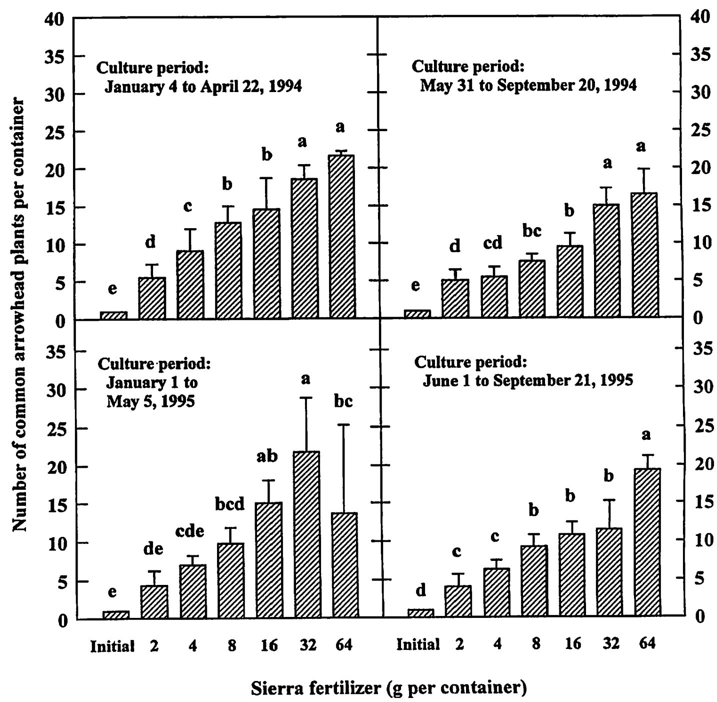

Figure 4. Number of common arrowhead plants cultured for 16 weeks.

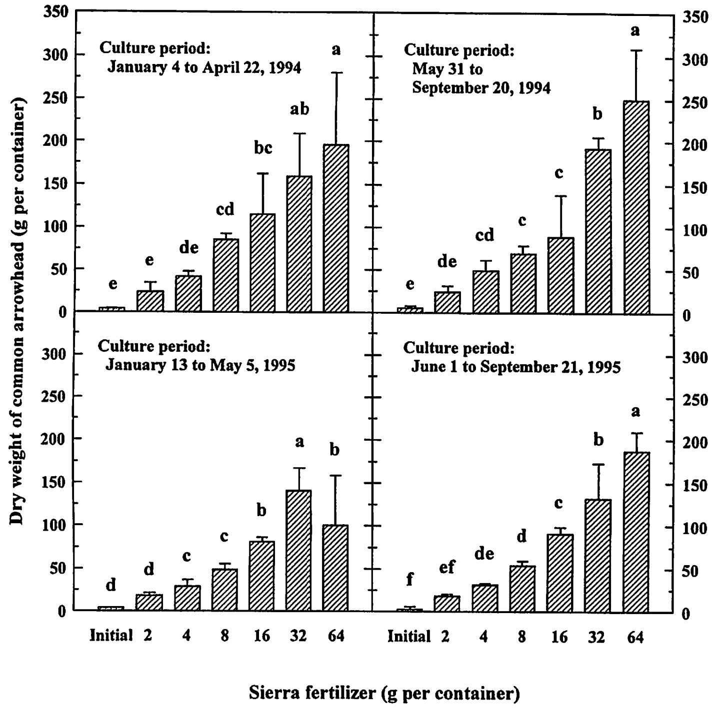

Figure 5. Dry weight of common arrowhead cultured for 16 weeks.

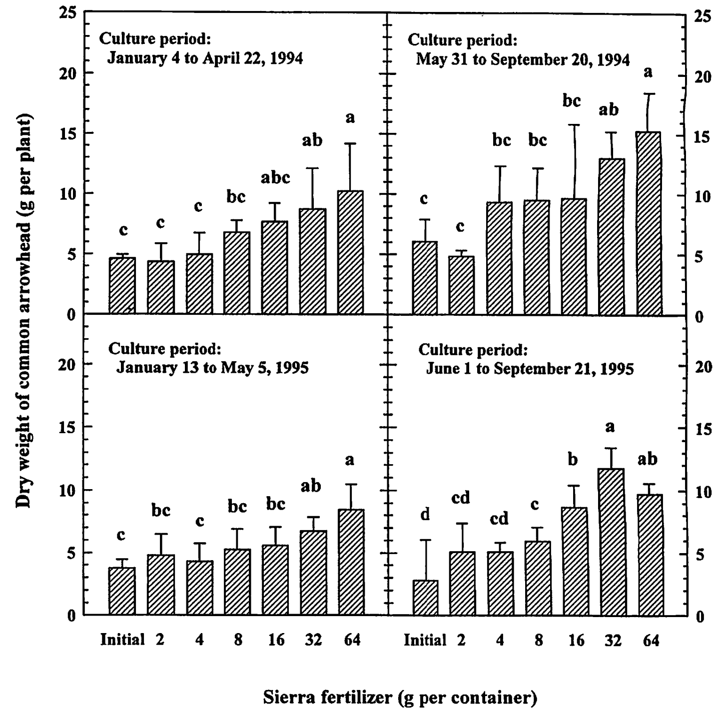

Figure 6. Individual dry weight of common arrowhead cultured for 16 weeks.

treatment for these culture times. For the winter culture periods of January 4 to April 22, 1994 and January 13 to May 5, 1995, plants in the 32-g treatment averaged 159 g and 141 g per container, respectively. As shown by the means separations, no statistically significant differences were observed for the 16-, 32-, and 64-g treatments for the first winter period, but the 32-g treatment for the second winter period produced the highest dry biomass of all the treatments.

The plants initially averaged 3 g for June 1 to September 21, 1995 and 7 g for May 31 to September 20, 1994 (Fig. 6). Plants in the 64-g treatment for the first summer period averaged 15 g apiece but were not significantly different from the 32-g treatment. Plants for the second summer period averaged 12 g each but were not different from the 64-g treatment. Differences in individual plant weights were not as obvious during the winter period as during the summer.

Plants for June 1 to September 21, 1995 were separated into roots and shoots at the time of harvest. The ratios of the roots to shoots are shown in Fig. 7. The ratio of roots to shoots for the 32- and 64-g treatments were lower than the 2-, 4-, 8-, and 16-g treatments.

Barko et al. (1991) suggest that root:shoot ratios more than 1 for submersed aquatic plants are an indication of poor growth in sediments low in fertility. Data with common arrowhead support this idea because 32- and 64-g fertilizer rate produced the best growth of all the treatments and the root:shoot ratios of the plants were below 1.

This study shows the feasibility of mass production of common arrowhead plants cultured in sand amended with a controlled-release fertilizer. Based on results from the summer period of June 1 to September 21, 1995 for the 32- and 64-g rate, production of 135 and 214 plants per m² averaging 12 and 10 g per plant, respectively, could be expected in a 16-week period.

The ease with which common arrowhead plants can be cultured in sand amended with a controlled-release fertilizer is shown in this study. Correct fertilization rates of the rooting medium of common arrowhead will be required to produce large plants with wide leaves.

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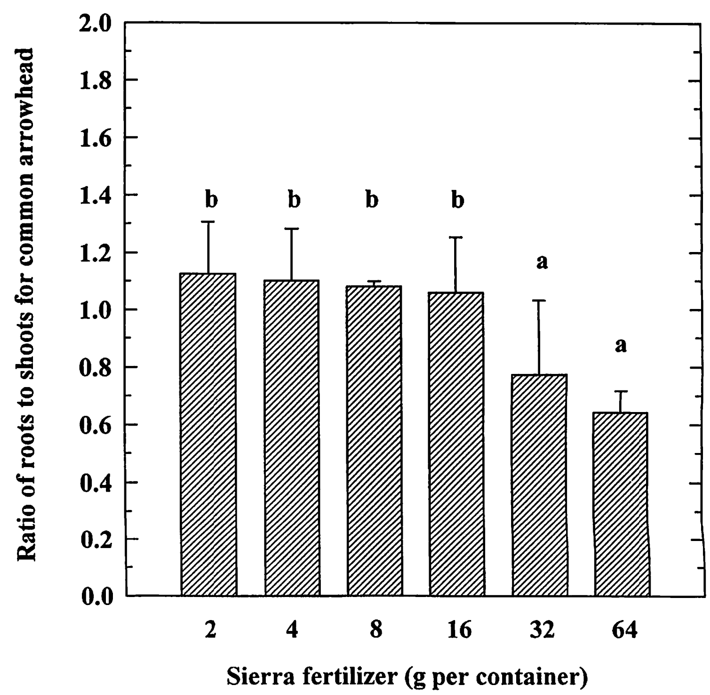

Figure 7. Ratios of roots to shoots of common arrowhead cultured June 1 to September 21, 1995.

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COMPUTER ASSISTED DESIGN AS A PLANT MATERIALS TEACHING TOOL IN A LANDSCAPE DESIGN COURSE

GREG L. DAVIS AND EDWARD F. GILMAN
Environmental Horticulture Department
University of Florida, IFAS
Gainesville, FL 32611

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Abstract. **College courses in landscape design integrate not only fundamental design concepts for the functional and aesthetic arrangement of plants, but also graphical communication skills and detailed knowledge of plant materials. Students enrolling in the University of Florida's Environmental Horticulture Department's Introduction to Landscape Horticulture course must have completed at least one course in plant identification which included at least 200 Florida and southeastern landscape species and cultivars. By employing data base capabilities of landscape computer software in one segment of the course, students are able to apply their understanding of the plants they have learned in preceding courses, learn unfamiliar plants, and rapidly assemble plant lists for landscape plans.**

Horticulture instructors are continually challenged to offer learning activities that go beyond the traditional classroom lecture format. In order to reach today's students of diversified backgrounds and learning styles, instructors offer myriad activities, including "hands-on" laboratory exercises, case studies, discussion groups, multi-media presentations and discovery learning opportunities. Discovery learning is a method of stimulating students to search beyond guided instruction to access information outside the lesson plan and find details that are not specifically required in the course (White et al., 1990). These teaching methods facilitate learning beyond rote memorization into levels of cognition described by Weinstein and Mayer (1986) to include processing, application, analysis, synthesis, creating and evaluation.

Plant identification is one example of a course that offers potential discovery learning opportunities. The proliferation of computers and software in educational settings has greatly expanded the options for instructors to incorporate an increasing variety of such learning activities. Many sound learning principles described elsewhere (Caldwell, 1980) can be applied to computer-based learning in today's horticulture classroom.

Horticulture students traditionally learn about plant materials through successful completion of plant identification courses. Many teaching aids are available for instruction in plant identification, including textbooks, manuals, video and CD-ROM discs, slide collections, and herbarium and live specimens. Students majoring in horticultural sciences at the University of Florida are required to take at least one plant identification course. Our plant identification courses focus not only on the identification of plants, but also on plant classification and nomenclature, taxonomy, morphology, culture, pests and other problems and uses of each plant in the landscape or interior plantscape. Many of the above resources are employed in plant material instruction at U.F.

Those students at U.F. who are interested in applying their plant knowledge further in landscape horticulture may take a landscape design course (ORH 3815), in which they learn drafting and the design process as they are applied to small scale residential landscape development. The course requires students to generate landscape plans—first by hand drafting, and then by using computer assisted design and drafting (CAD) software (Green Thumb Software, 1995). To successfully complete the course, students must regularly review and be able to integrate their understanding of plant materials into the abstract development of a planting design. This implies that students must reach beyond simply remembering and must analyze, synthesize and create to successfully use plants in a landscape design.

Materials and Methods

Students have access to computer hardware and software for the landscape design course in the College of Agriculture's computer laboratories. The software used for design and plant identification activities includes several CD-ROMs: LandDesigner Professional Series (Green Thumb Software, 1995) and the Florida Landscape Selector and Florida Plant Selector (Gilman et al., 1991), available through the Florida Agricultural Information Retrieval System (FAIRS Disc 4). A fourth CD-ROM program, Southern Trees (Gilman et al., 1995; Beck et al., 1993) will be available for student use in 1996. The software packages operate on IBM compatible computers with at least an 80386 processor, at least 4 mb RAM, VGA+ graphics capability and a CD-ROM player.

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