Fig. 4. Mature marigold plants grown with conventional P fertilizer (control) or two treatments with Al–P releasing P at 3.05 ± 0.21 μM P (low Al) and 9.26 ± 1.47 μM P (high Al). Note the uniform distribution of the roots in alumina-buffered P (high-Al and low-Al) plants.

water use efficiency in Al–P plants.

Use of buffered phosphorus fertilizer may provide bedding plant growers with a means to improve plant quality and stress tolerance while reducing fertilizer leaching and attendant waste-management problems. This research clearly shows that marigold and impatiens plants grown with lower concentrations of P provided by the buffered-P fertilizer have equal or better quality and improved tolerance to drought.

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The Effect of an Interdisciplinary Garden Program on the Environmental Attitudes of Elementary School Students

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Additional index words. environmental education, children, gardening, outdoor activities, active learning

Summary. Project GREEN (Garden Resources for Environmental Education Now) is a garden program designed to help teachers integrate environmental education into their classroom using a hands-on tool, the garden. The objectives of this research project were to 1) develop an interdisciplinary garden activity guide to help teachers integrate environmental education into their curricula and 2) evaluate whether children developed positive environmental attitudes by participating in the activities. Students participating in the Project GREEN garden program had more positive environmental attitude scores than those students who did not participate. Second-grade students in the experimental and control groups had more positive environmental attitudes than fourth-grade students. In addition, this research found a significant correlation between the number of outdoor related activities students had experienced and their environmental attitudes.

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This research was supported by a grant awarded by the Interdisciplinary Research Initiatives Program sponsored by the Office of the Vice President for Research and Associate Provost for Graduate Studies at Texas A&M University. 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.

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Conservation and preservation of the environment have become very important goals in today's world. It is becoming apparent that schools need to educate children on environmental issues since they will be the ones making future policy and decisions. Milbrath et al. (1990) found that students, while concerned about the environment, have little knowledge about how the environment works, how personal and societal actions impact the environment, and ultimately how environmental problems impact society. Increased environmental awareness comes with increased knowledge about the environment and new knowledge can lead to a change in attitudes (Ramsey and Rickson, 1976). Sound environmental knowledge combined with a positive environmental attitude are important factors necessary for improving human actions toward the environment (Ramsey and Rickson, 1976).

It is evident that many children in Western society have little direct experience with living things and their ecosystems and often depend on abstract cognition through secondary sources such as adults, peers, and the media to learn about their environment (Cohen and Horm-Wingerd, 1993). These sources may not be as effective in teaching children about the environment, since students learn better and acquire more knowledge when actively involved in the learning process (McCormick et al., 1989). Horticulture provides an excellent opportunity for such hands-on environmental learning.

Environmental education is not a classroom subject in itself; it is an approach that extends across formal and informal curricula. It is often issue-based, and these issues cut across many disciplines. In developing environmentally responsible citizenry, much more than a simple understanding of scientific principles and ecology is involved (Kelly, 1984). However, current educational practices predominately infuse environmental education into the science curricula with minimal exposure in social studies, reading, language arts, art, health, music, math, and physical education. Since environmental education is an issue-based subject, it lends itself perfectly to interdisciplinary education through the integration of new content and skills into existing curricula without jeopardizing the integrity of the courses themselves (Simmons, 1989).

One of the objectives of this research project was to develop an interdisciplinary approach to environmental education by infusing activities centered around a hands-on tool, the garden. With very few requirements, garden activities and programs can be successfully infused into existing curricula of all disciplines. Gardening activities can help teachers introduce environmental education into the existing curriculum in a way that makes learning enjoyable for children of all ages (Eames-Sheavly, 1994).

In addition, gardens can provide an environment in which students can learn to work with peers, teachers, parents, and volunteers while growing plants and discovering the relationships between people, plants and wildlife (Alexander et al., 1995). Another objective of this study was to evaluate whether students developed positive environmental attitudes by participating in gardening activities.

Materials and methods

ACTIVITY GUIDE. An interdisciplinary garden activity guide was developed to help teachers integrate environmental education into their curricula. The document developed was *Project GREEN Activity Guide: Book 2, Interdisciplinary Activities* (Skelly and Zajicek, 1997). This activity guide is designed to incorporate the garden and garden activities into all disciplines, including math, science, English, history, social studies, and art. The activities in the guide are divided into seven units. Each unit consists of various plant or plant-related activities for use in the garden. The objectives and the related educational disciplines are listed for each activity.

The units in Book 2 include topics on seeds, plant parts, having fun with plants, herbs, and Native American traditions and gardening. In total, 33 different activities are included in the seven units. The activities found in this guide, on average, require ≈40 min to complete. The guide can be used year round; however, many of the activities require use of a garden or indoor grow lab. Teachers are free to choose activities, according to their specific needs.

SAMPLE POPULATION. This study was conducted during the 1996–97 school term. Second- and fourth-grade teachers from four elementary schools in Texas volunteered their classes for the study. Classes were divided into two groups—experimental and control—depending on whether or not teachers volunteered to incorporate school gardening into their curricula. Children in the experimental group participated in the Project GREEN program during the 1997 spring semester, while children in the control group did not participate in the Project GREEN program. The experimental group consisted of 153, second- and fourth-grade students. The control group consisted of 84 second- and fourth-grade students. All students were administered a survey at the end of the 1997 spring school semester.

IMPLEMENTATION OF PROJECT GREEN. Each participating school, except for the control population, received garden materials before initiation of Project GREEN including seeds, transplants and garden tools. Raised garden beds also were installed on the school grounds. The number of garden activities used from the activity guide varied between schools from 12% to 55%, because each teacher was free to choose which activities best suited his or her needs.

INSTRUMENTATION. The environmental attitudes of the students were assessed using the Children's Environmental Response Inventory (CERI), developed by Bunting and Cousins (1983). The CERI contains eight categories of questions designed to assess a child's environmental personality. For the purposes of this study, only the pastoralism and environmental adaptation categories were used, and the scores from these two categories were combined. Pastoralism is defined as "enjoyment of the natural environment in an intellectual and aesthetic fashion" (Bunting and Cousins, 1983), while environmental adaptation is defined as "belief in man's right to use technology to adapt and dominate nature" (Bunting and Cousins, 1983). The attitude inventory measured questions on a Likert-type scale (Likert, 1967). The five possible responses to each statement were 1 = Disagree Very Much, 2 = Disagree, 3 = Don't Know, Don't Care, 4 = Agree, and 5 = Agree Very Much. Bunting and Cousins (1983) report a reliability for pastoralism at 0.89 and 0.87 for environmental adaptation for a population of 1100, fourth-, sixth-, and eighth-grade stu-

Table 1. ANOVA comparing the environmental attitude scores of children participating in the Project GREEN garden program (experimental group) versus children not participating in the program (control group).

Group	Cases (no.)	Mean score[z]	SE	df	F	Significance
Control	84	163.8	3.62	1	10.44	0.001
Experimental	154	182.5	2.85			

[z]Scores range from 43 to 215. An attitude score of 129 indicates a neutral environmental attitude. A score higher than 129 indicates a positive environmental attitude. A score lower than 129 indicates a negative environmental attitude.

Table 2. Posthoc ANOVA comparing the environmental attitude scores of children participating in the Project GREEN garden program (experimental group) versus children not participating in the garden program (control group) for each grade level.

Group	N	Mean score[z]	SE	Significance
Control				
Second grade	33	171.8	4.71	0.042
Fourth grade	51	162.2		
Experimental				
Second grade	102	185.3	3.59	0.045
Fourth grade	52	178.0		

[z]Scores range from 43 to 215. An attitude score of 129 indicates a neutral environmental attitude. A score higher than 129 indicates a positive environmental attitude. A score lower than 129 indicates a negative environmental attitude.

Table 3. The effect of number of outdoor activities on children's environmental attitudes.

Outdoor activities (no.)	Mean score[z]	SE
1	163.0	20.37
5	169.3	7.03
10	170.1	6.52
15	180.0	5.69

[z]Scores range from 43 to 215. An attitude score of 129 indicates a neutral environmental attitude. A score higher than 129 indicates a positive environmental attitude. A score lower than 129 indicates a negative environmental attitude.

dents. A Cronbach's alpha reliability test indicated that for this sample and study the reliability of the instrument was 0.80.

The survey also included a section for student biographical information including questions on gender, grade, ethnicity, place of residence, previous gardening experience, and sources of plant information. Also included in the student information section of the survey was a question evaluating the number of outdoor-related activities students had experienced. There were 18 possible outdoor-related activity choices, and students were asked to indicate all the activities from the list they had experienced. Examples of activities on the list included climbed a tree, planted seeds and watched them grow, played in a park, and grown a houseplant. All students completed the surveys at the end of the school year.

DATA ANALYSIS. The data collected from the control and experimental groups was analyzed using the Statistical Package for the Social Sciences, (SPSS) for Windows Release 7.5 (SPSS, 1997). Statistical procedures included general factorial tests of comparison, t tests, and ANOVA tests to show any differences or relationships between experimental and control groups.

Results and discussion

Significant differences were found in environmental attitude scores of children in the two groups (Table 1). Children who participated in the Project GREEN garden program had on average, more positive environmental attitudes, scoring 18.75 points higher on the CERI inventory, compared to children who did not participate in the program. These findings support the ideas expressed by many researchers that environmental education creates more positive environmental attitudes in students (Bradley et al., 1997; Harvey, 1989a, 1989b; Jaus, 1982, 1984; Ramsey and Rickson, 1976).

Differences were also found between individual statement responses on the CERI inventory. Of the 45 attitude statements included in the CERI, children in the experimental group scored significantly higher on 30 statements. Overall, statements indicating active involvement with the environment and concern about the environment received high scores from the experimental group. In contrast, students in the control group were not as concerned about man's potentially negative influence on nature or wasting natural resources. The results from these analyses illustrate that a gardening program which provides hands-on experience with the environment may provide a means to foster positive environmental attitudes.

AGE. Analysis of the demographic variables indicated no significant effects on environmental attitude scores based on the variables of gender, ethnicity, and place of residence. However, second-grade students in the experimental and control groups scored 7 to 9 points higher on the CERI than fourth-grade students (Table 2). Other researchers have reported similar findings indicating that younger students are better able to develop more positive environmental attitudes than older students (Bryant and Hungerford, 1977; Cohen and Horm-Wingerd, 1993; Jaus, 1982, 1984).

OUTDOOR RELATED ACTIVITIES AND ENVIRONMENTAL ATTITUDES. The number of outdoor-related activities students experienced was significantly correlated with their environmental attitude scores regardless of treatment group ($r^2 = 0.415$, $p < 0.001$). Results indicated that, in general, the more outdoor-related activities a child experienced, the more positive environmental attitude score they possessed (Table 3). This supports research reporting that children's contact with nature elicits concern for the environment, thus cultivating more positive environmental attitudes (Hart and Chawla, 1981; Harvey, 1989a, 1989b). Gardening activities comprised 5 out of the 18 possible choices that students could check on the biographical survey. These activities appear to contribute to this increase in environmental attitude scores.

PREVIOUS GARDEN EXPERIENCE. On the biographical survey, children were asked to indicate whether they had worked in a garden before participat-

Table 4. ANOVA comparing environmental attitude scores of children based on previous garden experience.

Experience	N	Mean score[z]	SE	df	F	Significance
Worked in a garden?						
Yes	198	171.9	2.03	1	0.460	NS
No	37	170.4	4.17			
Worked in a home garden?						
Yes	124	181.9	3.78	1	1.287	NS
No	114	174.2	4.22			
Worked in a school garden?						
Yes	82	179.2	4.24	1	2.096	NS
No	156	176.3	3.75			

[z]Scores range from 43 to 215. An attitude score of 129 indicates a neutral environmental attitude. A score higher than 129 indicates a positive environmental attitude. A score lower than 129 indicates a negative environmental attitude.

Table 5. ANOVA comparing environmental attitude scores of children based on sources of plant information.

Source	N	Mean score[z]	SE	df	F	Significance
Learned from books?						
Yes	39	177.3	4.77	1	0.958	NS
No	199	176.4	3.95			
Learned at home?						
Yes	72	176.1	4.96	1	10.109	NS
No	166	177.4	3.80			
Learned while playing?						
Yes	8	182.6	8.00	1	0.419	NS
No	230	174.3	2.70			
Learned at school?						
Yes	170	180.0	4.07	1	0.128	NS
No	68	172.0	4.60			

[z]Scores range from 43 to 215. An attitude score of 129 indicates a neutral environmental attitude. A score higher than 129 indicates a positive environmental attitude. A score lower than 129 indicates a negative environmental attitude.

ing in this study. Findings indicated no significant differences in the environmental attitudes of children and previous garden experience, regardless of treatment group (Table 4). These results indicate that gardening alone does not have a significant impact on students' environmental attitudes and that some formal educational structure may be necessary to affect student's environmental attitudes. However, 52% of the children surveyed had been involved with garden activities at home. These families may represent a new audience for children's gardening programs and research.

SOURCES OF PLANT INFORMATION. Students were also asked how they had learned about plants. They could indicate on the questionnaire if they had learned about plants while playing, from books, at home, or at school. These sources did not significantly affect the students' environmental attitude scores regardless of treatment group (Table 5). The results did, however, show that most students taking part in this study learned about plants while attending school. This is important because many researchers believe that schools are the instruments to teach environmental education (Ham and Sewing, 1987; Kelly, 1984; Knapp, 1972).

The youth of today will become the future voice in environmental preservation and policies. It is, therefore, important to educate today's youth about the environment and help them form positive environmental attitudes. The results from this study show that environmental education at early grade levels is necessary to have the strongest impact on students' environmental attitudes. Additionally, these findings indicate that if environmental education is hands-on, children have a greater potential for understanding what they learn and in turn relating it to the environment.

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Establishment Success and Relative Costs of Four Annual Species for Roadside Planting

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Additional index words. wildflowers, *Celosia argentea* 'Pampas Plumes', *Cosmos sulphureus*, *Helianthus annuus* '7111', *Zinnia elegans* 'Gold Medal Mixture'

Summary. Seeds of *Celosia argentea* L. 'Pampas Plumes', *Cosmos sulphureus* Cav., *Helianthus annuus* L. '7111', and *Zinnia elegans* Jacq. 'Gold Medal Mixture' were mixed with clean sand and hand-broadcasted over 60-ft² (6.7-m²) plots at rates of 4 or 8 oz/1000 ft² (122 or 244 g/100 m²). Each plot was either left undisturbed after sowing or the seed was raked into the soil surface. Estimated costs were calculated using the approximate number of seeds planted per plot and the cost per seed versus the number of plants reaching anthesis. *Celosia* and *Zinnia* bloomed for 42 days, *Cosmos sulphureus* for 28 days, and *Helianthus* for 12 days. Seeding rate had little effect on the number of plants maturing to flower in all species except *Cosmos*. There were no significant differences in number of weeds between treatments for any of the species. Raking the seed into the soil significantly improved germination at 2.5 and 5 weeks for *Celosia*, *Cosmos*, and *Helianthus*, but not for *Zinnia*. In *Celosia*, raking the seed into the soil more than doubled the number of plants maturing to flower, while in *Cosmos* the number reaching anthesis was not significantly altered by raking. The lowest costs per flowering plant occurred when the seed was raked into the soil for *Celosia*, *Helianthus*, and *Zinnia*.

Flowers have been popularized as an alternative to turf for roadside planting. Their use has increased since the 1960s and early 1970s when they were heavily promoted by Lady Bird Johnson in the beautify America movement (Johnson and Lees, 1988). Early promotion of wildflowers led to the development of a national roadside beautification program in 1973 by the Federal Highway Administration. In Texas, North Carolina, Virginia, Vermont, and other states, extensive floral plantings have increased the visibility and public awareness of this program. Of all the highway programs, the roadside beautification program receives the most accolades and support from the public, whereas safety and utility programs are often taken for granted (Baker and Barrett, 1990; Johnson and Lees, 1988). Wildflowers break up the monotony of roadside vegetation and can provide a calming effect on motorists in areas of heavy traffic (Billings, 1990). They have also been cited as a way to reduce maintenance costs while providing aesthetic variety to the roadside. While wildflowers are not maintenance free, their maintenance costs have been reported to be less than those for turf (Billings, 1990), but this may not be consistent for all states (Bartels, 1992).

Good seed to soil contact and ample moisture are required for successful wildflower seed germination (Dusablon, 1988; Martin, 1986), with some relief from overcrowding by invasive weeds also required. The primary objective when planting is to get as many desirable plants established with as few weeds as possible, including grasses, to produce the maximum visual impact (Dusablon, 1988). For roadsides, however, elimination of all weeds is rarely possible and often unnecessary. A few weeds may become "invisible" to the motorist traveling at normal highway speeds.

Two considerations arise when examining suitable species for roadside planting: prospective species or-

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We thank the Virginia Department of Transportation for financial support of this work. 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.

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