Proc. Fla. State Hort. Soc. 116:15-21. 2003.

WATER CONSERVATION SURVEY OF MIAMI-DADE COUNTY AGRICULTURAL AND GOLF COURSE COMMERCIAL WATER USERS

RAFAEL MUÑOZ-CARPENA[1] AND JONATHAN H. CRANE
University of Florida, IFAS
Tropical Research and Education Center
Homestead, FL 33031

GLENN D. ISRAEL
University of Florida, IFAS
Agricultural Education and Communication
Gainesville, FL 32611

CHARLES YURGALEVITCH
Miami-Dade County Cooperative Extension Service
Homestead, FL 33030

Additional index words. drought, flooding, fruit crops, golf courses, irrigation, nursery crops, soil moisture monitoring, vegetable crops, water conservation

Abstract. **Water use, management, and quality are major issues in south Florida's Miami-Dade County where periods of flooding and drought are experienced occasionally. Agricultural practices (e.g., irrigation and fertilizer management) potentially affect the water quality of the Biscayne Aquifer in the environmentally sensitive agricultural area adjacent to Everglades and Biscayne National Parks. However, water conservation practices by the Miami-Dade County agricultural community and golf courses are largely undocumented. The University of Florida is undertaking extension and research programs in Miami-Dade County to help the agricultural community conserve water, deal with flooding and drought, and improve irrigation and fertilizer management. A comprehensive survey of water conservation practices across commodity groups (e.g., vegetables, tropical fruits, ornamental nurseries, and golf courses) was conducted in 2002 to help identify the practices these users adopted to conserve and protect their water supply. The approach was to quantify the existing water management and irrigation practices and motivations for their adoption. A random sample of over 600 agricultural and golf course water users in Miami-Dade County were asked to respond to a questionnaire about their current water-use practices. The overall number of respondents was 27%. Results generally showed an increase in water conservation practices during the last 20 years, although there still remain educational challenges to optimize water use while protecting the environment. The results and analysis of this water-use survey will be used in planning water-related extension and research programs for the community.**

The Miami-Dade County agricultural industry employs over 15,000 people and has a billion dollar impact on the state economy (Degner et al., 2001a). In addition, the golf course industry in Miami-Dade County is worth an estimated $200 million annually and employs about 2,300 people (Haydu and Hodges, 2002). There are about 40,411, 15,611, 12,010, and 6,039 acres of vegetable, fruit, nursery, and livestock (mostly horse) production, respectively. The reported vegetable acreage is somewhat misleading as some acreage is annually double and triple cropped (Degner et al., 2001a). Miami-Dade has 48 golf courses with about 8,400 acres of turf (Haydu and Hodges, 2002). The estimated number of vegetable, fruit, and nursery producers ranges from about 80 to 100, 265 to 823, or 573 to 1053, respectively, depending upon the criteria and sources used to estimate it (Degner et al., 2001b; Hodges and Haydu, 2000; T. Olczyk, H. Bryan, J. Crane, C. Balerdi, and C. Yurgalevitch, personal communication).

Over 82% of the farms in Miami-Dade County operations have irrigation systems, representing about 85% of the agricultural land in production (Degner et al., 2001b). All golf courses in Miami-Dade County are irrigated to some extent (C. Yurgalevitch, personal communication).

The authors thank Tina Dispenza, Sandra Brown, Carmen Kameko, Yuncong Li, Don Pybas, Teresa Olczyk, Carlos Balerdi, Ray Rafie, Wagner Vendrame, Robert Carew, and Joseph Garofalo for their cooperation with this project. The University of Florida's Institutional Review Board approved the proposal (UFIRB #2002-556). Funding for this project came from the South Dade Soil and Water Conservation Service and University of Florida, SHARE Foundation.Funding for this project came from the South Dade Soil and Water Conservation Service and University of Florida, SHARE Foundation. This research was supported by the Florida Agricultural Experiment Station, and approved for publication as Journal Series No. N-02367.

[1]Corresponding author.

The major issues facing the agriculture, golf course and landscape industries in south Florida, include marketing and foreign competition, land use planning, water and fertilizer management, natural disaster avoidance and mitigation, and sustainable cultural practices. Due to the ongoing Everglades and Biscayne National Park restoration projects, water and fertilizer management practices for the agricultural and golf course industries have become critical components of the sustainability of these industries.

Water use, management, and quality are major issues in south Florida's Miami Dade County where periods of excessive rainfall (flooding) and extended dry spells (drought) are experienced occasionally. Agricultural practices (e.g., irrigation and fertilizer management) potentially affect the water quality of the Biscayne Aquifer and Biscayne Bay. However, water conservation practices by the Miami-Dade County agricultural community and golf courses are largely undocumented. The University of Florida is undertaking extension and research programs in Miami-Dade County to assist the agricultural community to conserve water, deal with flooding, and improve irrigation and fertilizer management.

A previous irrigation management survey of tropical fruit producers in Miami-Dade County reported about 60% used low volume irrigation systems in their orchards. In these orchards, irrigation scheduling was based mostly on the amount and frequency of rainfall (73%) and only 15% on soil moisture monitoring (Li et al., 2000). Similar results were found for agricultural water users in Ontario, Canada (Dolan et al., 2000). This paper describes an extensive survey distributed to agricultural industry representatives across commodity groups and reports some initial finding from the results.

Materials and Methods

The survey involved a random sample of over 600 agricultural and golf course water users in Miami-Dade County selected from mailing lists obtained from the Miami-Dade County/IFAS Cooperative Extension Service and other growers' organizations in Miami-Dade County. The survey recipients were selected according to the size of their operation to obtain a maximum of 400 surveys per commodity group with a range in the sizes of operations. This represents close to 50% of the sampled population (Table 1).

The survey instrument used contained questions concerning water consumption and irrigation practices, issues affecting water use, drought and flooding experience, and water management information sources. The survey was tailored to each of the four main commodities in Miami-Dade County (vegetables, tropical fruits, ornamental plants and golf courses). The survey protocol adopted follows social sciences methodology to allow statistical analysis of results and the assessment of the influence of the economic, technical, and sociological factors on water conservation practices in the area. Each potential respondent received a letter informing him or her of the purpose of the survey. Two weeks later the surveys were sent out and telephone follow up was done 4 and 8 weeks later. The survey data was analyzed using SAS software FREQ and MEANS statistical procedures (SAS, 1999).

Results and Discussion

Although an initial random sample of over 1000 surveys were sent out, some were not returned and some were purged (no longer in business) so that a base of 598 returned surveys sent were considered (Table 1). Mail-back survey response rates of 10 to 50% are common and typically may be as low as 20% (Dolan et al., 2000; Nachmias and Nachmias, 1976; Neuman, 1997). The overall survey response rate was 27%, representing almost a fifth (18%) of the agricultural and golf course land area (Table 1). Interestingly, whereas 87 fruit growers represented about one-third of the commercial fruit growers and 25% of the orchard land, just 6 vegetable growers represented 21% of the vegetable acreage. Despite a relatively good survey response from the ornamentals producers (21%), only 10% of the nursery acreage was represented. The survey response from golf course managers was low (12%). More responses are being requested through the commodity association but are not available yet so the data presented here for this group is preliminary.

The mean orchard size was 48 acres, which is similar to what was found in a recent agricultural economic study (Degner et al., 2001a; 2001b). Land was about evenly distributed among those producers, who owned, leased, or managed orchards on someone else's property (Table 2). Ornamental nurseries averaged about 19 acres with most (88%) operations owning their land. Mean vegetable land area for respondents was 1050 acres which is much higher than that reported previously (Degner et al., 2001a) (Table 2). This is because a disproportionate number of vegetable survey respondents had large operations and many small producers did not return their survey. Sixty-one percent of the vegetable producers responding owned their own land and 39% leased land. The mean land area for golf courses was 117 acres with 69% of the respondents managing and 31% owning the golf course.

Nearly all the fruit orchards are irrigated (96%) which is to be expected because irrigation is the main method of cold protection (Crane, personal communication) (Table 2).

Table 1. Sample size surveyed for the vegetable, fruit, nursery, and golf landscape sectors.

Sector	Number of operations[z]	Number surveyed	Number returned	Percent returning survey	% Acreage represented
Fruit	265	208	87	42%	25%
Ornamental nursery	573	310	66	21%	10%
Vegetable	80	54	6	11%	21%
Golf-landscape	48	26	3	12%	4.2%
Total	966	598	162	27%[y]	18%

[z]Vegetable, fruit, and golf course landscape operations are based on the estimates from local Univ. of Fla. Coop. Ext. Agent faculty. The number of nursery operations is based on Degner et al., 2001b.
[y]Overall percentage of surveys returned.

Table 2. Size and ownership of operations surveyed across commodity groups.

Sector	Mean acreage	Owned (% of total)	Leased (% of total)	Managed (% of total)	% of land irrigated
Fruit	48	34%	30%	36%	96%
Ornamental nursery	19	88%	8%	4%	53%
Vegetable	1050	61%	39%	0%	62%
Golf-landscape	117	31%	0%	69%	68%
Across-groups	75	54%	31%	15%	56%

Over half (53%) the ornamental nurseries are irrigated which reflected those nurseries that have containerized plant operations as opposed to field nurseries with plants in the ground. Nearly two-thirds of the vegetable and all the golf course land areas were reported to be irrigated.

Changes in Irrigation Technology

There have been dramatic changes in irrigation system technology and soil water content monitoring during the past 20 years (average time in the agricultural and golf industries for respondents). Generally, irrigation efficiencies have been improved in agricultural operations (i.e., fruit, vegetable, and ornamentals) by more direct water delivery systems that limit the application rate and land surface area irrigated (e.g., drip, microsprinkler) and by the use of soil water content monitoring devices (e.g., tensiometers, capacitance probes) that enable producers to reduce leaching and apply water based only on crop needs.

Fruit crop orchards. Nearly two-thirds of the fruit growers reported having a high volume irrigation system (e.g., high volume overhead, high volume under tree, high volume in-tree) when their operation first started and currently (Fig. 1). A high volume system applies water at 0.20 inches/acre per h or more using a diesel engine. The purpose of high volume systems is to protect trees during freezing events. This is highly recommended as freeze tolerance of subtropical and tropical fruit trees are limited (Schaffer and Andersen, 1994). The use of rotating water cannons (also called "big guns") for irrigation has decreased by about 50% (Fig. 1). This is due to a loss of 'Tahiti' lime acreage and replacement of big gun irrigation to high volume or more efficient irrigation systems. Big gun irrigation is a high volume system but the distribution and application timing is not appropriate for freeze protection.

About 30% of the fruit growers reported using low volume irrigation when first starting their operation (Fig. 1). However, over 75% of the producers reported that they now used these systems. The slight decline in drip irrigation use and doubling of microsprinkler use reflects a shift to low volume irrigation systems that have a larger area of water distribution compared to drip systems. Low volume systems are more water and energy efficient and have the capability of applying liquid fertilizers, which may save time, labor, energy, and fertilizer.

Ornamental nurseries. There was no significant change in the use of high volume irrigation (high volume overhead, high volume under plant) by the nursery industry (84% before to 89.0% now) (Fig. 1). As with fruit crops, this is a reflection of the need for these systems for freeze protection. The use of big gun irrigation has slightly increased. This probably reflects the preference in field nurseries to have a mobile irrigation system that may be moved from field nursery to field nursery, reducing the need to establish a costly high volume solid set system. In contrast, there was a doubling in the use of low volume irrigation systems (i.e., drip, microsprinkler) from about 26% to 52%. This is a reflection of the efficiency and versatility of these systems.

Vegetable farms. The use of high volume over head irrigation has declined to zero; however, the use of high volume solid set systems has not changed (Fig. 1). The decline in the use of high volume overhead irrigation systems is mostly due to establishment of fruit orchards on land used temporarily for vegetable crops during the last 3 years (J. Crane, personal communication). High volume solid set irrigation systems for vegetable crops are composed of lightweight aluminum detachable tubing with high volume sprinkler heads that can be taken apart and moved and reassembled easily. The use of big gun irrigation has not changed (66.7%). This is a reflection of the increased snap bean acreage where the cost of establishing a high volume solid set irrigation system is not economical. In contrast, the use of drip irrigation has increased by 50%. This reflects its utility in bedded vegetable production systems with such crops as tomato, peppers, and eggplant.

Golf courses. Golf courses use high volume overhead and pop-up irrigation systems exclusively (Fig. 1). The high volume overhead systems are modified to allow the insertion and removal of the sprinkler pipes so that they do not interfere with the golf game and are capable of covering large areas. Pop-up systems possess sprinkler heads that emerge above ground by water pressure and submerge below ground level once the water is turned off.

Water Sources

The use of open, uncased wells has declined by 7.3%, 7.5%, and 16.7% for fruit, ornamental, and vegetable crop operations, respectively (Fig. 2). In contrast, the use of capped, cased wells has increased for the fruit (50% before, 54% now) and ornamental nursery (46% before, 49% now) industries by about 3% and not changed for the vegetable operations (33%). The increased use of capped, cased wells for fruit and ornamental nursery operations reflects the relatively permanent location for irrigation wells for these types of operations. In contrast, the location of farmed vegetable land and crops grown changes annually making permanent wells often impractical. The use of open/uncased (33.3%) and city water (66.6%) sources for golf courses did not change.

Flooding and Drought

About one-third of the fruit, ornamental, and vegetable operations have experienced flooding within the last five years (Table 3). Of those operations reporting flooding, 57% to 75% reported a yield and/or a reduction in commodity quality as a result of flooding. Nearly 44% of the ornamental

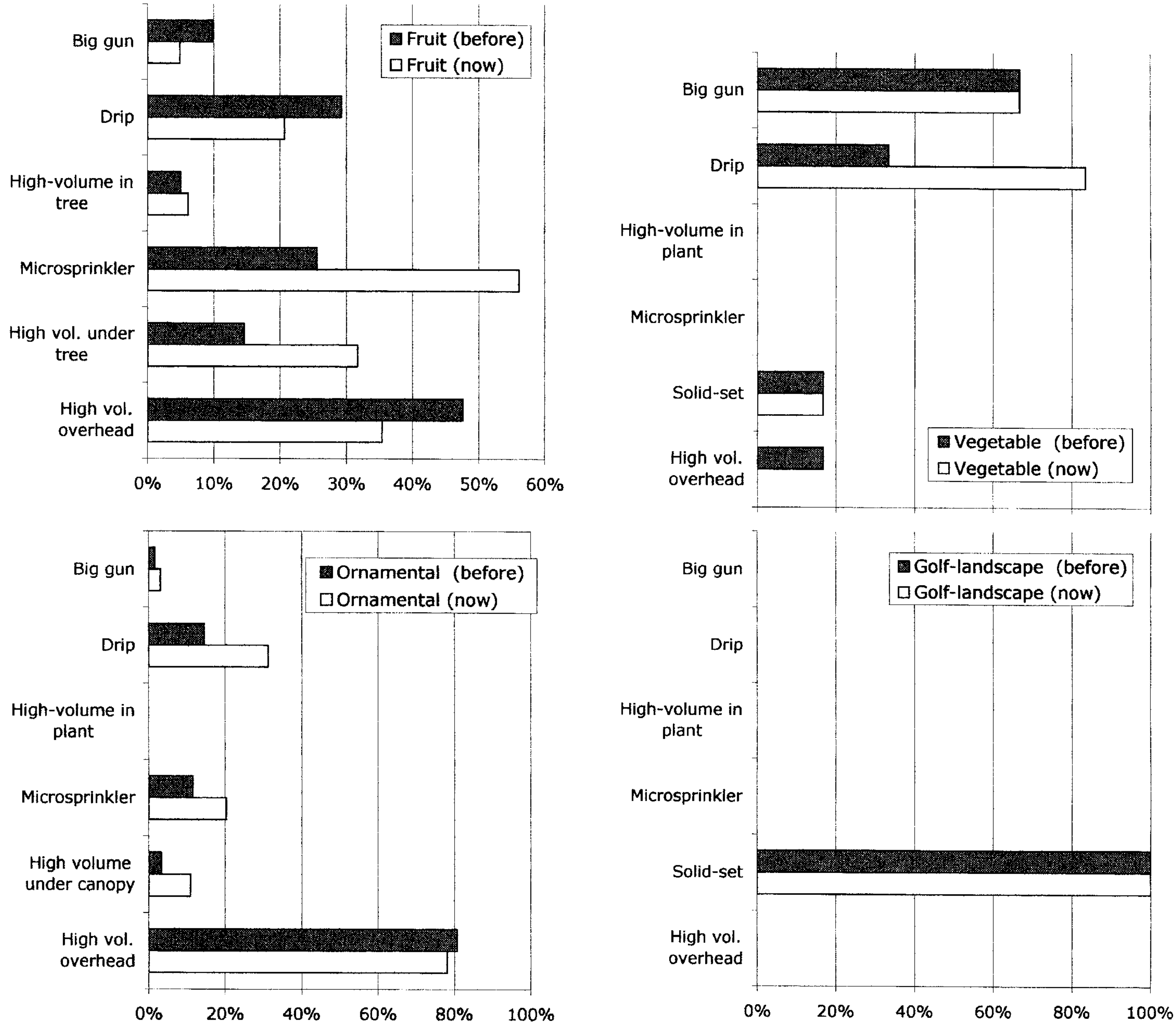

Fig. 1. Changes in irrigation systems used by fruit, vegetable, and ornamental nursery producers, and golf courses with time. The term "before" denoted irrigation system used when first started farming and "after" denoted current irrigation system used.

nursery operations and about a quarter and third of the fruit and vegetable operations, respectively, experienced drought sometime in the last five years. Of those operations experiencing drought, 25% to 50% reported a reduction in yield or commodity quality (Table 4). In a statewide nursery industry survey about 56% of the nursery operations reported a dramatic decrease in sales due to drought (Hodges and Haydu, 2000) confirming drought as a major production problem in the ornamental nursery industry. Drought was reported by about two-thirds of the golf course operations but only 10.5% experienced flooding during the last 5 years.

Water Conservation Practices

The survey included questions on the adoption of over 15 water conservation practices and motivations for adopting them. A subset of seven (Table 5) is presented here.

Fruit crop orchards. Designed and used properly, microirrigation systems (e.g., drip, microsprinkler, spaghetti tubing) conserve water. Over 90% of the fruit operations reported they use a drip or microsprinkler irrigation system in at least part of their operations (Table 5). About half of the fruit operations reported using some type of soil moisture monitoring; nearly 60% monitored weather data, and about two-thirds monitor rainfall as part of their irrigation decision-making. Nearly one quarter of the fruit operations kept irrigation records and about 30% used the services of the South Dade Soil and Water Conservation District's Mobile Irrigation Laboratory. This service is designed to assess the water and energy use efficiency of irrigation systems at no charge to producers. Recommendations for repairs and/or upgrades are provided in an effort to increase irrigation efficiency and conserve water.

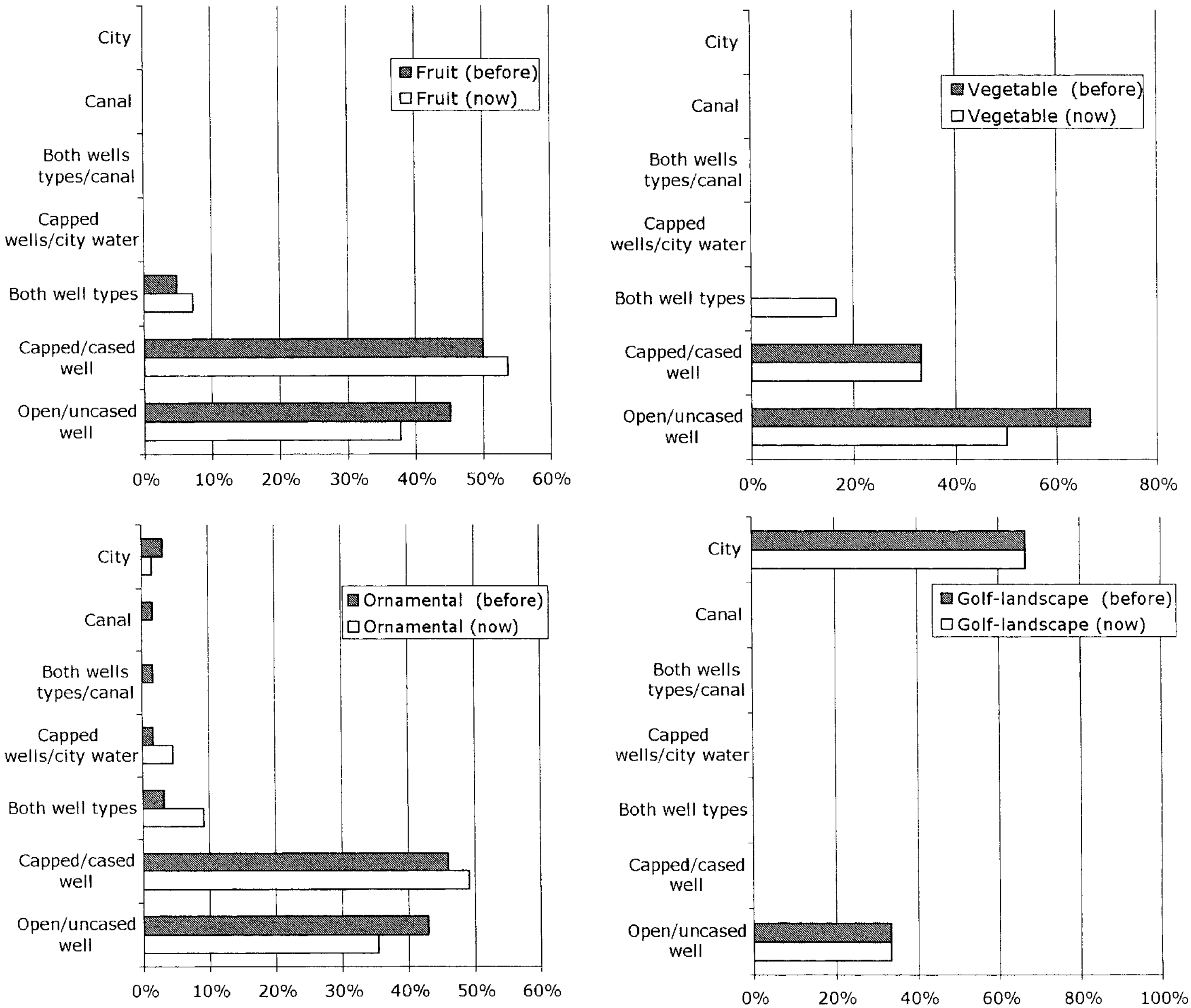

Fig. 2. Changes in water sources used by fruit, vegetable, and ornamental nursery producers, and golf courses with time. The term "before" denoted the source of water used when first started farming and "after" denoted current water source used for irrigation.

Ornamental nurseries. About 45% of the ornamental nursery operations responding indicated using drip irrigation or some other type of low volume system (Table 5). This includes both container and field nursery operations many of which grow large specimens in containers or in the field, making use of low volume irrigation systems practical. About two-thirds of the nurseries reported monitoring soil moisture, rainfall, and weather to determine their irrigation scheduling. Only 4.7% of the nursery operations kept irrigation records and 25% used the services of the Mobile Irrigation Lab.

Table 3. Operations that experience flooding (or have in the last 5 years).

Sector	Surface area (% of total)	% respondents that experienced reduction in yields	% respondents that experienced reduction in quality
Fruit	27.3%	59.3%	57.7%
Ornamental nurseries	27.3%	64.6%	75.0%
Vegetable	35.0%	66.7%	66.7%
Golf-landscape	10.5%	0%	0%
Across-groups	10.0%	61.0%	65.4%

Table 4. Operations that experienced water shortages (in the last 5 years).

Sector	Operations (% of total)	% respondents that experienced reduction in yields	% respondents that experienced reduction in quality
Fruit	23.2%	29.6%	34.6%
Ornamental nurseries	43.9%	25.8%	46.9%
Vegetable	33.3%	50.0%	50.0%
Golf-landscape	66.7%	100.0%	100.0%
Across-groups	33.1%	30.2%	42.9%

Table 5. Percentage of adoption of some water conservation practices by respondents.[z]

Question	Fruit	Ornamental	Vegetable	Golf course
Drip irrigation	36.9% (W)	45.3% (WM)	83.3% (WMT)	—
Other highly efficient irrigation (e.g., microsprinkler)	55.4% (WM)	—	33.3% (MT)	—
Soil moisture monitoring	48.8% (WMT)	65.6% (W)	83.3% (WMT)	66.7% (WM)
Measure rainfall	64.3% (W)	65.1% (W)	100% (WMT)	—
Weather data for irrigation scheduling	59.0% (WM)	62.5% (WMT)	100% (WMT)	66.7% (WM)
Keep irrigation records	24.1% (W)	4.7% (WM)	50.0% (WMT)	100% (M)
Use services of Mobile Irrigation Lab	29.8% (W)	25% (WM)	50% (MT)	33% (—)

[z]In parenthesis main reason for adoption: W-Water savings; T—Time saving; M—Money savings.

Vegetable farms. Over 100% of the vegetable operations survey reported utilizing drip irrigation or some other highly efficient irrigation system in at least part of their operations (Table 5). This is somewhat confusing in that many producers farm multiple crops some of which utilize low volume irrigation systems (e.g., tomato) and others that use big guns (e.g., bush beans). In addition, most vegetable growers farm separate pieces of land simultaneously (i.e., they were using different irrigation systems for different crops and land areas). The water use efficiency of the drip and other low volume systems along with their capability for liquid fertilization is attractive from a management and economic standpoint.

All the vegetable operations reported using rainfall and weather data for scheduling irrigation and over 80% utilize some type of soil moisture monitoring (Table 3). All the vegetable operations surveyed monitor rainfall and weather as a factor in when and how much to irrigate.

Golf courses. Golf courses generally used some type of high volume sprinkler system (Fig. 1) and about two-thirds reported using some type of soil moisture monitoring and weather data for irrigation scheduling (Table 5). All the golf courses reported keeping irrigation records and about one-third utilized the services of the Mobile Irrigation Lab.

Motivation for water conservation. The three most common motivations reported for utilizing water-conserving equipment, record keeping, and the services of the Mobile Irrigation Lab were water, time, and money savings. The most consistent reason given was water savings, followed by money savings. Vegetable producers consistently gave time as a reason for water conservation. This makes sense since the acreage farmed tended to be large (Table 1).

Conclusions

A large-scale mail-back water conservation survey was conducted in 2002 among four large water users in south Miami-Dade County. The overall response rate was deemed satisfactory (27%), although it varied by commodity group (11-42%).

Results generally showed an increase in the adoption of water conservation practices between the time when operations first started and currently. Challenges in the improvement of water delivery systems (e.g., the phase out of big-guns in vegetable crops, introduction of low volume irrigation systems in golf and ornamental operations), water sources (e.g., increase in the use of capped and cased wells) and management practices (record keeping, periodic irrigation evaluation by Mobile Irrigation Lab) remain. All agricultural commodity groups have adopted low volume irrigation systems and irrigation scheduling technologies from a moderate to a large extent. One-third to two-thirds of the respondents reported periodic flooding and drought with a reduction in yield and product quality reported by over one-half of the respondents. The main reason for adoption of water conservation practices varied by commodity although the most consistent reason given was water savings; time was a factor given consistently by vegetable producers.

The potential benefits of these survey results include fine-tuning the Cooperative Extension's educational programs and research activities at the Institute of Food and Agricultural Sciences, Tropical Research and Education Center for agricultural producers and golf course keepers. Our plan of work will include strategies to make it easier for participants to use and understand extension information as well as introduce and develop new and existing technologies for water conservation and management.

Literature Cited

Degner, R. L., T. J. Stevens, and K. L. Morgan. 2001a. Miami-Dade Agricultural Land Retention Study: Summary and Recommendations, Vol. I. Fla. Agri. Market Res. Center, IFAS, Univ. of Florida, Gainesville. p. 89.

Degner, R. L., T. J. Stevens, and K. L. Morgan. 2001b. Miami-Dade Agricultural Land Retention Study: Summary and Recommendations, Appendix B. Fla. Agri. Market Res. Center, IFAS, Univ. of Florida, Gainesville. p. 201.

Dolan, A. H., R. Kreutzwiser, and R. de Loë. 2000. Rural water use and conservation in southwestern Ontario. J. Soil and Water Conservation 55:161-171.

Hodges, A. W. and J. J. Haydu. 2000. Economic impacts of the Florida Environmental Horticulture Industry, Econ. Information Report EI-02-3. Food and Resource Economics Dept., Fla. Coop. Ext. Service, Gainesville. p. 87.

Hodges, A. W. and J. J. Haydu. 2000. Florida's environmental horticulture industry. Food and Resource Economics Dept., Fla. Coop. Ext. Service, Gainesville. p. 12.

Haydu, J. J. and A. W. Hodges. 2002. Economic impacts of the Florida golf course industry, Econ. Information Report EIR 02-4. Food and Resource Economics Dept., Fla. Coop. Ext. Service, Gainesville. p. 34.

Li, Y., J. H. Crane, B. Boman, and C. Balerdi. 2000. Irrigation management survey for tropical fruit crops in south Florida. Proc. Fla. State Hort. Soc. 113:40-42.

Nachmias D. and C. Nachmias. 1976. Research Methods in the Social Sciences. New York: St. Martin's Press.

Neuman, L. W. 1997. Social Research Methods: Qualitative and Quantitative Approaches. 3rd ed., Boston: Allyn and Bacon.

SAS Institute, Inc. (1999). SAS 8.01 [Computer software]. SAS Institute, Inc., Cary, N.C.

Schaffer, B. and P. C. Andersen. 1994. Handbook of environmental physiology of fruit crops, Vol. II: sub-tropical and tropical crops. CRC Press, Inc., Boca Raton, Fla. p. 310.