of the wind. Wind mixes the dry and the moist, the cold and the warm and in the process destroys some of the diversity of conditions that makes uniform protection difficult to provide.

Evaporation consumes energy. It is accelerated by dry wind. However evaporation produces water vapor which is quite buoyant. The resulting rising plumes of vapor tend to organize a vertical structure to the layers of air through which they move, and this vapor island effect deflects wind *much as does the canopy*. Circulations within the canopy driven by vapor plumes distribute moisture throughout the canopy. This mixing within the canopy makes the canopy appear more dense to the approaching wind. Evaporation may be playing the leading role in a process that distributes the effect of under-tree sprinkling upward in the canopy beyond anything that the fusion models have visualized.

Literature Cited

Barfield, B. J. and J. F. Gerber [Editors]. 1979. Modification of Aerial Environment of Plants. ASAE Monograph No. 2. St. Joseph, MI. 538 pp.

Barfield, B. J., K. B. Perry, J. D. Martsolf, and C. T. Morrow. 1990. Modifying the aerial environment. In: G. J. Hoffman, T. A. Howell, K. H. Solomon, (ed.). Management of Farm Irrigation Systems. Amer. Soc. Agric. Engineers Monograph. Chapter 22, pages 825-869.

Barfield, B. J., L. W. Walton, and R. E. Lacy. 1981. Prediction of sprinkler rates for night-time radiation frost protection. Agric. Meteorol. 24:1-9.

Businger, J. A. 1965. Frost protection with irrigation. Amer. Meteorol. Soc. Meteorol. Monographs 6(28):74-80.

Davies, D. L., R. G. Evans, G. S. Campbell, and M. W. Kroeger. 1988. Undertree sprinkling for low temperature modification in apple orchards. Trans. Amer. Soc. Agr. Engr. 31(3):789-803.

Downton, M. W. and K. A. Miller. 1993. The freeze risk to Florida Citrus. Part II: Temperature variability and circulation patterns. J. of Clim. 6(2):364-372.

Ferguson, J. J. and C. L. Taylor. 1993a. The 1992 Statewide Citrus Management Survey. Proc. Fla. State Hort. Soc. 106:in press.

Ferguson, J. J. and C. L. Taylor. 1993b. 1992 Citrus Management Survey. Univ. of Fla. Coop. Ext. Service Circular PE-39, August, 16 pages.

Gerber, J. F. and D. S. Harrison. 1964. Sprinkler irrigation for cold protection of citrus. Trans. of ASAE 7(4):464-468.

Gerber, J. F. and J. D. Martsolf. 1965. Protecting citrus from cold damage. Agr. Ext. Serv., Univ. of Fla., Cir 287, 29 pp.

Gerber, J. F. and J. D. Martsolf. 1979. Sprinkling for frost and cold protection. In: B. J. Barfield and J. F. Gerber (editors). Modification of the aerial environment of plants. ASAE Monograph 2:327-333.

Heinemann, P. H., C. T. Morrow, J. D. Martsolf, R. M. Crassweller, and K. B. Perry. 1992. A decision support program for the protection of crops from frost. 3rd Int. Symp. on Computer Modeling in Fruit Research and Orchard Management. Palmerston, New Zealand. Acta Hort. 313:219-225.

Heinemann, P. H., C. T. Morrow, J. D. Martsolf, R. M. Crassweller, and K. B. Perry. 1993. A decision support program for the design and management of frost protection systems. In: D. G. Watson, F. S. Zazueta, and A. B. Bottcher [Editors]. Computers in Agricultural Extension Programs. Proc. of 5th International Conf., Orlando, Fla., ASAE Publ. 1-93, In press.

Kalma, J. D., C. P. Laughlin, J. M. Caprio, and P. J. C. Hamer. 1992. The Bioclimatology of Frost. Springer-Verlag, New York, NY. 144 pp.

Martsolf, J. D. 1989. Heated irrigation cold protection. Proc. Fla. State Hort. Soc. 102:64-69.

Martsolf, J. D. 1990a. Cold protection strategies. Proc. Fla. State Hort. Soc. 103:72-78.

Martsolf, J. D. 1990b. Grove heating, good news and bad. Citrus Industry Magazine 71(11):24-30.

Martsolf, J. D. 1992. Cold protection mechanisms. Proc. Fla. State Hort. Soc. 105:91-94.

Martsolf, J. D. 1993. Citrus cold protection with sprinklers. HortScience 28(5):199.

Martsolf, J. D. and H. E. Hannah. 1991. In-tree versus under-tree sprinkling for protection of young citrus trees from cold damage. Proc. Fla. State Hort. Soc. 104:139-142.

Martsolf, J. D., P. H. Heinemann, and C. T. Morrow. 1991. Protection from frost or freeze with sprinklers. HortScience 26(6):729. [Abst]

Martsolf, J. D., W. J. Wiltbank, H. E. Hannah, F. Johnson, Jr., R. A. Bucklin, and D. S. Harrison. 1988. Modification of temperature and wind by an orchard cover and heaters for freeze protection. Proc. Fla. State Hort. Soc. 101:44-48.

Miller, K. A. 1991. Response of Florida citrus growers to the freezes of the 1980's. Clim. Res. 1:133-144.

Miller, K. A. and M. W. Downton. 1993. The freeze risk to Florida citrus. Part 1: Investment decisions. J. of Clim. 6(2):354-363.

Perry, K. B. 1986. FROSTPRO, a microcomputer program to determine overhead irrigation rates for frost/freeze protection of apple orchards. HortScience 21:1060-1061.

Perry, K. B., C. T. Morrow, A. R. Jarrett, and J. D. Martsolf. 1982. Evaluation of sprinkler application rate models used in frost protection with a note on a distribution factor. HortScience 17(6):884-885.

Proc. Fla. State Hort. Soc. 106:70-74. 1993.

THE 1992 STATEWIDE CITRUS MANAGEMENT SURVEY

J. J. FERGUSON
Horticultural Sciences Dept.
IFAS, University of Florida
Gainesville, FL 32611

C. L. TAYLOR
Program Evaluation and Organizational Development
IFAS, University of Florida
Gainesville, FL 32611

Additional index words. extension, production.

Abstract. **Management problems and information needs of Florida's approximately 12,000 citrus growers on 791,290 acres were identified by a statewide citrus management survey. During the summer of 1992, citrus county agents' mailing lists were compiled to create a master list of 2,964 addresses, from which a sample of 833 growers was selected by a stratified proportional sampling procedure. Three hundred ninety-eight useable questionnaires were returned from commercial citrus grove owners and managers in 23 citrus producing counties, representing 307,022 acres, 39% of the current acreage. Survey data on general management, young tree care, pest management, water management and cold protection was further analysed by whether respondents' acreage was bedded or unbedded. Information from this citrus survey**

Florida Agricultural Experiment Station Journal Series No. N-00822.

and previous ones has been used to develop and evaluate comprehensive extension programs in the above areas as part of the IFAS overall effort in "Challenge '95, Excellence in Florida Extension Programs."

Given the size and diversity of the Florida citrus industry, research and extension faculty have frequently conducted surveys, based on both sampling methods and personal interviews, to identify production problems and information needs and to quantify current production practices. Surveys have been conducted on Florida citrus nursery practices (Castle and Ferguson, 1982; Williamson and Castle, 1989), young tree care (Jackson et al., 1986), annual tree loss (Muraro, 1988), nutrition and fertilization of bearing groves (Tucker et al., 1990), occurrence of the citrus nematode (Ferguson, 1984), the citrus root weevil (Israel et al., 1991), incidence of *Phytophthora* in citrus nurseries (Sitko et al., 1987), weed control in the Indian River area (Spyke et al., 1977), commercial organic citrus growers (M. E. Swisher, University of Florida, personal communication) and the biennial commercial citrus inventory surveys conducted by the Florida Agricultural Statistics Service since 1966 (Florida Agricultural Statistics).

When the Institute of Food and Agricultural Sciences, University of Florida began to formulate specific, goal-oriented extension programs in commodity departments, a statewide citrus extension program, "Citrus Management in Florida" was developed in 1987. Baseline data in 5 production and discipline areas—young tree care, pest management, water management, cold protection and business management—was obtained through a mailed survey drawn from a sample of 3,560 citrus producers and used to design extension programs for a long range plan of work from 1987-1991 (Jackson, 1988). Focusing on areas similar to those of the 1987 document, a shorter, follow-up survey conducted in 1992 and reported in this paper, provided information to both evaluate the first 4-year plan of work and define extension priorities for the second 4-year plan from 1992 to 1995.

Materials and Methods

To obtain a representative cross section of the Florida citrus industry, county agent mailing lists were compiled from 23 counties where citrus is commercially grown to create a master address list. After duplicate and inappropriate entries were removed, 2,964 addresses remained. A stratified proportional sampling procedure was used to obtain a sample of 833 growers. Three hundred eighty-nine useable questionnaires were returned, providing an expected error rate of ±4.7% with a 95% confidence interval. Responses from 374 respondents, who indicated that they held major decision-making responsibilities for a commercial citrus operation of ten acres or more, were included in the survey.

The Total Design Method of gathering survey information as developed by Dillman (1978) was used to guide the survey process. The survey instrument consisted of informational and multi-item, scaled questions. Concepts were developed by state and county extension faculty with survey design, question format and data analysis done by faculty in the Extension Program Evaluation and Organizational Development Unit. Questions focusing on general management were followed by sections on young tree care, pest management, water management and cold protection.

Each questionnaire provided 339 response options. Data were analysed according to frequency—the number of times an option is chosen—and percent—the number of times an option is chosen divided by the total number of respondents who answered that question. Ranked lists were determined by first weighting the response options (a response at one end of the scale would be weighted five, a response at the other end weighted one) then multiplying the frequencies of the options by their weightings. For each question, the weighted values from each point along the option scale were added together to arrive at a weighted total that could be ranked among other weighted totals. On each figure n = number of respondents for that question.

Since citrus is grown in Florida on both the deep, well-drained, sandy soils of the central Florida ridge with **unbedded** groves and the shallow, poorly-drained flatwoods soils of southern Florida with **bedded** groves, responses to certain questions were further analysed by these regional categories. In specific questions, the numbers of bedded and unbedded acreage may not add up to the total acreage since not all respondents answered all questions.

The survey form and all follow-up correspondence were sent from the Extension Program Evaluation Unit in Gainesville. Separate mailings were made in the following order: a prenotification postcard informing each individual of the forthcoming survey; the questionnaire and cover letter with postage-paid business reply envelope; an immediate follow-up letter, another survey form and business reply envelope to those not responding within 14 days. Identification numbers were assigned to all individuals surveyed. These numbers were placed on questionnaires to allow follow-up of non-respondents. Confidentiality of response was assured in the cover letter.

Results and Discussion

General management. Of the 374 respondents who indicated they held major decision-making responsibilities for a commercial citrus operation of ten acres or more, 24% owned an average of 189 acres but were not involved in day-to-day operations; 57% owned and managed an average of 488 acres and managed an average of 1,557 acres for others; 19% were managers only.

More growers (68%) produce oranges for the processed market than for the fresh market (18%), with more growers on **unbedded** groves (95%) producing oranges for either market than on **bedded** groves (73%). A smaller percentage of all growers surveyed produce grapefruit for the fresh (12%) and the processed market (1%). Twenty-four percent of these fresh grapefruit growers are located on bedded groves, with only 2% on unbedded land (Table 1). Less than 1% of all surveyed growers produce mandarins or mandarin hybrids, with about 1% of those growers on **bedded** and 2% on **unbedded** acreage (Table 1).

Different spray programs are recommended for fresh and processed citrus. However, this does not preclude fruit grown for the fresh market from being diverted to the processed market or vice versa. Forty-one percent of all growers divert crops grown under fresh fruit programs to the processed market. Thirty-eight percent of all growers send crops grown under a processed program to the fresh market. However, more growers with **unbedded** groves

Table 1. Fruit Production for Fresh and Processed Markets.[z]

	Growers (%)		Acreage		
	Bed[y]	Unbed[x]	Bed	Unbed	Total
Oranges					
Fresh	14	19	26,907	12,944	40,211
Processed	59	76	119,490	41,092	163,078
Grapefruit					
Fresh	24	2	24,392	1,513	25,964
Processed	2	1	506	52	588
Mandarins and mandarin hybrids	1	2	65	281	364

[z]Mean ± 4.7% at 5% level.
[y]Bedded groves.
[x]Unbedded groves.

(49%) send fresh fruit to processed markets than do growers with **bedded** groves (34%).

When asked to identify their five most important information needs, growers with **bedded** groves specified pest management, cost effective chemicals, marketing, government regulations and water management (Figure 1) whereas those on **unbedded** groves choose pest management, cost effective chemicals, cold protection, fertilization/liming and water management (Figure 2). In a related question growers said they relied upon fertilizer and pesticide representatives (57%), University of Florida (IFAS) personnel (54%), IFAS publications (54%), other growers and managers (54%), industry meetings (50%), trade magazines (49%), consultants (28%) and the futures market (9%) for making production and marketing decisions (Figure 3). Given a list of current issues pertaining to citrus production and management, more than 80% of respondents said they thought pesticide/water use restrictions and foreign competition would increase over the next 10 years and that land availability (80%) and labor availability (53%) would decrease. In a related question, greater than 70% said pesticide/water restrictions and foreign competition would have a negative effect on citrus operations, along with 31% who felt land and 55% who thought that labor availability would also have a negative impact. At the same time, 95% of growers thought that restrictions on water usage, pesticide application and other related issues to protect the environment were at least somewhat necessary. Approximately nine percent of all respondents use livestock or poultry manure on 14,001 acres, 11,305 of them bedded,

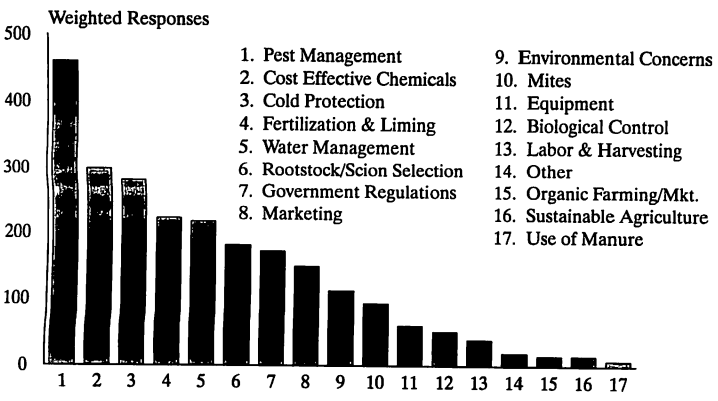

Fig. 1. Ranking of information needs of growers with bedded groves (n = 148).

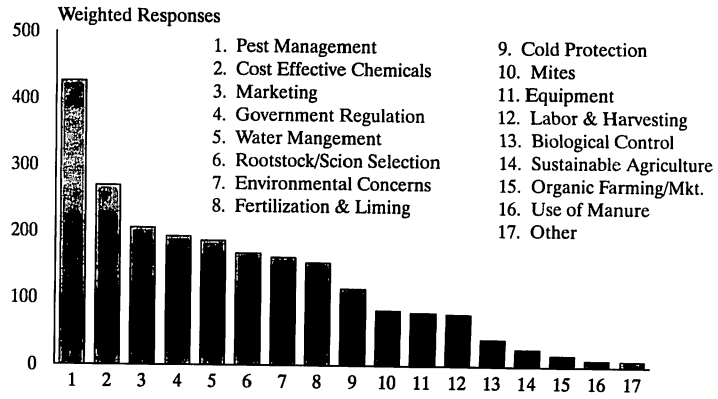

Fig. 2. Ranking of information needs of growers with unbedded groves (n = 160).

2,644 unbedded. Seven percent use treated sludge on 17,236 acres, 16,130 bedded and 1,006 unbedded. Only two percent of all respondents use treated wastewater on 2,593 acres, 1,778 bedded and 735 unbedded. The total acreage treated with manures, sludges and municipal wastes, 33,830 acres total, represent 4.3% of the total citrus acreage.

Young tree care. A young tree is defined here as a typical citrus nursery tree planted in the field for up to three years. Sixty-three percent of all young trees purchased are bare root and 37% are containerized. Forty-one percent of growers buy only bare root trees; 19% buy only containerized trees; 40% buy both types of nursery trees.

Growers with **bedded** groves reported fire ants, weed control, foot/root rot, cold protection and insect pests to be the top five problems in young tree care (Figure 4), with the most common causes of tree death being foot/root rot, fire ants, cold damage, poor planting methods and inadequate irrigation (Figure 5). Growers with **unbedded** groves ranked cold protection as the most important problem, followed by fire ants, weed control, mites and foot/root rot (Figure 6), with the most common causes of tree death being cold damage, fire ants, foot/root rot, inadequate irrigation and poor tree condition at planting (Figure 7). Growers statewide reported an average 4% death rate for resets (young trees that replace trees that have died).

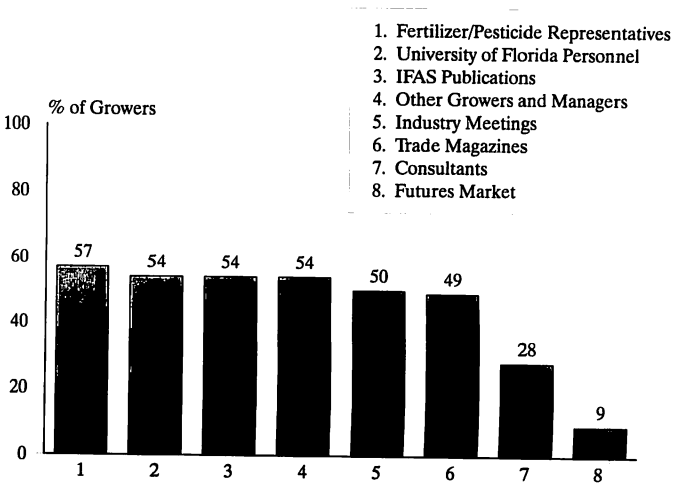

Fig. 3. Sources of information for production and marketing decisions (n = 375).

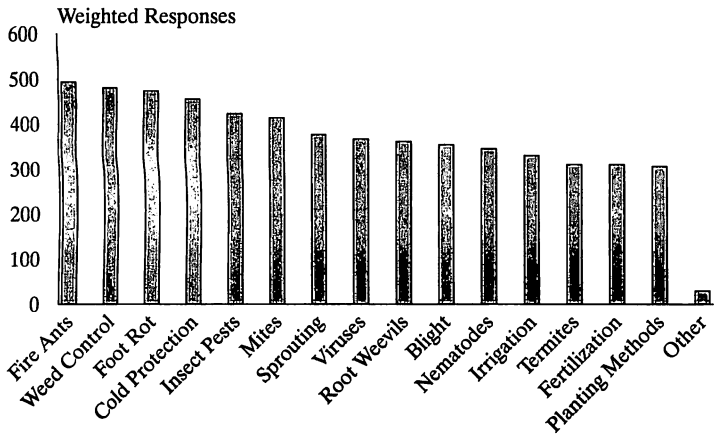

Fig. 4. Ranking of young tree care problems for growers with **bedded** groves (n = 165).

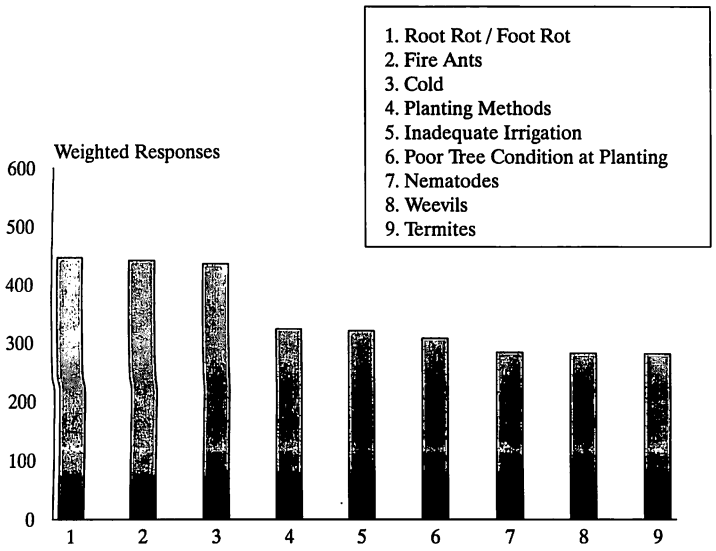

Fig. 5. Ranking of the causes of young tree death for growers with **bedded** groves (n = 165).

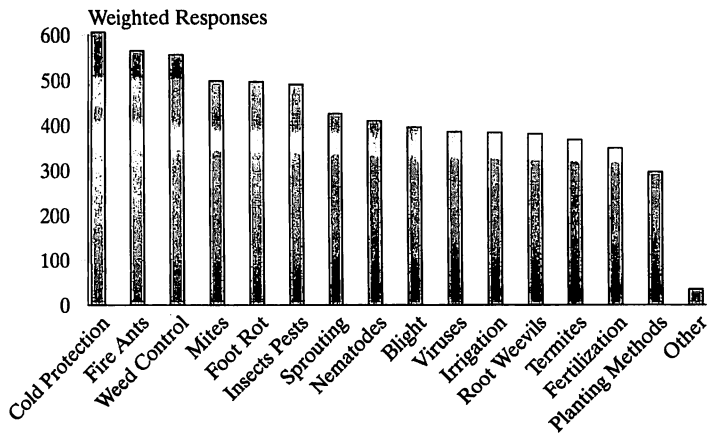

Fig. 6. Ranking of young tree care problems for growers with **unbedded** groves (n = 148).

On the average, trees are spaced 15 feet (± 6 feet) apart within the row and 24 feet (± 4 feet) apart between rows, indicating a considerable variation in tree spacing for orange

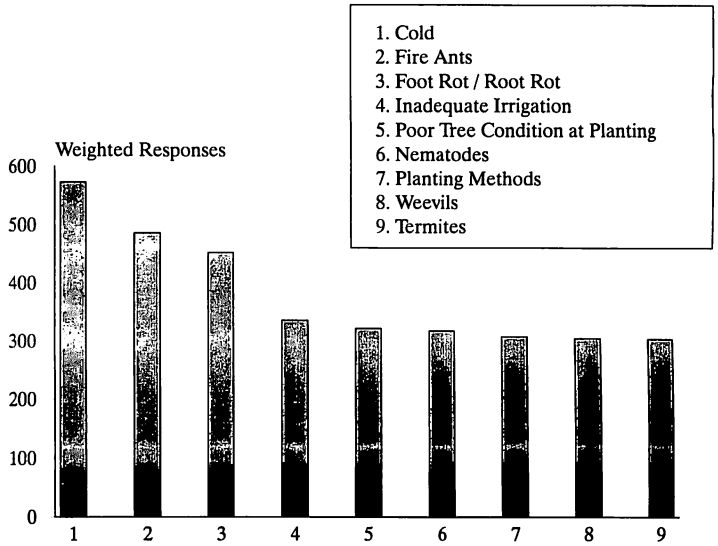

Fig. 7. Ranking of the causes of young tree death for growers with **unbedded** groves (n = 185).

and grapefruit trees. A 15 × 24 spacing equals 121 trees per acre. Using the above standard deviations, spacings of 21 × 28 and 9 × 20 would produce 74 and 242 trees per acre, respectively. Both bedded and unbedded trees at 2, 3, 4 and 5 years of age produce on the average 0.45, 0.55, 1.5 and 2.5 90-pound boxes of fruit, respectively.

Following planting, 62% of growers use water-soluble dry fertilizers, 35% use controlled release materials and 49% fertigate. Of those using fertigation, 1% use it daily, 30% weekly, 43% biweekly and 26% monthly. The five most commonly used cold protection methods for young trees are irrigation (64%), wraps (40%), irrigation with wraps (40%), soil banks (28%) and, no protection (7%).

Pest management. An overwhelming majority (98%) of the survey respondents apply the following types of chemicals for weed control near their young trees approximately twice per year: burn down (i.e. paraquat), soil residual/ burn down (i.e. bromacil + diuron/paraquat), soil residual (i.e. norflurazon), and systemic herbicides (i.e. glyphosate). Growers were then asked if the number of weed species that cannot be controlled with currently available herbicides is increasing, decreasing or not changing. Forty-one percent of growers with **bedded** and 34% of growers with **unbedded** acreage said the number is increasing; no change was indicated by 48% of **bedded** and 54% of **unbedded** growers; a decrease was noted by **bedded** (11%) and **unbedded** (12%) producers. For weed management in row middles, 54% use only mechanical methods, with 40 and 6% using mechanical/chemical and chemical methods only, respectively.

Fifty-one percent of the respondents apply approximately seven treatments per year to control fire ants on young trees and 62% apply systemic fungicides to control foot/root rot. Forty-five percent of growers surveyed sample for nematodes but only 31% apply nematicides. Of those who use nematicides, 38% apply aldicarb and fenamiphos and 66% of this group apply these materials annually, 16% every 2 years and 8% every 2 out of 3 years. These materials are applied by 56% of growers from trunk to dripline, 27% at the dripline only, 7% from trunk to

trunk only and 5% to row middles. Approximately half of those using aldicarb and fenamiphos said they use them at less than maximum rates.

Water management and cold protection. Ninety-three percent of all growers had irrigation systems of the following types: microsprinklers (79%) on 70% of the acreage, drip (16%) on 10% of the acreage, flood/seepage (13%) on 11% of the acreage, overhead (12%) on 6% of the acreage, portable or self-propelled guns (4%) on 0.80% of the acreage, and under tree rotary (2%) on 0.15% of the acreage. The percent growers reporting types of irrigation totals more than 100% since some growers have more than one type of irrigation system. Approximately 60% of respondents said that water quality was not a problem. Those who identified water quality as a problem specified bacteria or algae (52%), iron or sulfur (44%), dissolved solids (43%) and non-waterborne particles (34%). Some respondents were unsure of the specific cause of their water problems and a few cited high pH as a concern.

The five most important factors **bedded** growers use to determine when to irrigate bedded groves are soil appearance, number of days since last rain, tree wilting, the accounting method and other scheduling methods, with the first two items reversed for **unbedded** growers. Low volume irrigation systems were run most frequently during the spring (2.3 times per week), and 1.8, 1.7 and 1.6 times per week during the summer, fall and winter, respectively. Almost all respondents (97%) irrigated their resets, most commonly with microsprinklers (87%), volume gun (23%) and water wagons (14%). Over half of the citrus producers (57%) surveyed designed their irrigation systems for fertigation and/or chemigation. Of this population 94% injected fertilizers, 42% fungicides, 35% herbicides and 24% insecticides. The five most important information needs concerning cold protection were correct freeze forecasts, using irrigation for cold protection, interpretation of forecasts, use of current frost protection methods and the use of tree wraps. Half of the growers surveyed indicated that the National Weather Service was their primary source of Weather Information, with 27% using tv/radio sources and 13% using local extension offices.

The most common cold protection method for mature groves was microsprinkler irrigation systems (74% of growers), with 18% using flood/seepage, 17% using no cold protection methods, 5% using heaters, and 3% using wind machines. **Bedded** growers who use irrigation systems for cold protection could run drip systems on an average of 751 acres, flood/seepage on 1,068 acres and microsprinklers on 819 acres. Growers with **unbedded** groves could run drip irrigation on 89 acres, flood/ seepage on 139 and microsprinklers on 143 acres. Thirty-five percent of growers who use irrigation to protect young trees from cold turn on their irrigation systems at temperatures from 36-40F, with 43% doing so at 33-35F. Thirty-three percent turn off their systems at 40-45F and 45% do so at 35-39F. When microsprinklers are used during months when freezes can occur, **bedded** growers use an average of 12 gallons per tree per hour for an average of 36 hours during the winter months. Those with **unbedded** groves use an average of 13 gallons per tree per hour for an average of 42 hours. When microsprinklers are elevated for cold protection, 55% of **bedded** growers place emitters at less than 12 inches, 7% at 12 to 24 inches and 6% at 25 to 36 inches. Forty-nine percent of **unbedded** growers place emitters at less than 12 inches, with 37% at 12 to 24 inches and 11% at 25 to 36 inches.

Although the 2 previous citrus management surveys (Jackson et al., 1986; Jackson et al., 1988) and the current one differ in design and comprehensiveness, data from similar survey questions provide information for extension and research programing. Major production problems identified by growers, with some regional emphasis, include pest management, cold protection, government regulations, labor, selection of cost effective chemicals and water management. Similarly, important young tree concerns include cold protection, fire ants, weed control foot/root rot, and insect pests. Young tree mortality in all 3 surveys range from 0-100% per year, with a mean of about 4%. Although the same percentage of growers applied treatments for fire ants and weed control since 1987, more growers used systemic chemicals to control foot/root rot in 1992 (62%) than in 1987 (30%). Although growers thought the increasing number of pesticide regulations would have a negative inpact on grove operations, interest in environmental concerns, biological control and sustainable agriculture ranked relatively low in the current survey. Microsprinkler irrigation is used on more acreage now (70%) than 5 years ago (39%) but irrigation decisions are still based primarily on general observations of soil moisture, tree wilting and incidence of rainfall than on any accounting or scheduling method. Irrigation, either alone or in combination with other methods, remains the most widely used method of cold protection for young trees. Growers continue to rely heavily on the National Weather Service and commercial tv/radio for reports and interpretation of weather and rank highly the need for information on current cold protection methods.

Literature Cited

Castle, W. S. and J. J. Ferguson. 1982. Current status of greenhouse and container production of citrus nursery trees in Florida. Proc. Fla. State Hort. Soc. 95:42-46.

Dillman, D. A. 1978. Mail and telephone surveys. The total design method. John Wiley and Sons.

Ferguson, J. and R. Dunn. 1984. Occurrence and control of the citrus nematode. Citrus Industry. 65:17-20, 23.

Florida Agricultural Statistics Service. 1992. Commercial Citrus Inventory. 1992. 109 pp. Florida Agricultural Statistics Service, 1222 Woodward St., Orlando, FL 32803.

Israel, G. D., C. L. Taylor, W. C. Stephenson, and J. L. Knapp. 1991. The citrus root weevil in Florida groves, PE-15. 11 pp. University of Florida.

Jackson, L. K., W. R. Summerhill, and J. J. Ferguson. 1986. A survey of young citrus tree care practices in Florida. Proc. Fla. State Hort. Soc. 99:44-46.

Jackson, L. K., C. L. Taylor, and R. M. Davis. 1988. Statewide citrus manager survey results. Proc. Fla. State Hort. Soc. 101:83-87.

Muraro, R. P. 1988. Estimated average annual percent tree loss for Florida's citrus industry. Proc. Fla. State Hort. Soc. 101:63-66.

Spyke, P. D., L. K. Jackson, and J. Soule. 1977. Weed control in the Indian River area. Proc. Fla. State Hort. Soc. 90:14-17.

Tucker, D. P. H., R. M. Davis, T. A. Wheaton, and S. H. Futch. 1990. A nutritional survey of southcentral, southwest and east coast flatwoods citrus groves. Proc. Fla. State Hort. Soc. 103:324-327.

Williamson, J. G. and W. S. Castle. 1989. A survey of Florida citrus nurseries. Proc. Fla. State Hort. Soc. 102:78-82.

Zitko, S. E., L. W. Timmer, and W. S. Castle. 1987. Survey of Florida citrus nurseries for *Phytophthora* spp. Proc. Fla. State Hort. Soc. 100:82-85.