Thirteenth Annual Report

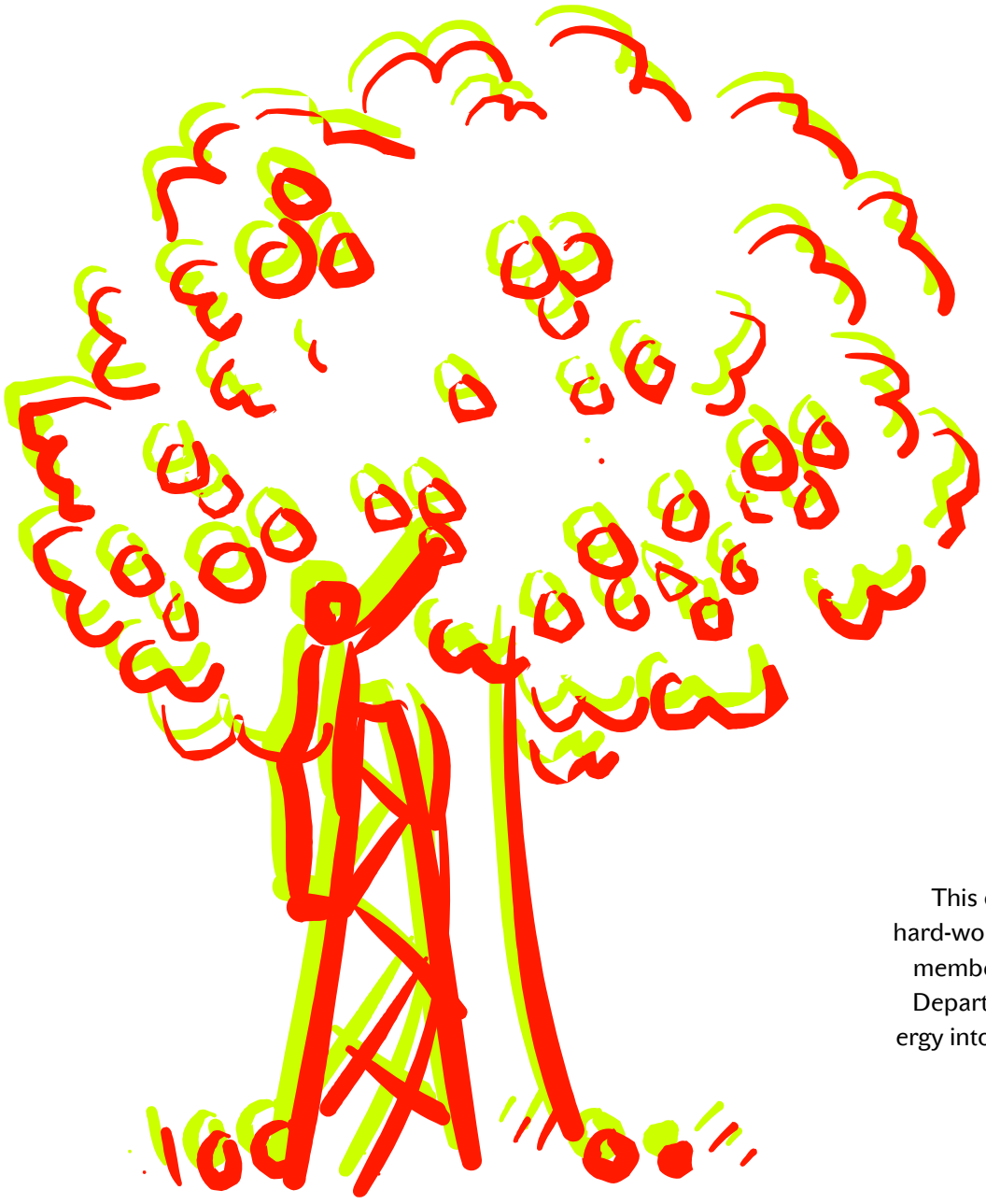
2004 to 2005

FCPRAC

FLORIDA CITRUS PRODUCTION RESEARCH ADVISORY COUNCIL

Thirteenth Annual Report

July 1, 2004 to June 30, 2005



Version: 1-21-06-E
Press Submission

This document is dedicated to the many hard-working researchers, FCPRAC Council members and the CREC Word Processing Department who invest their time and energy into serving the Florida citrus industry.
Cover design by Roy Scott.

Administered by
Charles H. Bronson, Commissioner
The Florida Department of Agriculture and Consumer Services

Florida Citrus Production Research Advisory Council

This document prepared by

Steven Rogers
Scientific Coordinator
University of Florida – CREC
Lake Alfred, FL 33850
863-956-1151
steve@fcprac.com
www.fcprac.com

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fcprac council members

Members

Peter McClure (2006), Chairman
10410 Bluefield Road
Okeechobee, FL 34972
(863) 763-4869 x 311 phone
(863) 763-4367 fax
pmcclure@evansprop.com

Bill Barber (2006), Vice-Chairman
7 Lykes Road
Lake Placid, FL 33852
(863) 465-4127 phone
(863) 465-7111 fax
bill.barber@lykes.com

Fred Saunders (2006)
13100 W. Colonial Drive
Winter Garden, FL 34787
(407) 656-2291 phone
(407) 656-1433 fax
gfs1780@yahoo.com

John Strang (2006)
PO Box 1364
Auburndale, FL 33823
(863) 956-3485 phone
(863) 956-5106 fax
gapway.grove1@verizon.net

Mark Sanchez (2004)
7735 County Road
Fellsmere, FL 32948
(772) 571-1940 phone
(772) 571-0675 fax
mark@sunaginc.com

George Walker (2004)
16217 Bowline Street
Bokeelia, FL 33922
(239) 860-4625 phone
(239) 283-0379 fax
gwalker31@comcast.net

Wayne Jackson (2006)
PO Box 610
LaBelle, FL 33975
(863) 675-3119 phone
(863) 675-7171 fax

Alternates

Andrew Pike (2004)
465 34th Court SW
Vero Beach, FL 32968
(941) 628-0733 phone
(863) 465-6326 fax
pikeabp@aol.com

Larry Davis (2004)
PO Box 668
Wauchula, FL 33873
(863) 735-0021 phone
(863) 735-2991 fax
(863) 781-0768 cell

Charles Counter (2004)
PO Box 337
Haines City, FL 33845
(863) 422-4924 phone
(863) 421-2613 fax
charles@hilltopcitrus.com

Steve Farr (2008)
Post Office Box 127
Frostproof, FL 33884
(863) 635-2251 phone
(863) 635-7333 fax

Tom Hammond (2006)
PO Box 3278
Vero Beach, FL 32964
(772) 778-6560 phone
(772) 778-6532 fax

Ed English (2004)
9500 County Road 858
Immokalee, FL 34142
(239) 229-8855 phone
(239) 657-4462 fax

Jerry Newlin (2006)
12010 NE Highway 70
Arcadia, FL 33821
(863) 494-4939 x 201 phone
(863) 494-2655 fax
jnewlin@sunletter.com

Steven Rogers, PhD
Scientific Coordinator
University of Florida–CREC
700 Experiment Station Rd.
Lake Alfred, FL 33850
(863) 956-1151 phone
(863) 956-4631 fax
steve@fcprac.com
www.fcprac.com

Marshall Wiseheart
Council Secretary
7 Lykes Road
Tallhassee, FL 33852
(850) 488-4366 phone
(850) 922-0374 fax
wisehem@doacs.state.fl.us

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Presented in this Thirteenth Annual Report is information about research conducted during Fiscal year 2004–2005 by the Florida Citrus Production Research Advisory Council. The Council operates under the Florida Citrus Production Research Marketing Order. This research support program was established under the more general Florida Marketing Act, which enables Florida Citrus Growers to tax themselves to provide funding to support essential research needs. Growers approved the marketing order by referendum in 1991 and again recently in 2004 for another 6-year term. The Council began its work in 1992.

Introduc

Financial Summary for Fiscal Year 2004–2005

Balance Forward — 7/1/2004	$2,152,011
Revenue — 7/1/04 to 6/30/05	1,258,737
Total Cash	$3,410,749
Disbursements	
Total Disbursements	2,055,613
Available 2004-2005	$1,355,136

TABLE 1. FCPRAC financial summary for Fiscal Year 2005–2006. Amounts are represented in total dollars and are rounded to the nearest dollar.

tion

TABLE 2. FCPRAC funding by years for each category. Smaller numbers in parentheses are numbers of projects (new and continued). Larger numbers in each cell represent funding in dollars.

	Entomology	Manage/Phys.	Pathology	Improvement	Totals
FY 93 – 97	(10) 306,702	(10) 314,792	(12) 304,818	(3) 127,398	(25) 1,053,710
FY 97 – 98	(13) 258,814	(14) 372,064	(10) 363,354	(3) 135,000	(40) 1,129,232
FY 98 – 99	(16) 349,248	(17) 462,291	(14) 453,379	(4) 177,000	(51) 1,441,918
FY 99 – 00	(13) 250,035	(7) 163,965	(9) 300,513	(9) 338,722	(38) 1,053,235
FY 00 – 01	(10) 239,070	(10) 221,810	(10) 351,057	(8) 360,500	(38) 1,172,437
FY 01 – 02	(13) 326,154	(13) 333,500	(12) 516,251	(3) 578,000	(41) 1,753,905
FY 02 – 03	(10) 523,870	(11) 372,500	(10) 640,579	(4) 687,965	(35) 2,224,914
FY 03 – 04	(7) 493,340	(12) 459,700	(8) 552,292	(3) 703,000	(30) 2,208,332
FY 04 – 05	(6) 201,375	(13) 407,000	(7) 567,240	(3) 843,000	(29) 2,018,615
FY 05 – 06	(3) 96,030	(4) 140,060	(5) 264,864	(3) 708,800	(15) 1,209,787
Totals	(100) 3,044,671	(110) 3,247,682	(96) 4,314,347	(45) 4,659,385	(342) 14,056,298

Message from the

Scientific Coordinator

It was once said that it is easy to work together when times are good. But the true test of a group of people is their ability to work together when the going gets tough. If this is true, then the Florida Citrus Production Research Advisory Council by any measure is a *good organization*.

Events over the last six months have changed the face of the Florida citrus industry forever. I might even say that the industry changed more this last year than over the previous 20 years put together. Canker spread over a large area due to the hurricanes of 2004 and 2005. Citrus greening was confirmed in the state and spread so far as to not be subject to eradication. The Florida citrus nursery industry all but shut down. Scores of meetings and discussions have resulted in no clear plan yet emerging as to how to deal with these threats. And CVC (citrus variegated chlorosis) is positioned to be found in the state at any time.

Through all of this, the members of the Florida Citrus Research Advisory Council preserver, still managing to get their jobs done through difficult hurricanes, cell phone outages, breaks in e-mail communication and tree destruction programs in some of their groves. Everyone in the industry – researchers, growers, consumers and even the citizens of Florida – owe these guys a huge debt of gratitude.

This is why it is a privilege to work with the Council in this funding program. They unselfishly take time to review proposals, attend meetings, follow up and debate the benefits of the different projects that come before them. They do all this is spite of the pressing work in their own businesses. If there is any way that in my job as Scientific Coordinator that I can make the Council member's jobs a little easier or more enjoyable, then I have accomplished much. But, a scientific coordinator's work is never done and I am constantly thinking about and trying to find ways to make the administration of the FCPRAC research grants even more efficient and effective.

Over the last year, we introduced a new e-mail communications system that automatically notifies program participates of major milestones and events. All our group communications are instantly archived on the web, which provides a rich historical record of the activities of the FCPRAC. We have worked to enhance the design of the FCPRAC information materials to make them more interesting and valuable to people outside the program. In an organization such as the FCPRAC, there are two great measures of its value: 1) the quality of its research and its application by growers; and 2) the quality of the organization's historical record. To these ends, I will constantly try to innovate, improve and implement.

Through all of this, the members of the FCPRAC tolerate what may at times seem like their Scientific Coordinator going off on strange tangents. However, the work always ends up centered to result in what I hope is a highly polished and professional presentation of all the organization's essential documents and records.

A special note of thanks is due FCPRAC Chairman, Peter McClure. Peter works tirelessly to have the FCPRAC provide the most benefit to the growers of the state as possible. He takes on what may at times be unpleasant tasks, all with the goal of making this funding program the greatest value to all its participants.

We have challenging years ahead of us. It will require all of us working together to come up with the best solutions to the new issues we will face going forward. Because of all these reasons, I consider it an honor to serve the Council, the researchers and the growers of Florida as the FCPRAC Scientific Coordinator. I look forward to working with you in the coming year.

– **Steven Rogers**, Highland City, FL, January 2006

Message from the Council Chairman

The Florida Citrus Production Research Advisory Council (FCPRAC) offers this annual report to the Citrus Growers of Florida in order to keep you abreast of where we have spent your tax dollars and the results that have been put forth over the last year. Please contact your area Council members with any feedback, good or bad, that you have. It is our desire to operate as transparently as possible, to provide great value to Citrus Growers with their investment in citrus research and to provide funding and direction to the Research Community to assist them in their efforts to increase and expand the knowledge base of growing citrus.

Thanks to Dr. Steven Rogers for the high quality work and professional manner in which he operates as the Scientific Coordinator. Thanks to Dr. Calvin Arnold and Dr. Harold Browning for their assistance in making this program as efficient and effective as possible. Thanks to Marshall Wiseheart for his efforts as liaison with FDACS and the Commissioner of Agriculture. Thanks to the many researchers and their associates who are working in the background to help growers survive and thrive in the Citrus Industry. A special thanks to the beleaguered Florida Citrus Grower for facing such tremendous adversity and still having enough hope to fund citrus research.

Now for some editorial comment on current events. And I thought last year was bad!

Denial.
Anger.
Bargaining.
Depression.
Acceptance.

You may recognize these as the "5 Steps of Grief" that people go through after tragedy. I can certainly recognize these symptoms in myself and in other growers. I can also recognize them in the Citrus Industry as a whole.

So, what do we do? Cry. Yes, well, we won't talk about that. However, there is an acronym for what to do to overcome grief. It's called TEAR.

T = To accept the reality of the loss.
E = Experience the pain of the loss.
A = Adjust to the new environment.
R = Reinvest in the new reality.

Now, this is where it gets relevant to the Florida Citrus Production Research Advisory Council. Adjust to the new environment. Reinvest in the new reality. That is where we need to go. This is what the Council aims to do.

The red carpet has been rolled out to welcome illegally imported pests and diseases to enter the State of Florida. Canker is bad. Greening is far worse. CVC is just around the corner and heading this way. Others are waiting in the wings. Currently, there is not a proven horticultural strategy to grow any citrus varieties and survive the Asian strain of Greening that we have found in Florida. There is also not a proven horticultural strategy to grow Hamlins, Pineapples, Navels, or grapefruit with canker. Citrus and ornamental nurseries are currently at risk to spread disease throughout the rest of the citrus industry. Dooryard citrus is a largely unregulated spawning ground for illegally imported pests and diseases. Hurricanes have decided to get busy again and exacerbate these problems.

This is our new reality.

We must adjust to and reinvest in this new reality. All other scientific study becomes pointless if we do not learn, and learn quickly how to survive these scourges. Can we as an industry come up with feasible and effective solutions? In time? History will answer those questions. The only opportunity to make history is NOW!

– **Peter McClure**, St. Lucie County, FL, December 2005

Overview

The Florida Citrus Research Advisory Council views the monies invested through this program to be contributed by growers to enhance existing research efforts. The Council monitors overall citrus production research expenditures to ensure growers that their tax monies are in fact enhancing programs.

This section provides a summary of information received from IFAS and USDA-ARS regarding their research expenditures. The Council has not verified this information and may see some adjustments in the future since definitions have not been established for each aspect of research.

Most of this information has not been previously presented in this form before and can only be provided because of the candid disclosures of the research institutions. The Council appreciates their openness and cooperation.

TABLE 3. Florida citrus production research overview for the University of Florida, Institute of Food and Agricultural Sciences (IFAS). This table provides a summary of information received from IFAS regarding their research expenditures. Council monies shown reflect actual expenditures and do not reflect balance of grants held in reserve.

	Total (1)	Third-Party (2)	State/Federal (3)	FCPRAC Grants (4)
1992–1997	$ 95,300,000	$ 6,900,000	$ 1,800,000	$ 700,000
1997–1998	98,900,000	8,500,000	1,800,000	1,000,000
1998–1999	98,100,000	8,800,000	2,900,000	1,200,000
1999–2000	111,000,000	10,900,000	4,300,000	800,000
2000–2001	114,500,000	10,800,000	5,200,000	1,000,000
2001–2002	124,800,000	12,100,000	4,500,000	1,500,000
2002–2003	124,200,000	11,400,000	7,100,000	1,800,000
2003–2004				

(1) Total all institutional research expenditures, including citrus and all others; (2) Other third-party grants in citrus production research; (3) State and Federal citrus production research expenditures; and, (4) FCPRAC Council grants.

TABLE 4. Florida citrus production research overview for the United States Department of Agriculture, Agricultural Research Service (USDA). This table provides a summary of information received from USDA regarding their research expenditures. Council monies shown reflect actual expenditures and do not reflect balance of grants held in reserve.

	Total (1)	Third-Party (2)	State/Federal (3)	FCPRAC Grants (4)
1992–1997	$ 4,800,000	n/a	$ 3,400,000	$ 200,000
1997–1998	5,600,000	n/a	3,900,000	80,000
1998–1999	6,200,000	n/a	4,100,000	100,000
1999–2000	6,600,000	n/a	4,200,000	100,000
2000–2001	6,700,000	n/a	4,500,000	110,000
2001–2002	7,600,000	n/a	4,700,000	150,000
2002–2003	8.600,000	n/a	4,900,000	400,000
2003–2004	9,200,000	n/a	5,100,000	500,000

(1) Total all institutional research expenditures, including citrus and all others; (2) Other third-party grants in citrus production research (n/a represents data not available); (3) State and Federal citrus production research expenditures; and, (4) FCPRAC Council grants.

# of Florida Citrus Research

Approved Projects
FY 2005–2006

TABLE 5. FCPRAC funding for approved FY 2005–2006–projects by category. Total for all projects is shown in the lower right corner.

	Totals
Entomology	$ 96,063
Improve/Other	708,800
Manage/Phys.	140,060
Pathology	264,864
	$1,209,787

TABLE 6. FCPRAC funding for approved FY 2004–2005 projects by principle investigator. Investigators are organized by last name. This list also represents the list of Annual Reports that will be required in June 2006. The approved total on the next page differs from the total given in Table 3 due to the withdrawal of one project and expenses for the scientific coordinator.

2005–2006 approved projects

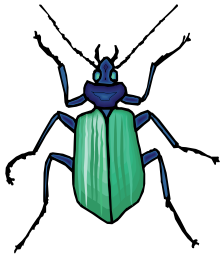
www.fcprac.com > Announcements > Funded 2005–2006 FCPRAC Projects

These projects for funding during the 2005–2006 season were approved by the Florida Citrus Production Research Advisory Council, Peter Clure, Chairman, at their recent annual meeting. There were originally about 50 projects submitted. This list of 16 was selected through the FCPRAC annual competitive grant funding process. The total funded distribution was $1,268,513.

For more information:
Steven Rogers, PhD
Scientific Coordinator
University of Florida–CREC
700 Experiment Station Rd.
Lake Alfred, FL 33850

steve@fcprac.com
(863) 956-1151 phone
(863) 956-4631 fax
www.fcprac.com

Name	Project ID	Project Title	Approved $1,268,513
Albrigo	042-13M	Decision Information Systems for Citrus (DISC)—Further evolution of the system and integration of production practices and record and bookkeeping systems	$28,200
Bowman	025-92I	Development of promising new rootstocks and scions for Florida citrus	$278,800
Browning	IO0501BW01	Provision of office, computer & clerical support for Dr. Steven Rogers, Scientific Coordinator for the FCPRAC	$5,000
Buker	MP0503BU01	Withdrawn	NA
Castle	043-05M	Rootstock performance in relation to soils in Flatwoods citrus and the development of a case-based expert system to select rootstocks	$59,220
Castle	045-11E	Assessing rootstocks and management tactics on the suppression of *Diaprepes* root weevil larvae and adults	$47,000
Chung	033-02P	Identification of effective compounds of antagonism for controlling foliar fungal pathogens of citrus	$51,442
Chung	033-03P	Effects of hormone inhibitors on yield production of citrus associated with postbloom fruit drop (PFD) and fungal pathogenicity of *Colletotrichum acutatum*	$49,814
Duncan	042-10E	Use of endemic entomopathogenic nematodes to increase efficacy against citrus root weevil: The role of adaptation	$27,369
Gmitter	0110-03I	A comprehensive program for the genetic improvement of Florida citrus scion and rootstock varieties	$425,000
Graham	013-99M	Young tree replant failure	$26,320
Graham	042-01P	Control of citrus canker with novel chemical compounds	$58,798
Grosser	042-02P	Rapid and efficient clean-up of CTV-infected field sources	$16,450
Rogers	EN0503RG01	Insect control in young citrus trees	$21,694
Schumann	034-10M	Optimizing variable-rate application technology for Florida citrus	$26,320
Timmer	043-07P	Management programs for fungal diseases of fruit and foliage	$88,360



Entomology

2005 Annual Progress Report

Project No. 043-02E Year 3/3

Classical Biological Control of *Diaprepes abbreviatus*

C. W. McCoy (CREC-UF-IFAS, Lake Alfred, FL), D.G. Hall (USDA-Fort Pierce, FL), H. Browning (CREC-UF-IFAS, Lake Alfred, FL), P. Stansly(SWREC-UF-IFAS, Imokalee) and R. Nguyen (FDOACS-Gainesville, FL)

Exotic parasitoids, Quadrastichus haitiensis and Aprostocetus vaquitarum, were introduced from the Caribbean into Florida for control of Diaprepes root weevil. Releases of the parasitoids were conducted in multiple locations. Both parasitoids are established in the Miami area in Dade County. A. vaquitarum is established in Broward County and it continues to be found sporadically in citrus growing areas. Two additional parasitoids were introduced from the Caribbean - the new species, Fidiobia dominica and Haeckeliania sperata. Both parasitoids have been reared since 2002 under quarantine conditions and their specificity as parasitoids were determined and petitions for their release in Florida citrus groves were filed. We plan to release these parasitoids as soon as we obtain permission from APHIS PPQ.

Entomology

Funding Sources

FCPRAC	$48,000
Agency	50,000
Other	67,000
Total	$165,000

Objectives

1. Survey for parasitoids of the Diaprepes root weevil in citrus groves. 2. Introduce new parasitoids into Florida. 3. Rear and test for specificity.

Accomplishments

The parasitoids Quadrastichus haitiensis and Aprostocetus vaquitarum were released for control of the Diaprepes root weevil. While both parasitoids are established in South Florida, only A. vaquitarum continues to be found in other areas, although these recoveries are erratic. A. vaquitarum is affected by several insecticides (e.g., carbaryl, imidan) applied in citrus. More than 200,000 A. vaquitarum were provided to citrus growers between 2003 and 2005. Two additional new parasitoid species, Fidiobia dominica and Haeckeliania sperata, were collected in the island of Dominica during 2002 and introduced into Florida and placed under quarantine conditions. The colonies of both parasitoids have been maintained under these conditions in Homestead. Specificity of the parasitoids on different insect species were tested. Applications to obtain permission to release the parasitoids were submitted to APHIS PPQ.

2005 Annual Progress Report

Project No. 025-01E Year 3/3

Ants, Pesticides and Biological Control of *Diaprepes abbreviatus*

Clayton W. McCoy and Robin J. Stuart (UF-IFAS-CREC, Lake Alfred, FL)

Ants are major predators of Diaprepes abbreviatus (L.) eggs, larvae, and adults, and will be an important component of any IPM program to control this weevil. Our research shows that several ant species, especially Solenopsis invicta Buren (the red imported fire ant) and Pheidole moerens Wheeler, are effective predators of Diaprepes neonates in central Florida, and suggests that maintaining high numbers of appropriate ant species could help suppress Diaprepes. The proposed research will provide growers with important new information concerning the role of ant predation in citrus groves, provide a basis for recommendations to maximize ant predation on Diaprepes, and enable growers to make informed decisions about alternative pest control strategies and their ramifications for this important group of natural enemies.

Entomology

Funding Sources

FCPRAC	$39,075
Agency	41,245
Other	0
Total	$80,320

Objectives

1. Evaluate ant populations in groves to determine how the abundance and diversity of ants relates to environmental conditions, management practices and the intensity of Diaprepes infestations. 2. Conduct manipulative field experiments to determine how alterations in ant communities impact predation on Diaprepes and other insect pests. 3. Use greenhouse microcosm experiments to investigate interactions between soil characteristics and the effectiveness of ants as predators. 4. Continue a field study on the mobility and longevity of Diaprepes adults.

Accomplishments

Our research continues to show that ants are major predators of Diaprepes abbreviatus neonates in Florida citrus groves, and we have increasing evidence that certain pesticides used against Diaprepes also reduce ant populations and predation on neonates. Most predation on neonates placed under citrus canopies is by ants with at least nine ant species being involved. Solenopsis invicta (the red imported fire ant) and Pheidole moerens are the primary predators. Sampling at additional sites across the state is continuing and has increased our list of known ant predators in groves under various conditions. Assessments conducted in a grove following a five-year field study comparing pesticide applications against Diaprepes found that Sevin, Micromite, and BioVector 355 (entomopathogenic nematodes) had little impact on ground ant communities, whereas Capture reduced ground ant populations by 74.5-79.5% and red imported fire ants by 94.7-96.0%. In a field study using granular ant baits to suppress fire ants, we found a strong positive correlation between fire ant population levels and predation rates on neonates. An experiment using tree trunk bands has shown differential effects in excluding various ant species from citrus canopies and research is continuing to evaluate the secondary effects of exclusion on other insect pests. Because of last year's hurricanes, we were unable to complete all of our objectives but our research program is continuing with alternative funding and additional results, including those on the movement and longevity of adult Diaprepes in groves, will soon be available. Additional publications are also forthcoming.

2005 Annual Progress Report

Project No. 032-05E Year 2/2

Biological Control of Citrus Leafminer with the Parasitic Wasp, *Citrostichus Phyllocnistoides*

Phil Stansly (UF-IFAS-SWFREC Immokalee FL)

Biological control as a viable option for control of citrus leafminer (CLM) not yet been fully exploited in Florida. Ageniaspis citricula was widely released and established throughout the region but has not provided sufficient control. CLM is still a serious pest of young trees and greatly increases the risk of canker. CLM opens wounds in young foliage increasing susceptibility to canker and producing multiple infection sites that further augment inoculum and rate of spread. Although no one can accurately predict the effectiveness of a particular biological control agent, additional releases improve the likelihood of finding a winner. CLM was once a serious pest in Spain requiring multiple sprays, but not any more. Many species of parasitic wasp were released but only one, Citrostichus phyllocnistoides, has been credited with getting the job done. This species offers good prospects for improving biological control of this important pest, thereby reducing the risk of canker for every grower in the state.

Entomology

Funding Sources

FCPRAC	$45,000
Agency	0
Other	0
Total	$45,000

Objectives

1. Ascertain compatibility of C. phyllocnistoides with existing biological control agents of CLM. 2. Import and permit C. phyllocnistoides for release. 3. Establish C. phyllocnistoides in the field and evaluate effectiveness against CLM.

Accomplishments

Cage studies were conducted in Spain that demonstrated the compatibility of parasitoids C. phyllocnistoides and Ageniaspis citricola. An assessment of likely impact of releasing the new parasitoid in Florida citrus was submitted for internal review and approval to request a release permit granted by the Dean of Research. PPQ form 526 and accompanying justification requesting permission to release the parasitoid was submitted and receipt confirmed by USDA-APHIS on 12 March. PPQ indicated their itention to submit the request for review by the North American Plant Protection Organization (NAPPO) in Canada. Meanwhile, they agreed to allow the parasitoid to be released into an non-quarantine laboratory at DPI in Gainesville, and DPI signed their concurrence on 26 April. However, neither I nor DPI has received any confirmation from PPQ, nor any word on progress of the NAPPO review as of 23 August 2005. Meanwhile, there are new canker finds every day.

2005 Annual Progress Report

Project No. 042-10E Year 1/2

Use of Endemic Entomopathogenic Nematodes to Increase Efficacy against Citrus Root Weevil: The Role of Adaptation

Larry Duncan (UF-IFAS-CREC, Lake Alfred, FL) and Khuong Nguyen (UF, ENT-NEM, Gainesville, FL)

Numbers of Diaprepes weevils and damage to citrus tend to be higher in some areas of the flatwoods than on the Central Ridge. Some endemic species of entomopathogenic nematodes (EPN) that effectively attack weevils on the Central Ridge are unknown in the flatwoods. Other endemic EPN species persist and are predominant in flatwoods environments. We propose to identify isolates of EPN species best adapted to specific soil environments in the flatwoods. We believe that use of nematodes adapted to the various soil environments will expand the areas in which nematodes can be used profitably.

Entomology

Funding Sources

FCPRAC	$27,369
Agency	9,600
Other	20,000
Total	$56,969

Objectives

1. Isolate populations of EPN specifically adapted to fine and coarse textured flatwoods soils. Our hypothesis is that isolates will exhibit greater efficacy in soils of texture similar to that from which they were isolated. 2. Isolate S. riobrave (exotic) and S. diaprepesi (endemic) from the field and compare with commercial isolates of both species. Our hypothesis is that field derived nematodes will exhibit greater efficacy and persistence than nematodes maintained in laboratory cultures. 3. Determine non-target effects of treating soil with different entomopathogenic nematode species. Our hypothesis is that applications of EPN increase the prevalence of antagonists that then suppress endemic EPN.

Accomplishments

Objective 1. Steinernema diaprepesi (Sd), S. glaseri(Sg), H. zealandica (Hz), and Heterorhabditis indica (Hi) were recovered from surveys of 3 sites within each of five flatwoods and three Ridge orchards. The survey revealed Hi as the most cosmopolitan and prevalent EPN species. The ITS DNA sequences were highy congruent (>99%) among 11 Hi populations. Assays comparing the ability of the isolates to move, persist, and kill weevil larvae in soils of different textures are in progress.

Objective 2. Sd and Sr were isolated from the field. The wild isolates of both species persisted significantly longer and killed more weevils in unpasteurized soil than did isolates maintained under commercial conditions. Longevity and efficacy did not differ among wild and commercial isolates in pasteurized soil. Thus, maintenance conditions had little effect on inherent longevity of isolates, but affected the ability to survive in the presence of antagonistic organisms. The data support the hypothesis that the exotic Sr can adapt to habitats in Florida and that laboratory adaptation of the endemic Sd can attenuate its efficacy.

Objective 3. Mortality of both Sr and Sd in soil is significantly greater if Sr is added to the soil 5 days previously. The effect does not occur if soil is air-dried to remove fungi prior to the experiment. Three species of nematophagous fungi that increase in response to EPN augmentation were isolated from raw soil. Mortality of Hi is unaffected by pretreatment with Sr in either raw or air-dried soil.

2005 Annual Progress Report

Project No. 045-11E Year 1/5

Assessing Different Management Tactics for Suppressing Diaprepes

Michael E. Rogers, William S. Castle and Robin J. Stuart (UF-IFAS-CREC, Lake Alfred, FL)

The Diaprepes root weevil (DRW), Diaprepes abbreviatus (L.), continues to be a major localized pest of commercial citrus in Florida. The combination of larval feeding injury to roots and root infection by plant pathogenic Phytophthora spp. results in one of the most severe decline syndromes affecting Florida citrus, particularly in poorly drained clay loam soils common to the flatwoods. Chemical treatments for insect control and disease resistant rootstocks are recommended to growers but little is known regarding the long-term effectiveness of these tactics on tree vigor and yield. In this study, we are assessing the long-term effects of chemical treatments for both disease-resistant and non-resistant rootstocks, which include C-22, C-32, and C-35 citrange, Cleopatra mandarin and Swingle citrumelo. Additional information from this study on chemical treatment performance, scouting insects and diseases, timing of treatments, and effect of chemical treatments on natural enemies will help growers make better decisions on how to maximize tree health and production through better stewardship of various control tactics over time.

Entomology

Funding Sources

FCPRAC	$50,000
Agency	34,242
Other	0
Total	$84,242

Objectives

1. Identify rootstocks capable of withstanding herbivory by DRW and Phytophthora spp. based on tree health and productivity. 2. Evaluate current IFAS chemical control tactics for DRW and long-term impact on tree health and productivity.

Accomplishments

To date, our results have demonstrated that foliar applications of sterilant and toxicant chemical mixtures with biological activity against the egg and adult stages of DRW that are timed according to 1) adult emergence from the soil, 2) adult abundance on the tree, and 3) the development of the summer flush stimulated by frequent rainfall effectively suppress the DRW. In our study, chemical applications significantly reduced adult DRW populations for trees on all rootstocks, and chemically treated trees had a faster growth rate (except Cleopatra mandarin), larger tree canopies, fewer adult weevils, and less tree decline than trees receiving no chemical treatment.

Comparing the different rootstocks, trees on C-32, C-35, and Swingle citrumelo had higher growth rates, canopy volumes, and weevil populations, and exhibited less tree decline than those on C-22 and Cleopatra mandarin. Our evidence indicates that root injury by DRW larvae created sites for infection and bark damage by Phytophthora, and that Phytophthora contributed to tree decline. Our study presents the first evidence for the positive effect of foliar chemical sprays in reducing plant injury from DRW. Our data also suggest that the Phytophthora/Diaprepes complex can kill trees on susceptible rootstocks, such as Cleopatra mandarin, regardless of weevil control, and that vigorous rootstocks with resistance to Phytophthora, such as Swingle citrumelo and C-35 citrange, can tolerate high weevil populations. Articles on the results of this study have appeared or are in press in the Proceedings of the Florida State Horticultural Society, Citrus Industry, and Arthropod Management Tests.

2005 Annual Progress Report

Project No. 043-05E Year 1/3

Mass Production and Rearing Improvement of *Diaprepes abbreviatus* to Meet Essential Needs of Florida Researchers

George H. Schneider III, Suzanne Fraser and Reed E. Burns (FDACS-DPI, Gainesville, FL)

Numerous researchers are continuing to investigate a variety of control strategies to limit the damage caused by Diaprepes abbreviatus to the Florida citrus industry. Increasing concern from the general public, environmentalists and the EPA about the use of numerous pesticides for the control of agricultural pests, including Diaprepes, makes finding more environmentally friendly chemical compounds, effective biological control agents and/or economical grove management practices extremely important. For the past five years, the FDACS-DPI has undertaken the task of providing needed Diaprepes life stages to various researchers throughout Florida. This project for mass rearing and improvement of those specialized techniques will ensure that the demand for these various life stages will continue to be met so that researchers will not be slowed in their pursuit to find effective control measures against this serious pest of citrus.

Entomology

Funding Sources

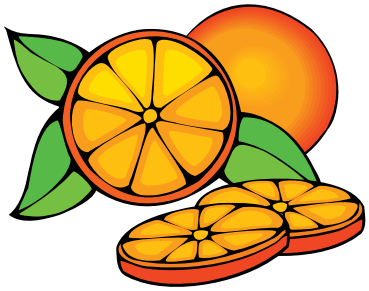
FCPRAC	$33,300
Agency	62,727
Other	0
Total	$96,027

Objectives

1. Provide a continuous supply of any Diaprepes life stage to various researchers in both the government and private sectors. 2. Continuously evaluate and improve upon the mass-rearing procedures for Diaprepes to make production more efficient and/or economical.

Accomplishments

Multiple diet cups were infested with approximately 166,000 neonates, about 60,000 of which were transferred to single cups, from which 44,000 pupated and 38,000 emerged as adults. This represents a 39% decrease in neonate infestation, a 19% decrease in grub transfers, a 6% decrease in pupae, and 12% decrease in adult production from the previous year. These decreases were precipitated by a decreased demand for the various life stages by researchers. This was in part due to the unprecedented multiple hurricanes striking our state which diverted funding from projects, suspended some, or prevented the completion of others. Hurricane Frances also caused the failure of an important component in the linear accelerator used to irradiate larval diet, which necessitated changing several production routines. The diet could not be made in advance due to a shorter shelf life and weekend egg production could not be used due to higher microbial counts which also contributed to the decrease in neonate infestation. However, shipments of life stages did included 15,000 neonates, 1,300 grubs and 28,000 adults to eight different researchers developing a wide range of control strategies against this agricultural pest. A new way to label diet cups was investigated to save time and labor while minimizing the chance for data errors. Unfortunately, a one-way ANOVA showed no significant differences among the three tested methods, with the current hand-written method still being the fastest.



Plant Improvement

and Other Projects

2005 Annual Progress Report

Project No. 025-02I Year 3/8

Development of Promising New Rootstocks and Scions for Florida Citrus

Kim Bowman, Greg McCollum, Randy Niedz (USDA-ARS-USHRL, Ft. Pierce, FL), Jim Graham (UF-IFAS-CREC, Lake Alfred, FL) and Robert Adair, Jr. (Florida Research Center, Vero Beach, FL)

Most problems that reduce production efficiency and profitability can be eliminated by planting better scion cultivars on improved rootstocks. This project is focused on developing new varieties that fill these needs. For scions, the emphasis is on high yielding, pest resistant selections that produce fruit with outstanding quality characteristics, and which have potential for the fresh and/or processed industry. For rootstocks, the target is a superior replacement for sour orange (supersour) that produces a tree with high yield, good fruit quality, and superior resistance to diseases, pests and soil problems. The funded research will help to more rapidly develop new rootstocks and scions with superior field performance for use by the Florida industry.

Improvement	
Funding Sources	
FCPRAC	$338,000
Agency	1,800,000
Other	0
Total	$2,138,000

Objectives

1. Candidate rootstock and scion cultivars will be created by hybridization, mutation, and transformation. 2. The most promising new cultivars will be identified through use of biological and molecular screens and entered into long-term field trials at multiple sites. 3. Field performance will be evaluated for numerous traits, including tree size, survival, disease resistance, and fruit yield, quality, and storage problems. 4. Release of new rootstock and scion cultivars will be based on performance information from these trials over multiple years.

Accomplishments

Crosses of 43 parental combinations were completed in 2005 to create supersour hybrid rootstocks. About 5,540 seeds were collected from supersour crosses completed in 2004. Promising rootstocks from previous crosses are continuing in testing for important traits. Propagations were made from 100 different rootstock selections, including the most promising supersour hybrids, in preparation for replicated phytophthora, CTV, and salinity tests and field trials. Replicated field trials of new rootstock selections were planted at the USDA research farms near Ft. Pierce and Leesburg. Planned plantings of cooperator field trials were postponed because of citrus canker. Performance information was collected from established rootstock field trials. Documentation is being prepared to release the hybrid rootstocks US-802 and US-897. Sixteen advanced scion selections were propagated for replicated field testing. About 1,200 irradiated selections of a high quality mandarin were planted into the field at the Whitmore farm to evaluate seedlessness. Yield and fruit quality data were collected from established plantings of advanced scion selections. Planning was completed for consumer tests of the high quality early grapefruit selection 77-19 in Canada, Japan, and France. Trees are being propagated for replicated field trials with the most promising seedless Fallglo selection. Introgression of canker resistance from citrus relatives into cultivars with good fruit quality is continuing. Rootstocks transformed with anti-phytophthora protein AP-24 are being prepared for testing. To protect against potential loss from citrus canker, duplicate trees of the most promising advanced rootstock and scion selections were established in greenhouses at three locations (Ft. Pierce, Leesburg, Tifton).

2005 Annual Progress Report

Project No. 0110-031 Year 5/10

A Comprehensive Program for the Genetic Improvement of Florida Citrus Scion and Rootstock Varieties: Section 1 - Scion Improvement

Fred Gmitter, Jude Grosser, Bill Castle (UF-IFAS-CREC, Lake Alfred, FL) and Gloria Moore (UF-Horticultural Sciences, Gainesville, FL)

Florida faces many challenges in the production and marketing of citrus products. To insure that the Florida citrus industry can have the most genetically advanced varieties to maintain a competitive advantage, an integrated and comprehensive program for the genetic improvement of scion and rootstock varieties has been established. The overall goal of this project is to develop, test, and release new rootstock and scion varieties for Florida growers through the application of appropriate genetic tools and strategies. Additionally, research focused on the development of basic information and improved tools for breeding and selection is being conducted.

Improvement	
Funding Sources	
FCPRAC	$475,000
Agency	600,000
Other	515,000
Total	$1,590,000

Objectives

1. Resistance to devastating diseases and pests. 2. Adaptation to diverse soils, growing conditions, and environmental stresses. 3. Improved product marketability through enhanced fruit and juice quality and extension of the harvest season. 4. Lower input costs, along with increased yields and profits. 5. High quality, seedless, easy-peeling mandarins.

Accomplishments

SECTION 1 – SCION IMPROVEMENT

Sexual Hybridization: Approximately 7000 flowers were pollinated in spring 2004, 634 fruit were harvested, 3,914 embryos were rescued from interploid crosses and 2,415 plants regenerated. 3,790 plants from embryos rescued previously were field planted, including 3013 triploids. Evaluation and Selection: Juice quality data from several sweet orange trials continued to be collected, hundreds of clones were sampled from various plant families throughout the season. Sensory panel evaluations comparing new processing sweet oranges continued and promising late-maturing clones of Valencia were identified. A controlled-access Repository was established. Currently, 44 "mother" plants reside as foundation plant material. Propagation of this material was initiated to increase quantities of plants for screening and hybridization. Approximately 400 acid-fruit triploid hybrids (lemon/lime types) were planted at the CREC. Released Materials: The patent application on LB8-9 tangelo is nearly complete (planned 2006 release) and adequate data have been collected to prepare patents for a superior Valencia processing somaclone that matures in January and a seedless Valencia somaclone for fresh market. Somaclonal Variation: Preparation of new sweet orange somaclones for field planting was continued, as was evaluation of 2nd generation advanced Valencia selections for early and late maturity, color and flavor. A second early-maturing Valencia somaclone with good fruit quality was identified (T1-19). A population of somaclones derived from the earliest maturing Valencia somaclone SF14W-62 was planted at the new Balm site. Somatic Hybridization: Cybrid plants of Murcott, Kinnow, and FG #302with Satsuma mitochondria were developed for potential seedlessness.

2005 Annual Progress Report

Project No. 0110-031 Year 5/10

A Comprehensive Program for the Genetic Improvement of Florida Citrus Scion and Rootstock Varieties: Section 2 - Rootstock Improvement

Fred Gmitter, Jude Grosser, Bill Castle (UF-IFAS-CREC, Lake Alfred, FL) and Gloria Moore (UF-Horticultural Sciences, Gainesville, FL)

Florida faces many challenges in the production and marketing of citrus products. To insure that the Florida citrus industry can have the most genetically advanced varieties to maintain a competitive advantage, an integrated and comprehensive program for the genetic improvement of scion and rootstock varieties has been established. The overall goal of this project is to develop, test, and release new rootstock and scion varieties for Florida growers through the application of appropriate genetic tools and strategies. Additionally, research focused on the development of basic information and improved tools for breeding and selection is being conducted.

Improvement	
Funding Sources	
FCPRAC	$475,000
Agency	600,000
Other	515,000
Total	$1,590,000

Objectives

1. Resistance to devastating diseases and pests. 2. Adaptation to diverse soils, growing conditions, and environmental stresses. 3. Improved product marketability through enhanced fruit and juice quality and extension of the harvest season. 4. Lower input costs, along with increased yields and profits. 5. High quality, seedless, easy-peeling mandarins.

Accomplishments

SECTION 2 – ROOTSTOCK IMPROVEMENT

Sexual Hybridization: Several new crosses were made in spring 2005 to combine genes for multiple disease resistance, soil adaptations, tree size control and superior nursery and field performance. Seed from 2004 crosses were sown and hybrids were selected for evaluation. Selection: Screening procedures were refined and promising new rootstocks were tested for tolerance to various edaphic and disease conditions. More than 140 plants were screened for factors including $CaCO_3$ - induced iron chlorosis, flooding and salinity. Disease screens included 180 plants subjected to Phytophthora nicotiana and P. palmivora and 570 plants subjected to CTV-induced quick-decline. Over 380 rootstock selections were started from seed to analyze for quantity and uniformity of germination and growth habit. Continued greenhouse screening of 'tetrazyg' hybrids and diploid pummelo x mandarin hybrids for tolerance of the Phytophthora/Diaprepes complex using two new hybrids with good tolerance were identified. Somatic Hybridization: Twenty new mandarin +pummelo combinations were produced as candidates to replace sour orange. Field Trials: Planting efforts included resetting a cooperative rootstock trial near Clewiston, completing another section of a trial in Collier County and planting over 200 rootstock seed trees at the new Balm site. Propagation continued for cooperative rotation trials. Emphasis continued on the blight field-screening program, as over 1000 trees of 100+ new hybrids were propagated. Data collection continued from rootstock trials for various sweet oranges, trials to evaluate budding height and interstocks for size control and evaluation of rough lemon selections with possible blight tolerance.

2005 Annual Progress Report

Project No. 0110-031 Year 5/10

A Comprehensive Program for the Genetic Improvement of Florida Citrus Scion and Rootstock Varieties: Section 3 - Plant Molecular Genetics

Fred Gmitter, Jude Grosser, Bill Castle (UF-IFAS-CREC, Lake Alfred, FL) and Gloria Moore (UF-Horticultural Sciences, Gainesville, FL)

Florida faces many challenges in the production and marketing of citrus products. To insure that the Florida citrus industry can have the most genetically advanced varieties to maintain a competitive advantage, an integrated and comprehensive program for the genetic improvement of scion and rootstock varieties has been established. The overall goal of this project is to develop, test, and release new rootstock and scion varieties for Florida growers through the application of appropriate genetic tools and strategies. Additionally, research focused on the development of basic information and improved tools for breeding and selection is being conducted.

Improvement	
Funding Sources	
FCPRAC	$475,000
Agency	600,000
Other	515,000
Total	$1,590,000

Objectives

1. Resistance to devastating diseases and pests. 2. Adaptation to diverse soils, growing conditions, and environmental stresses. 3. Improved product marketability through enhanced fruit and juice quality and extension of the harvest season. 4. Lower input costs, along with increased yields and profits. 5. High quality, seedless, easy-peeling mandarins.

Accomplishments

SECTION 3 – PLANT MOLECULAR GENETICS

Gene Cloning: Three genes upregulated in blighted plants are being characterized. Transgenic plants containing antisense constructs of chalcone synthase and isomerase were determined to have consistently decreased levels of naringin in leaves. Poncirus and grapefruit genes (CBF) analogous to an Arabidopsis gene for cold acclimation were cloned and shown to be differentially upregulated. Several citrus sequences similar to the rice Xa21 gene for Xanthomonas resistance were isolated and are being used to recover similar genes from canker resistant plants. Sequence comparisons between R and S genomic regions revealed the most likely candidates for CTV resistance. New markers for nematode resistance have been developed. Mapping: 50 SSR markers are ready to map on the Citrus Core Mapping Population (CCMP). Initiated identification of pummelo-mandarin hybrids (candidates to replace sour orange) that yield nucellar seeds for rootstock propagation using RAPD and SSR molecular markers. In order to identify molecular markers linked to the citrus canker resistance gene(s) and develop a genetic map quickly, the amplified fragment length polymorphism (AFLP) technique combined with bulked segregant analysis (BSA) was applied to screen an F1 population from the cross between susceptible Palestine sweet lime x resistant Ichang papeda. Phenotyping the individuals of the mapping family revealed a normal distribution. As a result of screening 93 pairs of AFLP primer combinations, 85 from the determined 950 polymorphic bands (present in the resistant parent and absent in the susceptible parent) were found tightly associated with the canker resistance gene(s).

2005 Annual Progress Report

Project No. 0110-031 Year 5/10

A Comprehensive Program for the Genetic Improvement of Florida Citrus Scion and Rootstock Varieties: Section 4 - Genetic Transformation

Fred Gmitter, Jude Grosser, Bill Castle (UF-IFAS-CREC, Lake Alfred, FL) and Gloria Moore (UF-Horticultural Sciences, Gainesville, FL)

Florida faces many challenges in the production and marketing of citrus products. To insure that the Florida citrus industry can have the most genetically advanced varieties to maintain a competitive advantage, an integrated and comprehensive program for the genetic improvement of scion and rootstock varieties has been established. The overall goal of this project is to develop, test, and release new rootstock and scion varieties for Florida growers through the application of appropriate genetic tools and strategies. Additionally, research focused on the development of basic information and improved tools for breeding and selection is being conducted.

Improvement	
Funding Sources	
FCPRAC	$475,000
Agency	600,000
Other	515,000
Total	$1,590,000

Objectives

1. Resistance to devastating diseases and pests. 2. Adaptation to diverse soils, growing conditions, and environmental stresses. 3. Improved product marketability through enhanced fruit and juice quality and extension of the harvest season. 4. Lower input costs, along with increased yields and profits. 5. High quality, seedless, easy-peeling mandarins.

Accomplishments

SECTION 4 – GENETIC TRANSFORMATION

Over 320 transgenic orange and grapefruit plants have been produced containing the most likely CTV resistance candidate genes cloned from Poncirus. CTV challenge assays (using ELISA) are underway. Transgenic plants containing pieces of the CTV genome continue to show resistance after two years of greenhouse challenges. Additional transgenic Hamlin plants containing the intron-free cDNA of Xa21 (a Xanthomonas resistance gene) were produced using our protoplast/ GFP transformation system (more than 150 plants from >75 independent transformation events). These plants have been propagated for a canker challenge assay to be conducted in the quarantine facility in Gainesville. Real-time PCR is being developed for determining the copy numbers of transgenes integrated into transgenic plants. A pre-experiment was set up to estimate the copy numbers of GUS reporter gene in transgenic plants. The copy number of transferred disease resistant genes in the transgenic plant will be estimated in the near future. Core Citrus Transformation Facility (CCTF): The CCTF continued to function as a service lab for producing transgenic citrus plants, processing a steady flow of orders. Transgenic plants produced included: 47 Marsh grapefruit and Valencia orange plants containing a Lipid Transfer Protein; 15 Marsh and Valencia plants with a gene for ACC oxidase; 9 Carizzo and sour orange plants for canker resistance, and several plants with putative resistance genes from CTV.

2005 Annual Progress Report

Project No. 0110-11O Year 1/1

Provision of Office, Computer and Clerical Support for Dr. Steven Rogers, Scientific Coordinator for FCPRAC

Harold W. Browning (UF-IFAS-CREC, Lake Alfred, FL)

The FCPRAC provides significant financial support and direction to citrus production research conducted by IFAS, the USDA, ARS, and other research organizations in Florida and beyond. The grower-driven process has brought greater interaction between the growers and production managers and the research agencies, leading to improved progress towards solving industry challenges related to production. A great deal of this improvement is due to enhanced communication and coordination of efforts and every opportunity should be recognized to enhance this communication. The CREC, as a major recipient of FCPRAC funding, has the infrastructure in place to support the Research, Extension, and Teaching Programs of the Center and provides access to these facilities to Emeritus Faculty and Visiting Scientists as a matter of course. Thus, the offering of space and support to the FCPRAC Coordinator is in keeping with established policy, and the funding request is to provide for the expendable supplies and to aid in deferring the personnel costs associated with the work load.

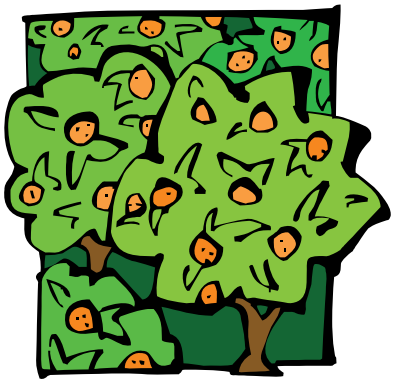
Other Funding Sources	
FCPRAC	$5,000
Agency	0
Other	0
Total	$5,000

Objectives

1. Provide office, computing, and clerical support to FCPRAC Scientific Coordinator at UF, IFAS, CREC.

Accomplishments

Provision of office, computing, and clerical support was provided at UF-IFAS-CREC during 2004 -2005 as planned. Office space in building 7110 was made available and Internet- and network-linked computing was available. Clerical support was available to assist with calls for preproposals, proposals, processing and management of proposals and preparation of the annual report. The UF-IFAS-CREC website housed some documentation for FCPRAC, and the calls for proposals, instructions for researchers, and annual reports were updated for broad access. Timely management of the FCPRAC documentation and grant processing by Dr. Rogers was facilitated through the support provided by UF-IFAS-CREC.



Management & Physiology

2005 Annual Progress Report

Project No. 041-06M Year 1/1

Foliar Application of NPK: Value of P in Foliar Applications and Comparison of Time and Rate of Application on Fruit Set and Yield of Florida Citrus

L. Gene Albrigo (UF-IFAS-CREC, Lake Alfred, FL)

Previous work has shown that winter urea sprays enhance flowering and yields, and bloom and post-bloom application of NPK can increase set and yield. The earlier work provided little comparative data on timing of the winter urea spray or on using various combinations of the three seasonal timings, nor did it resolve the issue of whether P sources provided any benefit since the amount of P in the fruit is small compared to N and K. P uptake was only 1/10th of K in previous studies. A rate study of bloom time PO_3 applications was added a year ago because of the phytotoxicity observed 2 years ago and no injuries were observed indicating a one-time problem. Previous work has not systematically looked at one versus 2 spring applications nor at application rates of foliar NPK. The proposed work is looking at these issues to provide more information for grower decisions on use of foliar NPK nutrition. The first year of the on-going study only allowed treatment applications. This additional year's data will provide sufficient yield information (4 years) for foliar recommendations in a comprehensive nutrient management plan.

Manage/Physiology

Funding Sources

FCPRAC	$30,000
Agency	44,000
Other	5,000
Total	$79,000

Objectives

1. Determine flowering, fruit set and yield response of a 3 spray (winter urea (1), bloom (2) and post-bloom(3)) vs. no foliar NPK , or use of 1, 2 or 3 alone or 2 and 3 combined. 2. Determine effect of 2 rates of application of NPK in the bloom or post-bloom timing. 3. Determine if a P source in the foliar sprays is beneficial in increasing fruit set and yield by evaluating 2 sources of P in the bloom and post-bloom spray program compared to the NPK results and a spray treatment containing only N and K.

Accomplishments

No phytotoxicity symptoms developed from foliar applications of various NPK sprays at bloom and postbloom. For the third year, yields from plots in good Ridge and bedded groves were collected from the following cultivar blocks: Valencia (2), Hamlin (2), Flame grapefruit and navel orange (1 each) blocks treated with 2 rates of NPK (2-1-1 ratios) or treatments for foliar P evaluations. Rates of 8 or 16 lb N/ac were applied at both bloom or post-bloom or just at one or the other timing with or without a winter urea spray. Other Valencia and Hamlin blocks were treated with N-K sprays at bloom or postbloom with or without PO_4 or with PO_3 and with or without urea or PO_3 in the winter. In the third year of yield data, some treatments had yield increases but hurricane damage generally reduced yields and made results suspect. There still does not appear to be a consistent trend in which treatments gave the higher yields. Flower and fruitlet counts for the fourth year were made in all plots on spring and summer flush. These counts were only slightly lower than the previous year suggesting that yields could be reasonable after the 3 hurricanes. Yield data for the fourth year will be collected this fall and spring and a summary paper will be written.

Tree Thinning Studies to Improve the Production and Harvesting of Florida Oranges

Stephen H. Futch (UF-IFAS-CREC-Lake Alfred, FL)

Florida citrus growers have been planting citrus trees closer together to enhance returns on their investment with high fruit yields in early years. These groves have usually been good producers in the early years but with declining yields as the groves reach containment size. Tree thinning experiments were initiated in blocks which were planted in 1990, on two-row beds, with a tree spacing of 24 x 8 feet in a block containing Hamlins (Dec. 1998) and a separate block containing Valencias (May 2000) to determine if tree thinning would improve production. Trees were thinned by removing every second or third tree in the row by shearing the tree above the ground. Yield, fruit quality, soil and plant tissue analyses are being gathered annually to conduct an economic analysis on the impact of modifying tree density by thinning.

Manage/Physiology

Funding Sources

FCPRAC	$10,000
Agency	5,000
Other	0
Total	$15,000

Objectives

To determine the effects of tree thinning on fruit yield, fruit quality, tree growth and profitability.

Accomplishments

In a Manatee County grove, planted in 1990, tree thinning experiments were conducted in separate blocks of Hamlin and Valencia planted on two-row beds at 24 x 8 feet to determine the impact of reducing tree density by thinning on current and future yields. Trees were thinned by removing every second or third tree in the row by shearing the tree above the ground. Trials were initiated after harvest in December 1998 (Hamlin) and in May 2000 (Valencia).

In both trials, yields were reduced with increasing thinning rates. The reduction in yields narrowed on an annual basis as compared to the unthinned control. Thinning treatment yields never fully recovered to the yields of the unthinned control after six (Hamlin) or five (Valencia) years. Trunk circumference growth was greater with increased thinning rates.

Hamlin trial: Yields in boxes per acre were reduced in the first year by 58% and 43%, respectively, where every second or third tree was removed. Cumulative yields over six years were reduced by 17.8 and 11.7%, respectively. Annual and cumulative pound solid yields were similar to box reductions. This remains a highly productive grove yielding 802 boxes per year over the study period. One year yielded 998 boxes.

Valencia trial: Yields in boxes per acre were reduced by 56% and 50%, respectively. Five-year cumulative yields were reduced by 27% and 16%, respectively. Trial area yields vary by as much as 45% from the average of 572 boxes per acre for the unthinned control.

Citrus Yield Mapping System Using Machine Vision

Won Suk Lee, Thomas F. Burks (UF-IFAS-ABE, Gainesville, FL) and John K. Schueller (UF-MAE, Gainesville, FL)

A citrus yield mapping system using machine vision was developed to identify citrus fruits and to estimate yield of citrus grove. The system was installed on a trailer bed in the back of a truck and took non-overlapping images of citrus trees. The system was tested twice in citrus groves. Three different classification techniques, Bayesian, neural network (NN) and Fischer's linear discriminant were implemented to differentiate fruit from the background in the images, using hue and saturation as the separation features. The NN classifier produced better results for fruit size estimation. The root mean square error for the NN classifier for both fruit size estimation (0.2 inch) and fruit count (2.6) was smaller than the other two classifiers. The errors in fruit size estimation could be caused by inaccuracies obtained in ultrasonic range measurements. Partial occlusion of fruits, variable illumination, and clustering of fruits produced errors in both the fruit count and size estimates.

Manage/Physiology

Funding Sources	
FCPRAC	$35,000
Agency	0
Other	0
Total	$35,000

Objectives

1. Complete a machine vision based yield mapping system using a camera, image processing hardware/software, GPS receiver and a microprocessor. 2. Calibrate and test the yield mapping system in a commercial citrus grove. 3. Evaluate performance by mapping single tree yield by hand-harvesting.

Accomplishments

From the previous year's experiments, it was found that one camera was not able to take images of entire citrus trees, which caused incorrect yield estimation. Therefore, one more camera was added to the current yield mapping system. The two cameras were mounted on a metal pole in such way that the images from them were not overlapped. An extension was added to the pole so that the height of the cameras could be adjusted according to tree heights. A grid frame with two windows was made in order to take non-overlapping consecutive images, and placed in the front of the cameras. The system was tested for counting the number of fruits in the images and estimating fruit size using ultrasonic sensor measurements. Actual size of a sample fruit in each image was measured manually on the tree. Three different classification techniques, Bayesian, neural network (NN) and Fischer's linear discriminant were implemented to differentiate fruit from the background in the images, using hue and saturation as the separation features. The segmented images were analyzed to find the diameter of the fruit in the images. The root mean square error for the NN classifier for both fruit size estimation (0.2 inch) and fruit count (2.6) was smaller than the other two classifiers. The errors in fruit size estimation could be caused by inaccuracies obtained in ultrasonic range measurements. Partial occlusion of fruits, variable illumination, and clustering of fruits produced errors in both the fruit count and size estimates.

Implementation of Precision Agriculture Technology to Improve Profitability of Florida Citrus

Arnold Schumann, William Miller, Masoud Salyani (UF-IFAS-CREC, Lake Alfred, FL), John Schueller and Won-Suk Lee (UF-IFAS-ME,ABE Gainesville, FL)

Recent studies showed that soil variability is a dominant factor affecting in-field spatial variability and profitability of citrus. We have identified some specific soil factors responsible such as water tables, organic matter content and iron deficiency, by using precision agriculture techniques. Maps of fruit yield, quality, and canopies along with topography, soil characteristics, available water, fertility, leaf analyses, and pest populations are the basis for varying application rates of water, nutrient, and pesticides in citrus production. We propose to conduct further research into causal soil factors in different representative areas of the citrus industry, and also to develop and test suitable site-specific remedies, rates of amendments and cultural practices for these weak soils. After this information has been mapped and the required cultural practices determined, variable rate, control and sensing equipment will be used to apply the required remedy or cultural practices as needed in the site-specific areas.

Manage/Physiology

Funding Sources

FCPRAC	$42,000
Agency	65,000
Other	120,000
Total	$227,000

Objectives

1. Evaluate strategies for linking spatial yield variability with measurable grove variability (identify cause and effect relationships). 2. Improve profitability by i) varying inputs and management strategies to optimize returns from both highly productive and less productive areas of a grove, ii) develop custom remedies for under-performing soils to improve productivity, iii) remove the least profitable portions of groves out of production in order to curtail losses. 3. Evaluate costs and returns of precision agriculture with interested citrus growers.

Accomplishments

The performance of a commercial variable rate granular fertilizer spreader was tested in a 20-ac Valencia grove with significant tree-to-tree variability resulting from resetting. The spreader had an average on-off response time of 3 s, and an average rate changing response time of 2-5 s using the hydraulic servo valves supplied. These slow response valves are not suitable for rapid fertilizer rate changes between single tree spaces, but would be acceptable for prescription maps covering larger soil zones. We tested new faster, proportional valves on the spreader and found that the rate transition time could be reduced to ~0.5 s, which should be accurate enough for fertilization in typical tree-to-tree variability found on the Ridge. To determine optimal performance in granular fertilizer applications, an independent PC-level control system has been developed to provide real-time data acquisition and control plus the capability for simulation testing. This year we developed and published a new precision agriculture website reporting on CREC research,

(http://128.227.177.113/precision agriculture/ or browse from http://www.crec.ifas.ufl.edu/).

We compared ultrasonically measured tree canopy size with tub-mapped yield in a highly variable Valencia grove. A linear calibration model showed that ultrasonically-sensed tree canopy sizes correlated significantly (R^2 = 0.80) with fruit yield. Therefore, tree sizes could be used to estimate fruit yield within the grove. Two systems were assembled and tested for DGPS data logging and control of aldicarb (Temik) for citrus applications. Monitoring is essential to document a 300 ft setback from potable wells when the material is applied.

2005 Annual Progress Report

Project No. 042-13M Year 1/2

Decision Information System for Citrus (DISC) – Further Evolution of the System, Integration of Production Practices Record Keeping with Bookkeeping Systems and Distribution to Growers

L. Gene Albrigo, William S. Castle, Ronald P. Muraro, and L. W. Timmer (UF-IFAS-CREC, Lake Alfred, FL), Howard W. Beck and Fedro S. Zazueta (UF-IFAS, Gainesville, FL)

Citrus production practices and management options have become more complex; environmental and regulatory matters plus scheduling all grove operations now compete for a manager's time. The management tools in DISC will assist growers and production managers when making decisions. To date, the most successful module developed under this program is the Citrus Flowering Monitoring module. This module predicts intensity and date of flowering and provides recommendations to alter flowering events in favor of the grower. Before this program, the Florida citrus industry did not have good information about flowering events nor any production practices to alter bloom events. Major efforts during this project period included: data collection for and expanded testing and refinement of the Citrus Production Planning and Scheduling System (CPPSS). The module will include predicted times of fruit development and flushes with best timings for many production practices. A very complete record keeping system for production practices is included that was developed and expanded with grower inputs. The Cu

Manage/Physiology

Funding Sources	
FCPRAC	$46,500
Agency	44,500
Other	15,000
Total	$106,000

Objectives

1. Test Citrus Production Planning and Scheduling System (CPPSS) with 6 to 8 operations from different regions. Emphasize production practices and record keeping. Improve fruit development phenology model, driven by a flowering and bloom date expert system. Link irrigation and fertilization to growth. 2. Expand Copper Spray Schedule for new compounds for scab, alternaria and greasy spot along with copper (Beck, Albrigo and Timmer). 3. Develop and integrate a Comprehensive Nutrient Management Plan into CMS (FDEP funding, Beck). 4. Complete relational database for Pre-plant Decision System (Castle and Beck). 5. Expand PDA scouting system for grove observations to a fully operational system that downloads into the CPPSS (Beck and Albrigo).

Accomplishments

The Flowering Expert System was tested with an expanded group of growers for a fourth year. While the program has been successful in predicting all bloom cohorts within 7 days in previous years, the unusually cool weather in Spring 2005 delayed bloom by about 3 weeks. The end period of the prediction model was not sensitive enough to adjust for this event. Adjustments are planned for the 2005-06 flower induction season. The FAWN weather network interface was very reliable this past season. Some progress was made in allowing AgriLink weather access for growers with that service. Data for the fruit growth model was collected (3 years of data now available). When this is added this year to the flowering model, a complete reproductive growth program for timing production practices will exist. The Production Practices Scheduling System was improved and further developed through interaction with 4 grove production operations. Irrigation, fertilization and some fruit development management programs are under development. A PDA-based scouting software program was further integrated with the record keeping system to allow data storage for short- and long-term evaluation. Grower requirements for record keeping are very good and a workable system is used by one cooperator. Worker protection and entry protocols were added during the year. More growers were recruited to cooperate in the integration of production practices and development of appropriate record keeping fields for additional grove operations.

Rootstock Performance in Relation to Soils in Flatwoods Citrus and the Development of a Case-Based Expert System to Select Rootstocks

Bill Castle (UF-IFAS-CREC, Lake Alfred, FL), Brian Boman (UF-IFAS-IRREC, Ft. Pierce, FL) and Tom Obreza (UF-IFAS-Dept. SWS, Gainesville, FL)

Attempts to maximize grove performance are compromised by two key factors: soil variation and the lack of proven rootstocks for specific site conditions. We initiated a project with two parts designed to learn how trees vary in behavior according to site conditions and the soils, and to identify conditions that may relate to the decline of trees on Swingle citrumelo rootstock. The goal of this research is to provide citrus growers with the information and methodology to decide which rootstocks to plant across a landscape based on specific soil properties that can be easily measured.

Manage/Physiology

Funding Sources

FCPRAC	$78,000
Agency	8,000
Other	2,000
Total	$88,000

Objectives

1. Conduct a comprehensive survey to determine the scope and conditions of Swingle decline. Explore possibility of developing an economic model of grove returns vs. soils and rootstocks using groves from the survey. 2. Characterize sites, soil layers, measure root distributions and identify important variables and relate to tree performance for a range of rootstocks and soils where trees have performed well or poorly. 4. Combine data and information from (1) and (2) into a practical, case-based database and expert system for conducting site assessments and choosing rootstock choices (an expert system is a computer application that performs tasks similar to humans). 5. Develop appropriate materials and conduct training sessions for using the expert system.

Accomplishments

A series of field trials involving 'Valencia' orange trees on 7 rootstocks has been planted in replicated areas of 5 soils. So far, tree growth and yield reflect known differences in rootstock vigor, and the relationship among rootstocks is similar among soils. A second focus of the project involves locating field sites and assessing them for such factors as depth to a clay or organic layer, water table fluctuations, and soil chemical characteristics. From this study, it is clear that the nature of the surface horizon and depth to clay are strongly linked to the behavior of trees on Swingle. That information has been used in developing several planting plans for growers where rootstocks are matched to specific soils or grove areas. A comprehensive survey was conducted to locate additional groves of poorly or well-performing trees on Swingle and other rootstocks. A soil identification field guide has been prepared for publication. The case-based reasoning (CBR) expert system has been expanded to over 100 cases and had progressed to a state where it is nearly ready for grower evaluation. Data from a pot study to observe growth and root development of trees in Riviera sand soil has shown that roots can grow in all parts of the profile, suggesting that other factors such as water table fluctuations limit root development.

2005 Annual Progress Report

Project No. 013-99M Year 4/5

Young Tree Replant Failure

Jim Graham, Steve Futch, Larry Duncan (UF-IFAS-CREC, Lake Alfred, FL),,Chris Wilson (UF-IFAS-IRREC, Ft. Pierce), Tom Obreza (UF-IFAS-SWS, Gainesville,FL), Kim Bowman, Joseph Albano, Dan Chellemi and Steve Lapointe (USDA-ARS, Ft. Pierce, FL)

Citrus reset/replant problems described by production managers as "failure to thrive" are becoming increasingly widespread in Florida citrus, and associated economic losses are considered highly significant. A survey based on mailings to the Florida Citrus Production Managers and an insert in Citrus Industry Magazine has been completed that identifies and characterizes the possible sources of reset/replant problems. Survey results provide key information for in-depth field studies under development to characterize problems and to find possible solutions. Multi-disciplinary teams have been assembled to address the remaining research objectives. Collaborative field-experiments will be conducted in selected production systems in representative regions of the citrus industry. The goal is to develop recommendations that increase young tree performance, while reducing management costs, to sustain earlier tree profitability.

Manage/Physiology

Funding Sources	
FCPRAC	$55,000
Agency	30,000
Other	50,000
Total	$135,000

Objectives

1. Conduct survey of production managers to evaluate the extent and severity of problems with young tree performance. 2. Conduct site surveys for detailed evaluation of abiotic, biotic and management problems. 3. Evaluate treatments that may improve young tree growth. 4. Conduct research on specific sources of young tree problems.

Accomplishments

Research studies continued to focus on specific problems associated with young tree performance. Sites in major citrus production areas (ridge, flatwoods southwest, and flatwoods east coast) were compared for differences in pest, pathogen and tree responses to varying soil types, and to clipping vs. pushing of trees before replanting. In both ridge and flatwoods locations, higher populations of Phytophthora on young trees initially occurred in sites with clipped tree sites vs. the push sites. In all locations and treatments, pathogen populations dropped to non-damaging levels after the second season. Hence, no difference between clip vs. push sites in young tree performance was detected. Parasitic nematodes were not a factor in any of the sites. In LaBelle, poor tree performance of 2-yr-old Valencia trees on Swingle in the adverse soils was linked to soil calcium carbonate, pH and pathogen activity. In Ft. Pierce, Hamlin trees on Cleopatra, Smooth Flat Seville, and Swingle rootstocks were planted to compare young tree performance on marginal versus good sites. Mulch of urban plant waste was applied in 2004 as subplots to monitor benefits and economic sustainability. In Central Florida, Diaprepes larval feeding predisposed 2- to 3-yr-old trees on Phytophthora susceptible rootstocks to tree mortality. Incidence of tree decline was closely related to the soil recovery of Phytophthora from each rootstock. Pesticide suppression of the weevil reduced tree decline on Phytophthora resistant rootstocks, but not on susceptible rootstocks. These results confirm the primacy of Phytophthora rootstock resistance and weevil control for management of the Phytophthora Diaprepes complex.

2005 Annual Progress Report

Project No. 034-08M Year 2/4

Effects of Irrigation Management on Sweet Orange

Larry Parsons and T. Adair Wheaton (UF-IFAS-CREC, Lake Alfred, FL)

Increasing energy costs, erratic rainfall, and periodic droughts have made economical management of citrus irrigation more critical than ever. At the same time, recent restrictions on water use permits have made water less available to growers. Less water will potentially be available for irrigation, and we do not have a great deal of quantitative data on the effects of reduced annual irrigation rates on microsprinkler-irrigated groves. This project is studying the effect of several different seasonal water application levels on citrus plantings. The first year yield data showed that irrigation in the spring at a) moderate or b) greater levels increased yield by 12.8% and 36.5%, respectively, over no irrigation. At $0.80/lb ss, a) moderate or b) greater irrigation increased income by $371 or $882/acre. This study will show how reduced irrigation impacts citrus production.

Manage/Physiology

Funding Sources	
FCPRAC	$45,000
Agency	5,000
Other	15,000
Total	$65,000

Objectives

1. Establish an experiment with Hamlin oranges at a ridge site that provides several irrigation levels.
2. Determine effects of different seasonal irrigation application levels on yield and profit.

Accomplishments

The irrigation system in a mature Hamlin/Carrizo grove at the Water Conserv II ridge site was modified to allow different application rates to selected trees. Six irrigation treatments were started in the spring of 2004. With a water budget model, different amounts of water were applied to the treatments. Soil moisture (Echo) capacitance probes were installed at different depths under selected treatment trees to monitor soil water content and depth of water movement. Due to hurricane damage in 2004 and later canker occurrence on the east coast, we were asked by a grower advisor to FCPRAC not to set up an irrigation study in the flatwoods at this time. Work continued on the ridge where the wettest treatment was irrigated at 25% depletion in both spring and fall, and the driest treatment received no irrigation (100% depletion) and survived on rainfall. The first complete year's yield was taken in December 2004. Trees that had less stress (25% depletion) in the spring averaged 861 bx/ac, which was 36.5% greater than the non-irrigated trees. Trees with moderate stress in the spring (50% depletion) averaged 711 boxes/acre which was 12.8% greater than the non-irrigated trees. Trees irrigated at 25% depletion produced 1,103 more pounds solids/acre than non-irrigated trees and 639 more lb ss/acre than trees irrigated at 50% depletion. At $0.80/lb ss, trees with less stress yielded $882/acre more than non-irrigated trees and $511/acre more than moderately stressed trees. It pays to irrigate frequently in the spring.

Microbial Soil Amendments to Improve Tree Performance on Florida Citrus Soils

Arnold Schumann, Jim Syvertsen, Gene Albrigo, Jim Graham (UF-IFAS-CREC) and Brian Boman (UF-IFAS-IRREC)

The profitability of Florida citrus groves is often limited by soil conditions, mostly by weak soils interspersed with better soils in production blocks. Research shows that the weak soils often have depleted soil organic matter content and generally weakened biological activities. There are many advertised amendments that claim to "condition" unproductive soils by improving the balance of beneficial microbes. Because there is no known research demonstrating the effectiveness and profitability of these products on citrus, we will undertake to test a selection of these in a potted greenhouse experiment and in the field. Four products will be screened in the greenhouse for tree growth and nutrient uptake response, soil water potential, and nutrient leaching. The best two candidates from the greenhouse tests will be included in three field-scale experiments at three locations (Southern flatwoods, Indian River, Ridge). At the end of the four-year study, we expect to establish the validity of recommending and profitability of using microbial soil conditioners for Florida citrus.

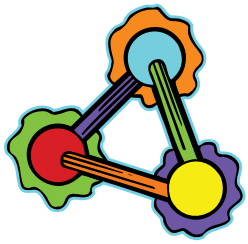
Manage/Physiology	
Funding Sources	
FCPRAC	$33,000
Agency	30,000
Other	0
Total	$63,000

Objectives

1. Conduct a potted tree experiment to determine if any of the available microbial products improve seedling growth and nutrient content in a ridge sand. 2. Use two products selected from objective (1) in field trials to determine if tree growth and yields respond to microbial products with or without surface bio-solid additions in three major growing areas.

Accomplishments

The greenhouse experiment was repeated in 2005 with the two selected microbial products due to the inconclusive results obtained in the first year. A replicated field experiment was established in each of the Ridge, Indian River and Southern flatwoods citrus growing areas during winter of 2003/04. Treatments were applied in spring, 2004 (two microbial products at recommended rates and control with or without a suitable rate of bio-solids). Response measurements taken so far are leaf nutrients, color, canopy size, soil nutrients and pH, organic matter, active carbon content, density, moisture holding capacity, and microbial respiration. A data logger with moisture probes was installed in one experiment to compare the wetting/drying responses and moisture contents of soils in adjacent plots treated with different microbial amendments. Fruit yield was not assessed from the 2004/05 season due to the devastating effects of three hurricanes. Microbial treatments and biosolids were reapplied in spring of 2005. Soil Phytophthora status and root density will be measured in the fall of 2005 and 2006. So far the results of leaf color measurement in one of the experiments showed nearly significant temporary leaf greening from microbial products in 2004, but not in 2005. The microbial respiration measured in the soil during the fall did not show any significant treatment effects, suggesting that the microbial products did not have good longevity through the summer season. The only significant differences detected in soil or leaf mineral nutrition were due to the addition of biosolids (N, P, Fe and B).



Pathology

Identification of Effective Compounds from Antagonism for Controlling Foliar Fungal Pathogens of Citrus

Kuang-Ren Chung (UF-IFAS-CREC, Lake Alfred, FL)

Microorganisms, mainly fungi and bacteria, produce many kinds of toxic compounds inhibitory to the growth and development of other organisms, representing enormous but largely untapped natural resources for disease controls. The goals of this project are to identify and characterize the microorganisms, specifically their secondary products with antagonistic activity against the major citrus foliar fungal pathogens such as Alternaria, Diaporthe, Elsinoe and Mycosphaerella, to investigate the antagonistic mechanisms, and to evaluate the inhibitory compounds for disease control in citrus.

Pathology

Funding Sources	
FCPRAC	$35,464
Agency	0
Other	0
Total	$35,464

Objectives

1. Isolation of antagonists from citrus phyllospheres, and characterization of antagonistic activities against foliar fungal pathogens, including Alternaria, Mycosphaerella, Elsinoe, and Diaporthe. 2. Investigation of antagonistic mechanisms (antibiosis, toxicity, mycoparasitism, or competition for resources), and identification of antagonistic compounds. 3. Initiation of greenhouse trials for disease controls.

Accomplishments

Four fungal saprophytes (designated LAL5, 11, 13 and 16) isolated from citrus leaves produced toxic and heat resistant compounds that exhibited growth inhibition to citrus pathogens Diaporthe and/or Alternaria. Both LAL5 and 11 isolates were identified as Cladosporium cladosporioides, and LAL13 and 16 isolates were Fusarium rigidiusculum. The cultural filtrates from LAL5 and LAL11 reduced Diaporthe growth by 90-95%, whereas they reduced Alternaria growth by 40-50%. In contrast, the cultural filtrates from LAL13 reduced Alternaria and Diaporthe growth by 60-75%. The cultural filtrate from LAL16 exhibited a strong growth inhibition to Alternaria (by reducing 75% growth), but had little effect on the growth of Diaporthe (by reducing 3% growth only). Interestingly, heating the cultural filtrate of LAL16 greatly increase the growth inhibition to Diaporthe (up to 40%). Studies using microscopy indicated that the cultural filtrates from LAL isolates altered hyphal morphology of Alternaria and Diaporthe. The types of media supporting the production of toxic materials by LAL isolates were also investigated. Determination of these toxic compounds and possible effects on disease control are currently underway. The information generated from this research may have a great potential on identifying and applying the microorganisms and active bio-products to the field through fermentation and/or genetic engineering manipulation.

2005 Annual Progress Report

Project No. 033-03P Year 2/3

Field Trials of Hormone Inhibitors on Yield Production of Citrus Associated with Postbloom Fruit Drop (PFD) and Fungal Pathogenicity of *Colletotrichum acutatum*

Kuang-Ren Chung (UF-IFAS-CREC, Lake Alfred, FL), Jacqueline K. Burns and L. W. Timmer (UF-IFAS-CREC, Lake Alfred, FL)

Postbloom fruit drop (PFD) of citrus is caused by the fungus Colletotrichum acutatum, usually resulting in fruit drop, production of persistent buttons, and leaf distortion. In this proposal, we determined the levels of hormones or growth regulators (IAA, ethylene, ABA, Jasmonic acid and salicylic acid) in response to fungal infection. Efficacy of hormone inhibitors in preventing yield losses was also evaluated. A KLP1 (Key Lime Pathogenicity) gene involved in fungal infection was cloned from C. acutatum. Functional analysis using a gene disruption is being conducted to verify the involvement of KLP1 in symptom development. The proposal intends to provide valuable information for future decision making on PFD management. Specific objectives are outlined below.

Pathology

Funding Sources

FCPRAC	$48,464
Agency	0
Other	0
Total	$48,464

Objectives

1. To evaluate the effectiveness of hormone inhibitors for preventing yield loss due to PFD. 2. To determine the effect of hormone inhibitors on gene expression and hormone accumulation. 3. To isolate and characterize the full-length KLP1 gene potentially involved in fungal pathogenesis. 4. To conduct gene disruption to confirm gene function associated with fungal pathogenesis.

Accomplishments

Colletotrichum acutatum infects citrus petals and induces premature fruit drop and the formation of persistent calyces. Studies indicated that imbalance of IAA, ethylene and JA in C. acutatum-infected flowers may be involved in symptom development and young fruit drop. After fungal infection, the levels of ethylene, IAA, trans- and cis-12-oxo-phytodienoic acid, cis-jasmonic acid (JA) and salicylic acid (SA) were elevated in affected petals, but not in pistils. ABA levels showed no significant response. No significant differences of ABA and trans-jasmonic acid (JA) were observed in citrus flower petals or pistils. Genes encoding ACC oxidase or ACC synthase, auxin-related proteins and 12-oxo-phytodienoic acid (12-oxo-PDA) reductase were highly expressed in affected flowers. Application of clofibrate (a putative auxin inhibitor), 2,3,5-triiodobenzolic acid (TIBA, an auxin transport inhibitor), ReZist, gibberellin (GA_3), or SA after inoculation significantly resulted in higher percentages of young fruit retention, providing a promising future for PFD management. A fungal gene, named KLAP1 (Key Lime Anthracnose Pathogenicity) encoding a transcription activator was identified from a C. acutatum KLA isolate and demonstrated to be required for infection. The funding from FCPRAC to this project has resulted in six publications.

Management of Citrus Tristeza Diseases in Florida

Bill Dawson, Steve Garnsey (UF-IFAS-CREC, Lake Alfred, FL), Tim Gottwald, Mark Hilf (USDA-ARS-USHRL, Ft. Pierce, FL), Peggy Sieburth (FDACS-DPI, Winter Haven, FL) and Scott Adkins (USDA-ARS-USHRL, Ft. Pierce, FL)

The first strategy to control or manage diseases caused by CTV is detection. We need to be able to identify undefined severe isolates. If severe isolates of the virus become established with an effective vector present, there are two strategies of managing the disease. The intermediate strategy is to attempt to protect trees by inoculation with mild strains. The long-range strategy is to produce virus-resistant trees.

Pathology

Funding Sources	
FCPRAC	$250,000
Agency	0
Other	180,000
Total	$430,000

Objectives

1. Continue to develop effective procedures capable of detecting new severe strains. 2. Adapt these new procedures for large scale screening by DPI. 3. Monitor commercial citrus for stem-pitting strains of CTV. 4. Engineer cross-protecting isolates of CTV to protect against severe isolates; and, Develop virus-resistant trees.

Accomplishments

Using these new methods, we recently discovered isolates that are in the VT group of CTV and which cause stem pitting in sweet orange and grapefruit in greenhouse tests. This virus appears to be efficiently moving in Florida. We began surveying the distribution of this virus and evaluating the symptom severity of these new isolates. A survey to detect the VT-like virus was undertaken for the eleven counties representing 80% of commercial citrus production in Florida. Forty-five percent (42 of 77) of the sites surveyed tested positive for the VT-like virus. Although most sites had an incidence levels of less than 5%, six sites had high incidence of markers for this strain of CTV.

Simultaneously, we were engineering mild strains of CTV (by disarming severe strains) to protect trees with cross protection. We are determining whether cross protection could prevent or substantially delay decline on the sour orange rootstock as a management strategy to allow the use of that rootstock. We also are developing procedures to protect against stem pitting in the event that a severe stem pitting strain is introduced into Florida. We are developing a cross protecting isolate to protect against the VT-like strain already in Florida in the event it becomes a serious threat.

Studies to Determine the Cause and Develop Strategies to Control Citrus Blight

Kenneth Derrick, Julia Beretta and Gary Barthe (UF-IFAS-CREC, Lake Alfred, FL)

The Florida citrus industry loses more than 600,000 bearing trees per year to citrus blight. There are no reliable methods for controlling blight and the cause of the disease is unknown. The symptoms associated with citrus blight can be reproduced by root graft inoculations, which indicates the disease is caused by a pathogen. A major effort to determine the cause of blight using subtraction hybridization techniques is ongoing.

Pathology	
Funding Sources	
FCPRAC	$56,822
Agency	100,000
Other	40,000
Total	$196,822

Objectives

1. To determine the cause of citrus blight. 2. To develop strategies to control citrus blight.

Accomplishments

In experiments to determine the cause of citrus blight (CB), a decline of unknown cause, subtraction hybridization was done using leaves and fibrous roots of an affected tree. Clones were identified that had similarities to Raspberry bushy dwarf virus (RBDV), the only known member of the genus Idaeovirus. The clones covered a 1555-bp region similar to RNA-2 of RBDV including 595 nts of the 3′ end of an ORF that was 60% identical in amino acids to the movement protein of RBDV and a 834-nt ORF that was 65% identical in amino acids to the coat protein of RBDV. RBDV is seed and pollen transmitted and is symptomless in some Rubus species. In more sensitive Rubus species, it causes a yellows disease or a condition called crumbly fruit but only causes bushy dwarf disease with mixed infections of the aphid-borne Black raspberry necrosis virus. The sequence of the putative citrus Idaeovirus (CIV) was used to make primers for RT-PCR. Based on RT-PCR assays, the virus appears to be unevenly distributed in citrus and is present in low concentrations making it difficult to determine whether a given tree is infected. Investigations continue to determine if CIV is associated with CB or any other disease of citrus either singly or in mixed infections with other viruses.

2005 Annual Progress Report

Project No. 042-01P Year 1/2

Control of Citrus Canker with Novel Chemical Compounds

J. H. Graham, J. K. Burns (UF-IFAS-CREC, Lake Alfred, FL) and T. R. Gottwald (USDA–ARS, Ft. Pierce, FL)

The estimated revenue loss due to increased fruit drop from citrus canker ranges from $80,137 per acre. Copper formulations, the standard control measure for fungal fruit and foliar diseases of citrus, have been demonstrated in our Brazil trials to reduce canker-induced fruit loss by up to 40%. The benefits of this research are aimed at improving control with more effective chemicals to maintain profitability of susceptible fresh and processed citrus varieties that comprise about 70% of the Florida citrus acreage. This will be achieved through examination of systemic chemicals and contact materials that might increase resistance and/or reduce infection of susceptible citrus tissues to canker and compliment activity of copper. The goals are to improve the efficacy of spray programs and to reduce the dependency on copper to minimize risks of bacterial resistance, soil accumulation and environmental contamination.

Pathology

Funding Sources

FCPRAC	$60,990
Agency	100,000
Other	50,000
Total	$210,990

Objectives

1. Screen new compounds for canker control in the greenhouse using the citrus bacterial spot (CBS) surrogate, Xanthomonas axonopodis pv. citrumelo. 2. Evaluate promising compounds from greenhouse tests in field situations utilizing existing nursery infestations of CBS for evaluation. 3. Test promising compounds resulting from the first two steps on X. a. pv. citri-infested trees under containment in Florida and under canker endemic conditions in Brazil.

Accomplishments

Induced systemic resistance (ISR) appeared promising in greenhouse bioassays with CBS and canker, but failed to produce useful levels of disease control under canker endemic conditions in Brazil. Basal resistance (BR) is induced by peptides associated with proteins on the surface of the pathogenic bacterium, such as flagellin. Two active peptides from flagellin induced bacterial disease control activity in the greenhouse and therefore merit further evaluation in combination with ISR to potentially fortify the plant's disease resistance levels. Three pathogenesis-related (PR) proteins from citrus have been evaluated as reporters of ISR and BR: chitinase (PR-4), chitinase-1 (PR-3) and beta-glucanase (PR-2). A total of 41 ISR compounds and 4 BR peptides (2 from Pseudomonas and 2 from Xanthomonas) have been tested by the greenhouse bioassay, and 12 ISR and 2 BR compounds tested with the PR gene reporter assay. The antibiotic, Gentamycin (Gowan), when formulated to increase its activity and longevity on the leaf surface, produced a 35% reduction in canker disease incidence in a field quarantine trial in South Florida. In Brazil, for the last 3 seasons on mid-season oranges, 6 applications of the label and 50% of label rate of copper hydroxide (CuOH) and copper oxychloride were effective for reducing canker on foliage, defoliation, fruit infection, and fruit drop. In 2003-04, copper formulations reduced yield loss due to canker-induced fruit drop ranged from 12 to 40%. Combination of the fungicide Famoxate (Dupont) with the reduced rates of CuOH has not shown greater control activity than the activity of CuOH alone.

2005 Annual Progress Report

Project No. 042-02P Year 1/2

Rapid Efficient Clean-up of CTV-Infected Field Sources

Jude W. Grosser (UF-IFAS-CREC, Lake Alfred, FL), Lisa Williams (FDACS-DPI, Gainesville, FL) and Peggy Sieburth (FDACS-DPI, Winter Haven, FL)

The Florida citrus industry will benefit greatly by the safe and rapid development of new citrus varieties. However, at present many promising new selections cannot be propagated for intermediate or advanced testing because they test positive for severe CTV (MCA-13 positive). This proposal will focus on the development of improved methodologies that will eliminate severe citrus tristeza virus in promising field trees that are intended for planting out in locations all over the state. The ultimate goal of the research will be to identify a rapid, reliable and safe procedure that can be used efficiently on a large number of selections with a minimal resource requirement. Efforts will focus on combining natural thermotherapy with serial micrografts in a hot greenhouse to generate virus-free plants of advanced selections. Trees set out free of citrus tristeza virus will have a good evaluation of all factors present in the testing environment including local tristeza virus strains. By the conclusion of this research, a mechanism will be in place for expeditious clean-up of potential new varieties developed by Florida's citrus breeders.

Pathology

Funding Sources	
FCPRAC	$17,500
Agency	0
Other	0
Total	$17,500

Objectives

1. To use a combination of natural thermotherapy and serial micrografts to produce virus free plants of advanced selections. 2. Compare the cost, timing and efficiency of any newly developed rapid clean-up procedure to standard growth chamber thermotherapy.

Accomplishments

Ninety percent of shoot tips from summer sprouts of CTV-infected field trees were found to be free of virus by PCR analysis. Attempts to micrograft these shoot tips were unsuccessful due to massive fungal contamination. Numerous treatments were tested in efforts to prevent fungal contamination while maintaining the viability of the shoot tips. Agents tested included (alone or in combination): vinegar, alcohol, chlorine, Topsin fungicide, and double decontamination with sequential tissue culture plating. The following treatment gave a satisfactory result regards to the contamination problem without severe injury to the tissue. Field materials were collected and soaked in Ridomil fungicide for 20 min. and then transferred to 70% ethanol for 1 min, followed by 15% bleach for 15 min followed by 4 rinses with water. The shoots were either inoculated on DBA3 medium in magenta boxes for 2 days, then used in micrografting, or the micrograft was performed immediately after the disinfection treatment. Chilling treatment of shoot tip branches did not improve survivability. Using larger shoot tips, micrografting conducted in the lab with field-derived shoot tips resulted in 10 successful grafts in culture tubes that will be transferred to soil next week, then they will be tested to determine whether they are virus free or not using PCR and ELISA. Efforts to improve this procedure are continuing, and the current focus is to apply an antitranspirant to the micrografts (Cloud Cover) to improve survivability. Significant progress was also made characterizing the new VT-type CTV isolate found in many of our field trees.

2005 Annual Progress Report

Project No. 043-07P Year 1/3

Management Programs for Fungal Diseases of Fruit and Foliage

LW (Pete) Timmer (UF-IFAS-CREC, Lake Alfred, FL)

Greasy spot causes defoliation and yield loss on citrus and rind blotch, Alternaria brown spot, scab and melanose reduce the marketability of fresh fruit. Ammonia fertilizers, lime or frequent irrigations can reduce spore production of the greasy spot fungus by 75-90%. Rates and frequencies of application will be evaluated to develop a commercially useful system to reduce inoculum. Infection of fruit by Mycosphaerella citri, the cause of rind blotch, will be monitored microscopically. Fungicide applications will be used to determine the time of fruit infection. The effect of variety, tissue age and types and fungicide application on sporulation will be assessed for Alternaria brown spot. With melanose, the effect of disease severity, twig diameter, and temperature on sporulation of Phomopsis and temperature and moisture effects on spore survival will be determined. On grapefruit, integrated programs emphasizing strobilurin fungicides, copper fungicides or fenbuconazole will be compared for control of scab, melanose and rind blotch. On Murcotts, programs emphasizing strobilurins, copper fungicides or resistance-

Pathology

Funding Sources	
FCPRAC	$98,000
Agency	75,000
Other	15,000
Total	$188,000

Objectives

1. Evaluate the potential of grove floor management treatments to reduce greasy spot inoculum from leaf litter. 2. Determine the best timing for control of greasy spot rind blotch; evaluate the effects of variety, tissue and fungicides on inoculum production with Alternaria brown spot and melanose. 3. Develop integrated programs for disease control on fresh fruit to enhance control and minimize resistance development.

Accomplishments

Large plot field tests have been established to ascertain the effect of irrigation frequency, lime application, fertilization with ammonium versus nitrate fertilizers on ascospore production of Mycosphaerella citi and infection by greasy spot. Ascospore deposition and infection of fruit by M. citri occurred primarily during the rainy season and fungicide applications in June and especially July appeared to be most critical for control of rind blotch on grapefruit. August and September applications were relatively ineffective. The age at which leaves developed resistance to Alternaria brown spot in greenhouse tests appeared to be strongly related to susceptibility of different citrus cultivars in the field.

Sporulation of Alternaria alternata on infected leaves began about 2 weeks after symptom appearance and continued for more than a month. Spore production was substantially reduced by applications of strobilurin and copper fungicides. Production of spores by Phomopsis citri was greatest on 3- to 5-mm diameter twigs that were severely affected by melanose. In laboratory tests, production was greatest on twigs soaked 3 to 4 hr on alternate days at 28 C. Field tests were established to evaluate the effect of petroleum oil viscosity, rate and spray volume on the control of greasy spot on grapefruit. A field experiment was established to compare integrated programs emphasizing inexpensive copper fungicides, strobilurins, and fenbuconazole for control of scab, melanose and greasy spot on grapefruit.

This document is the Thirteenth Annual Report of the Florida Citrus Production Research Advisory Council. The purpose of this document is to present a review and summary of the previous year's research projects and to present the current financial status of the program.

Florida Citrus Production Research Advisory Council

Administered by
The Florida Department of Agriculture and Consumer Services
Charles H. Bronson, Commissioner

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This document prepared by
Steven Rogers
Scientific Coordinator
University of Florida – CREC
Lake Alfred, FL 33850
863-956-1151
steve@fcprac.com
www.fcprac.com