The Florida citrus industry is reeling from a cascade of canker and greening disease incursions into nurseries and groves within the last year. But Florida is not the only major citrus producing state dealing with the onslaught of exotic diseases. Greening was discovered in Sao Paulo state (SP) in the epicenter of Brazil’s noble citrus area in 2004 and canker has been endemic in Parana state (PR) to the south since the 1950s.

In the 1990s, exposure to sharpshooter vectors of Xylella fastidiosa (the cause of citrus variegated chlorosis, CVC), forced the SP industry to protect nursery stock in enclosed structures. Unfortunately, introduction of the greening bacterium probably occurred about 10 years ago. Therefore, greening was likely spread by infected nursery stock to satellite regions throughout SP – ahead of when the nurseries were fully protected.

Experience in Brazil’s citrus areas provides Florida with practical lessons for disease management. Jim Graham, UF/CREC, organized a tour of citrus companies managing these diseases. The tour was sponsored by John Taylor, Jr., of Syngenta Crop Protection. Organizational support was provided by Juliano Ayres, scientific director of Fundecitrus, and Rui Leite, plant pathologist, from the Instituto Agronomico do Parana (IAPAR).

The aim was to show that citrus can be profitably produced in the presence of these diseases. Part I of this series details the practices in SP for:
1) nurseries that exclude vectors of greening and CVC, and
2) management of greening with disease survey, psyllid control and removal of infected trees.

Part II, which will run in the August issue of Citrus Industry, will present the programs for canker exclusion and management in different areas of PR.

On March 28, the group visited Fioresi Nursery near Ribeirao Preto to see an excellent example of protected citrus nurseries in SP. This nursery, located 25 miles from the closest citrus grove, produces 1.3 million trees in greenhouses covered with either screen.
houses covered with either screen or poly and using screened double door entryways. There are 20-30-foot-tall windbreaks of a native tree called Jambolao on all sides of separate ranges of greenhouses.

All citrus trees are grown in sleeve bags of clean soilless media and propagated on raised benches to prevent Phytophthora infection. Strict sanitation requires all workers at the nursery to shower and change into coveralls and rubber boots.

Disinfection stations for hands and shoes are located at the main entry gate and each entrance to propagation houses. Weekly sprays for vectors prevent infestations of potential disease vectors.

**FUNDECITRUS**

In the afternoon, the group traveled to Fundecitrus headquarters in Araraquara. There, the director, Osmar Bergamaschi, presented an overview of the mission of Fundecitrus. He explained that the foundation’s budget is generated from a box tax on fruit with over 85 percent allocated to survey of nurseries and groves for endemic and introduced pathogens and pests and eradication of citrus canker.

The scientific department headed by Juliano Ayres provided an in-depth overview of the program for greening disease diagnosis, survey, vector control and tree removal. Ayres reviewed the chronology of events for how Fundecitrus addressed the greening situation.

The symptoms of greening were first recognized in March 2004 near Araraquara. In July 2004, two strains of the greening bacterium were confirmed by pathologists as Ca. Liberibacter asiaticus and Ca. Liberibacter americanus. By August 2004, an aggressive grower awareness campaign was begun to call attention to the disease. In October 2004, a survey of the most affected areas was initiated.

Meanwhile, Fundecitrus developed federal legislation passed in March 2005 to enforce the removal of symptomatic trees.

In June 2005, a statewide inspection/eradication program for canker and greening was initiated with 800 inspectors. This program has inspected 126 million trees for greening and 138 million for canker. As of March 2006, the survey has detected 10,000 positive blocks of a total of 75,000 blocks inspected (Fig. 2). In 2005, the program resulted in mandatory removal of 280,000 trees and voluntary removal of 400,000 trees.

For grove survey, field diagnosis of greening relies on the symptoms on the newest hardened-off leaves. Emphasis is placed on maturity of leaves and asymmetry of the mottling (green island) pattern. Leaves with mineral deficiency symptoms, particularly Zn and Mg, and Phytophthora yellow vein chlorosis create the most confusion, but these patterns on the leaves are symmetrical.

The first survey of blocks occurs in every third middle (20 percent of trees). If one positive greening tree is detected, then 100 percent of the trees are inspected.

Fundecitrus inspects, marks suspects and maps location of each infected tree in each grove (a very labor-intensive process). The SP Secretary of Agriculture confirms positive symptoms, collects samples and sends leaves to APTA Citrus Center for visual diagnosis. A polymerase chain reaction (PCR) assay is performed only to confirm each new block.

So far, 167,000 samples have been processed by visual diagnosis and 87 percent are positive. Since July 2004, the Fundecitrus diagnostic lab has processed samples for growers who want PCR confirmation of unknowns from their survey. The lab uses the Bove 16s rDNA primers for C. L. asiaticus and C. L. americanus in the PCR assay.

By law, positive trees must be destroyed after the diagnostic report is communicated to the grower by phone. If the tree is not destroyed within 15 days, the SP Secretary of Agriculture grants Fundecitrus authority to remove trees and bill the grower. Growers must re-inspect infected blocks within six months. In 15-20 percent of the cases, the grower chooses to remove the entire block when greening is detected. In a few cases there have been delays in tree removal.

Our group was also given a presentation by Alexandre Tachibana of Branco Peres Agribusiness on greening management for a 600-acre grove near Araraquara. For psyllid surveys, one percent of trees in each block of 2,000 trees are inspected by examination of four branches per tree and 80 branches per block. If one branch is positive, a foliar insecticide is applied for psyllids. Thereafter, insecticide sprays occur every 15 days.

For greening surveys, each ground surveyor inspects 800 trees per day and each platform surveyor (see photo) inspects 5,000 per day in search of canker, greening and CVC (tractor speed 1.8 mph). The platform is used to detect greening in the tops of larger trees. There are five ground inspectors, two platform inspectors, and this crew surveys 75,000 trees per month.

Inspections occur every month, but May through July (winter) is the best time to detect symptoms. In September 2004, 5,000 trees (45 percent) were initially found to be greening positive; in May 2005 769 positive trees were detected (7 percent, 622 by platform, 147 ground); in June 2005 317 trees (1.5 per The group then traveled about
cent, 145 platform, 172 ground), and in July 2005 102 trees were positive (est. 0.2 percent).

**GROVE VISITS**

On March 28, the group visited Cambuhy Agricola, Ltda. in nearby Matao. There, Fernando Tersi gave an overview of their greening management program followed by a visit to the 17,000-acre grove to observe greening survey methods and CVC.

The greening management program is different from Branco Peres. In this farm, each surveyor inspects 500 trees per day. To insure inspection accuracy, “cross-checking” of the survey crews occurs every month.

Insecticide sprays are applied 18 times per year from October to March. Young trees receive soil applications of systemic insecticides two times per year. In 2005, the cost per tree was estimated to be $0.25 for survey and $0.22 for insect control. As of March 2006, 11,075 of the 1.7 million trees have been removed and the current incidence of greening is 0.007 percent.

Before the group left Araraquara on March 29, it visited a grove of six-year-old Hamlin trees under no greening management. Symptoms in the block have increased dramatically to 10-20 percent incidence since last year when greening was first detected in a few trees. In February, several trees displayed yellow dragons (see photo), but by late March the leaves and fruit had dropped from affected branches on most trees. Fundecitrus scientists estimate the time from infection to symptoms was two to four months in this block. Best expression of leaf symptoms was in winter, least in summer, so symptom progression is difficult to estimate because of the seasonal effect.

The group then traveled about 150 miles south to the edge of the greening epidemic area to Nova America’s Gaucho Farm in Santa Cruz do Rio Pardo. This farm has 1.4 million trees on 7,500 acres. Here the greening incidence is much lower, but the intensity of the inspection is just as high.

This company conducts four farm-wide inspections for greening each year. Each surveyor inspects 250 trees per day and one leader per 50 inspectors verifies where the surveyor has inspected and confirms positives. If the block is positive, 100 percent of the trees are re-inspected every 40 days.

Psyllid populations peak in March-April (fall) and August-September (spring). Insecticide sprays are only applied when 10 percent of trees are psyllid positive (inspect 25 trees per block). If psyllids are found upon re-inspection of the block, there is not a repeat spray until 10 percent of the trees are again positive. In 2004, 180 greening positive trees were found, 200 were detected in 2005, and the incidence overall is 0.05 percent. Greening positive trees are cut within two to three days after detection, and stumps are treated to prevent re-sprouting.

*Graham and Chamberlain are with the University of Florida at the Citrus Research and Education Center, Lake Alfred; Barber is with Lykes Citrus, Lake Placid.*