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# CITRUS BLIGHT INCIDENCE UNDER DIFFERENT FERTILIZATION AND LIMING PROGRAMS IN FLORIDA FLATWOODS

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*Abstract.* **Blight is a major disease affecting citrus trees in Florida. The causal agent of this disease has not yet been determined or agreed upon. Symptoms are typified by shortened internodes on branches and severely cupped and yellowed leaves in spite of water availability, as well as flushing of leaves and blooms before tree death. A study was carried out on 'Valencia' oranges, at Indian River Research and Educational Center, Fort Pierce, Florida, during 1990-2004 to compare a frequent fertilization program (five split applications) to a conventional Florida fertilization program (three applications). Two liming rates were used, since previous work showed higher values of blight incidence on citrus at high soil pH. There was no difference in blight incidence with fertilization treatment. Liming rate, however, did have an effect on the number of blighted trees. The number of trees showing visual blight symptoms increased about 2.6% per year for trees receiving the low lime rate. Trees under the high lime rate had an increase in blight symptomatic trees of 5.6% per year. Average annual yields were nearly identical between the lime treatments for the first 7 years of production. Due to the rising number of blighted trees with reduced yields in the High lime treatment, yields were reduced in comparison to the low lime treatments during the last few years, resulting in a cumulative advantage of 254 box/ac for trees in the low lime plots.**

Over the last 100 years, many studies have been conducted to determine the causes of citrus blight (decline). Studies have included pathogenic and non-pathogenic media. Non-pathogenic causes included low soil calcium and low soil organic matter. Nutritional components such as Mn and Zn deficiency symptoms may appear on blight trees (Wutscher, 1986; Wutscher and Cohen, 1997). High K applications usually lower Ca uptake, producing Ca deficiency symptoms. In many crops (e.g., celery), the uptake of Ca and B is minimal or low in the presence of drought or flooding (Mengel and Kirkby, 1987). High application of K and $NH_4$, and lime resulted in blight on citrus (Anderson and Calvert, 1970; Casafus et al., 1980;Wutscher, 1986; Wutscher and Bistline, 1988; Wutscher and Lee, 1988).

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Blight symptoms can be confused with symptoms of other diseases. Symptoms of blight include: high Zn in trunk bark and wood, presence of amorphous plugs in xylem, presence of certain proteins associated with blight, and non-conductance of water into the trunk (Brlansky et al., 2004; EPPO/CABI, 1996).

In general, non-pathogenic processes including good land preparation and fertilizer management, in addition to proper irrigation and drainage programs, together with careful liming practices, tend to decrease citrus tree decline (Anderson and Calvert, 1970; Casafus et al., 1984; Cohen, 1980; Cornell and Harison, 1997; Iley and Gupil, 1978; Wutscher, 1986). In Brazil, high fruit yield with good juice quality was obtained through a recommended fertility program. Most of the soils there were relatively high in clay. Thus, this fertility program was never tested on shallow sandy soils. The objectives of the study were to test the Brazilian fertilizer program using frequent fertilizer applications and low liming rates on 'Valencia' orange trees grown on shallow sandy soils against a conventional Florida fertilizer and liming program and to determine their effects on the incidence of blight.

## Materials and Methods

The experiment was conducted at the UF/IFAS Indian River Research and Education Center, Fort Pierce, Fla. on land that had previously never been in citrus production. The soil was an Oldsmar fine sand (sandy, siliceous, hyperthermic, Alfic-Arenic Haplaquods). The surface 4 inch layer was dark gray sand which overlaid a light gray sand. The gray sand was above a white sand layer at a depth of 18 to 24 inches. A spodic (black organic) layer of about 4 to 6 inches thickness was found at a depth of 30 to 36 inches. The subsoil below the spodic layer was a slowly permeable clay. Water furrows between the beds were cut to a depth of about 32 inches, with some spodic material brought to the tops of the beds which is typical of citrus bed formation in the area.

The field design used was a randomized complete block design with two fertilizer programs (5 applications F5 and three applications F3) and two liming rates [high and low (Hi and Lo)] for each program. There were five replicates of four treatments (F5Hi, F5Lo, F3Hi, and F3Lo). Each replicate consisted of 16 trees.

The pH averaged 4.7 from soil samples taken from the four quadrants of the planting area prior to bedding. Soil within each plot was sampled for pH analysis in 1991, 1994, 1997, and 1999. After bed construction in Apr. 1990, dolomite (49% $CaCO_3$, and 36% $MgCO_3$) was broadcasted on the tops of the beds and disced into the soil. Two rates of lime (dolomite) were used. The Lo treatment received 1.25 ton/acre of dolomite in April 1990 and 3.25 ton/acre were applied to the Hi plots at the same time. In Feb 1991, 1.0 ton/acre of dolomite was applied to the Hi plots. In July 1995, 1.0 ton/acre and 2.0 ton/acre were applied to the Lo and Hi plots, respectively. In May 1997, 1.0 ton/acre of dolomite was broadcast on Hi plots. Thus, the total dolomite applied during the period of the study was 2.25 ton/acre for the Lo treatments and 7.25 ton/acre for the Hi treatments.

'Valencia' orange [*Citrus sinensis* (L.) Osbeck] on Volkamer Lemon (*C.volkameriana*, Ten and Pesq.) rootstock trees were planted on 13 July 1990. The trees were planted in two-row beds at a 22 ft across-row and 12.5 ft within-row spacing on 50 ft wide double-row beds. The trees were irrigated by microsprinklers that delivered 10 gal/h and wetted an area of 15 ft diameter. Irrigation started when soil moisture tension value reached about 15 kPa (February to June) or 25 kPa (July to January). The fertilizer programs, continued during the years 1996-2001, were as follows:

*Five Split Application Fertilization Program (F5).* Five applications were made per year in February, April, June, August, and October. Total N applied was 0.82, 1.41, 1.50, 1.39, 1.63, and 1.41 lb/tree during 1996-2001, respectively in the form of $NH_4NO_3$. There were 139 trees per acre so application rates of N ranged from about 114 to 227 lbs/acre. P applications, using triple superphosphate as a source, were made at rates of 0.31, 0.42, 0.44, 0.51, 0.51, and 0.60 lb/tree of $P_2O_5$ during 1996-2001, respectively. K was applied as muriate of potash at rates of 0.68, 1.23, 1.23, 1.34, and 2.03 lb/tree of $K_2O$ during 1996-2001, respectively or about 95 to 282 lbs/acre. The fertilizers were applied by hand around the microsprinklers laterals, with a previously calibrated dispersing container. Micronutrients were applied each year as foliar sprays, in amounts enough to meet the tree requirements.

*Conventional Fertilization Program (F3).* Three applications of a granular mix (8-4-8 analysis) were made each year in February to March, May to June, and October to November time periods. Total N applied was 1.19, 1.19, 1.12, 1.21, 1.10, and 1.50 lb/tree during 1996-2001, respectively or 165 to 209 lbs/Ac. P applied totaled 0.60, 0.60, 0.57, 0.60, 0.66, and 0.75 lb/tree $P_2O_5$ during 1996-2001, respectively. K was applied at annual rates of 1.19, 1.19, 1.12, 1.21, 1.30, and 1.48 lb/tree $K_2O$ during 1996-2001, respectively. Micronutrients (Zn, Mn, Cu, Fe, B, and Mo) were mixed with the fertilizer and the amounts applied were enough to meet the plant requirements. The granular fertilizer mix was applied in the first 3 years using a young-tree shot spreader. In subsequent years, fertilizer was applied using a traditional spreader running down bed tops.

*Performance measures.* Trunk diameters were measured 4 inches above the bud union at various times throughout the study period. Fruit yields for each tree were measured using a portable optic sizing machine during normal harvest times in April or May of each year. Fruit yields were converted from size and fruit count data to boxes/tree using a USDA pack size (count) *vs.* diameter for round oranges using regression equations. Seven trees died of apparently non-blight causes during the 1996-2001 period (Table 1). Yields for these trees were not included in the mean yield calculations.

The 12 kDa protein (designated p12) is diagnostic of citrus blight and is present in leaves and xylem fluid from roots and stems of blight-affected trees (Ceccardi et al., 1999). The p12 protein is readily detected by SDS-PAGE of xylem fluid from blight-affected trees. Protein tests (p12 assay) were conducted annually on 4 leaves selected from each quadrant of each tree (Ceccardi et al., 1997; Derrick et al. 1990). In addition, all trees were visually examined and rated for blight symptoms in January or February of each year. The water uptake diagnostic test was utilized to verify blight symptoms in questionable trees.

## Results and Discussion

The dolomite applications resulted in about a 0.5 unit average increase in soil pH during the study. Average soil pH for the Lo and Hi treatments for samples taken in 1991, 1994, 1997, and 1999 were: 6.1 vs. 5.6, 6.0 vs. 5.9, 7.0 vs. 6.3, and 6.2 vs. 5.6 for the Hi and Lo treatments, respectively. With the exception of 1994, the results were significantly different using the LSD test at P = 0.05. Since the soil pH did not remain consistent through the study, the response data are expressed in terms of the rate of dolomite applied: Hi or Lo.

In 5 of the first 8 years of the study, the F3 fertilization treatment had slightly greater trunk diameter than F5 treatment trees (Table 1). However, by 1998 the trees had caught up and in subsequent years there were no differences in trunk diameter from fertilization treatment. There were no differences in trunk diameter due to dolomite application rate through 1999. Measurements taken in 2000 and 2001, showed slightly greater (2-3%) trunk diameters in the Hi lime treatment trees.

Trees with positive p12 assays first appeared in the south plots in 1995. Through 1997, nearly all of the symptomatic trees were located in the southern two replicates of the experiment. In 1998, symptomatic trees were found throughout the planting. By 2001 there were a total of 56 trees showing visual symptoms (Fig. 1). Of these, 14 (25%) were trees that were not

Table 1. Mean trunk diameter measured 4 inches above bud union by fertilizer treatment and lime application rate.

| Date (dd-mm-yy) | F5 (mm) | F3 (mm) | Significance | Hi (mm) | Lo (mm) | Significance |
|---|---|---|---|---|---|---|
| 08-13-90 | 15.1 | 15.1 | n.s.[z] | 15.1 | 15.1 | n.s. |
| 05-28-91 | 19.8 | 20.5 | n.s. | 19.9 | 20.3 | n.s. |
| 04-28-92 | 38.7 | 42.3 | * | 40.2 | 40.8 | n.s. |
| 03-09-93 | 57.8 | 61.3 | * | 59.1 | 60.0 | n.s. |
| 03-01-94 | 75.1 | 78.8 | n.s. | 77.0 | 77.0 | n.s. |
| 09-27-95 | 97.4 | 102.2 | ** | 99.9 | 99.7 | n.s. |
| 06-19-96 | 103.1 | 107.4 | ** | 105.6 | 105.0 | n.s. |
| 06-17-97 | 111.7 | 114.6 | * | 113.6 | 112.6 | n.s. |
| 06-18-98 | 119.8 | 122.0 | n.s. | 121.9 | 120.0 | n.s. |
| 05-25-99 | 125.0 | 126.7 | n.s. | 127.4 | 124.4 | n.s. |
| 04-20-00 | 130.9 | 131.8 | n.s. | 133.0 | 129.7 | * |
| 04-26-01 | 136.9 | 137.6 | n.s. | 139.2 | 135.2 | * |

[z]Means are non-significant (n.s.), significant at P = 0.05 (*), or significant at p = 0.01 (**) according to Duncan's Multiple Range test.

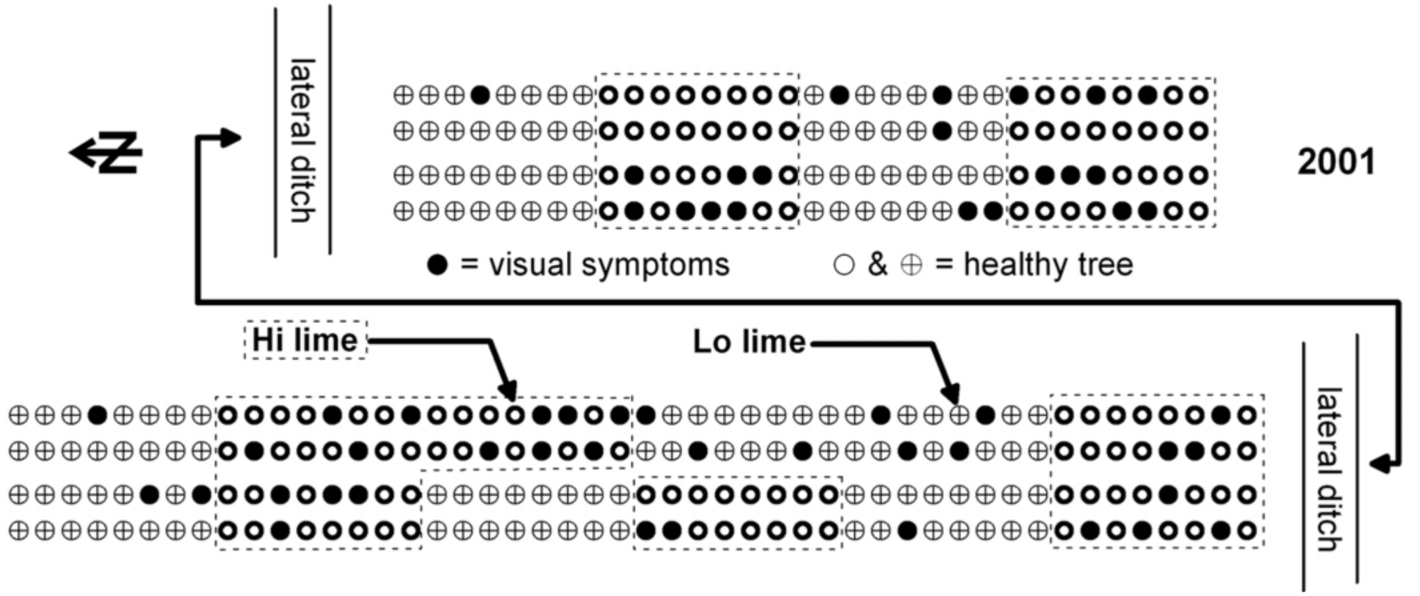


Fig. 1. Distribution of trees with visual blight symptoms in Jan. 2001.

adjacent to another symptomatic tree. By 2004, visual symptoms were present on 116 trees (Fig. 2). Many of the "new" declining trees in the 2004 map were in locations that were between symptomatic trees in the 2001 map. In 2004, only 9% of the trees with visual symptoms were not adjacent trees with symptoms.

Overall, trees with positive p12 assays totaled 2, 9, 15, 28, 53, 54, and 82 for 1995 through 2001, respectively. The total number of trees with visual symptoms was 2, 9, 16, 29, 40, 56, 85, and 116 for years 1995, 1996, 1997, 1998, 1999, 2001, 2003, and 2004, respectively. The overall progression rate of visual blight symptoms over the 10-year period beginning in 1995 was an increase of 3.7% of the trees within the block per year.

Fertilization treatment had no effect on the progression of blight within the block. By 2001, the F3 treatment had 25% of the trees with positive p12 assays compared to 26% for the F5 treatment (Table 2). Visual symptoms were also similar, with 16% of the F3 and 15% of the F5 treatment showing blight. By 2004, 34% of the F3 and 39% of the F5 trees had visual blight symptoms.

Liming rate did have an effect on the number of trees for both visual symptoms and positive p12 assays. The progression of blighted trees with positive p12 assays or showing visual symptoms was linear in nature (Fig. 3). The increase in the number of blighted trees increased about 2.6% per year for trees under the Lo lime treatment. The number of blighted trees in the Hi lime treatment was double that of the low lime treatments plots, increasing at a rate of 5.6% per year. These results agree with the findings by previous researchers (Wutscher, 1989; 1997; Wutscher and Lee, 1988), where less blight incidence and high yields were obtained when less dolomite (low soil pH) was applied.

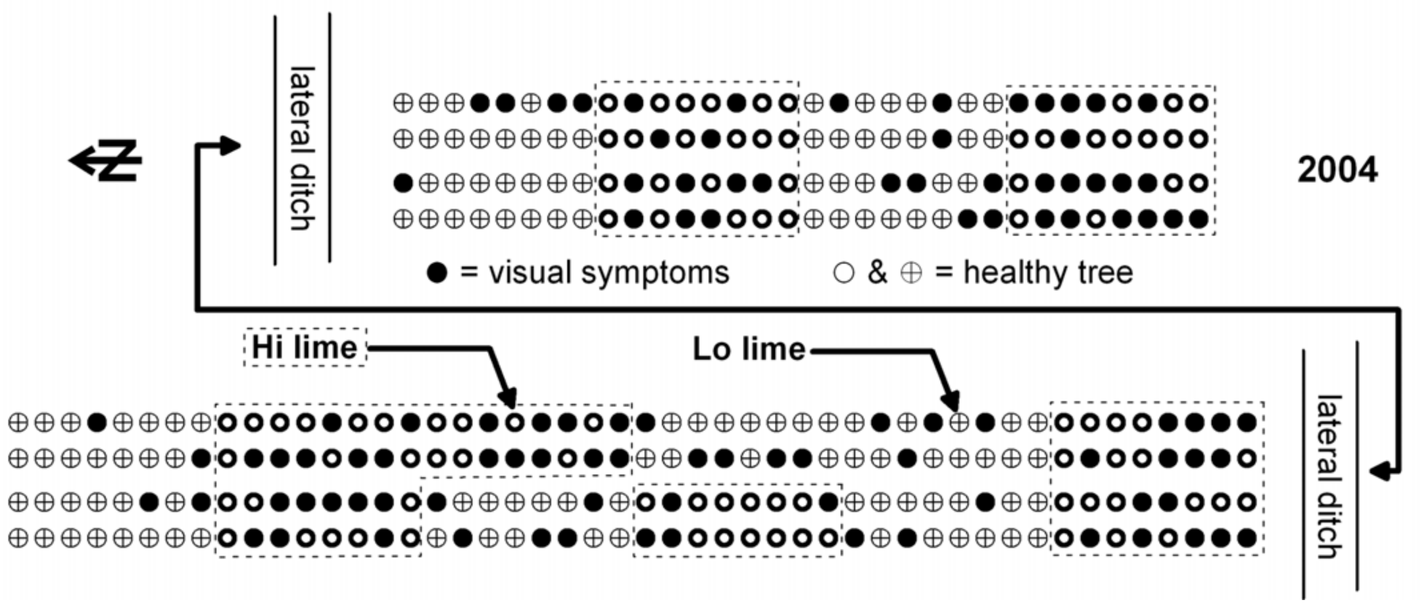


Fig. 2. Distribution of trees with visual blight symptoms in Jan. 2004.

Table 2. Dead, blighted, and healthy trees from field observations and p12 assays on leaves during 2001 (n = 80 trees per treatment).

| Treatment | Number of dead trees | Trees with blight symptoms: Visual symptoms from field observations (%) | Positive p12 assay (%) |
|---|---|---|---|
| F5Hi | 2 | 16 ab[z] | 25 ab |
| F5Lo | 3 | 14 bc | 17 bc |
| F3Hi | 1 | 23 a | 31 a |
| F3Lo | 1 | 3 c | 9 c |

[z]Means followed by the same letter in the same column are not significantly different, according to Duncan's Multiple Range test at 5% level.

The average annual yields were nearly identical between the lime treatments for the first 7 years of production (Table 3). However, the rising number of blighted trees with reduced yields in the Hi lime treatment resulted in numerically lower yields in the last 4 years. This equates to a significant 1.0 box per tree advantage in 2003 for the Lo treatment trees. As a result, the total yields from 1993 through 2003 were about 1.9 box/tree higher for the Lo lime treatment trees, which corresponds to 254 box/acre using the tree density of 139 trees/acre.

There were differences in yields among fertilizer treatments in about half of the years (Table 3). However, there were no consistent trends. In 4 of the earlier years, the advantage was in favor of the F3 treatment. However, in 2001 and 2002, yields were greater than 1.0 box/tree higher for the F5 treatment trees than for the F3 trees. Overall, the total yield for 1993-2003 were 1.8 box/tree higher for the F5 treatment trees than the F3 trees. This corresponds to 250 box/acre more for the F5 trees at the tree density of 139 trees/acre. The higher yields in the F5 treatments during the latter years may have resulted from the higher amounts of fertilizers applied under the F5 or the fact that the materials were hand placed around the trees rather than broadcast.

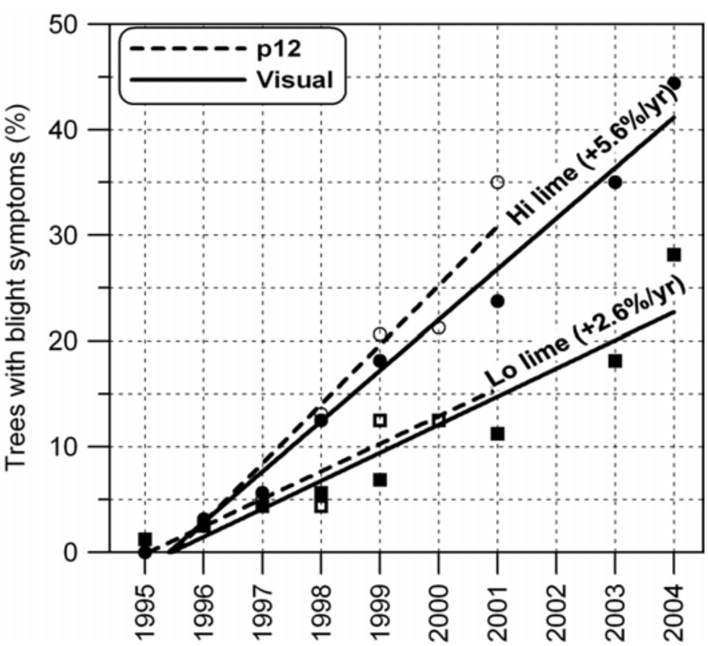


Fig. 3. Percentage of trees with positive p12 assay symptoms (open symbols) and visual blight symptoms (solid symbols) by year.

Table 3. Mean yields (boxes/tree) by year for fertilization and lime treatments.

| Year | Fertilization treatment: F5 | F3 | Significance | Lime treatment: Hi | Lo | Significance |
|---|---|---|---|---|---|---|
| 1993 | 0.1 | 0.5 | ** | 0.3 | 0.3 | n.s. |
| 1994 | 0.5 | 0.6 | n.s. | 0.5 | 0.6 | n.s. |
| 1995 | 0.6 | 0.7 | ** | 0.6 | 0.7 | * |
| 1996 | 1.4 | 1.6 | * | 1.5 | 1.5 | n.s. |
| 1997 | 1.3 | 1.8 | ** | 1.6 | 1.6 | n.s. |
| 1998 | 2.5 | 2.3 | n.s. | 2.4 | 2.5 | n.s. |
| 1999 | 2.6 | 2.2 | n.s. | 2.4 | 2.4 | n.s. |
| 2000 | 3.5 | 3.1 | n.s. | 3.1 | 3.4 | n.s. |
| 2001 | 3.9 | 2.9 | ** | 3.3 | 3.5 | n.s. |
| 2002 | 3.9 | 2.4 | ** | 3.0 | 3.3 | n.s. |
| 2003 | 2.9 | 3.3 | n.s. | 2.6 | 3.6 | ** |
| Total | 23.2 | 21.4 | * | 21.2 | 23.1 | * |

[z]Means are non-significant (n.s.), significant at P = 0.05 (*), or significant at P = 0.01 (**) according to Duncan's Multiple Range test.

This study has shown a reduced rate of blight progression with reduced liming rates. However, even the reduced lime rate had 25% of the trees with blight symptoms in 2004, 13 years after planting. Although the Hi lime trees were not significantly larger (as measured by trunk diameter) and had a higher incidence of blighted trees than the Lo lime trees, they managed to yield similarly to the Lo lime treatment until the last few years of the study. Projecting into the future, one would expect the cumulative yield advantage for the Lo lime to increase for several years since blight reduces the productivity of the Hi lime plots at a faster rate than in the Lo lime plots.

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