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A NUTRITIONAL SURVEY OF SOUTHCENTRAL, SOUTHWEST AND EAST COAST FLATWOODS CITRUS GROVES

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Abstract. **A survey of bearing citrus groves was conducted in the flatwoods growing areas of the southcentral, southwest and east coast regions of Florida to determine the nutritional status of citrus trees and associated soil fertility levels. Leaf and soil samples were collected and analyzed from 45 blocks of 'Hamlin' orange (*Citrus sinensis* (L.) Osb) on sour orange rootstock in 8 counties over a 3-yr period. Information was also gathered on fertilizer programs, yields and fruit quality. Few major differences among regions existed in leaf and soil analyses, yields or levels of nutrition. Leaf N levels were mostly above the optimal range while those for leaf K were below. Leaf P was generally in the recommended range and soil P, Ca and Mg levels were also mostly in the adequate to high range. Nitrogen fertilizer applications averaged 250 lb./acre/yr and K averaged 210 lb./acre/yr (250 lb. K_2O). The average yield of surveyed blocks was 550 boxes/acre.**

There are approximately 5 million acres of inherently poorly drained soils and marshes in the southwest, southcentral and east coast areas of Florida. Since the early 1960s many thousand acres of these flatwoods soils have been drained, bedded and planted to citrus (13). In the process of land preparation for drainage, soil profiles are disturbed to varying degrees. The trees therefore grow on profiles somewhat different from the land in its original, undisturbed state. Since the freezes of the 1980s, which resulted in the loss of much of the traditional citrus acreage on the central Florida ridge, flatwoods acreage has increased rapidly, and currently amounts to about 80% of the state's total citrus acreage. As this trend continues, more information needs to be gathered on the fertility status of the soils and on current nutritional programs to more accurately determine actual tree requirements. Nutritional inputs must strike a balance between those required for profitable citrus production and those acceptable for minimal environmental impact, particularly with respect to groundwater contamination. Flatwoods citrus fertilization practices have generally followed recommendations in IFAS Bulletin 536D (8), with application rates tending toward the high range or above. Based primarily on east coast studies, nutritional requirements of flatwoods citrus have not been considered to differ sigificantly from those of citrus planted on deep, sandy, ridge soils (1,2,3,4,5,6,10,11,12). Reasons cited for the generally higher rates of N and K applied in the flatwoods include a more rapid early tree growth, high irrigation input and the more shallow rooting behavior of trees on these soils.

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Fertilization of citrus trees accounts for approximately 20% of production costs. Yields, leaf tissue and soil analysis have been most extensively used as guidelines for fertilizer application. Considerable information is available from experimental plots showing the ranges of various essential elements in citrus leaves in response to varying supplies of nutrients. Extensive surveys have been conducted on ridge area citrus over the years leading to a wealth of information on tree nutrition on deep, well drained sandy soils (9).

As a result of the lack of corresponding information on southwest Florida flatwoods soils, a limited nutritional survey involving leaf and soil sampling was conducted utilizing 36 blocks of sweet oranges on various rootstocks in 8 commerial groves in Hendry and Collier counties during 1972 and 1973. Results showed a soil pH range of 5 to 8, with an average of 6.3. Both soil P and Cu levels were generally low, suggesting a need for routine applications of these elements for the maintenance of adequate levels (15).

This report presents results of another, more extensive survey conducted from 1987 to 1989 on a number of groves located on flatwoods soils of the southcentral, southwest and east coast regions of Florida.

Materials and Methods

The survey included 45 blocks (representing 32 ownerships) of 'Hamlin' trees on sour orange rootstock ranging in age from 10 to 30 yr selected in Hardee, DeSoto (southcentral), Hendry, Collier (southwest), Indian River, St. Lucie, Martin and Palm Beach counties (east coast). Care was taken during soil and leaf sampling not to use trees which appeared abnormal or unhealthy, and to avoid those growing in soil pockets atypical of the soil types on which selected blocks were located.

Blocks selected varied widely in acreage and, where particularly large, were divided and sampled separately. Most groves were either single or double bedded with a few multiple row beds or unbedded plantings at spacings ranging from 12.5 x 25 ft to 20 x 25 ft. A number of soil types were represented in the survey, including Immokalee, Ona, Felda, Smyrna, Riviera, Oldsmar and Wabasso. These soils are typical of those on which most flatwoods citrus is located. Irrigation systems varied, but were largely low-volume microsprinklers and some drip systems. Other blocks utilized flood and seepage systems.

Leaf samples were collected each yr for 3 yr from 6 to 7 months old nonfruiting spring flush terminals according to procedures outlined in IFAS Bulletin 536D (8). They were prepared and analyzed by conventional procedures. Soil samples were collected at the same time and locations and soils analyzed for P, K, Mg, Ca and Cu by the Mehlich I (double acid) method as described by the IFAS Soil Testing Laboratory (7). Soil pH was determined using a 1:2 soil to water ratio, and organic matter by the Walkley-Black Procedure (16).

Table 1. Annual fertilizer application (lb/acre) and N/K ratio.

Region	No. samples	N Mean	N Range	P Mean	P Range	K Mean	K Range	N/K Mean	N/K Range
Southcentral	54	267	176-452	19	0-40	228	147-346	1.18	0.68-1.45
East Coast	35	216	135-320	16	0-45	204	123-324	1.09	0.55-1.85
Southwest	33	222	112-325	10	0-35	191	102-280	1.17	0.84-1.66
Average		240	112-452	16	0-45	211	102-346	1.15	0.55-1.85

Results & Discussion

Trees in blocks selected for sampling appeared to be in good condition, exhibiting average to good vigor with few visible deficiencies, except for occasional transient minor-element symptoms. Annual applications of N, P and K differed little between regions, although N and K rates tended to be higher than the recommended range in Bul. 536D for groves with production levels found in the survey (Table 1). Applications of K relative to N were slightly higher than the recommended N/K ratio of 1 to 1.2 (N to K_2O of 1 to 1). Phosphorus application rates appeared to be within the range for tree nutrition on flatwoods soils, which are usually inherently low in this element. Routine applications of magnesium were made both as dolomite and in fertilizer mixtures. Dolomitic or calcitic limestone was applied on some schedule in most groves.

Average annual yields of surveyed blocks varied somewhat between regions, with those on the east coast being the lowest (Table 2). Yields were considered commercially acceptable, however, based on state averages. On a pounds of applied N per box of fruit basis, nitrogen levels were high particularly on the east coast where yields are traditionally lower.

Soil analysis results indicated a range of levels from below to well above recommended levels (Table 3). While soil potassium levels were in the low to satisfactory range, interpretation is difficult due to this element's high leaching potential and the general time of sampling in relation to fertilization, rainfall and irrigation events. Soil calcium levels were considered high in all regions with few exceptions, indicating satisfactory to possibly excessive liming programs. Few soil samples showed levels below 1000 lb./acre and none below 500 lb./acre. The high Ca levels are reflected in the overall satisfactory pH levels as well. Soil Cu levels tended to be in the satisfactory range despite the high pH levels, indicating an adequate copper nutrition program utilizing nutritional and fungicidal sprays and soil applications. Organic matter levels were typical for the surface horizons of flatwoods soils and higher than those for the typical ridge soils.

As might be expected from the N fertilizer rates, leaf N was high in all regions, with 70% of the samples above the recommended range. Of particular interest were the leaf K levels, 60% of which were below the recommended range in spite of the slightly higher than recommended K to N ratio in the nutrition programs. Leaf P levels appeared to be generally in the recommended range. Calcium levels showed some deviation from the recommended range but with roughly similar percentages above and below recommended values. Many leaf Mg levels were below the recommended range, particularly in the east coast area, in spite of the relatively high soil Mg levels (Tables 4 & 5).

Based on the soil pH and Ca data, liming programs for many of the groves sampled appear to have been adequate and perhaps should be reduced wherever pH levels exceeded 6.0. The survey indicates that in established groves the frequency of liming and amounts applied are being reduced. In some areas where well water of high pH is used, soil pH levels have risen even without liming. Considering recorded tree growth and yields, certain rootstock performance in relation to pH, the observed increased blight incidence in high pH soils and absence of high copper levels as found in established grove soils of the ridge, pH values higher than 6.0 to 6.5 are not justified.

While soil copper levels determined by the Mehlich I method appear satisfactory when values are correlated with those of the Spencer Color Test (14), correlation of the Mehlich I method with tree toxicity and deficiency symptoms are questionable at best. A need remains for a new test which provides a better correlation and thus is more accurately predictive.

Based on reported yields and the high leaf N levels found in the survey, there is some justification for lower annual N fertilizer applications, especially where they exceed 250 lb./acre/yr. In some exceptional cases with grove production in the 750 to 1000 box/acre range with good water management, higher rates may be justified.

Explanation for the low leaf K levels may involve several factors. High N applications have been shown to result in lower leaf K levels, particularly in high producing

Table 2. Annual yield (boxes[z]/acre) and fertilizer applied per box of fruit (lb/box).

Region	No. samples	Box/Acre Mean	Box/Acre Range	PS/Box[y] Mean	PS/Box[y] Range	N/Box Mean	N/Box Range	P/Box Mean	P/Box Range	K/Box Mean	K/Box Range
Southcentral	48	640	185-1033	5.6	3.86-6.46	0.45	0.22-1.10	0.04	0-0.16	0.39	0.22-1.00
East Coast	26	404	260-775	6.0	5.23-6.81	0.58	0.28-1.12	0.04	0-0.15	0.55	0.24-0.93
Southwest	27	552	250-780	6.2	5.34-6.72	0.44	0.19-0.92	0.02	0-0.06	0.38	0.16-0.77
Average		556	185-1033	5.8	3.86-6.81	0.48	0.19-1.12	0.03	0-0.16	0.43	0.16-1.00

[z]Box is 90 pounds.
[y]Pounds solids/box.

Tables 3. Soil analysis by region.

Region	No. samples	P Mean	P Range	K Mean	K Range	Ca Mean	Ca Range	Mg Mean	Mg Range	Cu Mean	Cu Range	OM Mean	OM Range	pH Mean	pH Range
		lbs/acre 6"													
Southcentral	54	126	24-384	57	8-185	1828	712-4000	269	128-464	19.4	2.7-54.6	1.88	0.79-4.13	6.2	5.3-7.2
East Coast	39	90	16-368	85	16-305	1928	424-4000	183	48-400	11.5	0.6-60.0	1.65	0.44-3.83	6.2	4.8-7.9
Southwest	35	104	16-320	51	8-265	2232	1088-4000	228	72-728	18.6	1.2-35.4	1.61	0.64-4.83	6.1	5.0-7.6
Average		109	16-384	64	8-305	1969	424-4000	231	48-728	17.1	0.6-60.0	1.74	0.44-4.83	6.2	4.8-7.9

Table 4. Leaf analysis by region.

Region	No. samples	N Mean	N Range	P Mean	P Range	K Mean	K Range	Ca Mean	Ca Range	Mg Mean	Mg Range
		% dry wt									
Southcentral	54	2.84	2.31-3.32	0.14	0.11-0.20	1.25	0.64-1.69	3.56	2.45-4.72	0.40	0.26-0.56
East Coast	39	2.83	2.30-3.20	0.14	0.12-0.16	1.04	0.45-1.61	4.15	2.25-5.77	0.30	0.21-0.46
Southwest	36	2.87	2.40-3.22	0.15	0.12-0.21	1.04	0.72-1.77	4.05	2.71-5.31	0.36	0.24-0.47
Average		2.85	2.30-3.32	0.14	0.11-0.21	1.13	0.45-1.77	3.88	2.25-5.77	0.36	0.21-0.56

groves, due simply to growth associated dilution effects. High soil Ca contents could also have an antagonistic effect on K uptake. A combination of fertilizer application timing, high leaching rates due to rainfall and irrigation, and late leaf sampling could also be involved. Lower leaf K levels have also been shown to occur in general for scions on sour orange rootstock (R.C.J. Koo, Univ. of Fla., personal communication).

The high soil Mg levels in relation to the relatively low leaf levels may be explained in some cases by antagonism caused by the high soil Ca levels. While the adequate soil P levels suggest no need for higher P application, it is important to remember that levels in native, previously uncropped flatwoods soils are usually minimal requiring substantial applications, preferably prior to planting.

Leaf minor element analyses were not included in the survey due to analytical problems associated with leaf surface contamination from foliar sprays. Such contamination is difficult to totally eliminate even with extensive washing procedures. While most groves received nutritional sprays containing Zn and Mn, levels of metal on a per acre basis are very low in many of the formulations commercially available. Routine applications are not required where symptoms do not exist. Where moderate to severe symptoms do exist, such low levels of metal application are usually not adequate for correction.

Table 5. Percent of leaf samples below (–) and above (+) the recommended range by region.

Region	No. samples	N –	N +	P –	P +	K –	K +	Ca –	Ca +	Mg –	Mg +
Southcentral	54	6	67	10	11	39	0	20	0	6	13
East Coast	39	3	77	8	3	69	0	13	31	61	0
Southwest	36	6	83	0	14	83	3	8	11	22	0
Average		5	71	5	7	60	1	15	13	27	6

While soil and leaf analyses are routinely used for diagnostic purposes, their real value to the citrus grower is in the development and maintenance of a sound nutritional program based on cost and production. For this to be achieved sampling must be done accurately and systematically, analytical results must be correctly interpreted, and long-term trends monitored.

For routine grove nutritional monitoring using soil analysis, pH, P, Ca, Mg, and Cu (by a satisfactory analytical method), and soluble salts are the only measurements of currently demonstrated value. Other tests, including those for minor elements are generally not considered worthwhile. The value of routine minor-element leaf analysis is questionable at present, even when the level of confidence in sample preparation is adequate in terms of surface contamination removal by washing procedures.

While the current survey's results represent the nutritional status of a relatively small sample of groves in Florida, we believe that the information may be useful to growers in comparatively evaluating their own nutritional programs. Important questions to be answered include whether recommended leaf and soil nutrient levels are adequate for sustained and profitable citrus production of groves in the flatwoods, and whether current inputs can be justified in terms of potential yield increase, offset by possible increased pest and disease incidence and potentially unacceptable environmental contamination levels.

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CLOGGING CHARACTERISTICS OF VARIOUS MICROSPRINKLER DESIGNS IN A MATURE CITRUS GROVE

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Abstract. **The clogging rates for 10 models of microirrigation emitters were observed over a 3.5-year period to determine if the emitter design could influence maintenance requirements. The emitters were located in a block of mature Temple orange trees on single beds with a 30 ft between-row x 23 ft within-row spacing. The irrigation system used a surface water supply with a 50 mesh screen as the primary filter. The experiment used 5 spray emitter models and 5 spinner models in a randomized complete block design with 5 replications. All emitters were on the same irrigtion zone, received water of the same quality, were irrigated at the same time and for the same duration. Emitters were examined twice per year, at which time the condition of each emitter was recorded. Clogging was generally caused by ants, spiders, or bacteria and algae. The average clogging rate per inspection period ranged from 2% to 38%, averaging 19%. The emitter design which used an enclosed cap to disperse water had the highest clogging percentage. The emitter which had a relatively large orifice and a mechanism to plug the orifice when not in use had the lowest clogging rate.**

The use of microirrigation in Florida agriculture has increased dramatically in recent years. Over 400,000 ac are now micro-irrigated in the state (3), with most of these systems associated with citrus production. Microirrigation emitters generally have operating pressures less than 30 psi, discharge rates from 5 to 25 gal h^{-1}, and throw diameters ranging from 5 to 30 ft (7). Growers can choose emitters from the many designs offered by manufacturers. Emitters vary in their performance under ideal conditions (1). Poor field performance can be caused by full or partial emitter clogging due to wind-blown particles, insect, biological growth, or chemical encrustation. Other major maintenance problems associated with the microsprinkler assemblies include dislodging of the emitter from the stake assembly and deterioration or destuction of the spaghetti tubing due to insects and rodents. These problems occur even with properly designed and maintained filtration systems.

Most recent microsprinkler field installations for citrus in Florida have used emitters discharging from 10 to 20 gal h^{-1} combined with stake assemblies and spaghetti tubing. One of the main factors that has caused growers to adopt microsprinkler systems has bee the demonstrated freeze protection that the systems provide for young trees (5). Over 80% of the citrus groves that utilize freeze-protection measures use irrigation for that purpose (4).

Many growers prefer spray or spinner emitters over drip systems because they provide a larger wetted area. The large pattern diameter is especially desirable in areas with coarse textured soils where lateral movement of soil water is limited. Stake assemblies raise the emitter 8 to 12 in above the ground and offer several advantages over emitters installed directly in the polyethylene (PE) lateral tubing or installed on risers plugged directly into the lateral. The stake assembly allows the emitter to remain in a fixed position when temperature extremes or other factors cause movement of the lateral tubing. Performance of the emitters is also enhanced since they stand on a firm base and do not rotate from vertical positions when the lateral tubing moves or twists. The added elevation can also increase the coverage diameter of many emitter models and allows water to be distributed above low-growing grass and weed species.

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