indicated the factor to be soil differences as determined by observed differences in an aerial photograph, and the organic matter content of the soil. Additional information indicated that annual applications of soluble magnesium to low-organic soils may maintain some retention by these soils, but that an application of dolomite ten years earlier to soils with an organic matter content greater than 1.5 percent, still provided sufficient magnesium as determined by soil and leaf analyses.

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LITERATURE CITED

1. Anderson, C. A., and D. V. Calvert. 1967. Effect of phosphate fertilizer on young citrus trees in flatwoods soils. Fla. State Hort. Soc. 80: 19-25.
2. Bryan, O. C. 1960. Objectives and progress report on the Duette Research Grove. Proc. Soil Sci. Found. 5: 21-23.
3. Bryan, O. C. 1963. Revised treatments—Duette Grove. Proc. Soil Sci. Found. 8: 22.
4. Jackson, M. L. 1958. **Soil Chemical Analysis.** Prentice-Hall, Inc., Englewood Cliffs, N. J. p. 219-222.
5. Peech, Michael (Revised by T. W. Young). 1948. Chemical studies on soils from Florida citrus groves. Bul. 448. Fla. Agr. Exp. Sta., Gainesville, Fla. 88 p.
6. Sandell, E. B. 1953. 2nd Ed. **Colorimetric Determination of Traces of Metals.** Interscience Publishers, Inc., N. Y. p. 419-425.

THE NUTRITIONAL STATUS OF THE 'ORLANDO' TANGELO (Citrus paradisi MACF. 'DUNCAN' x C. reticulata BLANCO 'DANCY')[1]

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ABSTRACT

A survey of 30 commercial 'Orlando' tangelo groves in Florida showed several meaningful trends. The predominant rootstock was 'Cleopatra' mandarin (*C. reticulata* Blanco) which characteristically results in low yields, and many groves had no provisions for ensuring satisfactory fruiting either through cross-pollination or girdling of this self-incompatible variety.

Nitrogen levels decreased more rapidly and were generally lower than those reported for sweet orange, *C. sinensis* Osbeck. Together with significant correlations between fertilizer N, leaf N, and yields, the generally low levels of leaf N in 'Orlando' groves in this survey indicate this variety needs to be more heavily fertilized than sweet orange.

None of the other mineral elements in this study were low as compared with sweet orange leaf standards and leaf K and Mg were high.

Soil analyses were not related to leaf analyses in general but the calcareous nature of soils in some groves appeared to depress leaf K.

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INTRODUCTION

The most promising and important of the interspecific hybrids in the genus *Citrus* are the tangelos (6). Approximately 3½ million boxes of tangelos were produced in Florida during the 1966-67 and 1967-68 crop years, with the 'Orlando' being by far the leading variety (4, 6).

One of the most important factors influencing the growth and productivity of fruit crops is the nutritional status of the tree (5). However, except for a greenhouse study by Northey *et al.* (12), a review of the literature reveals a noticeable lack of information concerning the nutrition of the 'Orlando' tangelo.

In order to investigate the nutritional factor

more completely, a survey of commercial 'Orlando' tangelo groves in Florida was initiated in March of 1968. It was hoped that information concerning the macronutrient status of the 'Orlando' could be obtained using techniques employed in surveys of other citrus varieties (7, 13, 16). Secondary objectives were to determine the fertilizer practices, rootstocks used and provisions for overcoming unfruitfulness due to sexual self-incompatibility.

Materials and Methods

Sampling and handling methods.—Leaf samples were collected using sampling patterns described in detail by Cooper (3). According to the layout of the grove, either a zig-zag or a diamond-shaped sampling pattern was used. In each grove leaves were taken equally from the trees in the sampling pattern to form a composite sample of 100 leaves.

Leaves were collected from marked non-fruit-bearing shoots of the spring flush at 3 times during the course of the survey: June, September, and December of 1968. Corresponding to the collection period, the leaves were 2-to-3-, 5-to-6-, and 8-to-9-months old. Soil sample were collected in September of 1968.

Analytical methods and statistical analysis.—Leaf samples were prepared for analysis and analyzed for N, P, K, Ca and Mg using methods described by Anderson *et al.* (1). Soil samples were prepared and analyzed using procedures employed by the Florida Soil Testing Laboratory (2). Fertilizer practices, rootstocks and other grove characteristics were obtained from grower records.

Statistical analysis was accomplished with standard procedures for correlation and mean separation (11).

Results and Discussion

Characteristics of groves sampled.—Thirty 'Orlando' tangelo groves representing nearly 3% (about 300 acres) of the bearing acreage in Florida were selected for the survey in the spring of 1968. Four nonbearing groves (5 years old) representing over 50 acres were also sampled. Tables 1 and 2 contain characteristics of groves sampled.

Approximately 75% of the groves were located on naturally well-drained acid sandy soil. Three groves were situated on calcareous soils of the Felda series (see Table 2). Drainage conditions were adequate in all groves.

Table 1.--Characteristics of groves sampled.

Characteristic	Number of groves				
Rootstock	Cleo	Rough lemon	Sour orange	Palestine sweet lime	Nucellar seedling
	20	5	2	1	2
Size (acres)	Less than 10		10 to 20		Over 20
	13		12		5
Tree age (years)	5		6 to 10		Over 10
	4		6		20
Girdling	Not girdled			Girdled	
	26			4	
Pollinators	No pollinators			Pollinators	
	20			10	
Kind of pollinator	Temple		Dancy		Robinson
	7		2		1

Ten groves were located in Lake County with 4 groves each in Indian River, Orange, and Polk Counties. Three groves each were located in Highlands and Manatee Counties and 1 grove apiece in Marion and St. Lucie Counties.

The predominant rootstock was 'Cleopatra', *C. reticulata* Blanco. Many groves had no provisions for ensuring a good fruit set through either cross-pollination or girdling. Research has established that, in the absence of cross-pollination or girdling, 'Orlando' on 'Cleopatra' yields very poorly (9); however, where the above practices are used to ensure good fruit set, 'Cleopatra' is a satisfactory rootstock (8, 10).

Fertilizer practices.—It can be seen from Table 3 that 'Orlando' groves over 10 years of age received an average of 262 pounds of N per acre per year, a figure higher than the maximum suggested rate of N for most citrus varieties (14). One 17-year-old seedling block received a high of 372 pounds of N per acre per year.

Table 2.--Distribution of groves with respect to county and soil series.

County	Number of groves	Soil series	Number of groves
Lake	10	Lakeland	18
Indian River	4	Felda	3
Orange	4	Ona	3
Polk	4	Orlando	2
Highlands	3	Sunniland	2
Manatee	3	Eustis	1
Marion	1	Lakewood	1
St. Lucie	1	Total	30
Total	30		

Table 3.--Fertilizer rates in 'Orlando' tangelo groves in pounds of fertilizer per acre.

Grove age (years)	Pounds per acre							
	Mean				Range			
	N	P_2O_5	K_2O	MgO	N	P_2O_5	K_2O	MgO
5 to 10[2]	156	19	146	44	77 to 254	3 to 43	77 to 232	22 to 76
over 10[3]	262	34	259	76	149 to 372[4]	9 to 98	126 to 458[4]	28 to 132

[1]3-year averages; [2]10 groves; [3]18 groves; [4]2-year averages.

Table 4.--Frequency of application[1] and analysis[2] of fertilizers used in 'Orlando' groves.

Number of groves				
Frequency of fertilizer applications (times per year)			Fertilizer analysis	
2	3	Over 3	Straight N materials	Mixed materials
				Less than 10% N / At least 10% N
4	16	8	8	5 / 8

[1]Based on 28 groves.

[2]Based on 21 groves.

Rates of K fertilization ranged from 126 to 458 pounds of K_2O per acre per year in groves over 10 years of age. The average K_2O applied was 259 pounds per acre per year.

Phosphorus and Mg fertilizer rates in mature groves (over 10 years old) averaged 34 and 76 pounds per acre per year, respectively.

Young groves received lower rates of fertilization than older groves, but a 5-year-old, high-density planting (128 trees per acre) in Lake County received 167 pounds of N and 173 pounds of K_2O per acre per year.

Table 4 shows that 24 of the survey groves were fertilized at least 3 times each year. Spring, summer, and fall were favored application times in mature groves.

Fertilizer analysis ranged from 8 to 18% N in dry mixed fertilizers, but were substantially higher than this for straight nitrogen materials (15.5 to 33.5% N). Table 4 shows that 8 groves received applications of straight N fertilizer materials. Only 5 groves were fertilized with materials containing less than 10% N.

Leaf analysis values. — Mean values and ranges of macronutrients in 'Orlando' tangelo leaves are shown in Table 5. In comparison to leaf analysis standards for 4-to-7-month-old sweet orange leaves compiled by Smith (15) 'Orlando' tangelo leaves were low in N. As illustrated in Fig. 1, leaf N declined much more rapidly and was consistently lower in 'Orlando' tangelo leaves than in sweet orange. Together with other findings presented in this paper, the rapid decrease of N in 'Orlando' leaves constitutes strong evidence that the 'Orlando' tangelo requires higher rates of N fertilization than sweet orange. However, it must be pointed out

Table 5.--Mean values[1] and ranges of macronutrients in 'Orlando' tangelo leaves (% dry weight).

Leaf age (months)	Mean values[2] and ranges for elements studied				
	N	P	K	Ca	Mg
2 to 3	2.59a	.141a	1.83a	3.19a	.552a
	2.08 to 2.89	.102 to .181	1.04 to 2.46	1.98 to 4.19	.370 to .955
5 to 6	2.28b	.121b	1.63b	3.44a	.532ab
	1.77 to 2.62	.093 to .173	.96 to 2.16	2.01 to 4.71	.385 to .915
8 to 9	2.31b	.123b	1.67b	4.15b	.487b
	1.61 to 2.66	.103 to .153	1.03 to 2.14	2.94 to 5.66	.350 to .895

[1]Averages represent 31 samples.

[2]Means within columns followed by different letters are significantly different at the 0.05 level.

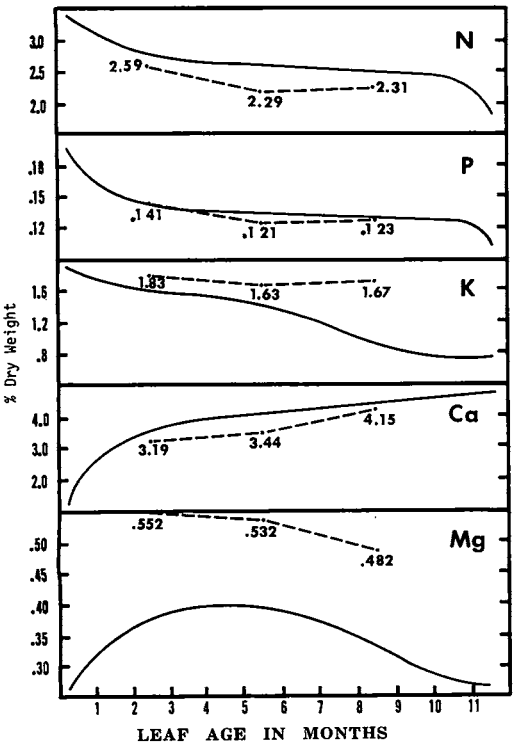

Fig. 1.—Schematic comparisons of seasonal changes in the macronutrient content of sweet orange and 'Orlando' tangelo leaves.[1]

[1]Adapted from Smith (15). Broken lines indicate nutrient levels in 'Orlando' leaves. Solid lines are for sweet orange.

that the 3 sampling periods in this study were separated by several months, whereas monthly sampling periods were used to describe seasonal trends in sweet orange leaves. Also, the spring flush subtended later growth flushes in many groves. Thus, the data for the 'Orlando' tangelo is weaker than that for sweet orange.

Leaf K fell in the optimum range for sweet orange leaves (1.2 to 1.7%) but ranged from deficient (.96%) to high (2.16%). In contrast to trends in leaf K for sweet orange, mean leaf K remained consistently high in 'Orlando' leaves, although several groves on calcareous soils were extremely low.

Mean P and Ca levels in 'Orlando' leaves fell in the optimum range according to sweet orange standards. Seasonal trends in leaf P and Ca were similar to sweet orange leaves.

Leaf Mg in 'Oarlando' was high compared to the satisfactory range for sweet oranges. However, the general levels of Mg in citrus leaves analyzed at the University of Florida Citrus Experiment Station have risen appreciably since the work reported by Smith (15). The cause of this is not known but Mg can be accumulated in leaves in "luxury" amounts; i.e., in amounts far in excess of that needed. It could be speculated that the large decrease in the use of sulfur sprays and dusts in recent years has resulted in less leaching of Mg from the soil but there is no specific data to substantiate this. Leaf Mg decreased more slowly with age in 'Orlando' leaves than in sweet orange leaves.

Leaf macronutrients and fertilizer rates.—Correlations between December leaf analysis values and fertilizer rates of N, P, K, and Mg are found in Table 6. The highly significant correlation between leaf N and fertilizer N (r=+.552**) shows that increased rates of N fertilization resulted in higher leaf N in December. The strength of the correlation and the visual observations of foliage color further suggest that higher rates of fertilizer N may be needed to maintain the appearance of 'Orlando' tangelos than are needed for sweet orange varieties.

Leaf levels of P, K, and Mg were not significantly related to fertilizer rates.

Correlations between soil and leaf analysis values.—The lack of correlations between soil and leaf analysis results could be due to a myriad of factors, but the pertinent fact is that soil analysis is of limited value in assessing the nutritional status of citrus trees.

Nitrogen-potassium fertilization and yields.—Highly significant correlations were found between fruit production and the rates of nitrogen (r=.842**) and potash (r=.613**) applied as shown in Table 7. However, the significant correlation of K with yields is misleading because leaf K was not correlated with yields or fertilizer applications. The correlation existed because K is commonly applied in a 1:1 ratio with N.

Table 6.--Correlations between leaf macronutrient levels and fertilizer rates.

Factor (X) % dry weight	Factor (Y) lbs/acre/year	Pairs of values	Correlation coefficient	Statistical significance
Leaf N	Fertilizer N	28	+.552	**
Leaf P	Fertilizer P	28	+.297	NS
Leaf K	Fertilizer K	28	+.340	NS
Leaf Mg	Fertilizer Mg	28	-.209	NS

**Highly significant.

NS Not significant.

Table 7.--Correlations between fertilizer rates and yields in 'Orlando' tangelo groves.[1]

Factor (X)	Factor (Y)	Pairs of values	Correlation coefficient	Statistical significance
Fertilizer N (lbs/acre/year)	Yield (boxes/acre/year)	16	+.842	**
Fertilizer K (lbs/acre/year)	Yield (boxes/acre/year)	16	+.613	**

[1]Yield represents an average of the 1966-67 and 1967-68 crop years. Average N and K rates for these years only were used in correlations.

**Highly significant.

The correlation between N rates and yields, together with the significant correlation between the leaf nitrogen content and the nitrogen applied, would indicate that the full fruit production potential has not been reached in the majority of the survey groves. These observations were further substantiated by the frequently observed chlorotic conditions of the 'Orlando' trees in winter. A close examination of the data show that the wide range in yields and fertilizer rates between the bearing and non-bearing groves may have influenced the correlations found in this study and a controlled study is needed to test the exact relation between N fertilization and 'Orlando' tangelo.

Nevertheless, data collected in this survey suggest strongly that 'Orlando' tangelo can effectively use more nitrogen than sweet orange. The increased fertilizer usage should be considered along with inclusion of pollinators, girdling, and rootstocks as means of increasing fruit production in 'Orlando' tangelo. Furthermore the recent report that the 'Murcott,' an apparent tangerine hybrid of unknown parentage, requires higher levels of N and K_2O than sweet oranges and grapefruit (16) suggests that the fertilizer requirements of other tangerine hybrids such as 'Robinson' should also be investigated.

LITERATURE CITED

1. Anderson, C. A., H. B. Graves, Jr., R. C. J. Koo, C. D. Leonard and R. L. Reese. 1968. Methods of analysis. Fla. Agr. Exp. Sta. Project 1398. Lake Alfred, Florida. Unpublished.

2. Breland, H. L. 1957. Methods of analysis used in soil testing. Soils Dept. Mimeo Rpt. 58-3. University of Florida, Gainesville, Florida, 25 pp.

3. Cooper, Talbert, Jr. 1969. The macronutrient status of 'Orlando' tangelos in relation to fertilizer practices. Master's Thesis. University of Florida, Gainesville, Florida. 61 pp.

4. Florida Agricultural Statistics — Citrus Summary. 1968. Fla. Dept. Agr., Tallahassee, Florida. 44 pp.

5. Gardner, V. R., F. C. Bradford and H. D. Hooker. 1952. The Fundamentals of Fruit Production. 3rd edition. McGraw-Hill, New York, N. Y. 739 pp.

6. Hodgson, R. W. 1967. Horticultural varieties of citrus. Chapter 4 in The Citrus Industry, Vol. 1, 2nd edition. Ed. by Reuther et al. University of California Div. Agr. Sci., Berkeley, California. 611 pp.

7. Koo, R. C. J. Reitz and J. W. Sites. 1958. A survey of the mineral nutrition status of 'Valencia' oranges in Florida. Fla. Agr. Exp. Sta. Tech. Bul. 604. 59 pp.

8. Krezdorn, A. H. 1960. The influence of girdling on the fruiting of 'Orlando' tangelos and navel oranges. Proc. Fla. State Hort. Soc. 13:49-52.

9. ———— and W. J. Phillips. 1967. The influence of rootstock on the size of tree, yield and quality of fruit of young 'Orlando' tangelo trees. Proc. Amer. Soc. Hort. Sci. Caribbean Region 11:72-81.

10. ———— and F. A. Robinson. 1958. Unfruitfulness in the 'Orlando' tangelo trees. Proc. Fla. State Hort. Soc. 71:86-91.

11. LeClerg, E. L., W. H. Leonard and A. G. Clark. 1962. Field Plot Technique. Burgess Publishing Co., Minneapolis, Minn. 373 pp.

12. Northey, J. E., C. H. Hendershott and J. F. Gerber. 1968. Effects of 3 rootstocks and 3 soil temperatures on growth of 'Orlando' tangelos. Proc. Amer. Soc. Hort. Sci. 93. In press.

13. Reitz, H. J. and W. T. Long. 1952. Mineral composition of citrus leaves from the Indian River area of Florida. Proc. Fla. State Hort. Soc. 65: 32-38.

14. ————, C. D. Leonard, Ivan Stewart, R. C. J. Koo, D. V. Calvert, C. A. Anderson, P. F. Smith and G. K. Rasmusseu. 1964. Recommended fertilizers and nutritional sprays for citrus. Fla. Agr. Exp. Sta. Bul. 536 B. 23 pp.

15. Smith, P. F. 1966. Leaf annalysis of citrus. Chapter 8 in Fruit Nutrition, 2nd edition. Ed. by N. F. Childers. Horticultural Publications. Rutgers University, New Brunswick, N. J.

16. Stewart, Ivan, T. A. Wheaton and R. L. Reese. 1968. Murcott collapse due to nutritional deficiencies. Proc. Fla. State Hort. Soc. 81: 15-18.