Nutrient Removal Estimates for Citrus Fruits Grown on Calcareous Soils in South Texas

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SUMMARY
Accurate estimates of nutrient removal amounts in harvested crops are crucial in developing balanced nutrition programs to ensure sustainable yields, quality, tree vigor/health, and environmental quality. Nutrient removal amounts by grapefruit (*Citrus paradissi*) and orange (*Citrus sinensis*) fruits harvested from several orchards across the Lower Rio Grande Valley, Texas were estimated. The orchards studied were at various stages of commercial production with fruit yields ranging from 8,500 to 25,000 lbs per acre. Fruits were sampled at harvest and analyzed for mineral contents. Average nutrient removal estimates ranged from 10-52 lbs N/acre, 1.1-3.8 lbs P/acre, and 14-36.9 lbs K/acre for grapefruit, and 11-64 lbs N/acre, 1.6-4.5 lbs P/acre, and 12-40 lbs K/acre for orange. Differences in fruit yield levels likely contributed to the observed broad ranges in removal estimates.

INTRODUCTION
Citrus is one of the most important perennial fruit tree crops with significant economic impacts globally. Appropriate citrus orchard nutrient management strategies are crucial for sustained fruit productivity. Harvested fruits can account for a major portion of annual nutrient removal from the soil-crop system (Alva and Paramasivam, 1998). Nutrient removal by harvested fruits together with losses to leaching, runoff, leaf drop, and other mechanisms must be replaced each season to ensure economic fruit yields, quality, tree vigor/health, and environmental quality. Knowledge of nutrient removal amounts in harvested fruits can assist in developing balanced nutrition programs for specific production regions. Current nutrient removal estimates for major citrus production regions such as Florida are of limited use for orchard nutrient management programs in other production regions. Differences in tree characteristics, management practices, and yield expectations limit universal applicability of existing estimates. In the current project, fruit nutrient removal values for orange and grapefruits grown on calcareous soils in South Texas were estimated.

PROCEDURES
Commercial citrus (orange and grapefruit) orchards in the Lower Rio Grande Valley, TX (longitude ~26N, latitude ~98W; elevation 21m; annual rainfall ~22 inches) were initially sampled during the 2010-2011 growing season and again during the 2011-2012 growing season. Soils in this region are predominantly calcareous (average pH 7.6; Table 1). All fields were managed following standard commercial practices. Ten grapefruit and five orange orchards were sampled for this investigation. Mature leaves were collected from outer canopy positions, rinsed with distilled water, dried, and ground to pass a 40 mesh screen. Between and five fruits were sampled from each orchard during the harvest season (December, 2012). Fruit fresh weights were recorded immediately after harvest.

Fruits were rinsed with distilled water and partitioned into juice, peel, juice sacs, and seeds. Dry weights of peels, juice sacs, and seeds were recorded and then ground to pass a 40 mesh screen. Total nitrogen (N) concentration of tissues was analyzed by the Kjeldahl method. Mineral nutrient concentrations in each fruit component were analyzed using inductively coupled plasma emission spectroscopy (ICPES) following tissue digestion with nitric acid and hydrogen peroxide. Soil samples were also collected and analyzed for mineral contents. Nutrient removal amounts were estimated from fruit yields, dry matter, and mineral nutrient concentrations.

RESULTS AND DISCUSSION

Soil nutrient concentrations were similar to those determined in 2011 (Table 1), and were generally within adequate levels for fruit bearing grapefruit and orange trees. Leaf macro-nutrient concentrations were generally within sufficiency levels for each crop (Table 2); however, the concentrations of nitrogen and potassium were only marginally sufficient. The lower concentrations may reflect nutrient remobilization from leaves to developing fruits which represent stronger sinks for nutrients and assimilates. With the exception of leaf boron concentrations which were significantly greater than the sufficiency range, all the other micro-nutrient concentrations were only marginally sufficient.

Grapefruit yields ranged from 256 to 303 boxes per acre (average 300 boxes/acre or ~12 ton/acre fresh fruit). Orange fruit yields ranged from 148-227 boxes per acre (~8 ton/acre fresh fruit). Estimates of nutrient removal amounts with marketable grapefruits were 23.5, 2.5, and 27.2 lbs/acre of marketable fresh fruit for nitrogen, phosphorus and potassium respectively. Similar estimates for orange were 23.4, 2.3, and 24.5 lbs/acre respectively. These estimates for 2012 are lower than those found in 2011 perhaps reflecting the lower fruit yield levels in 2012. Nevertheless, these estimates give a broad view of the nutrient amounts removed with fruits. Removal estimates do not imply the amount of nutrients required per acre to produce a crop. Information on other nutrient cycling processes such as remobilization for new shoot growth, leaching and gaseous losses, as well as input processes such as atmospheric deposition, biological nitrogen fixation, and fertilization are required to develop balanced nutrition programs. Balanced nutrition programs are critical especially for the new high-yielding varieties that remove relatively large amounts from the cropping system. Continued sampling over multiple years, and locations with varying weather conditions, soil types and yield scenarios is needed to establish realistic nutrient removal values that can be used to develop improved fertilizer management guidelines.

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REFERENCES

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Table 1: Soil chemical characteristics of grapefruit and orange orchards sampled for fruit nutrient removal estimates in 2012. Values are averages from ten grapefruit orchards and five orange orchards.

Crop	Soil Organic Matter (%)	pH	NO_3-N	P	K	Ca	Mg
			($mg \cdot kg^{-1}$)				
Grapefruit	1.9	7.9	94.2	61.3	643	13450	586
Orange	1.4	7.6	77.1	57.1	698	17621	627

Table 2: Average macro- and micronutrient concentrations in leaves of fruiting grapefruit and oranges trees sampled for fruit nutrient removal estimates in 2012. Leaves were obtained from ten grapefruit orchards and five orange orchards.

	N %	P %	K %	Ca %	Mg %	S %
Grapefruit	2.15±0.05	0.16±0.01	1.40±0.07	5.15±0.26	0.32±0.02	0.61±0.04
Sufficiency range	2.2-3.5	0.12-0.5	1.2-3	1.1-4	0.3-0.5	0.25-0.5
Orange	2.6±0.05	0.17±0.02	1.3±0.11	4.7±0.20	0.29±0.01	0.52±0.04
Sufficiency range	2.4-2.7	0.12-0.16	0.7-2	1.5-4	0.2-0.7	0.2-0.5

Table 2: (Continued)

	Fe ppm	Mn ppm	Zn ppm	B ppm	Cu ppm
Grapefruit	91.6±5.12	26.0±1.50	29.4±1.24	258.8±18.43	12.1±12.19
Sufficiency range	60-250	25-200	25-150	25-100	6-35
Orange	121.9±6.68	27.3±2.32	30.2±1.09	182.1±12.15	11.5±3.
Sufficiency range	60-200	20-200	20-75	20-100	5-35

Sufficiency ranges based on: Mills, H. A. y J. B. Jones Jr. 1996. Plant Analysis Handbook II.

Table 3: Average fruit yields and estimates of macronutrients removed with fruits from grapefruit and orange orchards.

Yield	Yield	N	P	K	Ca	Mg	S
	*boxes/acre	lbs/acre					
Grapefruit	301±13	23.5±1.3	2.5±0.1	27.2±0.7	14.1±0.5	2.8±0.1	4.8±0.4
Orange	185±11	23.4±2.4	2.3±0.1	24.5±1.1	18.3±1.3	2.8±0.1	3.7±0.2

*Orange: 85lbs per box; grapefruit: 80 lbs per box.