

SOILS AND FERTILIZERS
MODULE 14
FERTILIZATION PROGRAMS FOR CITRUS

1. Factors to consider when formulating a citrus grove fertilizer program.
 - a. Citrus is well-suited to the use of "program fertilization," where annual fertilizer applications are scheduled after considering a number of grove characteristics, such as:
 - i. Soils and production areas.
 - (1) Well-drained soils of the central Florida ridge (usually acidic; many are vulnerable to nitrate and pesticide leaching).
 - (2) Poorly-drained, finer-textured soils of the east coast (acidic or alkaline).
 - (3) Poorly-drained, sandy soils of central and south Florida (usually acidic).
 - ii. Age of trees.
 - iii. Destination of fruit.
 - (1) Grown for packinghouse (generally want large, early-maturing, non-green fruit).
 - (2) Grown for processing (want to maximize soluble solids per box and per acre).
 - (3) Nitrogen addition increases yield, soluble solids, acid, and green fruit; decreases fruit size.
 - (4) Potassium addition increases acid and fruit size.
 - iv. Past production (boxes/acre) - Gives an indication of a grove's production potential.
 - v. Fertilization history - Particularly relates to lime, phosphorus, and micronutrient applications.
 - vi. Irrigation type and management.
 - (1) Type of system affects choices of fertilizer application method.
 - (2) Poor water management will decrease the efficiency of applied fertilizers.
 - vii. Diagnostic information (leaf tissue and soil analysis).
 - (1) Quantifies a grove's spatial variation.
 - (2) Can be used to help evaluate a fertilization program.
 - viii. The more of the above information that one has about a grove, the more intelligent will the decision-making process be.
 - b. Fertilization programs should be formulated on a yearly basis; consider the first fertilizer application made in late winter-early spring as the beginning of the fertilizer year.
 - c. The fertilization plan for each grove management unit for the following 12-month period should include:
 - i. Which nutrients will be applied, and which will not.
 - ii. The chemical forms (sources) of each nutrient.
 - iii. The rate per acre at which each individual nutrient will be applied.
 - iv. The method by which each nutrient will be applied (e.g. dry fertilizer, fertilizer suspension with herbicide application, fertigation, foliar spray).
 - v. The distribution schedule for each nutrient.

- vi. The fertilizer dealer from which the materials will be purchased.
 - vii. The cost of the fertilization program, separated into application cost and materials cost.
 - d. It is important to have a plan in place before the next fertilization year commences; this is not to say that the plan cannot be altered in mid-season if justification is there. However, following a plan rather than randomly and recklessly fertilizing is the most economically favorable method and will lead to the greatest fertilization efficiency.
2. Determining which nutrients need to be applied.
- a. Nitrogen, Potassium, and Boron.
 - i. Applied consistently due to high mobility in the soil.
 - ii. Can assume that N, K, and B need to be applied every year.
 - b. Phosphorus.
 - i. Applied to young groves on new land because native P content is low.
 - ii. If grove has been planted on previously-cultivated land, P may not need to be applied.
 - iii. After trees reach bearing age, soil P may have accumulated to levels where further fertilization can be curtailed.
 - iv. Use soil testing and leaf tissue analysis to determine if P needs to be applied.
 - c. Calcium.
 - i. Applied to new land prior to planting as limestone if pH is low.
 - ii. If soil has been limed to pH 6.5, can assume that calcium is not limiting growth or yield; alkaline soils have an abundance of Ca.
 - iii. Ca is not normally applied as a fertilizer material by itself; it is added with superphosphate or in irrigation water.
 - iv. Test soil pH to determine if liming needs; use soil testing to monitor Ca levels.
 - d. Magnesium.
 - i. Applied to new land prior to planting as dolomitic limestone to raise soil pH.
 - ii. If soil Ca is extremely high, uptake of Mg may be limited.
 - iii. Use visual leaf symptoms, soil testing, and leaf tissue analysis to determine if Mg needs to be applied as fertilizer.
 - e. Sulfur.
 - i. Sulfur is a major component of soil organic matter, from which citrus derives much of its S requirement.
 - ii. Sulfur is applied to groves with other practices, e.g. elemental S for mite control, sulfates in fertilizer mixtures, foliar sprays of micronutrient-sulfates, and sulfur compounds in irrigation water.
 - f. Manganese, Copper, Zinc, Iron.
 - i. Usually included in young tree fertilizers for groves planted on new land.
 - ii. Micronutrients will accumulate in the soil, and most likely do not need to be applied to older groves; Cu may accumulate to excess from fungicides.
 - iii. Micronutrient availability is most limited in calcareous (alkaline) soils.
 - iv. Use visual leaf symptoms and leaf tissue analysis to determine if micronutrient fertilization is needed.

- g. Molybdenum.
 - i. Diagnose the need for a molybdenum application through leaf deficiency symptoms (yellow spot).
 - ii. Mo deficiency is usually not observed on limed soils.

3. Determining fertilizer rates - Young (non-bearing) trees (0 through 3 years).

Nitrogen and irrigation are the most important factors for young tree growth

- a. N-P-K.
 - i. For young trees planted on previously non-cropped soils, a general fertilizer formula should contain the following ratio of elements: N - 1, P₂O₅ - 1, K₂O - 1, Mg - 1/5, Mn - 1/20, Cu - 1/40, B - 1/300. The ratio could be different when planting trees on previously-cropped soils.

Year	Suggested lbs of N per tree per year	Application frequency, annual lower limit
1	0.15 – 0.30	6 (dry), 10 (fertigation)
2	0.30 – 0.60	5 (dry), 10 (fertigation)
3	0.45 – 0.90	4 (dry), 10 (fertigation)

- ii. Controlled-release N, with lower application frequency, is particularly well-suited for a young citrus tree fertilization program.

- b. Ca and Mg.
 - i. Lime requirement test if pH is low.
 - ii. A soil limed to near pH 6.5 should supply enough Ca.
 - iii. Use dolomitic lime to supply Mg if needed.
- c. Micronutrients.
 - i. Micronutrient applications can be based on visual symptoms.
 - ii. Can apply Mn and B as a foliar spray (2 lb Mn and 0.15 lb B per acre).
 - iii. If Fe is needed, apply an appropriate iron chelate.
 - iv. If Zn is required, use a foliar spray (2.5 lb Zn per acre).

4. Determining fertilizer rates - Mature (bearing) trees.

- a. Nitrogen.

Fruit type	Suggested range of lbs per acre of N	Application frequency, annual lower limit
Oranges	120 – 200	3 (dry), 10 (fertigation)
Grapefruit	120 – 160	
Other varieties	120 – 200	

Criteria used to select a rate within the range: Crop load, varieties (e.g. up to 250 lbs N/acre for Orlando tangelo, up to 300 lbs N/acre for Honey Tangerine), leaf

tissue testing, fertilizer placement, N fertilizer source, and soil characteristics (OM concentration).

- b. Phosphorus - If the need for P has been determined through leaf tissue or soil testing, should apply up to 80 lbs of P_2O_5 in a single year.
 - c. Potassium - Apply the same quantity of K_2O per acre as N, up to a maximum of 250 lbs per acre where K uptake is a problem (e.g. calcareous soils).
 - d. Magnesium - Apply at 15 to 30% of the N rate **only if needed**.
 - e. Manganese - Can apply to the soil (if pH is below 7) as $MnSO_4$ at 7 to 10 lbs Mn/acre; can also apply as a foliar spray (3 to 5 lb Mn per acre) **only if needed**.
 - f. Zinc - Apply as a foliar spray (3 to 5 lb metallic Zn per acre) **only if needed**.
 - g. Copper - Not usually applied to mature groves as fertilizer if Cu fungicides are used.
 - h. Boron - Soil-apply at 0.3% of the N rate, or apply as a foliar spray (0.15 - 0.40 lb B per acre).
 - i. Molybdenum - Apply as a foliar spray (2 oz sodium molybdate per acre).
5. Determining methods of application - The method of application will affect fertilization efficiency.
- a. Applying dry fertilizer.
 - i. Hand application (young trees or resets) - Consider use of controlled-release fertilizer.
 - ii. Mechanical spreaders.
 - b. Applying liquid (solution or suspension) fertilizer.
 - i. Fertigation should use true solution fertilizers only (need to evaluate clogging potential).
 - ii. Herbicide boom for solution or suspension fertilizers (need to check compatibility of mixes).
 - iii. Foliar application - airblast sprayer or airplane/helicopter.
 - c. Considerations:
 - i. Availability of equipment and labor.
 - ii. Type of irrigation system.
 - iii. Timing of other grove operations.
 - iv. Weather (rainy vs. dry season).
 - v. Type of fertilizer materials chosen.
6. Choosing fertilizer sources.
Considerations: Application method, timing, and cost; cost of materials; soil pH and OM concentration.
- a. Nitrogen.
 - i. Water-soluble N (least expensive, but must be applied at highest frequency).
 - ii. Ammonium vs. nitrate (Ammonium-N and urea can volatilize if left on the surface of soils with high pH).
 - iii. Synthetic controlled-release N (more expensive, but less frequent application).
 - (1) Natural organic materials (biosolids, manure, etc.).

- (2) Urea foliar sprays are now being used as a substitute for part or all of a soil-applied N program.
 - b. Phosphorus.
 - i. The superphosphates are the cheapest sources of dry fertilizer P.
 - ii. Must be careful with diammonium phosphate in regard to calcareous soils.
 - iii. P can be applied via fertigation using phosphoric acid, but care must be taken to avoid precipitation with calcium in irrigation water.
 - c. Potassium.
 - i. Potassium chloride is the cheapest; it can be applied dry or in solution.
 - ii. Potassium sulfate should be used where chlorides are a problem.
 - iii. Sul-Po-Mag could be used in instances where Mg is required in the fertilizer.
 - iv. Potassium nitrate is an option in liquids or as a foliar spray (fruit size increase?).
 - d. Magnesium.
 - i. Dolomitic lime.
 - ii. Magnesium sulfate, as in Sul-Po-Mag.
 - iii. Magnesium nitrate in a liquid fertilizer or a foliar spray.
 - e. Manganese - Manganese sulfate (dry or liquid), or manganese nitrate (liquid).
 - f. Zinc - Zinc sulfate, oxide, or chelates (dry), or zinc nitrate or chelates (liquid).
 - g. Copper - Copper sulfate or hydroxide used as a fungicide.
 - h. Iron - Iron sulfate, Fe-EDTA or Fe-HEDTA for acid soils; Fe-DTPA or Fe-EDDHA for alkaline soils.
 - i. Boron and Molybdenum - Sodium borate and sodium or ammonium molybdate.
- 7. Distribution schedules.
 - a. Nitrogen - Most critical nutrient with regard to scheduling.
 - i. Dry fertilization.
 - (1) Usually a minimum of 3 annual applications, spaced 3-4 months apart.
 - (2) Potential for greater N efficiency with higher frequency applications.
 - (3) If controlled-release N is used, frequency of application is not as critical.
 - ii. Fertigation.
 - (1) Trees have grown the same with fertigation frequencies ranging from 6 to 20 applications per year.
 - (2) Pollution of environment is less likely with higher frequency application.
 - iii. Combination - May be favored when considering rainy summer season (may not want to apply additional water to a wet grove in the summer; this complicates fertigation plans).
 - b. Phosphorus.
 - i. When P is needed as fertilizer, one application per year is fine.
 - ii. It does not hurt to split applications of P, as with fertigation.
 - c. Potassium - Usually applied with N, but applications do not need to be split as much because the K ion is positively charged and movement through the soil is slowed a bit.
 - d. Magnesium - When needed, one application per year is fine.

- e. Manganese, Zinc, Copper.
 - i. Foliar sprays are best absorbed by newly-expanding growth flushes; thus, the best time to apply is during the spring and summer flush period.
 - ii. For soil applications, once or twice a year is all that is needed.
 - f. Iron - May need to apply chelates several times per year because effects do not usually last more than a few months; Fe is poorly translocated between different plant parts.
 - g. Boron - Usually applied with N; two to three applications per year are sufficient.
8. Considerations when choosing a fertilizer dealer.
- a. Helpfulness and knowledge of sales force.
 - b. Inclusion of soil and/or leaf tissue sampling services (be careful).
 - c. Availability of the fertilizer sources you want.
 - d. Timeliness of deliveries.
 - e. Price of products.
 - f. Condition and quality of products.
9. Determining cost of fertilizer program.
- a. Cost of fertilizers and lime.
 - b. Cost of labor and equipment.
 - c. Cost of leaf and soil sampling program.
 - d. Can compare to summary of IFAS survey of Florida citrus care-taking costs.

Table 1. Effects of mineral nutrition and irrigation on fruit quality.

Measurement		Macronutrient element					Micronutrient element					Irrig
		N	P	K	Ca	Mg	Mn	Zn	Cu	Fe	B	
JUICE QUALITY	juice content	+	o	-	o	o	o	o	o	o	o	+
	soluble solids	+	o	-	o	+	o	o	o	+	o	-
	acid	+	-	+	o	o	o	o	o	o	o	-
	solids/acid ratio	-	+	-	o	+	o	o	o	o	o	+
	juice color (red)	+	o	-	?	?	?	?	?	?	?	o
	juice color (yel.)	+	o	-	?	?	?	?	?	?	?	+
	solids/box	+	o	-	o	+	o	o	o	+	o	-
	solids/acre	+	+	+	o	+	o	o	o	o	o	+
EXTERNAL QUAL.	size	-	o	+	o	+	o	o	o	o	o	+
	weight	-	o	+	o	+	o	o	o	o	o	+
	green fruit	+	+	+	o	o	o	o	o	+	o	+
	peel thickness	+	-	+	o	-	o	o	o	o	o	-
PEEL BLEMISHES	windscar	-	+	o	?	?	?	?	?	?	?	+
	russet	-	-	o	?	o	o	o	o	o	o	o
	creasing	+	o	-	?	?	?	?	?	?	?	o
	plugging	-	o	-	?	?	?	?	?	?	?	-
	scab	+	o	o	?	?	?	?	?	?	?	+
STORAGE DECAY	stem-end rot	-	o	-	?	?	?	?	?	?	?	-
	green mold	-	o	o	?	?	?	?	?	?	?	+
	sour rot	o	o	o	?	?	?	?	?	?	?	o

Effect of increasing element: Increase (+) Decrease (-) No change (o) No information (?)