Strategies to Improve Nutrient Uptake Efficiency

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UF/IFAS Citrus Research and Education Center
Citrus Nutrition Day, Lake Alfred, Florida
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Credit: T. Jones, UF/IFAS

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Outline

- Soil and foliar testing
- pH and nutrients
- 4 R’s
- Strategies

Soil and Tissue Test

- Always a good first step !
- Economic, environmental, and regulatory implications for guesswork
- Best in tandem
- Soil
  - More valuable when done throughout year and evaluated for trends over multiple years
  - Soil pH
- Tissue
  - Tells more of the story
  - What actually makes it into the plant

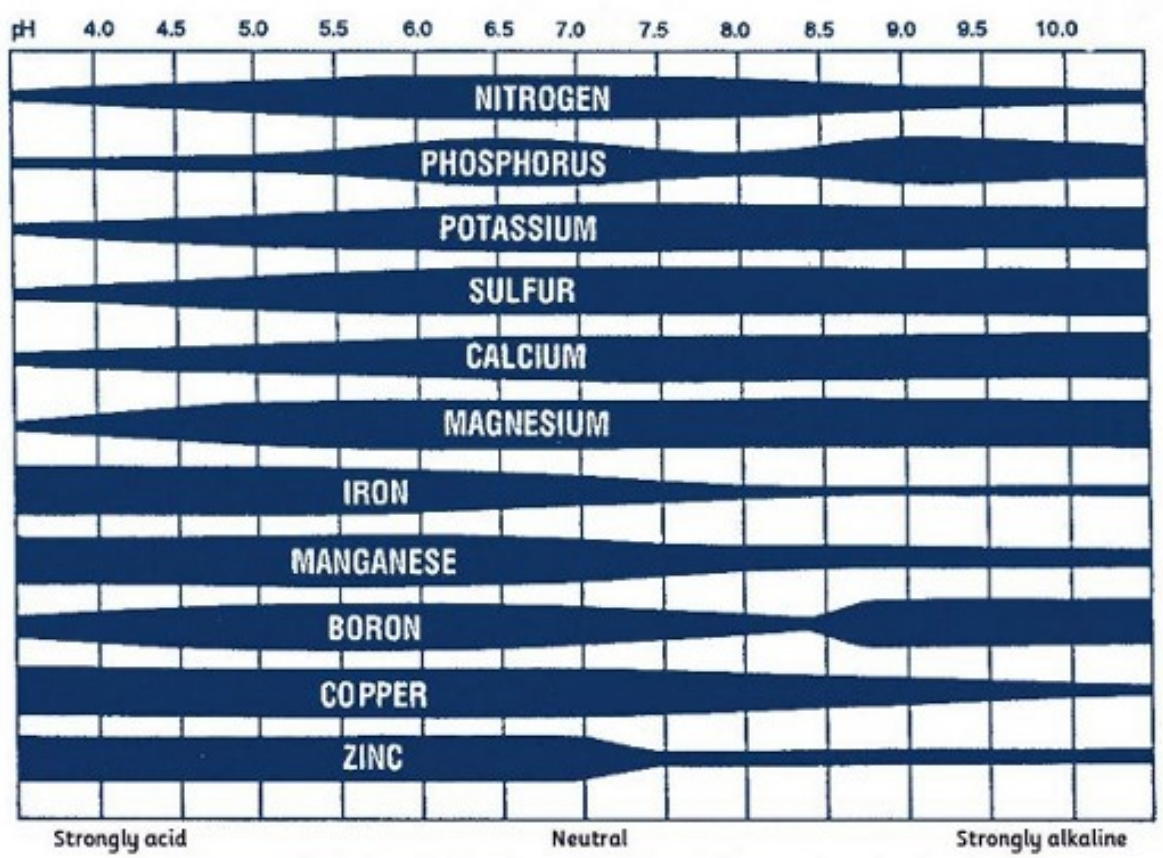
- ICYMI - Citrus Nutrition Box Program

After ensuring crops have sufficient water, what is the next most important thing to ensure for crop health?

Soil pH !

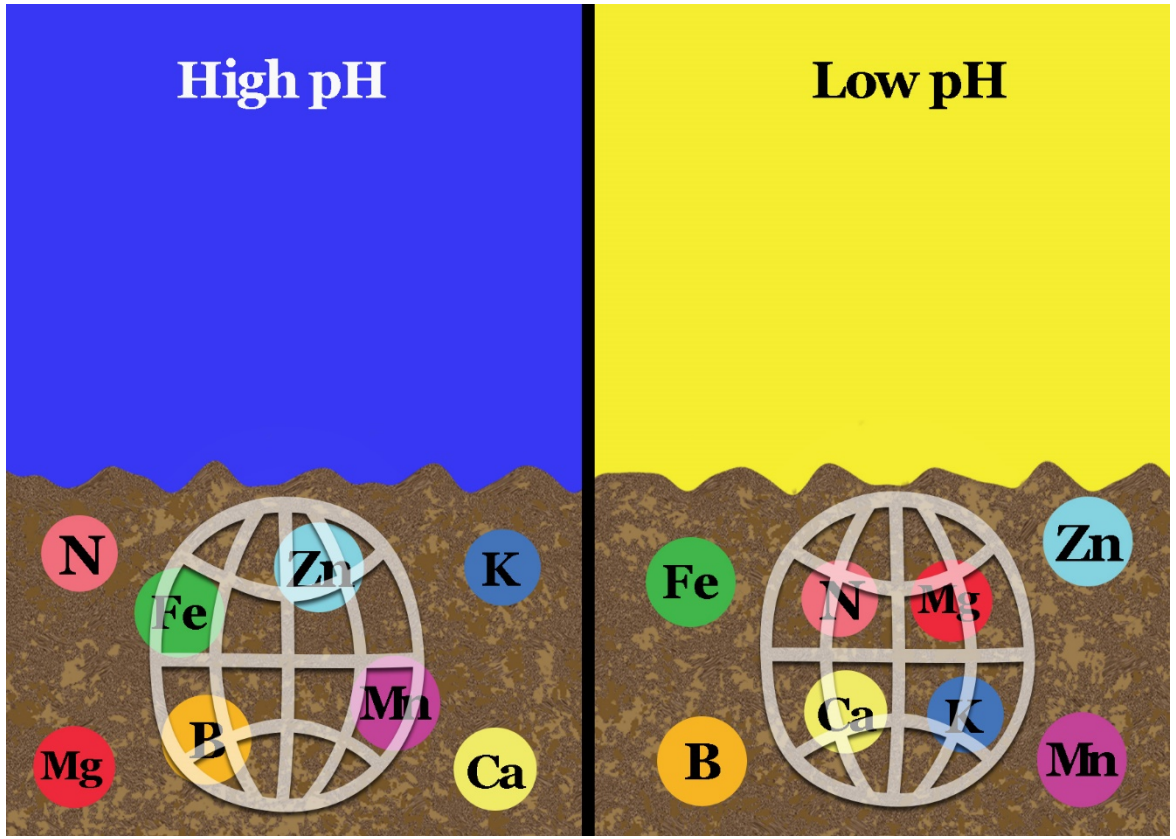
Importance of Soil pH

- Principle factor for fertility and crop nutrition
- Main factor determining availability (uptake) of soil essential nutrients
- Changes over time
  - Irrigation water/wells, plants acidifying, N fertilizers
- Continual adjustment – lime or acidification
- Recommended to keep soil pH between 5.8-6.5



Soil pH

- At high soil pH, most of the micronutrients bind to the soil and becomes unavailable
- At extremely low soil pH, most of the macro and secondary nutrients become unavailable
- The goal is to have right soil pH at the time when nutrient uptake is expected
- Proper soil testing is key



Credit: T.R. Weeks, UF/IFAS

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Essential Nutrients

Non-Mineral (95%) **Mineral (5%)**

C	H	O	N	P	K	S	Ca	Mg	Fe	B	Mn	Zn	Mo	Cl	Cu	Ni

Macronutrients (%) **Micronutrients (ppm)**

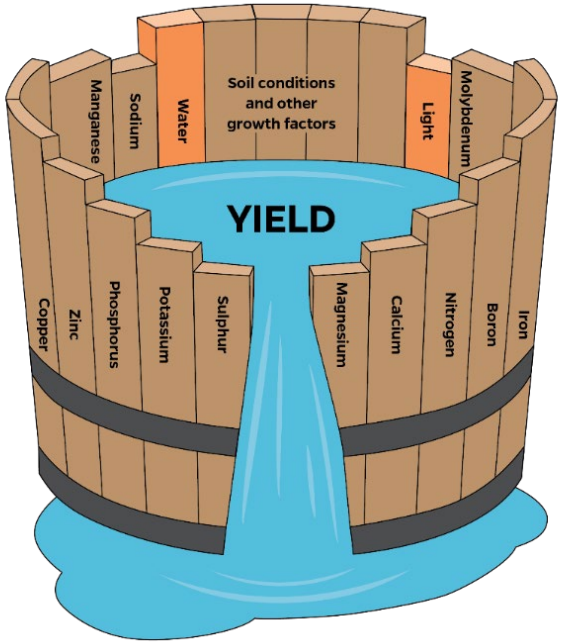
1.5	1.0	0.5	0.2	0.2	0.1	100	100	50	20	20	6	?	0.1
N	K	Ca	Mg	P	S	Cl	Fe	Mn	B	Zn	Cu	Ni	Mo

Mobile in Soil **Immobile in Soil**

N	S	Cl	Mo	B	P	K	Fe	Mg	Ca	Zn	Cu	Ni	Mn

Mobile in Plant **Immobile in Plant**

N	P	K	Mg	Ni	Cl	Mo	Zn	Ca	S	B	Mn	Fe	Cu

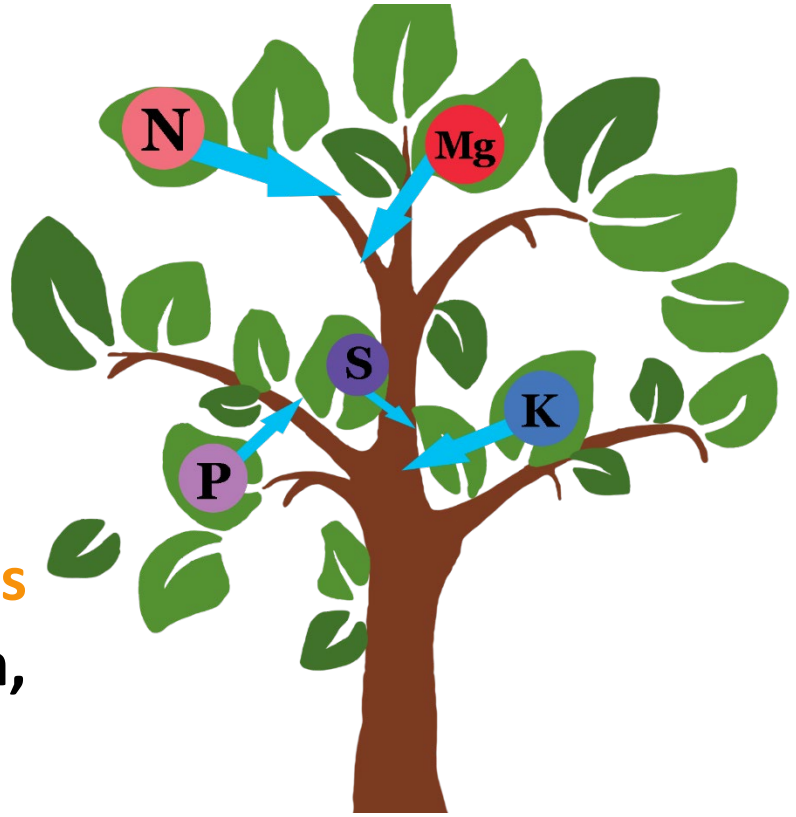


Liebig's law of the minimum

Don't guess, soil test!

What are mobile nutrients?

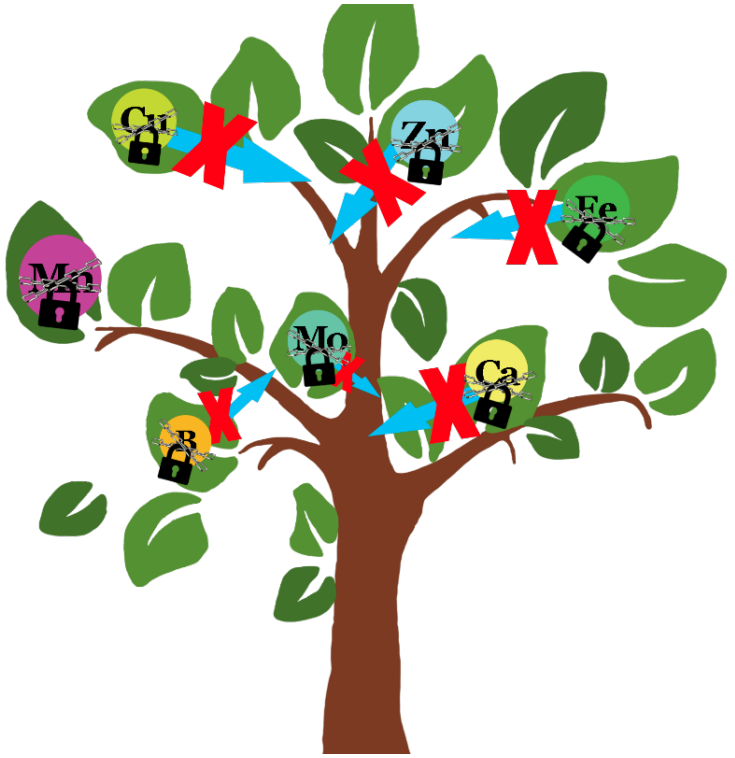
Mobile and immobile nutrients have equal and uniform distribution to all parts of the plant with movement of water



- Mobile Nutrients
  - Will move to new growth areas
  - Move in all direction
  - These nutrients can be transported via xylem and phloem
  - The **deficiency symptoms** will first show up in **older leaves**
  - Nutrients: **Nitrogen, Phosphorus, Potassium, Magnesium, Sulfur**
  - Soil-applied and foliar-applied both are adequate

What are immobile nutrients?

- Do not move in the plant
- Transported only via xylem
- Immobile nutrients will not move to new growth areas
- The **deficiency symptoms** will first show up in the **new leaves**/growth because they cannot take nutrients from the old leaves
- Nutrients: **Calcium, Iron, Zinc, Copper, Manganese, Boron, Molybdenum**
- Soil applied nutrients are adequate
- Should be supplied whenever there is growth



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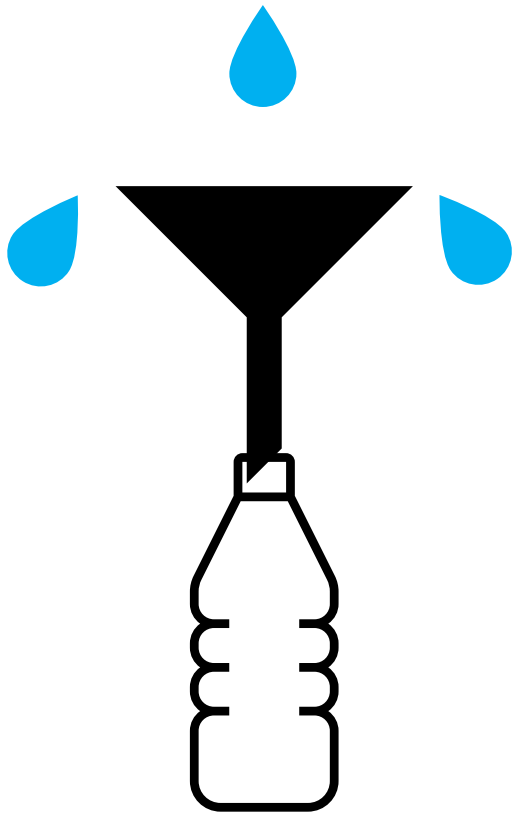
Our Soil as a Funnel Analogy



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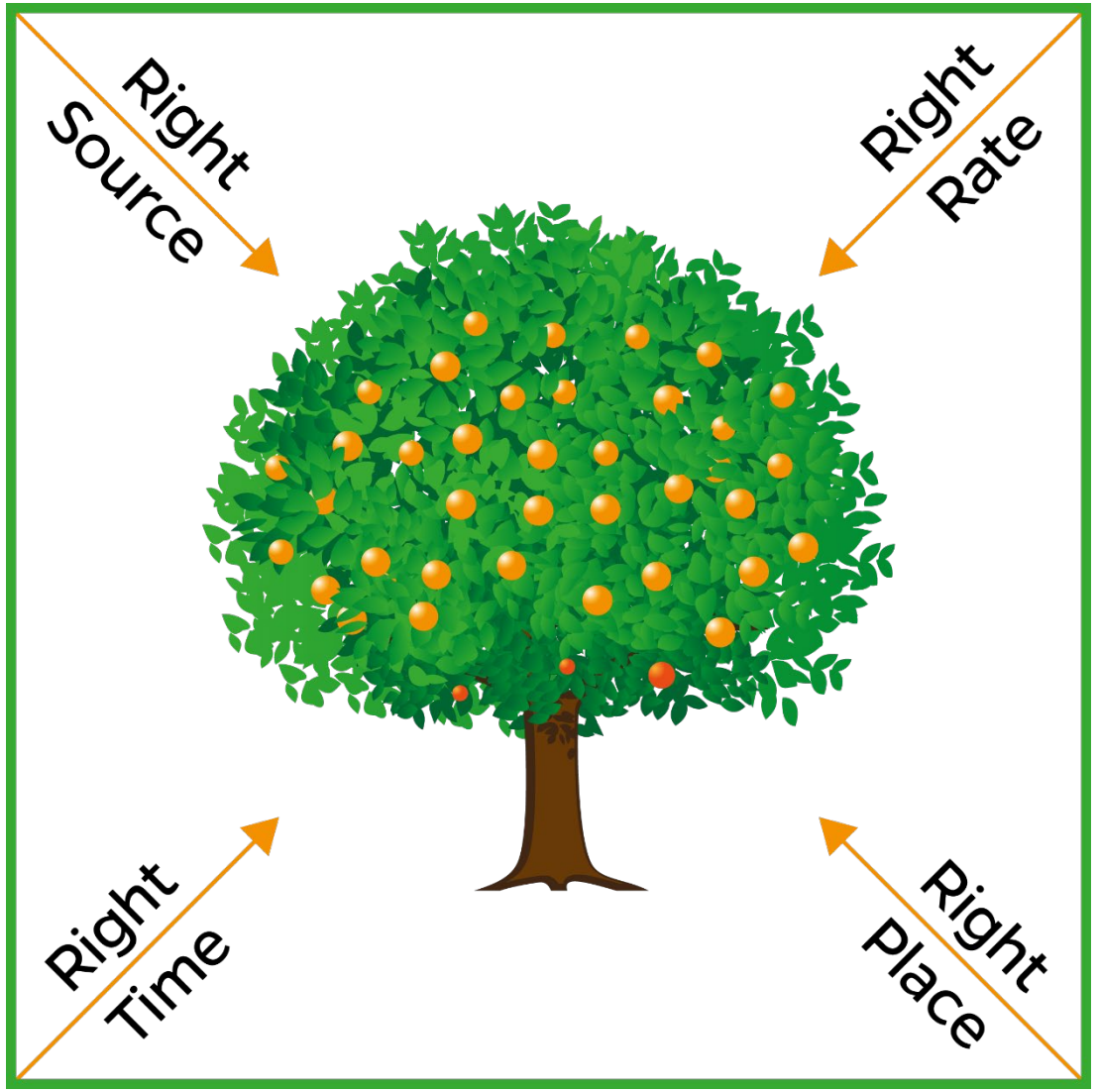
4R's of Plant Nutrition

- Right **Source**
  - Nutrients
- Right **Rate**
  - Amount
- Right **Time**
  - High demand
  - Morning or evening
- Right **Place**
  - Soil or foliar
  - Root zone



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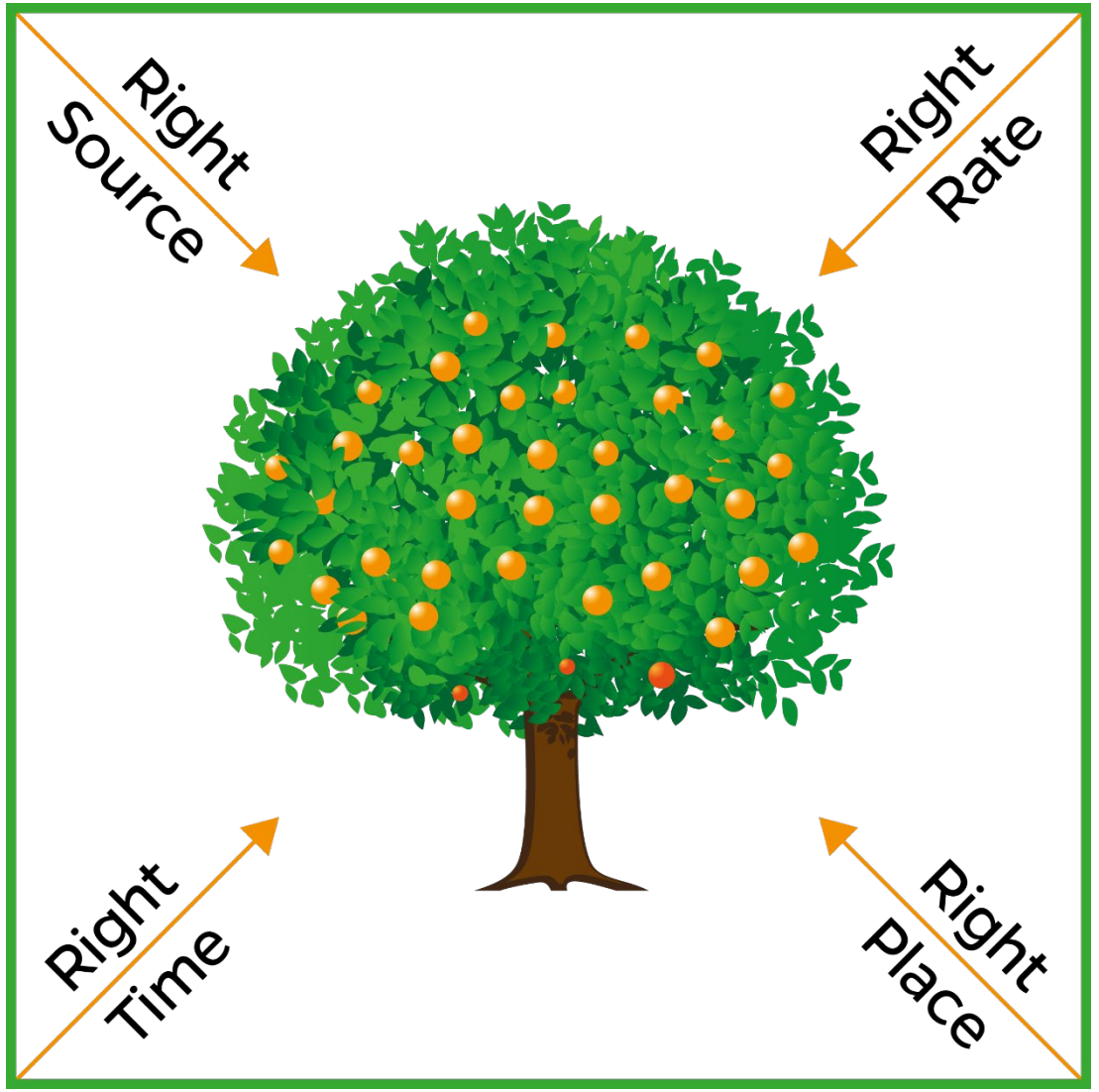


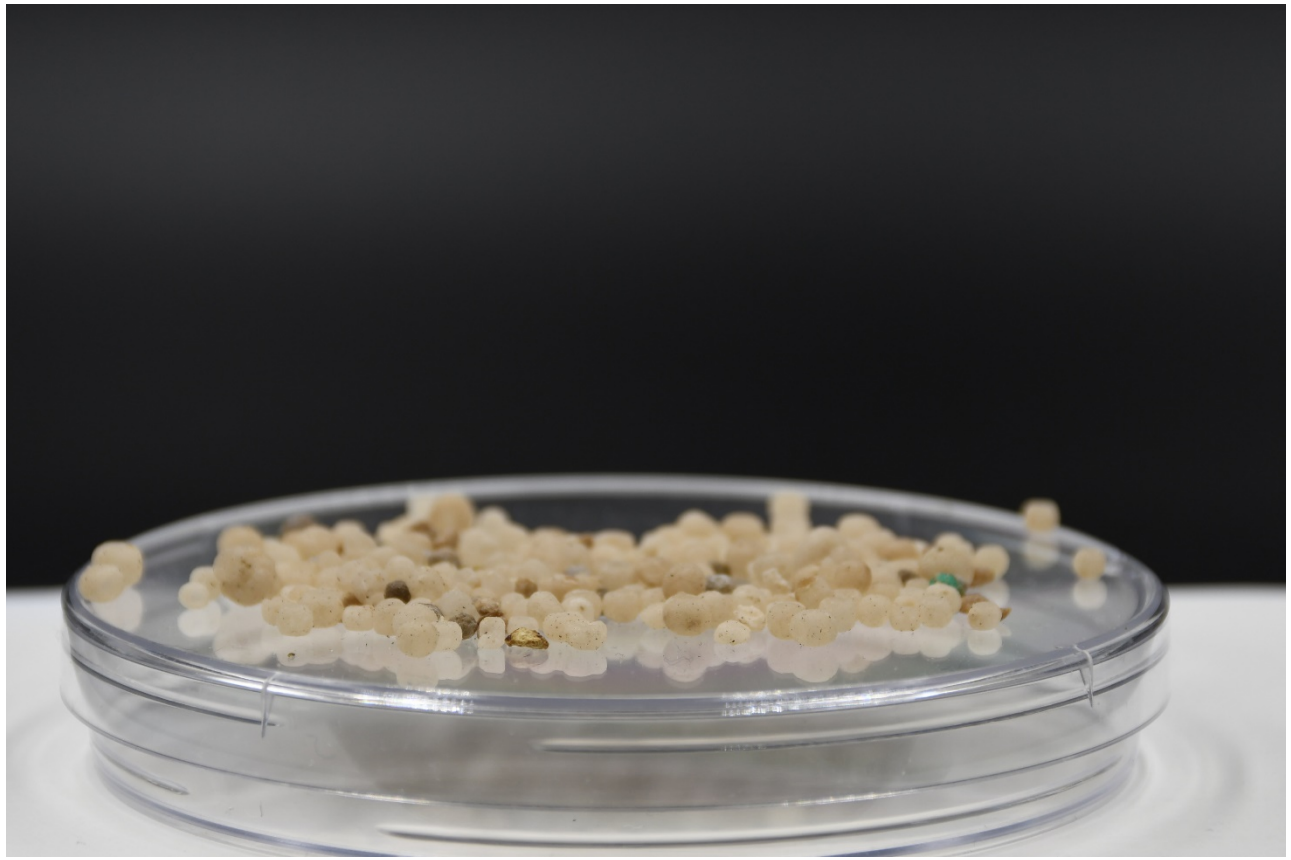
Methods

- Soil applied
  - Granular
  - CRF
  - Fertigation
- Foliar applied

Credit: J.D. Burrow, UF/IFAS

Granular (Dry) Fertilizer

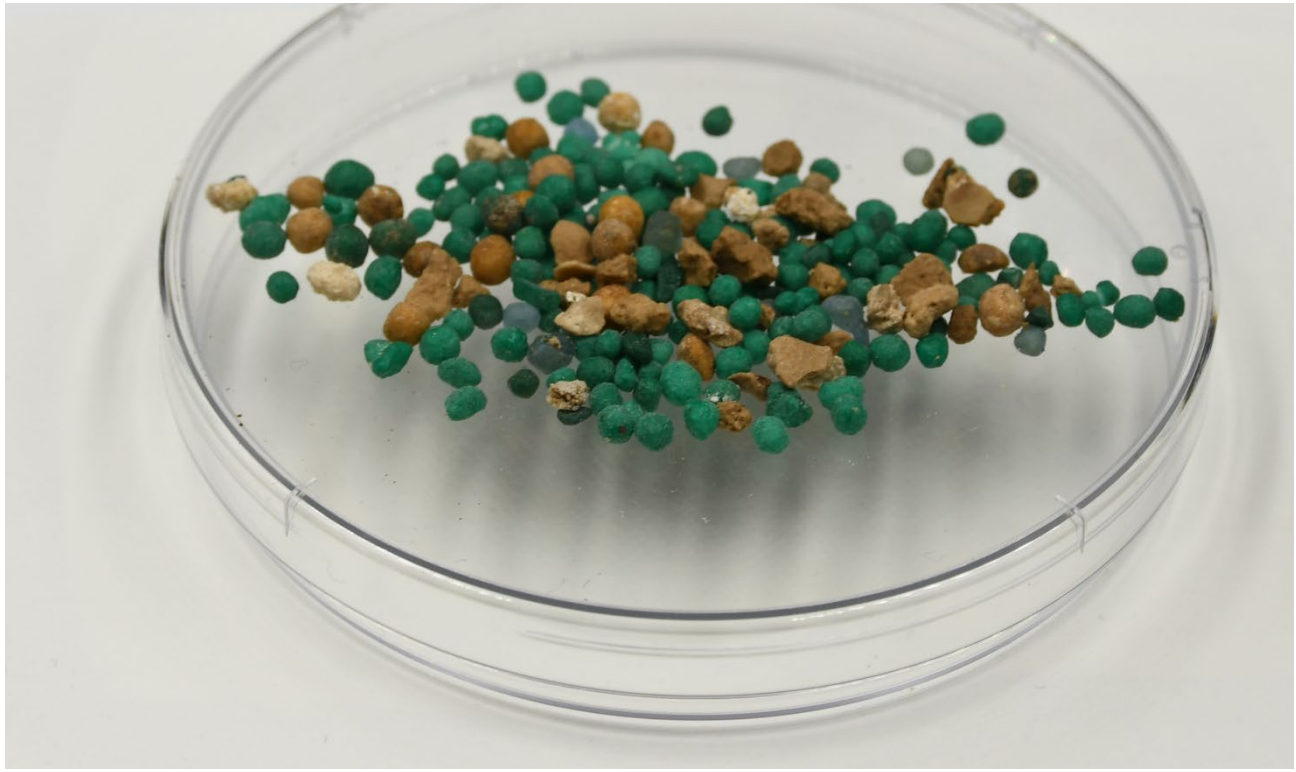
- Traditional soil applied fertilizer
- Advantages
  - Fertilizer is inexpensive
  - Readily available to plant
- Disadvantages
  - Subject to leaching (largely water soluble)
  - Multiple applications increase labor and costs



Credit: T.R. Weeks, UF/IFAS

Controlled Release Fertilizer (CRF)

- Granules release small amounts of fertilizer over time
- Advantages
  - Slowly released; therefore, a constant supply of nutrients
  - Fewer applications
- Disadvantages
  - Expensive



Credit: T.R. Weeks, UF/IFAS

Specific Nutrient Source

- Example - Iron deficiency
  - Foliar ? Granular ?

Iron Chelates	Effective pH Range
Fe-EDTA	4.0 to 6.5
Fe-HEDTA	4.0 to 6.5
Fe-DTPA (Sequestrene 330 or equivalent)	4.0 to 7.5
Fe-EDDHA (Sequestrene 138 Fe or equivalent)	4.0 to 9.0

Credit:UF/IFAS EDIS SL204

Fertigation

- Liquid fertilizer applied through irrigation system
- Advantages
  - Relatively inexpensive
  - Flexibility in application
  - Small doses and constant supply
- Disadvantages
  - High maintenance (have a cleaning/flushing plan)
  - Not suitable for all nutrients

Credit: T. Jones, UF/IFAS

Foliar Nutrition Program

- Yield can increase 10%-25% with supplemental foliar feeding versus conventional soil fertilization only
- Best used as a supplemental and not a substitute for soil-applied nutrition
- Best time to apply is morning or evening
  - Right temperature (temperatures above 80°F can cause burn)
  - Minimal wind to ensure full coverage
  - Leaf stomates are open to increase uptake
- Best to apply when crop demand is high and tree needs additional help (vegetative growth, flowering, fruit set, and fruit growth)
- Quickest method to correct a deficiency, although, if a deficiency is observed, potential yield lost has already occurred

Foliar Nutrition Program

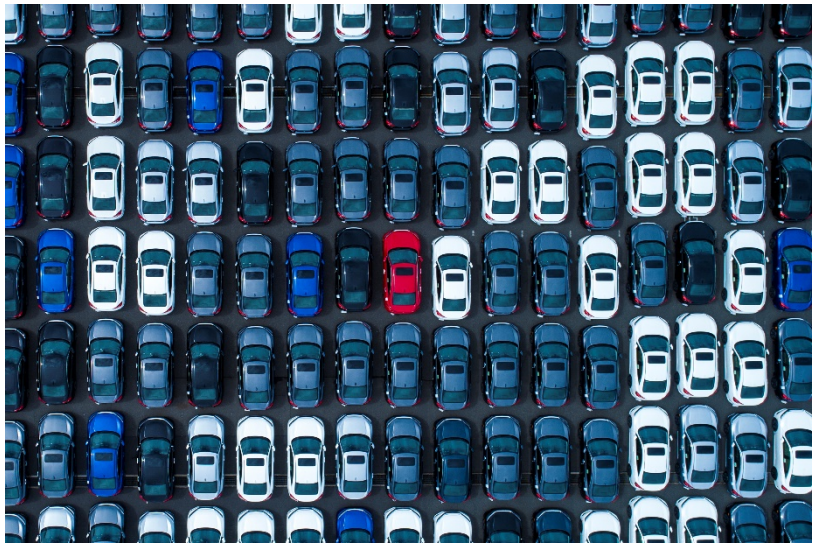
- Advantages
  - Quickest method
  - Assist trees during times of high demand or other hindering conditions (wet or dry conditions, cold weather, etc.)
- Disadvantages
  - Cannot use a foliar nutrition program alone, must be coupled with a soil nutrition program
  - Causes leaf burn when not applied at the correct time

Which fertilizer application method is best for fruit quality?

The method has no effect on fruit quality.

Fertilizer Application Method

- It is not the method, but what you put into the tree
- Example:



- Application method gets the nutrients in the tree

Credit: UF/IFAS Communications

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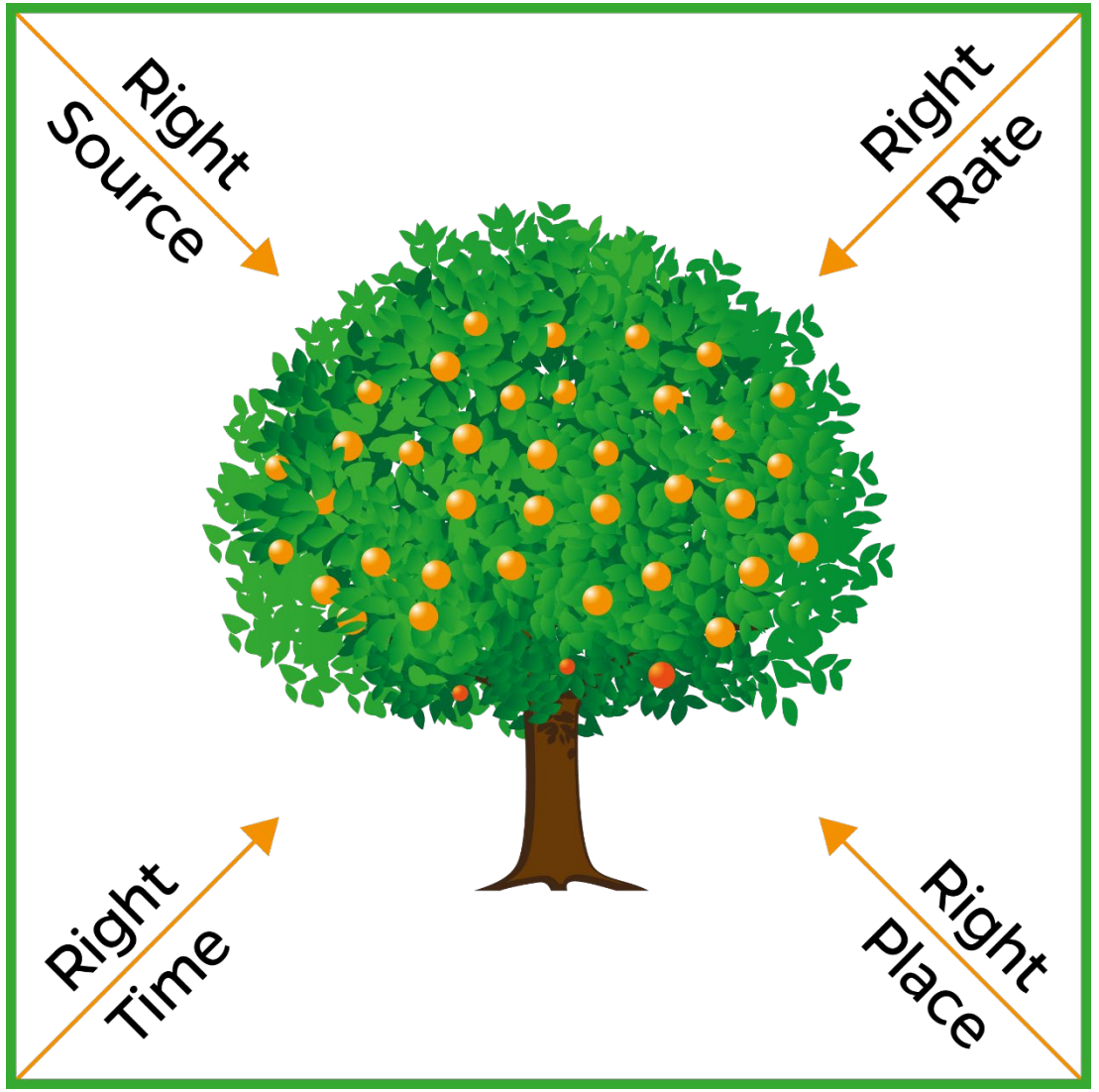

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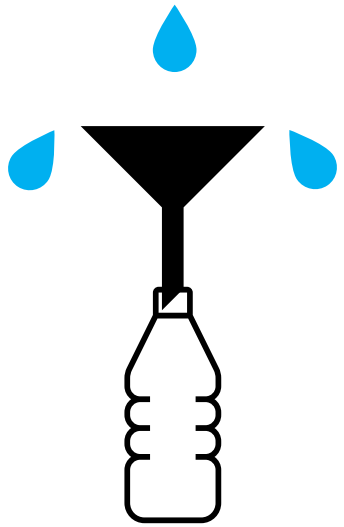
Staggered Applications

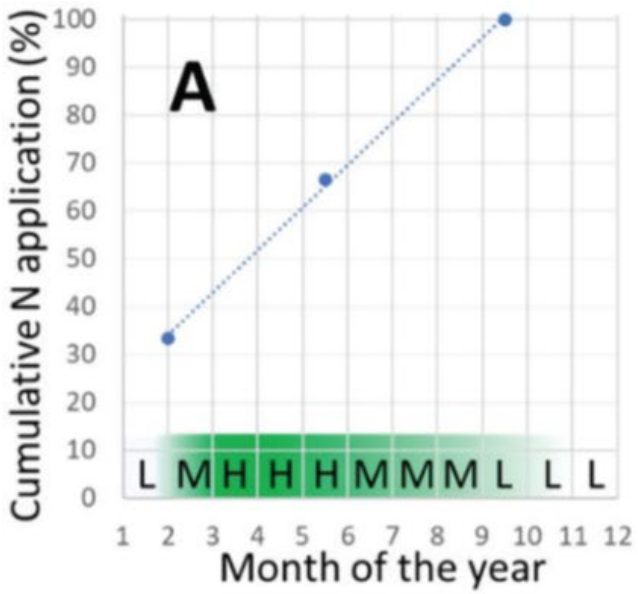


- Using advised rates (N,P)
- Dry fertilizer - minimum of 4-6 applications dry fertilizer/year
- Fertigation - 10-30 applications/year
- CRF - 2-3 applications/year

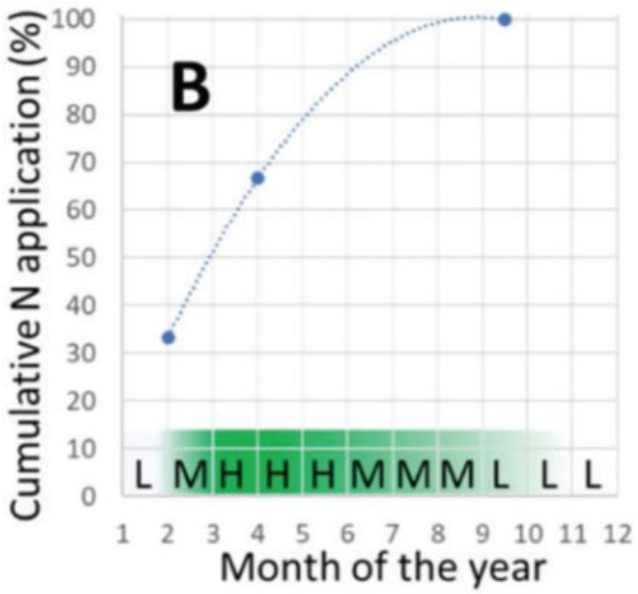
- Example
  - recommended N rate for mature bearing oranges (8+ years old) is 125 – 240 lb/ac → 200 lb/ac → 4 applications of 50 lb/ac at peak nutrient demand times
- Not during the summer

Timing

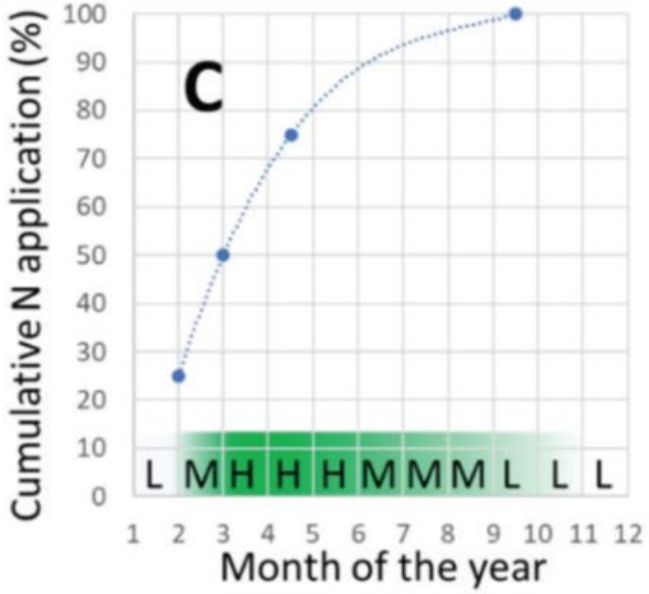
- Peak demands from bloom to end of fruit growth phase (late winter/spring)



Equally timed
Not recommended



Unequally timed
Better



Unequally timed
Better/best

Credit: UF/IFAS 2021-2022 Citrus Production Guide CMG13

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Timing (Foliar)

- Supplemental foliar feeding can increase yields by 10-25% compared to conventional soil fertilization

- 3 applications per year following flushes of March, May, September have been shown to maintain leaf concentrations of nutrients in optimum range

Kelly T. Morgan, Robert E. Rouse, and Robert C. Ebel. 2016. "Foliar Applications of Essential Nutrients on Growth and Yield of 'Valencia' Sweet Orange Infected with Huanglongbing." *HortScience* 51 (12): 1482–1493.

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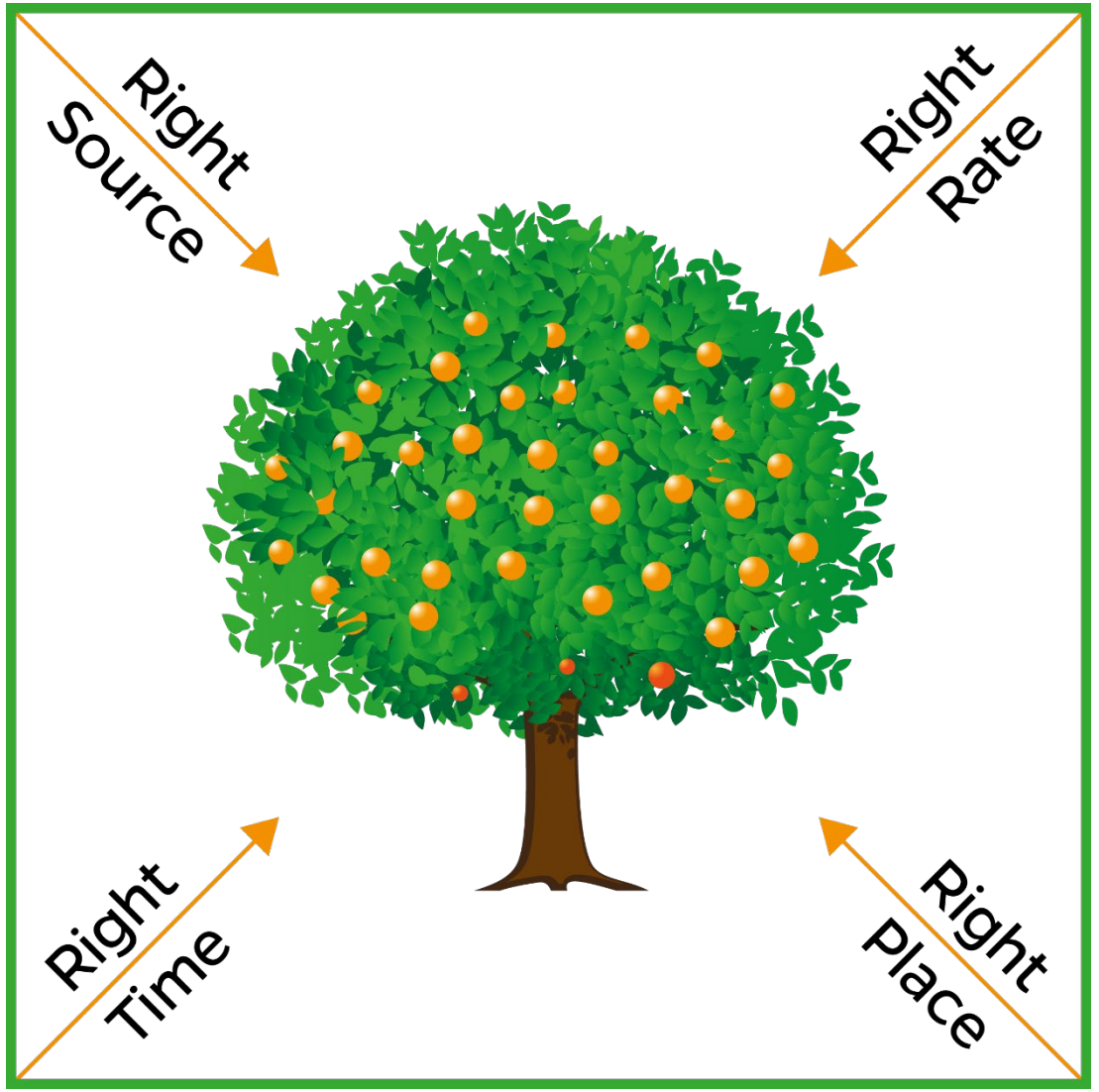

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Only where needed

- Within the root zone → area wetted by micro irrigation
  - i.e. don't fertilize the middle rows
- Try to avoid mass fertilizing large tree skip areas
- Variable rate application equipment *
- Determination between foliar and soil
  - High soil pH → more foliar applications?
- P is immobile in soil – needs to be where roots are


One Size Fits All

Thank you and Acknowledgments

Special thanks to Jamie and Dr. Vashisth for using some slides