Introduction to Apple Tree Nutrition & Orchard Nutrient Management

Lailiang Cheng

Horticulture Section, School of Integrative Plant Science

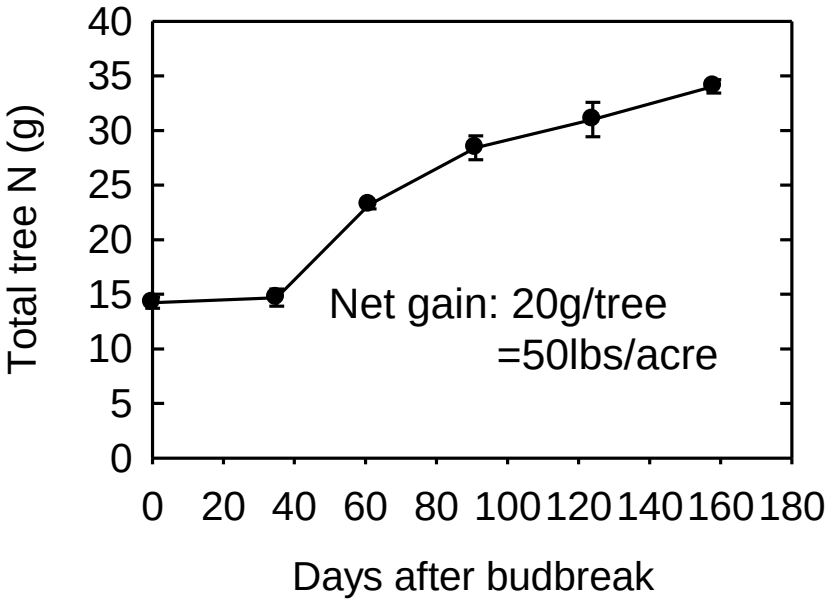
Cornell University

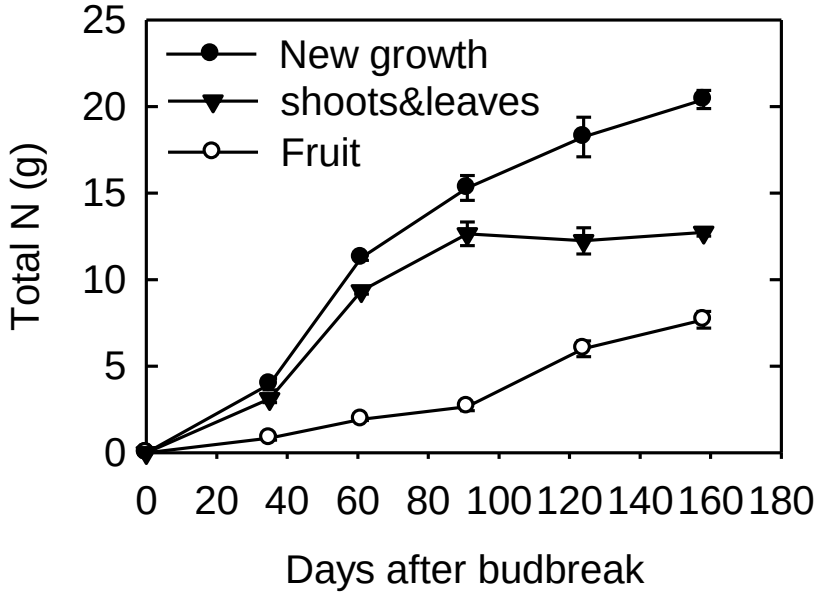
Apple trees on dwarfing rootstocks in high density orchards: crop earlier, have higher yield, but a smaller root system

Essential Nutrients

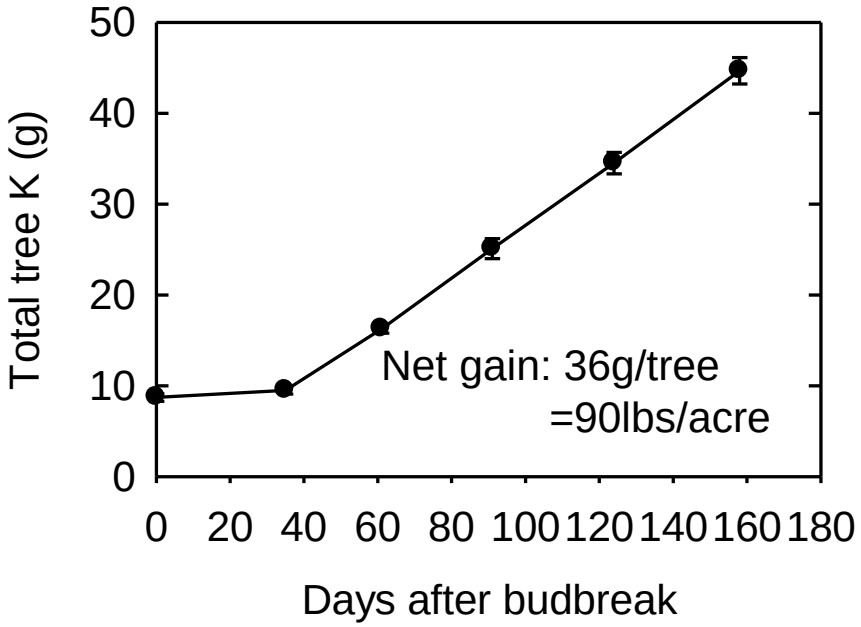
- **Macronutrients: N, P, K, Ca, Mg, S**
- **Micronutrients: B, Zn, Cu, Mn, Fe Mo, Cl, Ni.**

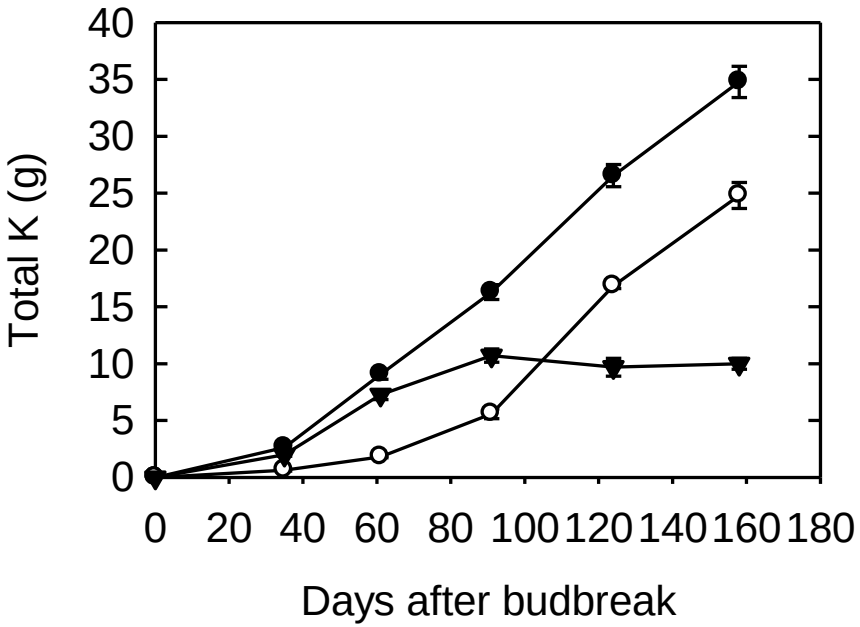
Total N in the whole tree and the new growth (fruit + shoots and leaves) of Gala/M.26 trees



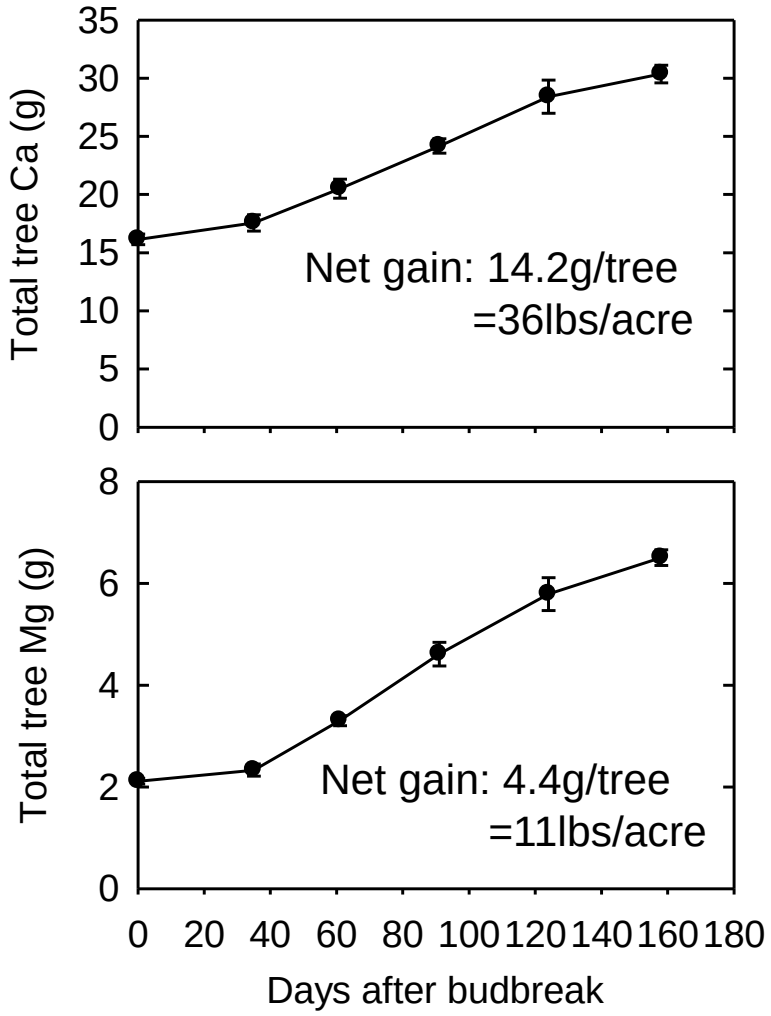


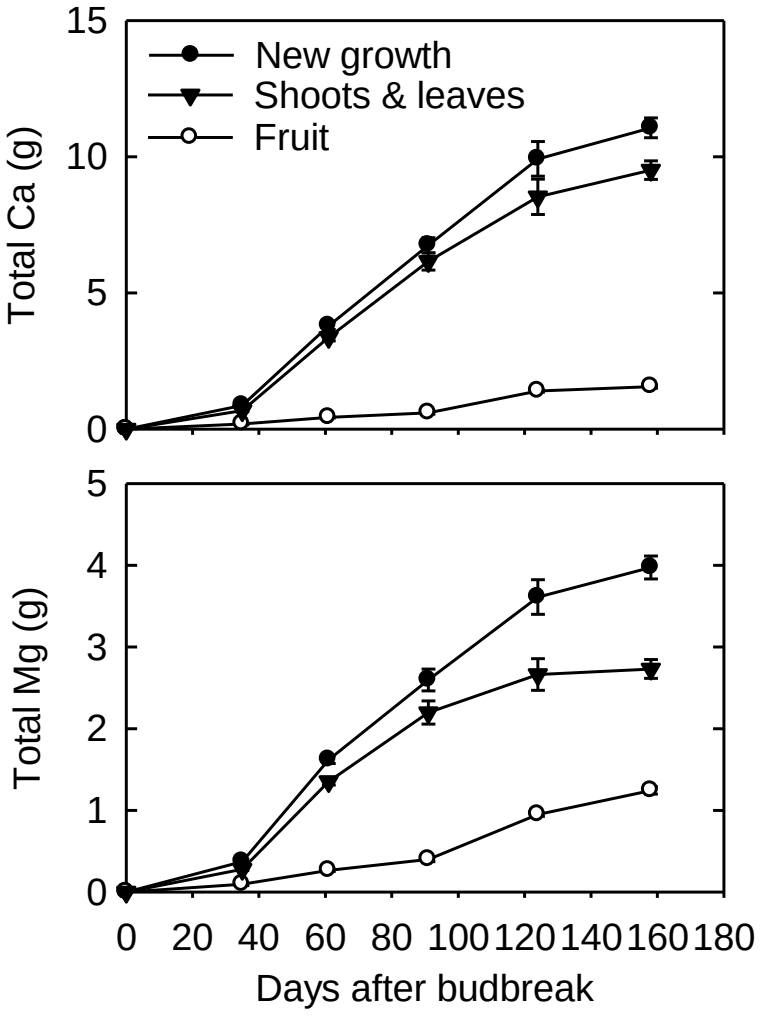
Total K in the whole tree and the new growth (fruit + shoots and leaves)





Total Ca and Mg in the whole tree and the new growth (fruit + shoots and leaves)





Soil pH

$$\text{Colloid-H}^+ \rightleftharpoons \text{H}^+ \text{ (Solution)}$$

$$\text{pH} = -\log[\text{H}^+]$$

- Optimal soil pH for apple: 6.5±0.5.

Tree nutrient requirements in relation to yield

Macronutrients (lbs/acre)

Fruit yield (b/a)	*N*	*P*	*K*	*Ca*	*Mg*	*S*
500	**22.1**	**3.7**	**40.2**	**15.9**	**4.9**	**1.8**
750	**33.2**	**5.5**	**60.2**	**23.9**	**7.3**	**2.7**
1000	**44.3**	**7.4**	**80.3**	**31.8**	**9.8**	**3.6**
1250	**55.4**	**9.2**	**100.4**	**39.8**	**12.2**	**4.5**
1500	**66.4**	**11.1**	**120.5**	**47.7**	**14.7**	**5.4**
1750	**77.5**	**12.9**	**140.6**	**55.7**	**17.1**	**6.3**
2000	**88.6**	**14.8**	**160.6**	**63.6**	**19.6**	**7.2**

Approximate needs for soil Ca, Mg and K

Soil texture	*CEC (meq/100g)*		*Ca (lbs/acre)*		*Mg (lbs/acre)*		*K (lbs/acre)*	
	0-8”	8-16”	0-8”	8-16”	0-8”	8-16”	0-8”	8-16”
Sand, gravel	5	3	1,500	800	185	100	150	100
Sandy loam	12	8	3,600	2,100	440	260	350	220
Loam, silty loam	18	12	5,500	3,200	660	385	525	335
Silty clay loam	20	14	6,100	3,700	740	450	580	370
Clay loam, clay	25	18	7,600	4,800	900	580	730	465

Apple leaf analysis standards for N

Tree type	*Leaf N (%)*
Young non-bearing apples	2.4 – 2.6
Young bearing apples	2.2 – 2.4
Mature soft varieties	1.8 – 2.2
Mature hard/processing varieties	2.0 – 2.4

Soft varieties: Cortland, Empress, Goldens, Honeycrisp, Mac, Jersermac, Jonagold, Jonamac, Jonathan, Macoun, Mutsu, Paulared, Spartan and other early ripening varieties

Hard varieties: Delicious, Empire, Gala, Idared, Liberty, Melrose, Rome, Stayman, York Imperial, and processing varieties

Nitrogen Application

- **Timing: budbreak to shortly after petal fall**
- **Rates:**
  - **Young trees: 30 to 80 lb/acre**
  - **Mature trees: 20-50 lb/acre**
- **As a rule of thumb, every 10% increase in fertilizer results in 0.1% in leaf N**




22 66 131 262 lbs N/A




Optimal Ranges for Other Nutrients

Nutrients	*Desired level*
Phosphorus	**0.13-0.33%**
Potassium	**1.35-1.85%**
Calcium	**1.3-2.0%**
Magnesium	**0.35-0.5%**
Boron	**25-50 ppm**
Zinc	**25-50 ppm**
Copper	**7-12 ppm**
Manganese	**50-150 ppm**
Iron	**50+ ppm**

Leaf Potassium

- Optimum range: 1.35 to 1.85%.
- Inverse relationship with cropload.
- N/K ratio: 1.00 ~ 1.25 for McIntosh and 1.25 ~ 1.5 for Delicious.
- Drought decreases leaf K.
- Maintenance (60 to 100 lb/A) vs correction (120 to 180 lb potash /A).

‘Gala’ macronutrient removal rates by fruit harvest in relation to yield

(lbs/acre)

Yield (b/a)	*N*	*P*	*K*	*Ca*	*Mg*
500	8.6	2.2	27.7	1.8	1.4
1000	17.2	4.4	55.3	3.5	2.8
1500	25.7	6.6	83.0	5.3	4.2
2000	34.3	8.8	110.7	7.0	5.6

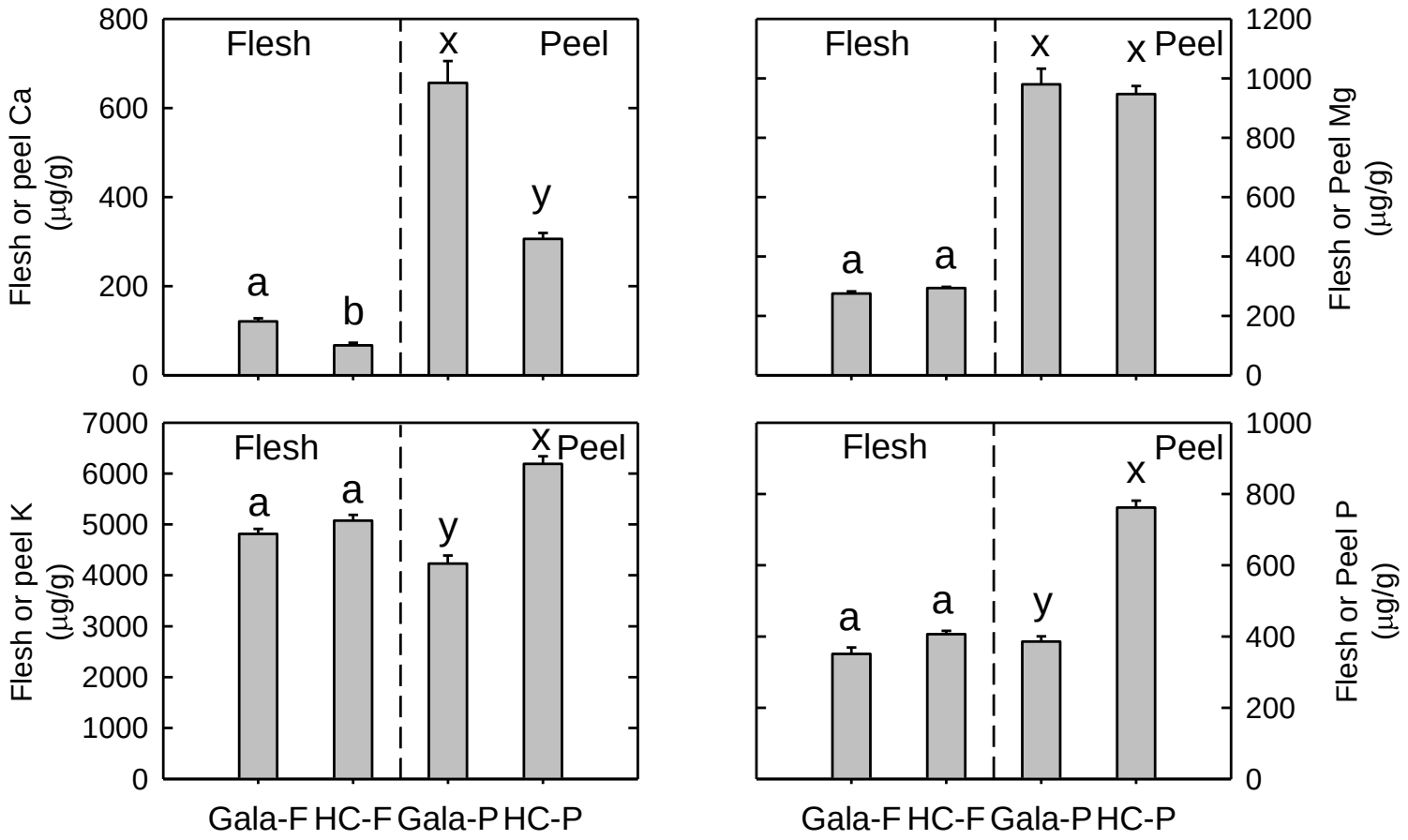
Calcium

- **Optimal leaf Ca range: 1.3 to 2.0%.**
- **Standards for Cox and Bramley fruit at harvest (mg/100 g fresh fruit) for long term storage.**

Variety	*N*	*P*	*K*	*Mg*	*Ca*
Cox	**50 - 70**	**11 (min)**	**130 - 170**	**5.0**	**5.0**
Bramley	**60 (max)**	**9 (min)**	**105 -115**	**5.0**	**5.0**

Bitter Pit

Fruit Nutrient Levels in Gala and Honeycrisp



Controlling bitter pit in Honeycrisp

- **Ensure adequate Ca supply in soil (pH) and maintain root growth & Ca uptake (B, Zn, water, etc)**
- **Control tree vigor (N supply, pruning etc) to mitigate competition with fruit for Ca.**
- **Strictly control K to balance fruit Ca with K.**
- **Adjust cropload to a medium level (avoid low cropload situation)**
- **Make foliar (fruit) Ca sprays**
- **Use growth regulators such as Apogee**


1.52
4.55
9.1
13.65
18.2g

Bitter Pit in Relation to Cropload in Honeycrisp

Courtesy of Dr. Jim Schupp

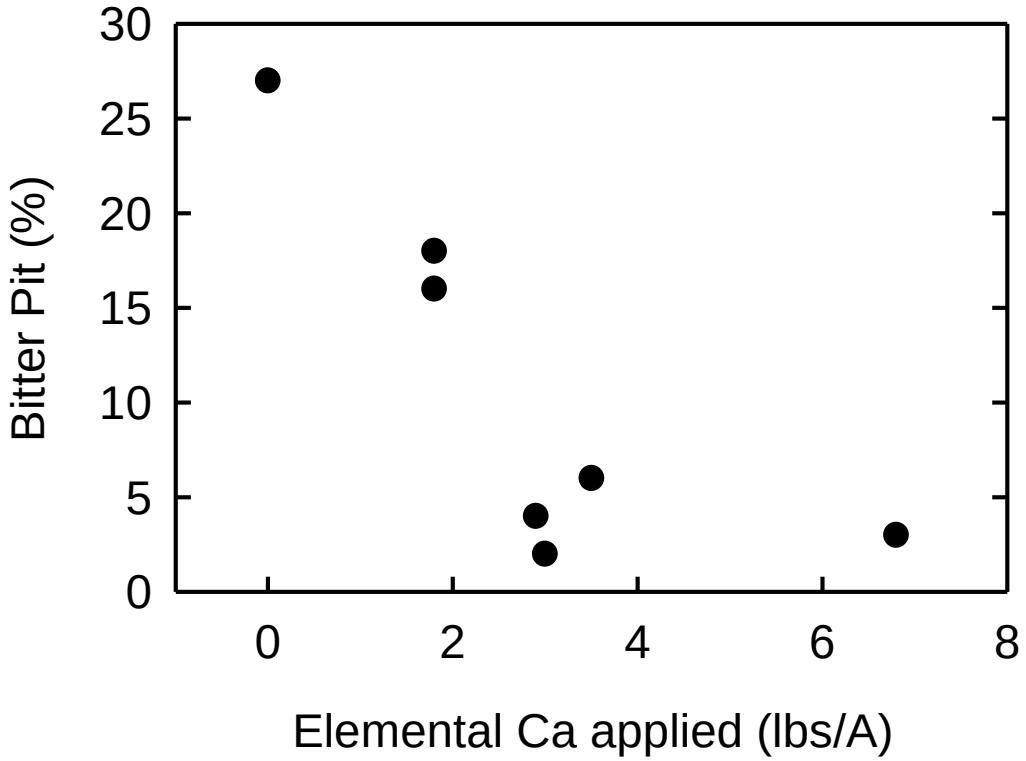
Calcium Sprays

- **Three to 4 sprays of 1.5 to 2 lbs of $CaCl_2$ (78%) or its equivalent per 100 gallons (dilute basis) at 10 to 14 day intervals beginning 7 to 10 days after petal fall.**

- **Two sprays of 3 to 4 lbs per 100 gallons at 2 week intervals starting from mid-season.**

This program provides 3.4-4.5 lbs of actual Ca per acre

Bitter Pit Occurrence vs. Amount of Ca Applied



Rosenberger et al, 2004

Take-home Messages

- **Understand tree nutrient needs and know your soil and tree nutrient status.**
- **Provide just enough N for tree growth; too much lowers fruit quality.**
- **K application is dependent on fruit yield, and needs to be balanced with Ca.**
- **Bitter pit is a complex problem, and therefore a comprehensive approach is required.**
- **Variety/rootstock-specific & site-specific nutrient management.**

Acknowledgments

- **Terence Robinson, Jim Schupp, Dan Donahue, Chris Watkins, Dave Rosenberger, Mario Miranda Sazo, Ben Orcheski, Huaiyu Ma, Yongzhang Wang, Hufeng Li, Richard Gaisser & Kaspar Kuehn**

- **Vandewalle Fruit Farm, Cherry Lawn Farm, Van Well Nursery and other cooperating growers**

- **USDA NIFA SCRI Apple Root to Fruit Project & NY Apple Research & Development Program**