Applications

Adequate nutrient management requires a good understanding of the orchard local conditions, soil type, irrigation systems, tree demand and nutrient supply or availability. Many factors should be considered when developing a nutrient management plan for the orchard. See **Tree Fruit Soil Fertility and Plant Nutrition in Cropping Orchards in Central Washington** <treefruit.wsu.edu> for details about how to create a fertility plan for your orchard. Maintaining nutrients in the soil and tissue is necessary to sustain tree health and fruit quality. Maintenance rates are recommended when soil nutrient levels are within adequate range (Table 1). Deficiency rates are recommended when deficiencies are detected either in the soil, leaf (Table 2) or plant symptoms appear. This guide is designed to help translate general spray recommendations into amount of product per acre, for most used products.

Major Nutrient Managements

Boron deficiency

Boron (B) is required in young growing tissue. In Washington and most tree fruit species, B deficiencies are common. Deficiency levels can be determined in the soil and leaves with standard testing. Foliar sprays are effective to manage B deficiency, however keeping soil levels within adequate range is important for root growth. Fertigation can lead to uneven distribution and toxicity (around leaks/junctions) and is not recommended. Boron mobility varies across tissue and development stages; thus, sprays need to be managed during active growth. Relevant application timings are pink to cell division and leaf drop. Excess of boron can lead to severe toxicity and application rate should be calculated carefully. Rates of actual B should not surpass 1.0 lb per acre.

Boron maintenance

Boron (B) is required in young growing tissue. In Washington and most tree fruit species, B deficiencies are common. Deficiency levels can be determined in the soil and leaves with standard testing. Foliar sprays are effective to manage B deficiency, however keeping soil levels within adequate range is important for root growth. Fertigation can lead to uneven distribution and toxicity (around leaks/junctions) and is not recommended. Boron mobility varies across tissue and development stages; thus, sprays need to be managed during active growth. Relevant application timings are pink to cell division and leaf drop. Excess of boron can lead to severe toxicity and application rate should be calculated carefully. Rates of actual B should not surpass 0.5 lbs acre.

Calcium (cracking)

Ca sprays in cherries can reduce the incidence of rain cracking. Effectiveness has been variable, as it depends on multiple environmental factors. Calcium Cloride CaCl has proven the most effective. Concentration and coverage are key factors for improved efficacy. Application timing is pre harvest during and post rain events. Note that post-harvest dipping has proven most effective for cracking (Winkler and Knoche, 2019)

Calcium deficiency

Calcium (Ca) is needed for cell wall development and strengthening, thus essential during fruit cell division stage. In Washington, soil deficiencies are rare, however given the limited mobility of Ca within the plant, fruit deficiencies might still be present. Deficiency levels in the soil and leaf can be determined with standard testing, while fruit deficiency is not well predicted with tissue testing. For Apples and Pears deficiency: Rate of 2-4 lbs of actual Ca per acre per application, from petal fall to late June. Up to 15 lbs of actual Ca per season.

Copper Deficiency

Copper (Cu) deficiencies are rare, given that several pesticides contain Cu. Deficiency levels can be determined in the soil and leaf with standard testing. Symptoms of Cu deficiency include chlorosis, leaf margin necrosis and curling. Given the low mobility of Cu in the plant, frequent applications during the growing season might be needed to overcome deficiencies

Iron deficiency

Iron (Fe) deficiencies are common in calcareous or high pH soils, also in saturated soils with lack of oxygen. Soil or leaf tissue testing are not good indicators of deficiencies, while symptoms of iron chlorosis are very distinct. Given the low mobility of Fe in the plant, frequent applications during the growing season might be needed to overcome deficiencies

Magnesium deficiency

Magnesium deficiencies are rare in Easter Washington soils, however in Western Washington or sandy soils, Mg can be leached and become deficient. Total Mg demand is low compared to other macronutrients; thus soil natural levels might be sufficient. Deficiency levels of Mg can be determined in the soil and leaves with standard testing. Most effective management of Mg is done via ground application, as it has medium mobility in soils and is mobile in plants. Foliar Mg sprays can be effective when deficiencies appear, usually in spur leaves with high crop loads. Best timing is during active fruit growth or when leaf deficiencies appear.

Nitrogen deficiency

Apply only as needed to apples or cherries. Not effective on pear or other stone fruits and can cause injury.

Zinc deficiency

Annual foliar applications are recommended in calcareous or high pH soils. Preferred timing is late dormant (stone fruit), silver-tip (apples and pears), and post-harvest (all tree fruits except for apricot). Zinc sprays should be avoided during the growing season unless deficiency symptoms occur. Zinc sulfates are common but can cause tissue damage when temperatures are greater than 85 ºF after the application. Zinc sulfate is also not compatible with dormant oil or lime sulfur. Zinc chelates are also available and are less likely to cause russet. If little leaf and/or rosette are present, use deficiency rates. The deficiency rates for Zn sulfate or Zn oxysulfate are 14 pounds actual Zn per acre (dormant timing sprays) and 9 pounds actual Zn per acre (postharvest). If sprays are applied during the growing season, use only 2 to 4 lb actual Zn as Zn sulfate or Zn oxysulfate per acre (non-bearing trees only). Because Zn deficiency is so widespread in Washington orchards, WSU recommends that Zn be applied every year in the form of Zn maintenance sprays even if little leaf or rosette are absent.

Dormant/Delayed Dormant

Nutrient Management	Chemical	Rate per Acre	Notes
Zinc deficiency	**zinc sulfate, dry, 36% Zn**	40 lb	Dormant spray only. Dissolve in hot water before adding to spray tank.
	zinc chelate or organic complex	See Label	
	basic zinc sulfate, liquid, 20-25% Zn	See Label	
	zinc sulfate, liquid, 10-12% zinc	12 gal	
Zinc deficiency, non-bearing trees	**basic zinc sulfate, dry, 50-52% Zn**	6-12 lb	Dormant spray only. Dissolve in hot water before adding to spray tank. Oil free sprays are more effective.
Zinc maintenance	**zinc sulfate, dry, 36% Zn**	6 gal	
	basic zinc sulfate, dry, 50-52% Zn	6-12 lb	Dormant spray only. Dissolve in hot water before adding to spray tank. Oil free sprays are more effective.
	zinc sulfate, liquid, 10-12% zinc	2-4 gal	
	zinc chelate or organic complex	See Label	
	basic zinc sulfate, liquid, 20-25% Zn	See Label	

Prepink/Pink

Nutrient Management	Chemical	Rate per Acre	Notes
Boron deficiency	**boric acid liquid, 10% B**	1 gal	
	boric acid, dry, 17% B	6 lb	
	sodium borate, dry, 16.5-20.5% B	5-6 lb	
Boron maintenance	**boric acid liquid, 10% B**	2 qt	
	boric acid, dry, 17% B	3 lb	
	sodium borate, dry, 16.5-20.5% B	2.5-3 lb	

Bloom

Nutrient Management	Chemical	Rate per Acre	Notes
Nitrogen and sulfur maintenance	**ammonium thiosulfate, liquid, 12%N, 25%S**	See Label	
Nitrogen deficiency	**urea**	2-10 lb	Make sure it has less than 0.25% biuret (check label).

Postbloom

Nutrient Management	Chemical	Rate per Acre	Notes
Boron deficiency	**sodium borate, dry, 16.5-20.5% B**	5-6 lb	Apply only if boron deficiency appears during growing season. Apply amount equivalent to 1. 0 pound actual B per acre.
	boric acid liquid, 10% B	1 gal	
	boric acid, dry, 17% B	6 lb	

Nutrient Management	Chemical	Rate per Acre	Notes
Boron maintenance	**sodium borate, dry, 16.5-20.5% B**	2.5-3 lb	Prepink to pink or postharvest timing is preferred. Apply amount equivalent to 0. 5 pound actual B per acre.
	boric acid liquid, 10% B	2 qt	
	boric acid, dry, 17% B	3 lb	
Calcium (cracking)	**calcium chloride, dry, 34-36% Ca**		
Calcium (pear alfalfa greening, Anjou cork spot)	**calcium chloride, dry, 34-36% Ca**	4 lb	Apply four applications from early June to August. Dilute sprays are most effective. Can cause fruit injury.
Calcium deficiency	**calcium nitrate liquid, 6-11% Ca**	1-2 qt	
	calcium chloride, liquid, 12% Ca calcium chloride, liquid, 12% Ca		
	calcium chloride, dry, 34-36% Ca	2-4 lb	
	Calcium Acetate Calcium Acetate	1-2 qt	
Copper Deficiency	**copper chelate or organic complex**		Follow manufacturer's label. May be incompatible with calcium chloride. Can cause fruit injury.
	basic copper sulfate, liquid		
Iron deficiency	**iron sulfate (5% Fe)**	See Label	
	iron chelate or organic complex	See Label	
Magnesium deficiency	**magnesium chelate or organic complex**		Apply in June. Repeat in July if necessary. Do not apply after August 1. Follow manufacturer's label for labeled product rates.
	magnesium sulfate		Apply in June. Repeat in July if necessary. Do not apply after August 1. Follow manufacturer's label for labeled product rates.
	magnesium nitrate 0.4LC	6-12 gal	
	magnesium nitrate, dry, 13.5% Mg	20-40 lb	
Nitrogen deficiency	**urea**	2-10 lb	Apply only as needed to apples or cherries. Not effective on pear or other stone fruits and can cause injury.
Zinc deficiency	**basic zinc sulfate, dry, 50-52% Zn**		
Zinc deficiency, bearing trees	**zinc chelate or organic complex**		Follow manufacturer's label.

Nutrient Management	Chemical	Rate per Acre	Notes
Zinc deficiency, non-bearing trees	**basic zinc sulfate, dry, 50-52% Zn**	6-12 lb	Dormant spray only. Dissolve in hot water before adding to spray tank. Oil free sprays are more effective.
	basic zinc sulfate, liquid, 20-25% Zn	See Label	
	zinc chelate or organic complex	See Label	
	zinc sulfate, dry, 36% Zn	6-12 lb	Can cause injury, particularly on stone fruits. Follow manufacturer's label for labeled products.
	zinc sulfate, liquid, 10-12% zinc	2-4 gal	Can cause injury, particularly on stone fruits. Follow manufacturer's label for labeled products.
Zinc maintenance	**zinc sulfate, dry, 36% Zn**	6 gal	

Fall

Nutrient Management	Chemical	Rate per Acre	Notes
Boron deficiency	**boric acid liquid, 10% B**	10 lb	
	sodium borate, dry, 16.5-20.5% B	5-7 lb	
Calcium deficiency	**calcium nitrate fertilizer grade**	14 lb	
Nitrogen deficiency	**urea**	17-22 lb	Make sure it has less than 0.25% biuret (check label).
	calcium nitrate, dry 15.5% N	14 lb	See label.
Zinc deficiency	**zinc sulfate, liquid, 10-12% zinc**	2-4 gal	
	zinc sulfate, dry, 36% Zn	6-12 lb	

See General Recommendations for guidelines on table use. Read all product labels carefully.

Table 1. Recommended soil test levels and testing methods for tree fruit.

Soil test	Unit	Low	Optimal	Excessive	Method[a]
Soil test	**Unit**	**Low**	**Optimal**	**Excessive**	**Method[a]**
pH	–	< 5.0	6.0 – 7.5	> 8.0	1:1 /CaCl

Soil test	Unit	Low	Optimal	Excessive	Method[a]
Soil test	**Unit**	**Low**	**Optimal**	**Excessive**	**Method[a]**
E.C paste	mmhos/cm	–	< 2.6	> 4	Paste
E.C 1:2.5 or 1:1	mmhos/cm	–	< 0.5	> 1	1:1
P-Olsen[b]	ppm	< 10	15 – 40	> 50	$NaHCO_3$
Potassium (K)	ppm	< 120	150 – 250	> 300	NH_4OAc
Potassium (K)	meq/100g	< 0.3	0.4 – 0.6	> 0.7	NH_4OAc
Calcium (Ca)	meq/100g	< 3.0	4.1 – 20		NH_4OAc
Magnesium (Mg)	meq/100g	< 0.5	0.5 – 2.5	> 2.5	NH_4OAc
Sodium (Na)	meq/100g		< 0.5	> 0.5	NH_4OAc
Boron (B)	ppm	< 1.0	1.0 – 1.5	> 1.5	CaCl 0,01 mol/L
Sulfur (S)[c]	ppm	< 4	9 – 20	> 20	$Ca3(PO_4)2$
Zinc (Zn)	ppm	< 0.25	0.6 – 1.0		DTPA
Copper (Cu)	ppm	< 0.1	0.6 – 1.0	> 20	DTPA
Manganese (Mn)	ppm		1 – 5	> 50	DTPA
Iron (Fe)[d]	ppm	> 4.5	–	–	DTPA
	ppm		0.11 – 0.20	–	DTPA

Table 2. Leaf tissue standards for recently mature leaves in different tree fruit species

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Nutrient	**Unit DW**	**Apple[a,c,d,e]**	**Pear[a,c,d,e]**	**Cherry[b]**	**Peach[b]**	**Apricots[a,b]**
Nitrogen (N)	%	1.7 – 2.5	1.8 – 2.6	2.00 – 3.03	2.7 – 3.5	2.4 – 3.3
Phosphorous (P)	%	0.15 – 0.3	0.12 – 0.25	0.10 – 0.27	0.1 – 0.30	0.1 – 0.3
Potassium (K)	%	1.2 – 1.9	1.0 – 2.0	1.20 – 3.3	1.2 – 3.0	2.0 – 3.5
Calcium (Ca)	%	1.5 – 2.0	1.0 – 3.7	1.20 – 2.37	1.0 – 2.5	1.10 – 4.00
Magnesium (Mg)	%	0.25 – 0.35	0.25 – 0.90	0.30 – 0.77	0.25 – 0.50	0.25 – 0.80
Sulfur (S)	%	0.01 – 0.10	0.01 – 0.03	0.20 – 0.40	0.2 – 0.4	0.20 – 0.40
Copper (Cu)	mg/Kg	5 – 12	6 – 20	0 – 16	4 – 16	4 – 16
Zinc (Zn)	mg/Kg	15 – 200	20 – 60	12 – 50	20 – 50	16 – 50
Manganese (Mn)	mg/Kg	25 – 150	20 – 170	17 – 160	20 – 200	20 – 160
Iron (Fe)	mg/Kg	60 – 120	100 – 800	57 – 250	120 – 200	60 – 250
Boron (B)	mg/Kg	20 – 60	20 – 60	17 – 60	20 – 80	20 – 70

Table 3. Nutrient extraction in pounds of element per ton of fruit harvested.

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Crop	**Nitrogen (N) Lbs/ Ton**	**Phosphorous (P) Lbs/ Ton**	**Potassium (K) Lbs/ Ton**	**Calcium (Ca) Lbs/ Ton**	**Magnesium (Mg) Lbs/ Ton**
Apple	0.9 – 2.1	0.2 – 0.4	2.0 – 3.9	0.1 – 0.3	0.1 – 0.2
Green apple	3.1	0.4	3.4	–	–
Apricot	8.3 – 11	1.3	6.6	–	–

Edit					
Crop	**Nitrogen (N) Lbs/ Ton**	**Phosphorous (P) Lbs/ Ton**	**Potassium (K) Lbs/ Ton**	**Calcium (Ca) Lbs/ Ton**	**Magnesium (Mg) Lbs/ Ton**
Cherry	1.9 – 5.0	0.5 – 0.9	2.9 – 6.3	0.3 – 0.4	0.2 – 0.4
Peach	4.5 – 12	1.2	8.1	–	–
Pear	1.3 – 2.7	0.6	3.0	–	–

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