Exploration of Potassium Fertilization Timing and Sources: Attaining Optimal Leaf Potassium Levels and Cost Reduction for Growers

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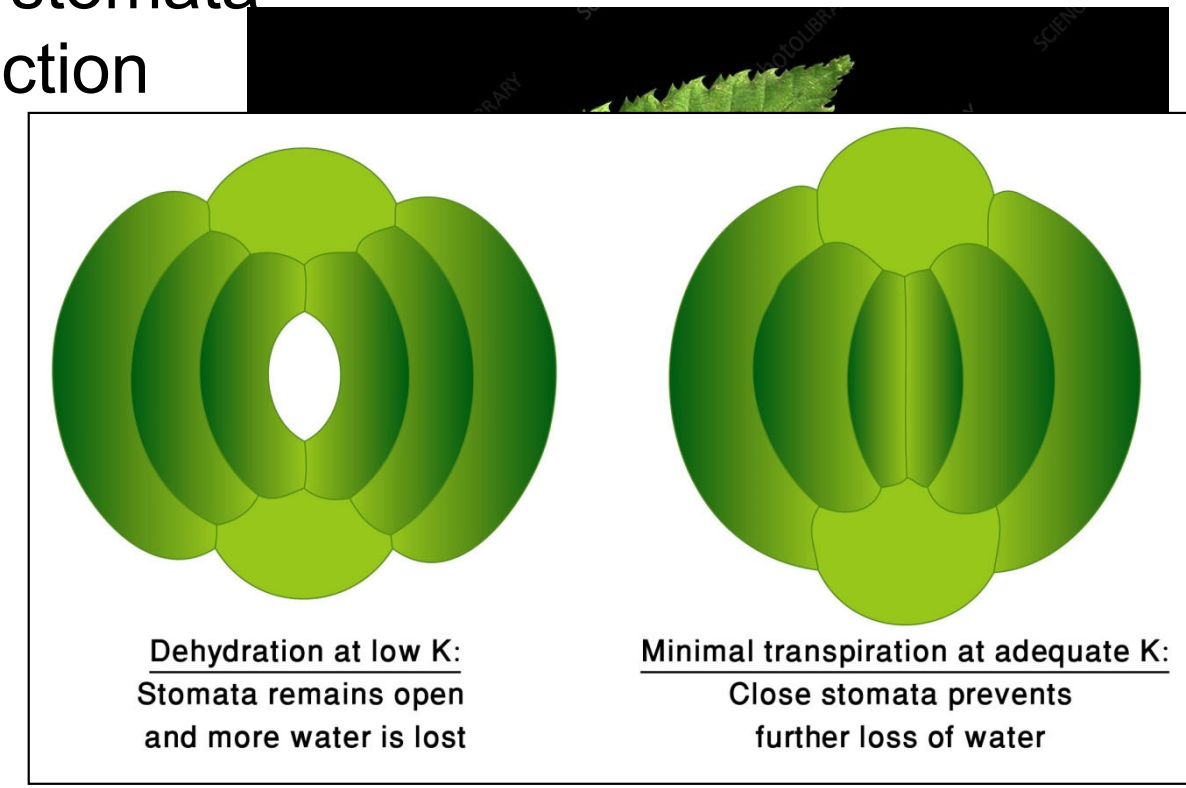
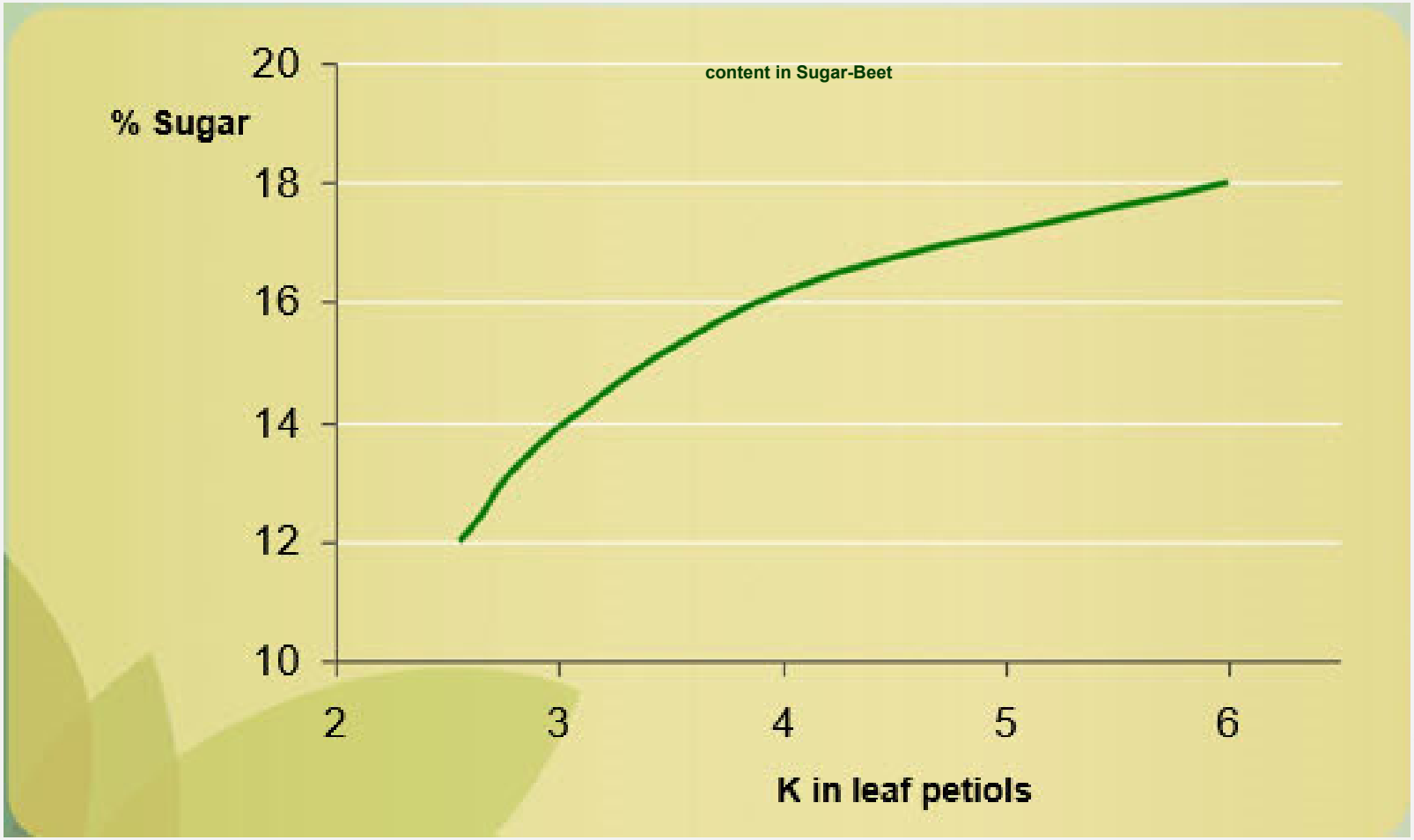
Potassium (K) in the plant

- Necessary for formation of sugars and starch
- Regulates opening of leaf stomata
- Activator of enzymatic reaction
- Maintains turgor
- Build cell walls



Source: Marschner 2011

Relation between K in petiols and sugar content in Sugar-Beet



Source: Haifa

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Potassium (K) in the plant

Due to its roles in many plant systems, potassium improves plant durability and improves yield quality:

- Improved drought resistance
- Increased winter hardiness
- Better disease resistance
- Improved yield quality
- Longer storage life

Symptoms of K deficiency

Source: Marschner 2011

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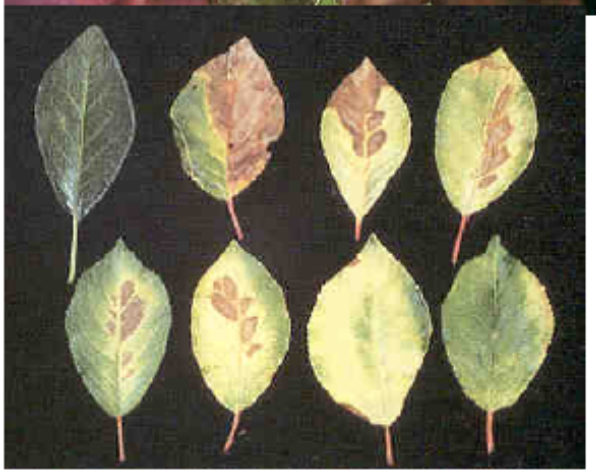
Potassium Deficiency in Prune:

Potassium Deficiency

Apple



Prune

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Potassium in Soils

- Soils may contain as much as 20,000 lb/A total K, or more.
- Most of this K is held in undissolved minerals (1°)
- Only a small amount of K is plant available during the growing season.

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Potassium is required in large amounts by many crops

Crop	Yield level/ac	K_2O taken up in total crop, lb
Prunes	**3 dry ton**	**90**
Almonds	3,000 lbs	270
Corn	160 bu	213
Tomato	35 tons	200
Wheat	60bu	122
Cotton (lint)	1,000 lb	85

K is required by a prune crop in the highest amount of any mineral nutrient

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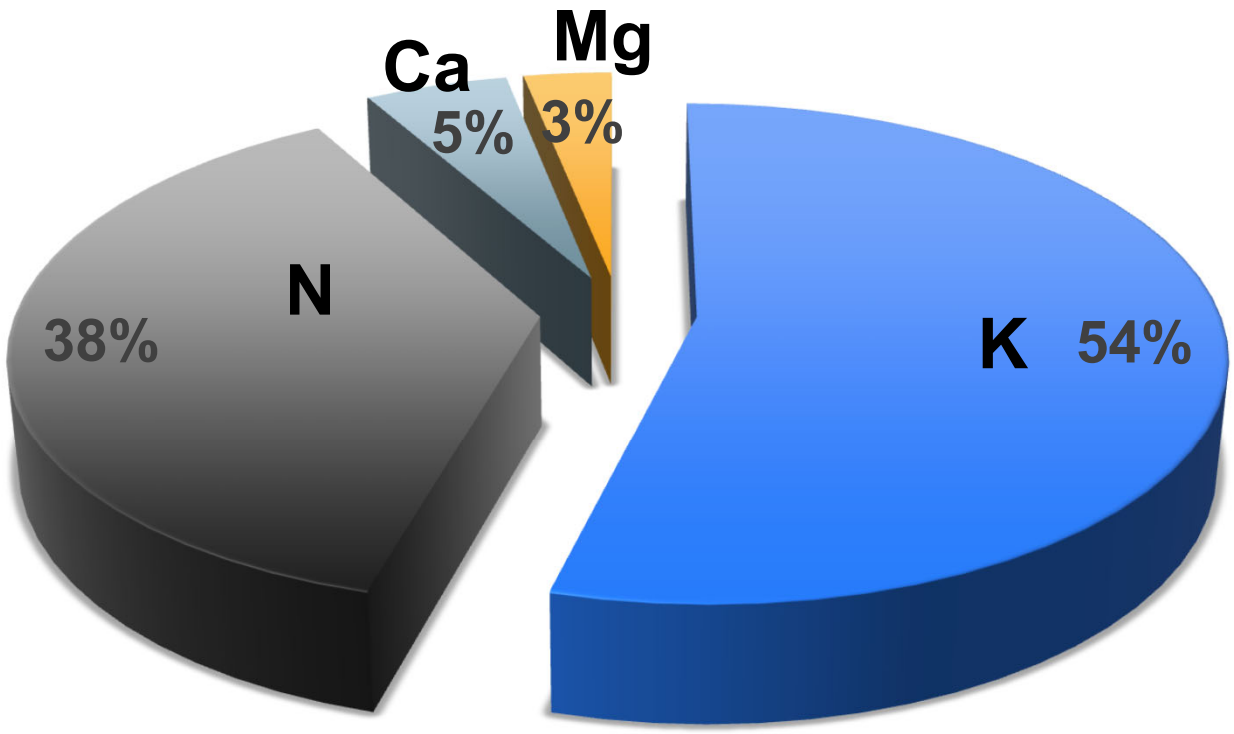
Macronutrient Composition in Prune Fruit



The prune fruit contains:
70% of total tree K
Prune fruit and leaves contain
89 % of total plant K

Source: Weinbaum et al., 1994

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K Fertilization 3rd Most Expensive pre-harvest cost

	Cash and Labor Costs per Acre					Total
	Labor	Fuel	Lube &	Material	Custom/	Annual
Operation	Cost	Costs	Repairs	Cost	Rent	Cost
Cultural:						
Irrigation Operation	67	0	0	500	0	567
Pruning & Sucker (Alt. Years)	0	0	0	0	378	378
Prune: Top Mechanical (Alt. Years)	0	0	0	0	30	30
Brush Disposal	13	10	5	0	0	28
Fertigate: (UAN 32) 3x	0	0	0	146	0	146
Fertigate: Potassium 3x	**0**	**0**	**0**	**294**	**0**	**294**

Source: UC Cost Studies

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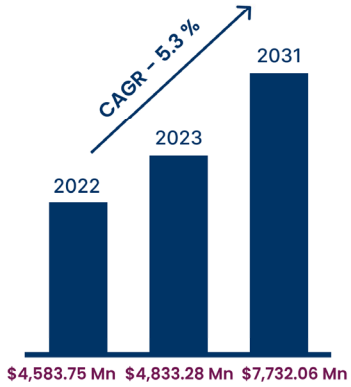
Potash Demand & Price Increasing

Potash Price Increasing

World Demand for Potassium Sulfate Increasing



Base Year :	2022
Forecast Period :	2023 - 2031
CAGR :	5.3 %
Market Value (2022) :	$4,583.75 Mn
Market Value (2023) :	$4,833.28 Mn
Market Value (2031) :	$7,732.06 Mn

Key Players :

- K+S Aktiengesellschaft
- SESODA CORPORATION
- Sigma-Aldrich Co.
- HOLLAND COMPANY
- Yara International ASA
- Van Iperen
- Merck KGaA
- Sunway Group
- K+S Minerals
- Tessenderlo Group

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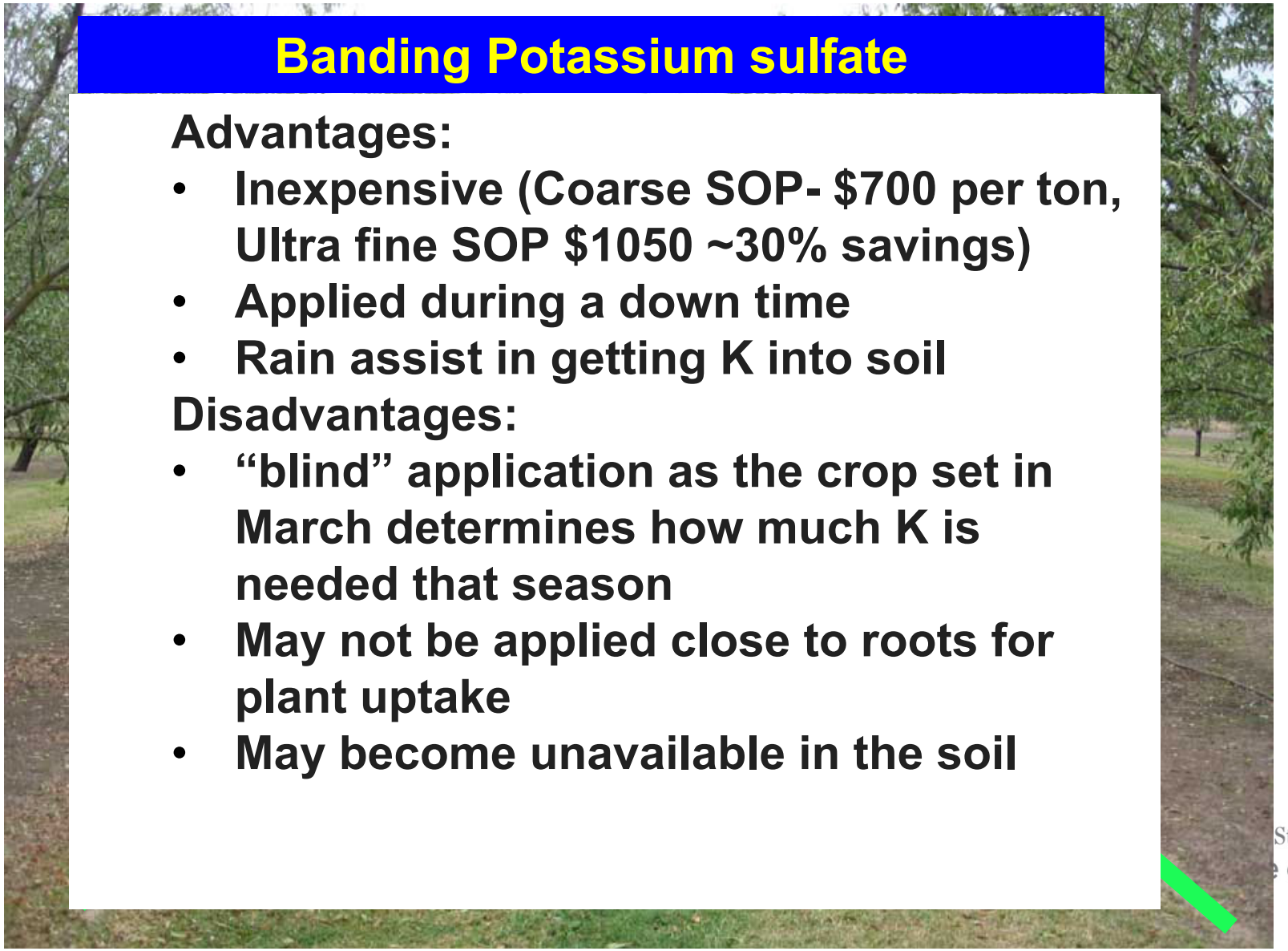
Current K Fertilizer Recommendations for Prune

:

1. Winter Application: banded soil applied K fertilizer (500-600 lbs SOP/acre)
2. In-season Application: Fertigated K at roughly half the winter rates;
3. Some combination of soil and foliar applied K fertilizer



Banding Potassium sulfate

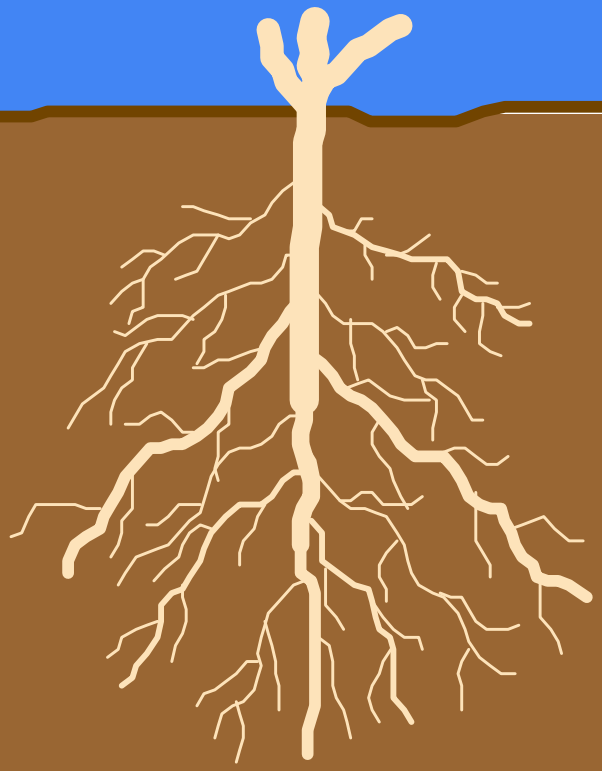
Advantages:

- Inexpensive (Coarse SOP- $700 per ton, Ultra fine SOP $1050 ~30% savings)
- Applied during a down time
- Rain assist in getting K into soil

Disadvantages:

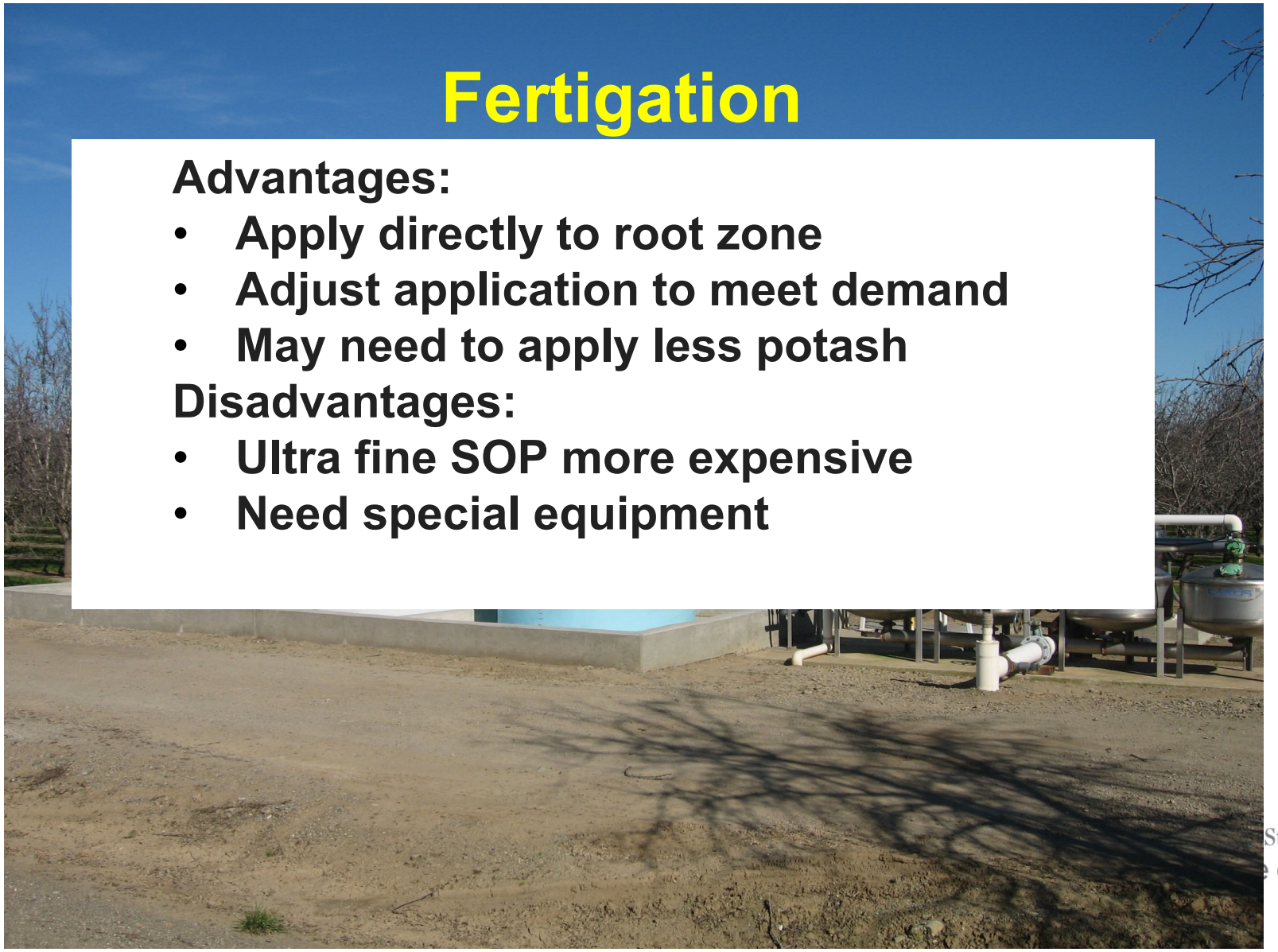
- “blind” application as the crop set in March determines how much K is needed that season
- May not be applied close to roots for plant uptake
- May become unavailable in the soil

Fate of Fertilizer K in the Soil



- Held in exchangeable form
- Remains in soil solution
- Move to roots largely by diffusion.
- Taken up by growing crop
- Leached in sandy or organic soils
- Fixed (unavailable or slowly available) by clays or silts of certain mineralogy.

Fertigation



Advantages:

- Apply directly to root zone
- Adjust application to meet demand
- May need to apply less potash

Disadvantages:

- Ultra fine SOP more expensive
- Need special equipment

Objectives

1. To evaluate the efficacy of in-season SOP applications in comparison to traditional fall applications
2. To evaluate different rates and timings for K application with the goal of maintaining adequate July leaf K levels.
3. To evaluate applied Rubidium (Rb) uptake (tracer for K) into the leaves applied at different periods during the season

The research seeks to determine if adjusting the timing of potassium application improve K uptake into the leaves and reduce costs for growers

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Objective 1: To evaluate the efficacy of in-season K applications in comparison to traditional fall application

Experimental Design:
Randomized complete block of five replications, set up at a grower's field. The four treatments will consist of 10 trees per treatment for a total of 200 trees.

Treatments:

1. untreated control (grower willing)
2. 600 lbs/a SOP in winter (dry, banded on soil) ($306/a)
3. 250 lbs/a SOP in winter (dry, banded on soil) ($127/a)
4. 600 lbs/a SOP in mid-April (dry, banded on soil)

Data Collection

- 100 leaf samples will be taken in early June, early July, and early August on fruiting and non-fruiting branches
- Samples will be analyzed for the percentage of K in the tissue at UC Davis Analytical Laboratory

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Objective 2: To evaluate different rates and timings for K application with the goal of maintaining adequate July leaf K levels.

Experimental Design: RCB with 4 replications. Treatments consist of 10 trees per treatment for a total of 320 trees. Potassium will be applied along drip hose or under microsprinkers to mimic K injection

Treatments:

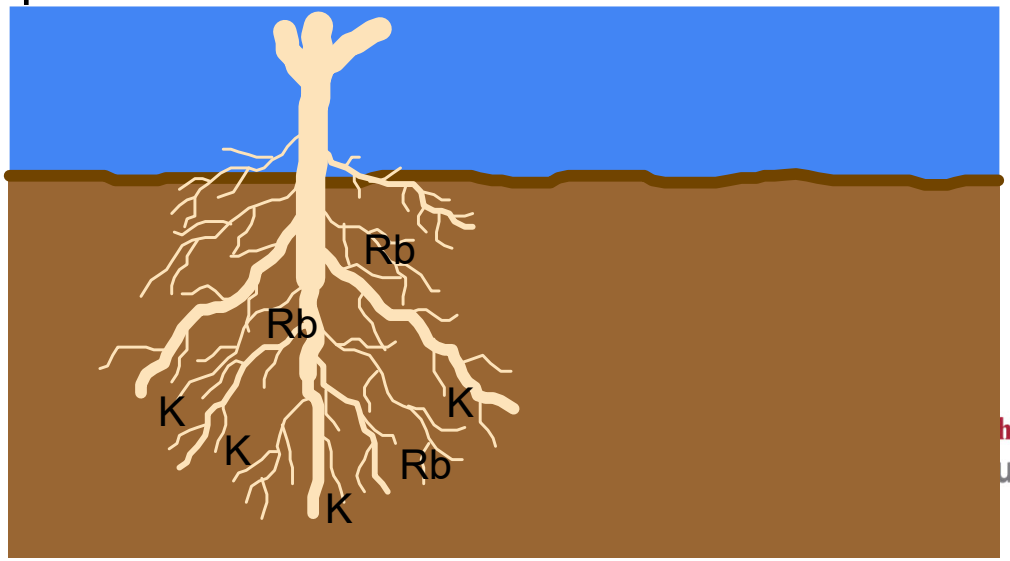
1. 250 lbs SOP/a as dissolved ultra-fine SOP in four applications
    a. April 15,
    b. May 15,
    c. June 15,
    d. July 15

Data Collection

- 100 leaf samples will be taken in early June, early July, and early August on fruiting and non-fruiting branches
- Leaves will be dried & Samples will be analyzed for the percentage of K in the tissue at UC Davis Analytical Laboratory

Why use Rubidium?

- Possesses similar chemical affinities as K
- Serves as a surrogate for K. While not precisely mimicking potassium's functional role in plant physiology, rubidium demonstrates non-toxicity, cost-effectiveness, and comparable mobilization within plant tissues.
- This methodology aids in elucidating the potassium uptake dynamics within the prune tree.



Objective 3: To evaluate Rb uptake into leaves applied at different periods during the season

Experimental Design: RCB with 4 replications. Treatments consist of 2 trees per treatment for a total of 64 trees. Rubidium will be applied along drip hose or under microsprinkers to mimic K injection

Treatments:

1. 25 g of $RbNO_3$ will be applied along drip hose or under microsprinkers to two trees in four
    a. April 15,
    b. May 15,
    c. June 15,
    d. July 15

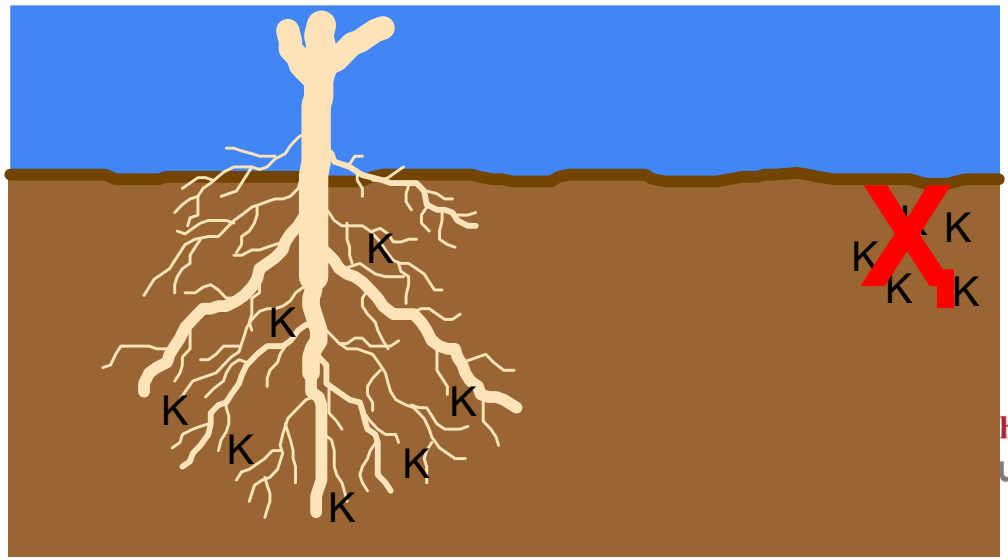
Data Collection

- 100 leaf samples will be taken in early June, early July, and early August on fruiting and non-fruiting branches
- Leaves will be dried & samples will be analyzed for the percentage of Rb in the tissue at UC Davis Analytical Laboratory

Desired Results:

By investigating the efficacy of in-season potassium vs Fall applications and using Rb as a tracer for K, this study endeavors to improve our understanding of the timing and source of K uptake to:

a. maintain adequate K in the fruit and
b. ↓ costs



Questions?

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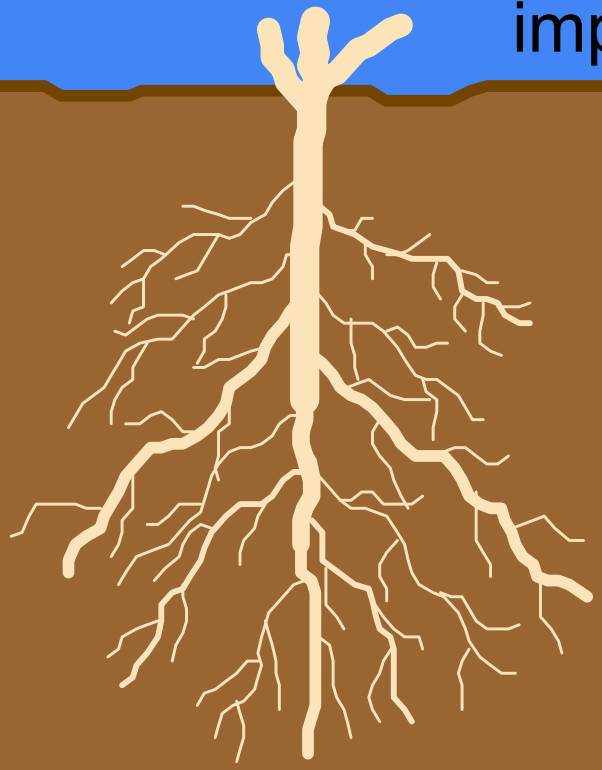
Certain Soil Stresses Warrant Placement of K in Root Zone to improve plant K availability



- **Cold soils**
- **Compacted soils**
- **Dry soils**
- **High CEC soils**
- **Weathered igneous parent material**

Current K Fertilizer Recommendations

:

1. Winter Application: (banded soil applied K fertilizer 400-500 lbs 0-0-50 or 0-0-60)
2. In-season Application: Fertigated K at roughly half the winter rates;
3. Some combination of soil and foliar applied K fertilizer in-season; or
4. Foliar fertilization, only. Foliar applied potassium nitrate effectively replaced winter banded K fertilizer in a four year UC research project, but at least 4 to 5 sprays (20-25 lbs KNO3/acre for each spray) were applied from April to early August. Banded, soil applied K fertilizer is more slowly available to the tree than in-season fertigated K.

•• Is required by a prune crop in the highest amount of any mineral nutrient – 23-25 lbs K2O/dry ton.

K deficiency in cotton

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K deficiency in pears

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Factors Reducing Rate of Diffusion and Root Growth Impact K Uptake

- Soil aeration
- K fixation
- Cation Exchange Capacity (CEC)
- Compaction

- Soil test K
- Soil temperature
- Soil moisture

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Rubidium as a Tracer for K

“Rubidium is frequently used as a tracer of K+ in plants and soils. However, uptake of Rb+ from soils by plants … is influenced by soil acidity.” (Tyler., 1997)

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