Improved Methods for Nutrient Tissue Testing in Alfalfa

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Largest acreage crop in California

- Important component of California's fertilizer and agricultural footprint
- Most limiting nutrients for alfalfa production in California are phosphorus followed by potassium, and sulfur
- Occasionally in the Intermountain boron and molybdenum
- Despite the importance of fertility management, many alfalfa growers do not assess the fertility status of fields
  - Fertilizer practices often based on past practices
  - Costly in terms of lost production or high fertilizer costs

Favorite Quote

“Last time I fertilized there was a government subsidy program to help pay for the fertilizer.”

“At that time I wasn’t sure it was worth it because when we fertilized, I had to spend so much more for baling wire”

Deficiency Symptoms

Nutrient Deficiency Symptoms in Alfalfa

Nutrient	Deficiency Symptoms
Nitrogen	Generally yellow, stunted plants.
Phosphorus	Stunted plants with small leaves; sometimes leaves are dark blue-green.
Potassium	Pinhead-sized yellow or white spots on margins of leaves: on more mature leaves, yellow turning to brown leaf tips and edges.
Sulfur	Generally yellow, stunted plants.
Molybdenum	Generally yellow, stunted plants.

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Diagnosing Nutrient Deficiencies in Alfalfa

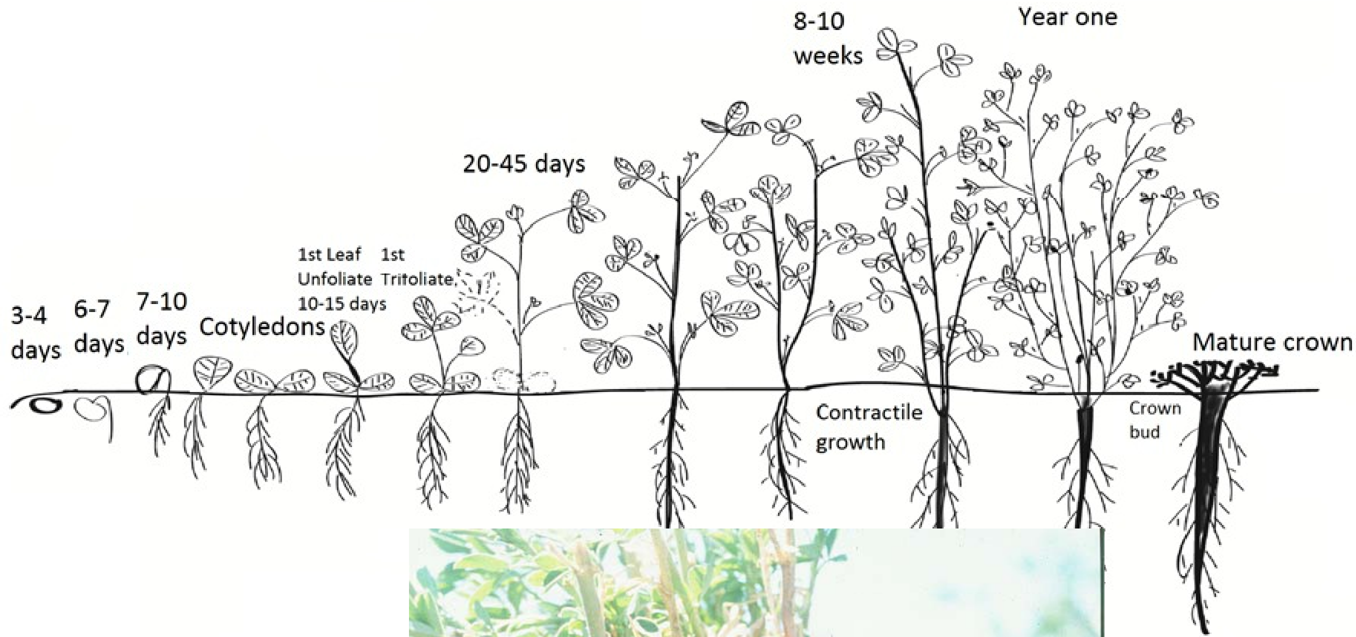
Visual Observation

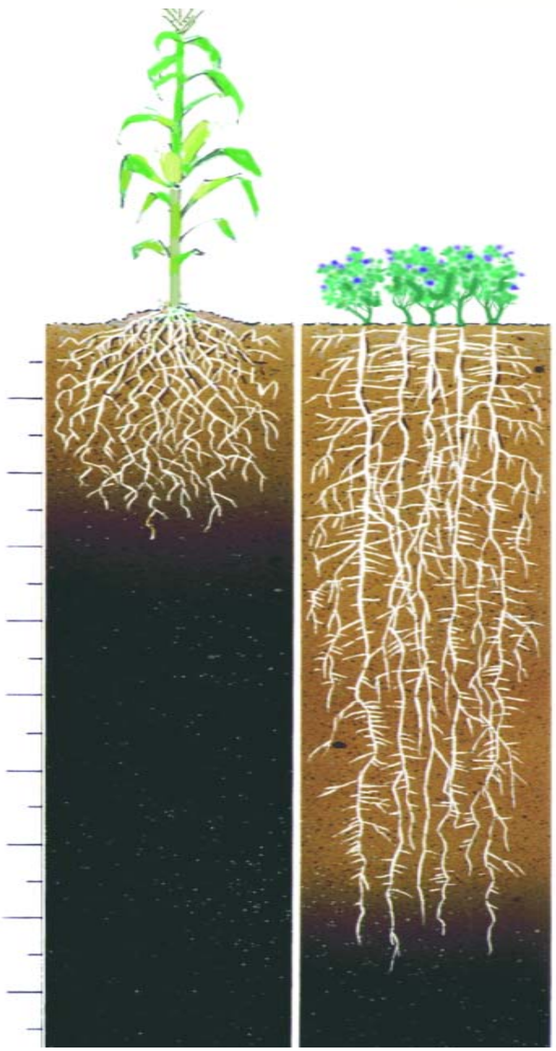
Soil Testing

Soil Test Interpretation

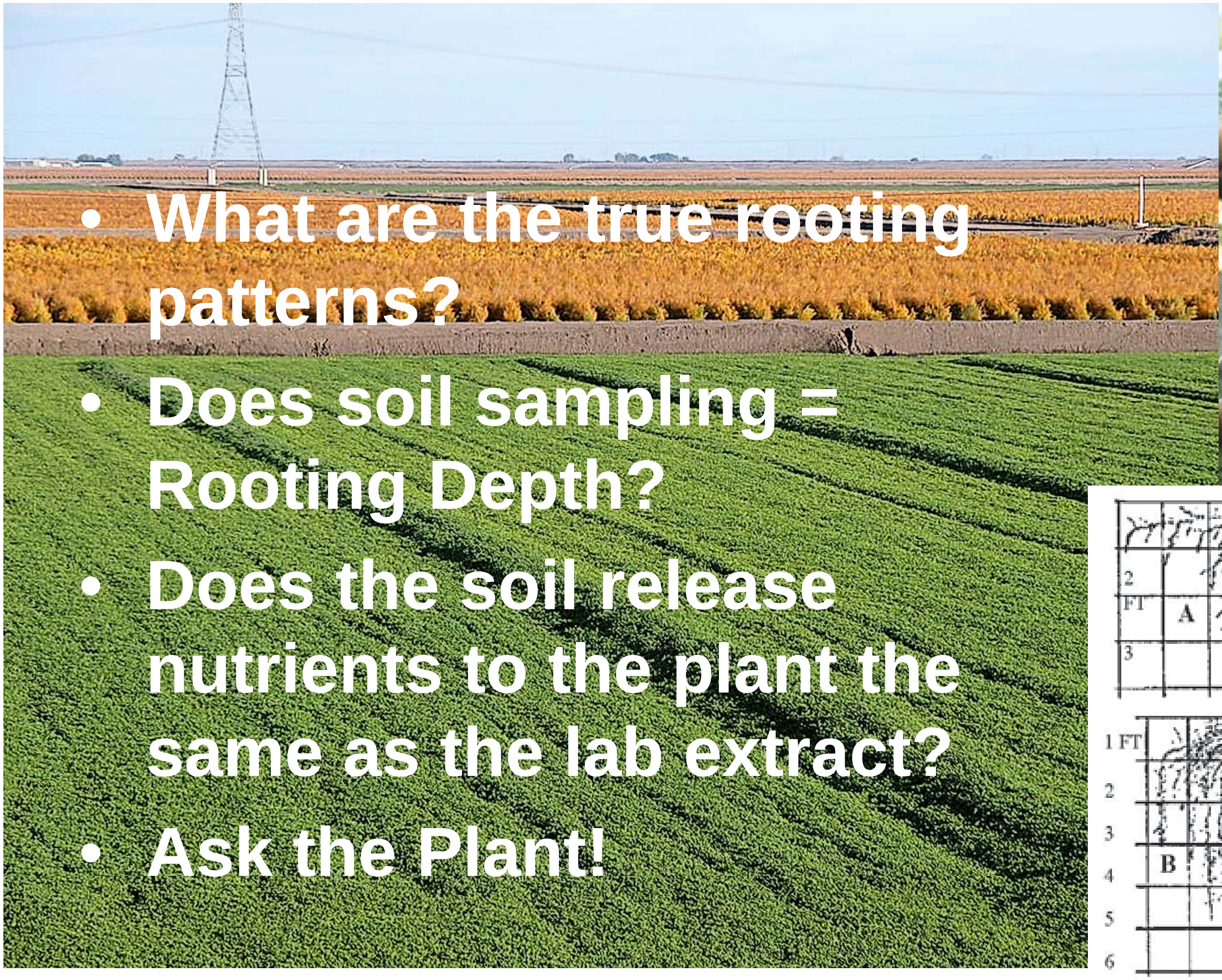
	SOIL VALUE (ppm)			
NUTRIENT	**DEFICIENT**	**MARGINAL**	**ADEQUATE**	**HIGH**
Phosphorus	<5	5-10	10-20	>20
Potassium ammon.acetate	<40	40-80	80-125	>125
Potassium Sulfuric acid	<300	300-500	500-800	>800
Boron	<0.1	0.1-0.2	0.2-0.4	>0.4

Where are the Roots?

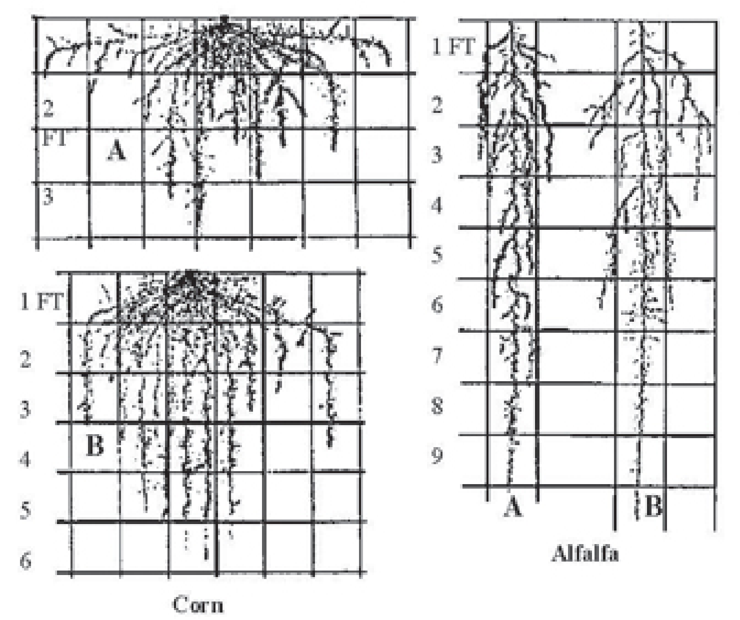




Soil samples are useful but….



- What are the true rooting patterns?
- Does soil sampling = Rooting Depth?
- Does the soil release nutrients to the plant the same as the lab extract?
- Ask the Plant!

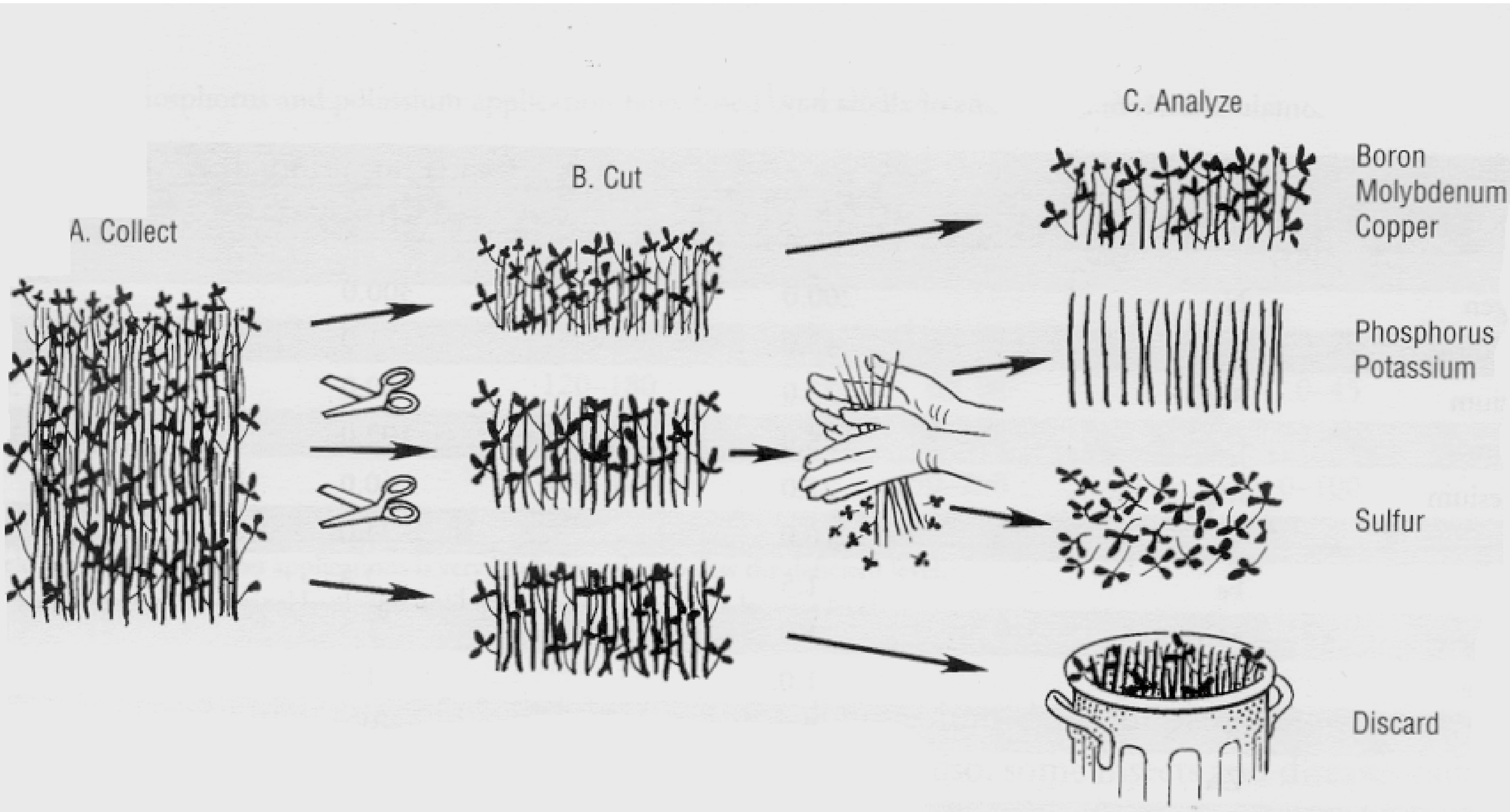


Relative Reliability of Soil and Plant Tissue Tests

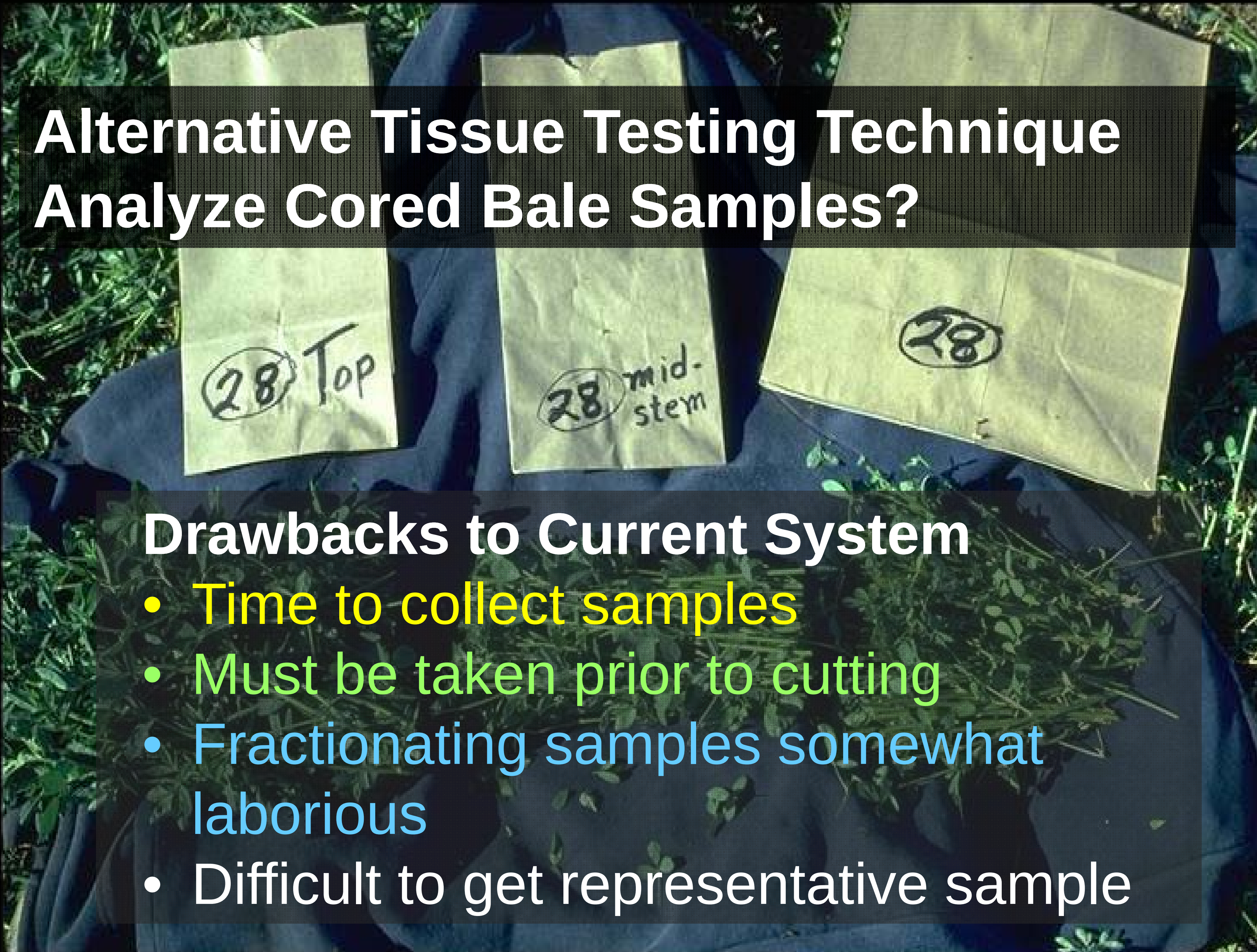
Nutrient	Symbol	Soil Testing	Plant Tissue
Phosphorus	P	**Good**	**Excellent**
Potassium	K	**Good**	**Excellent**
Sulfur	S	**Very Poor**	**Excellent**
Boron	B	**Poor***	**Excellent**
Molybdenum	Mo	Not Done	**Excellent**

*Good for evaluating toxicity of boron

Traditional UC Recommended Plant Tissue Testing

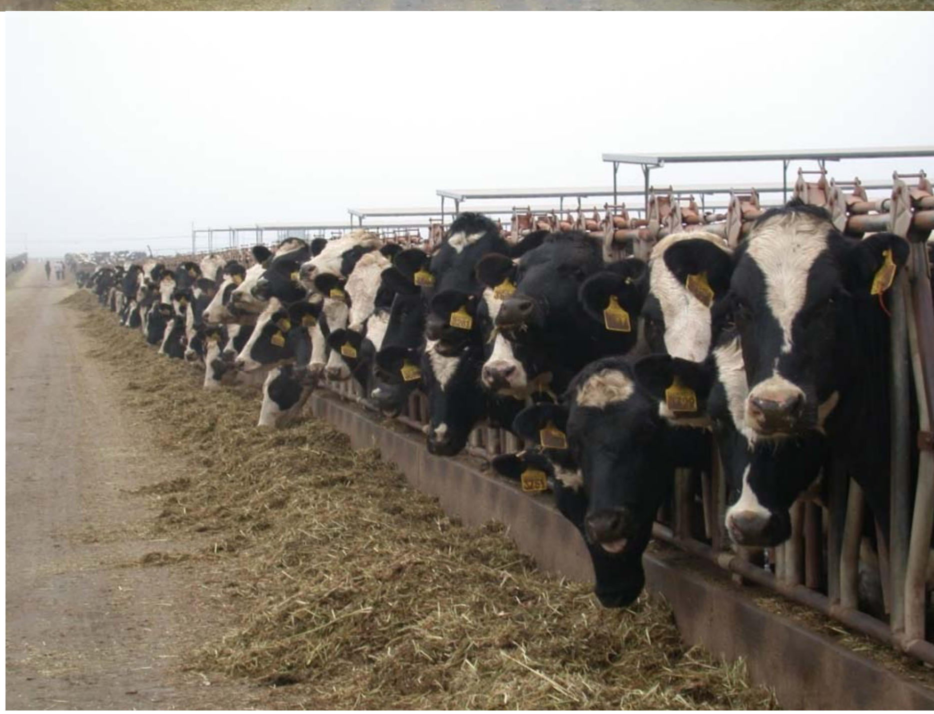


Alternative Tissue Testing Technique
Analyze Cored Bale Samples?



Drawbacks to Current System

- Time to collect samples
- Must be taken prior to cutting
- Fractionating samples somewhat laborious
- Difficult to get representative sample

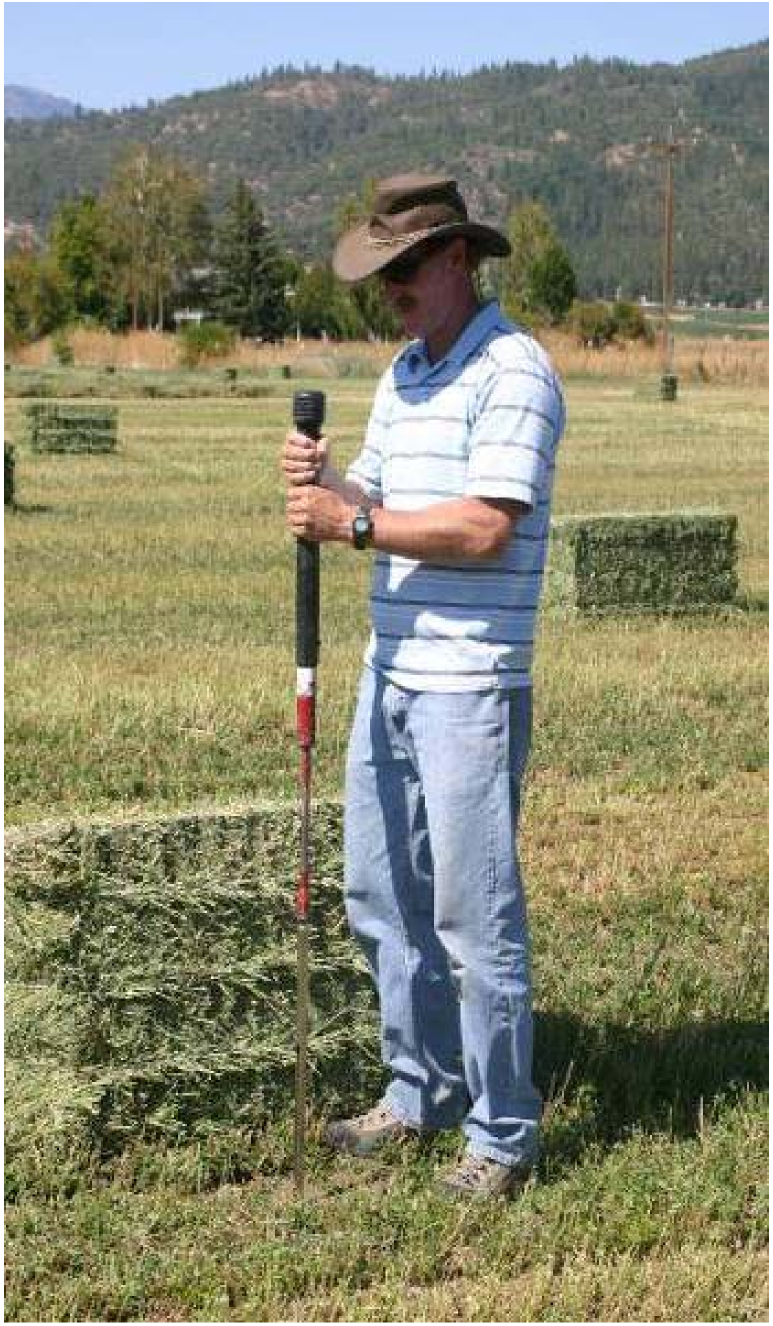


- Over 70% of the alfalfa hay used by dairies
- Average 2013 dairy cow produces >70% more milk than a cow in 1970, and dairies have demanded higher quality forage as a result
- Could the same sample used for FQ be used for nutrient analysis?

Two samples collected from area of each swath

One fractionated and one left as whole tops

Bales from each windrow cored before removed from field



Soil samples taken along each windrow

(15 to 20 cores)

Compare results from fractionated tops, whole tops, cored bales, soil samples

Average of 117 samples over 2 years

Siskiyou and Lassen Counties

	Soil		
	pH	Olsen P ppm	K ppm
Average	**7.2**	**17.1**	**192**
Deficient		<5	<40
Marginal		5–10	40-80
Adequate		10–20	80-125
High		>20	>125

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High		>20	>125
Low	5.6	2.0	25
High	8.1	74.7	632

Average of 117 samples over 2 years

Siskiyou and Lassen Counties

	Mid-Stems		Mid-Stem Leaves
	PO_4-P ppm	K %	SO_4-S ppm
Average	**1327**	**2.03**	**2390**
Deficient	300–500	0.4–0.65	<400
Marginal	500–800	0.65–0.80	400-800
Adequate	800–1500	0.80–1.50	800–1000
High	>1500	>1.50	>1000

Average of 117 samples over 2 years

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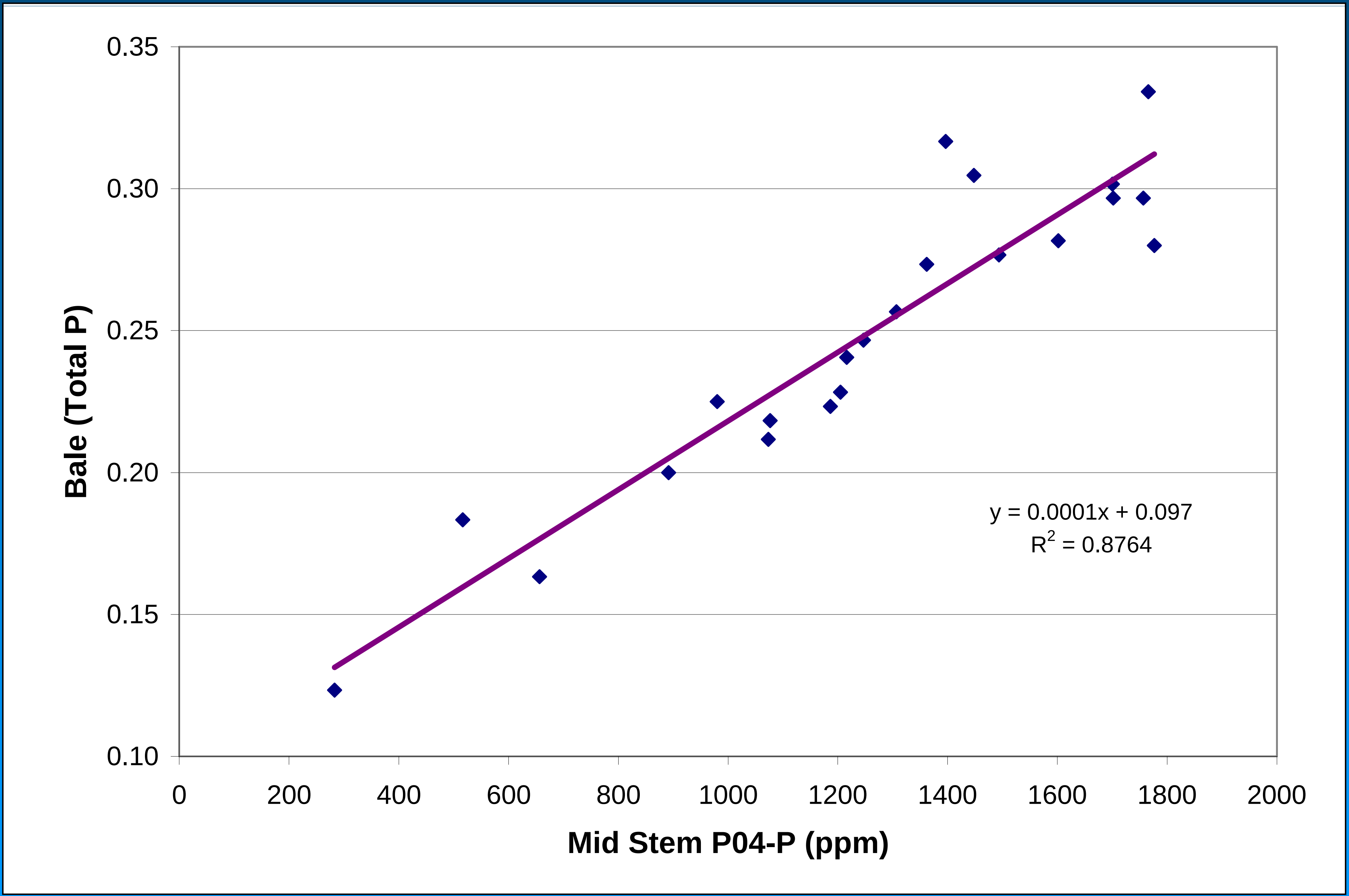
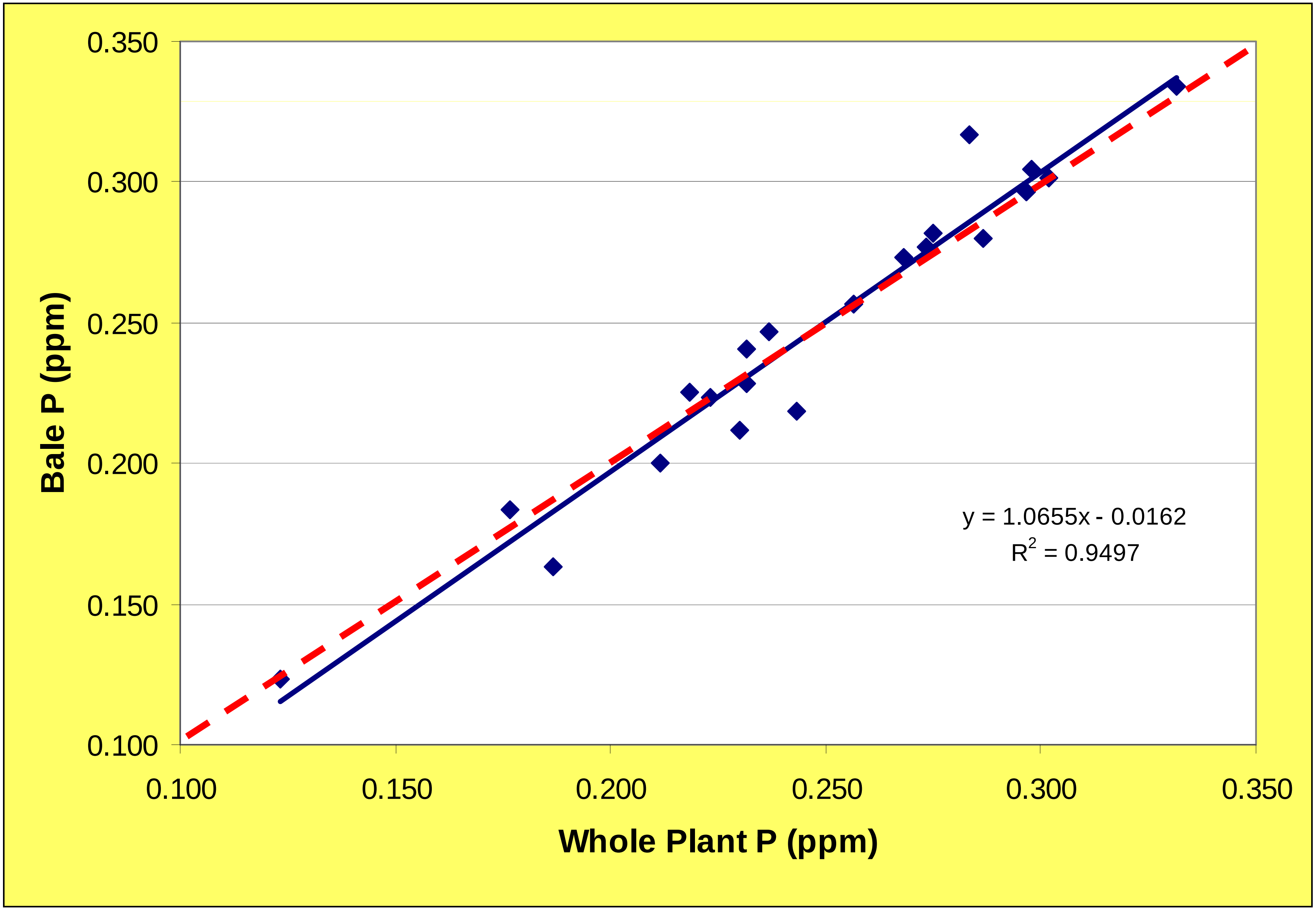
Deficient	300–500	0.4–0.65	<400
Marginal	500–800	0.65–0.80	400-800
Adequate	800–1500	0.80–1.50	800–1000
High	>1500	>1.50	>1000
Low	230	0.74	180
High	2220	4.18	5350

Mid-Stem PO_4-P vs. Bale Total P

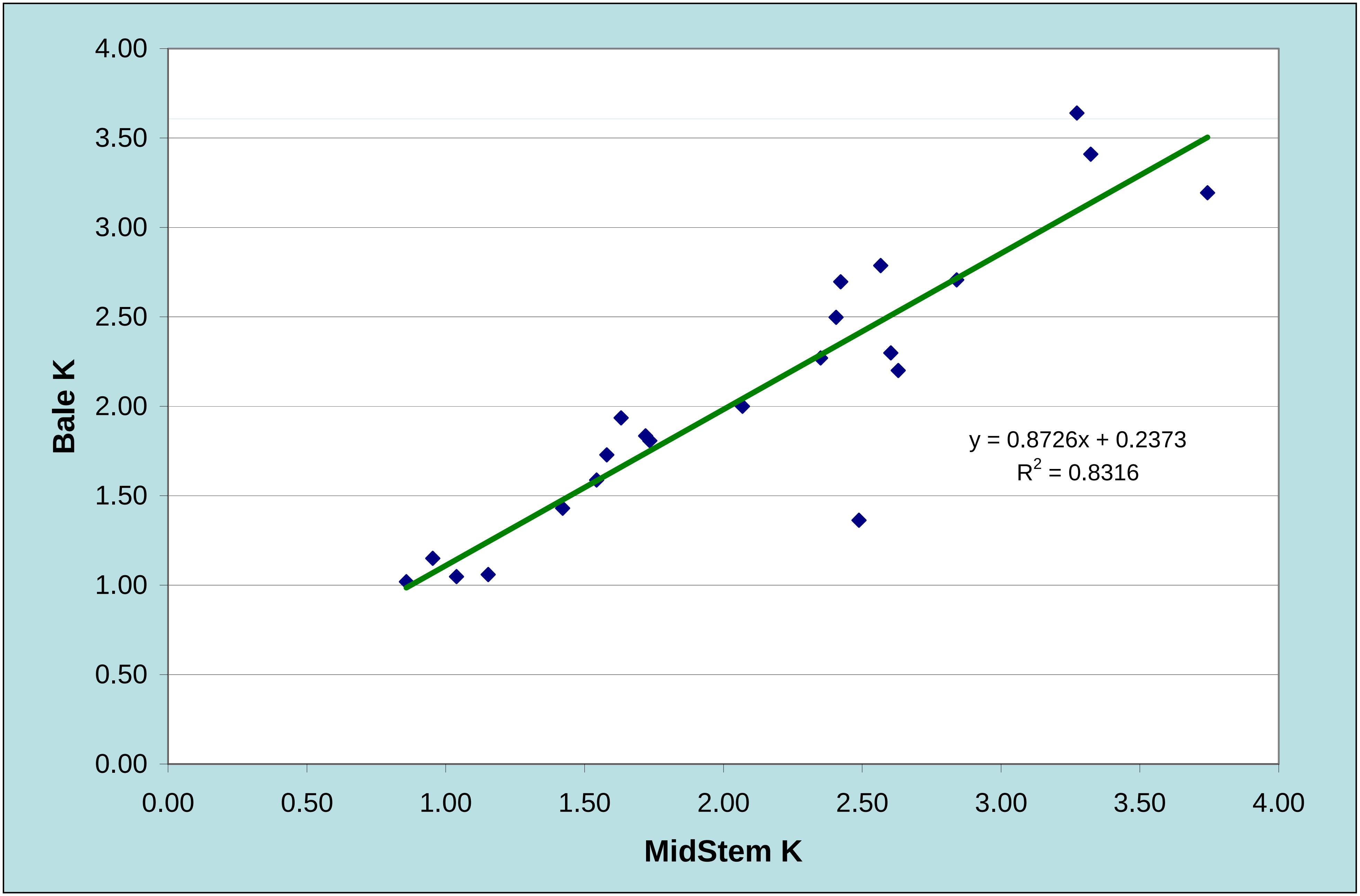


Concern over leaf loss

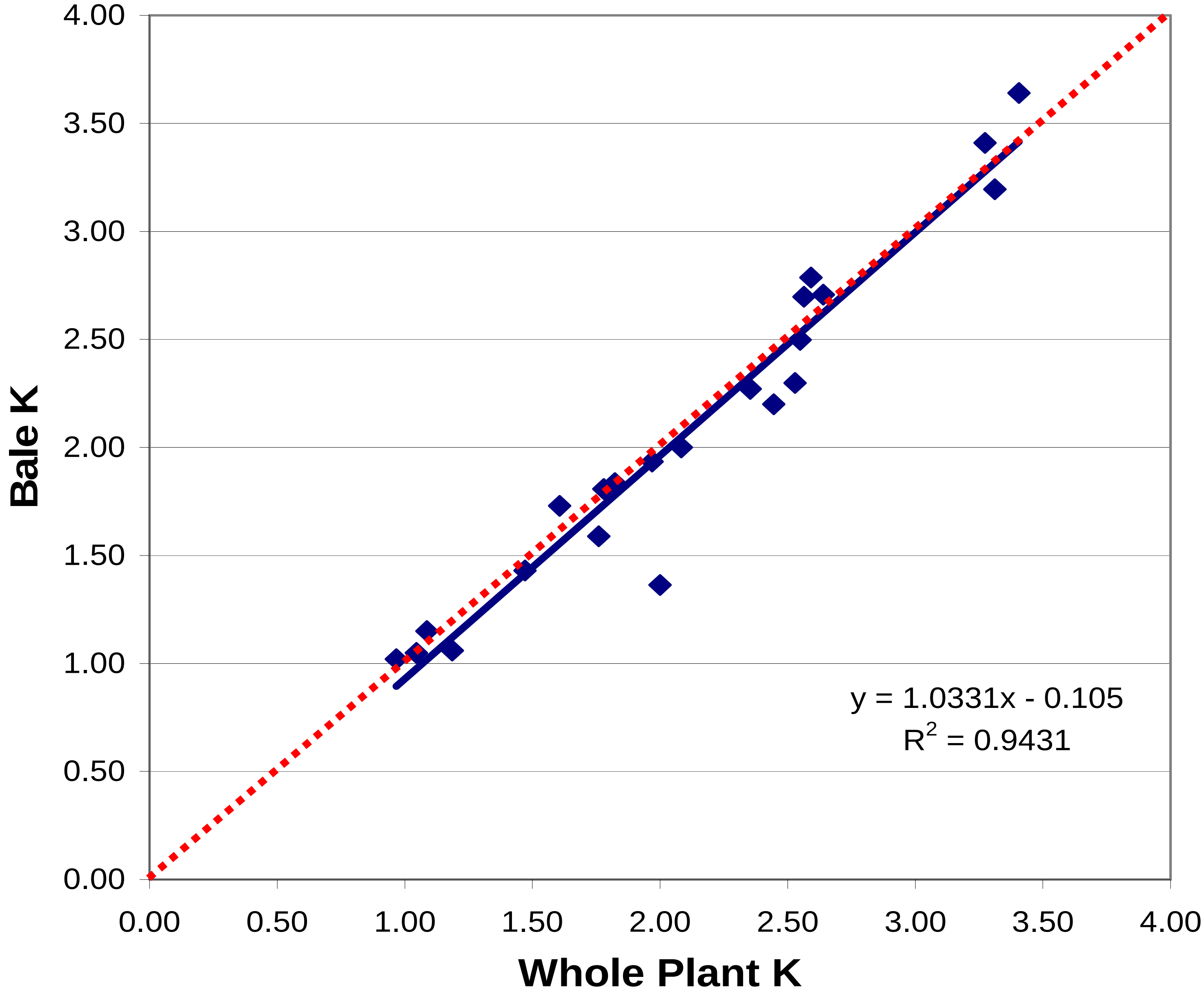
Whole Plant vs. Bale P



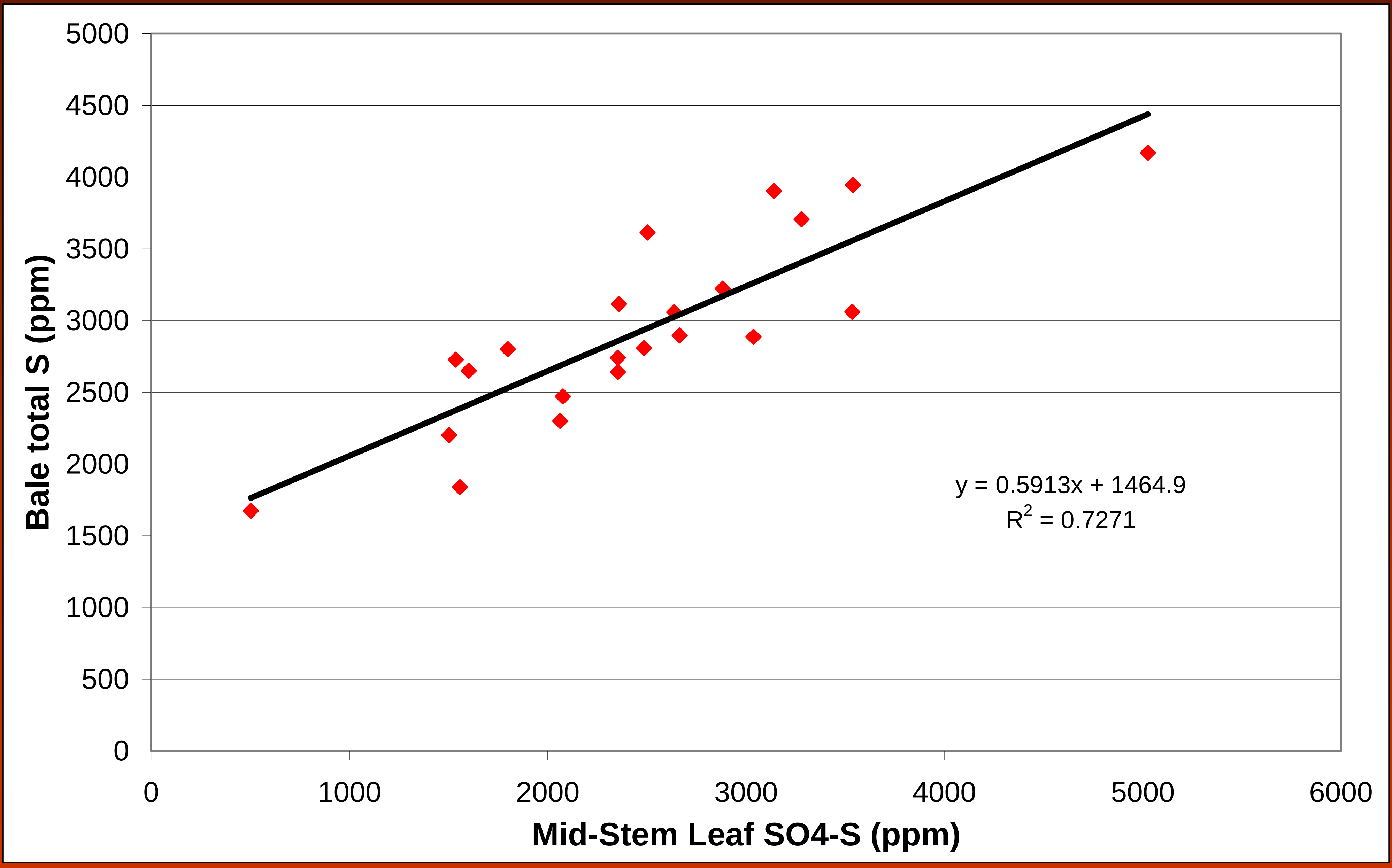
Bale vs. Mid Stem K



Whole Plant vs. Bale K



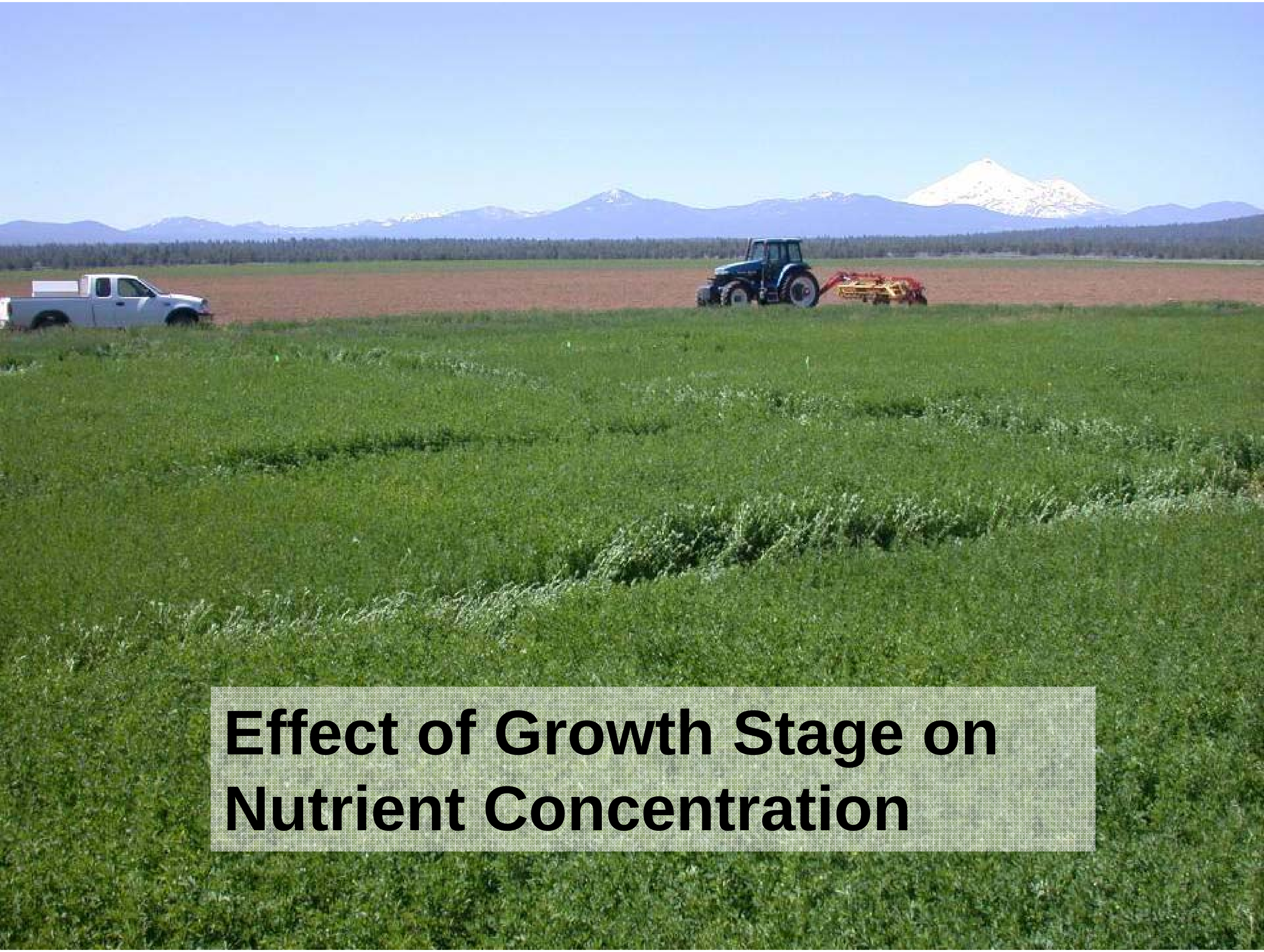
Mid Stem Leaf SO4-S vs Bale S



Interpretation of Test Results for Alfalfa Plant Tissue Samples Taken at 1/10th Bloom

Nutrient	Plant Part	Unit	Plant Tissue Value[a]			
			Deficient	Marginal	Adequate	High
Phosphorus (PO_4-P)	Mid 3rd stems	ppm	300-500	500-800	800-1500	Over 1500
Potassium	Mid 3rd stems	%	0.40-0.65	0.65-0.80	0.80-1.5	Over 1.5
Sulfur (SO_4-S)	Mid 3rd leaves	ppm	0-400	400-800	800-1000	Over 1000
Boron	Top 3rd	ppm	Under 15	15-20	20-40	Over 200
Molybdenum	Top 3rd	ppm	Under 0.3	0.3-1.0	1-5	5-10

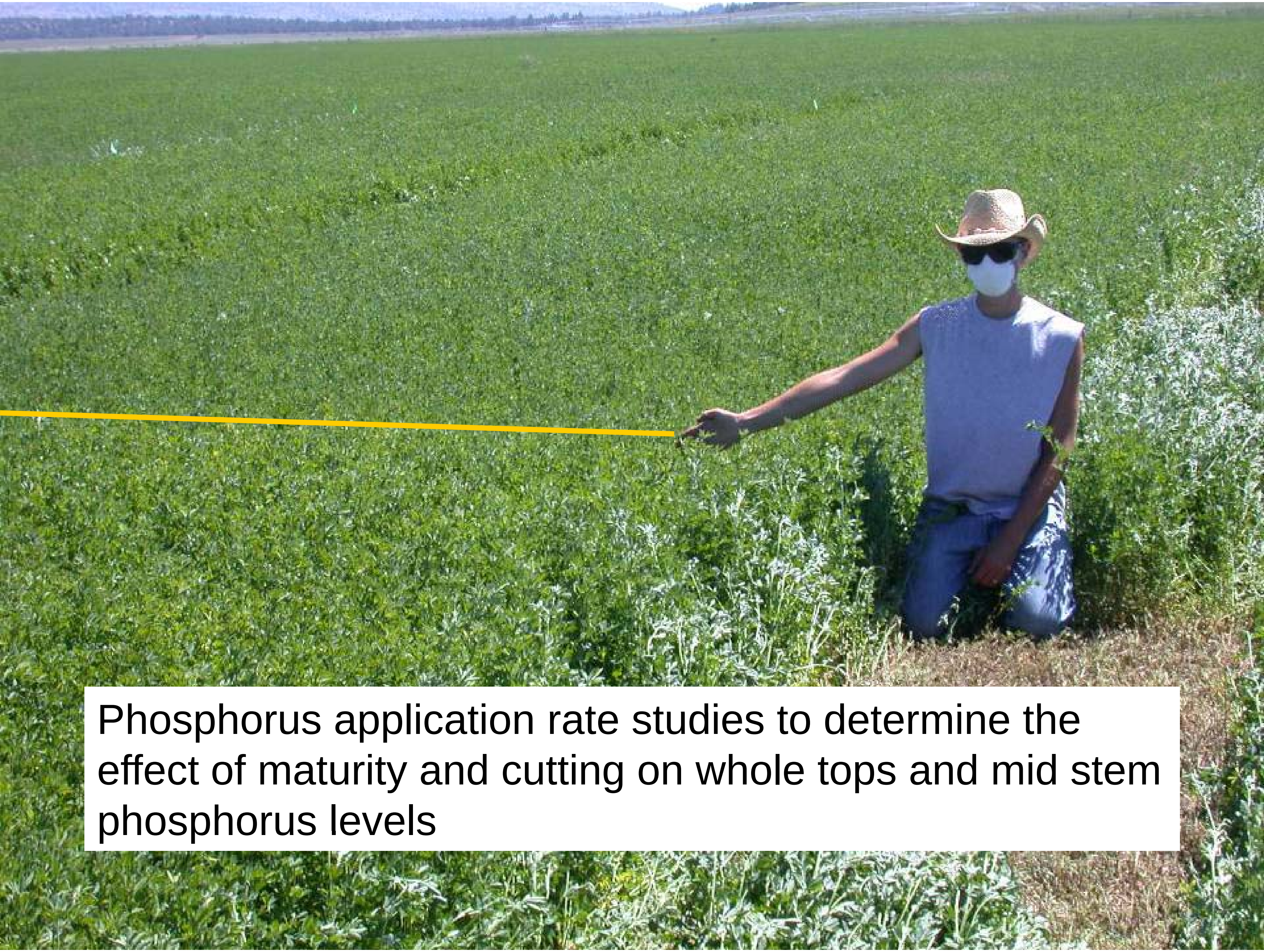
a) Nutrient concentrations should be approximately 10% higher than when sampled at the 1/10th bloom growth stage (multiply tabular values by 1.10).

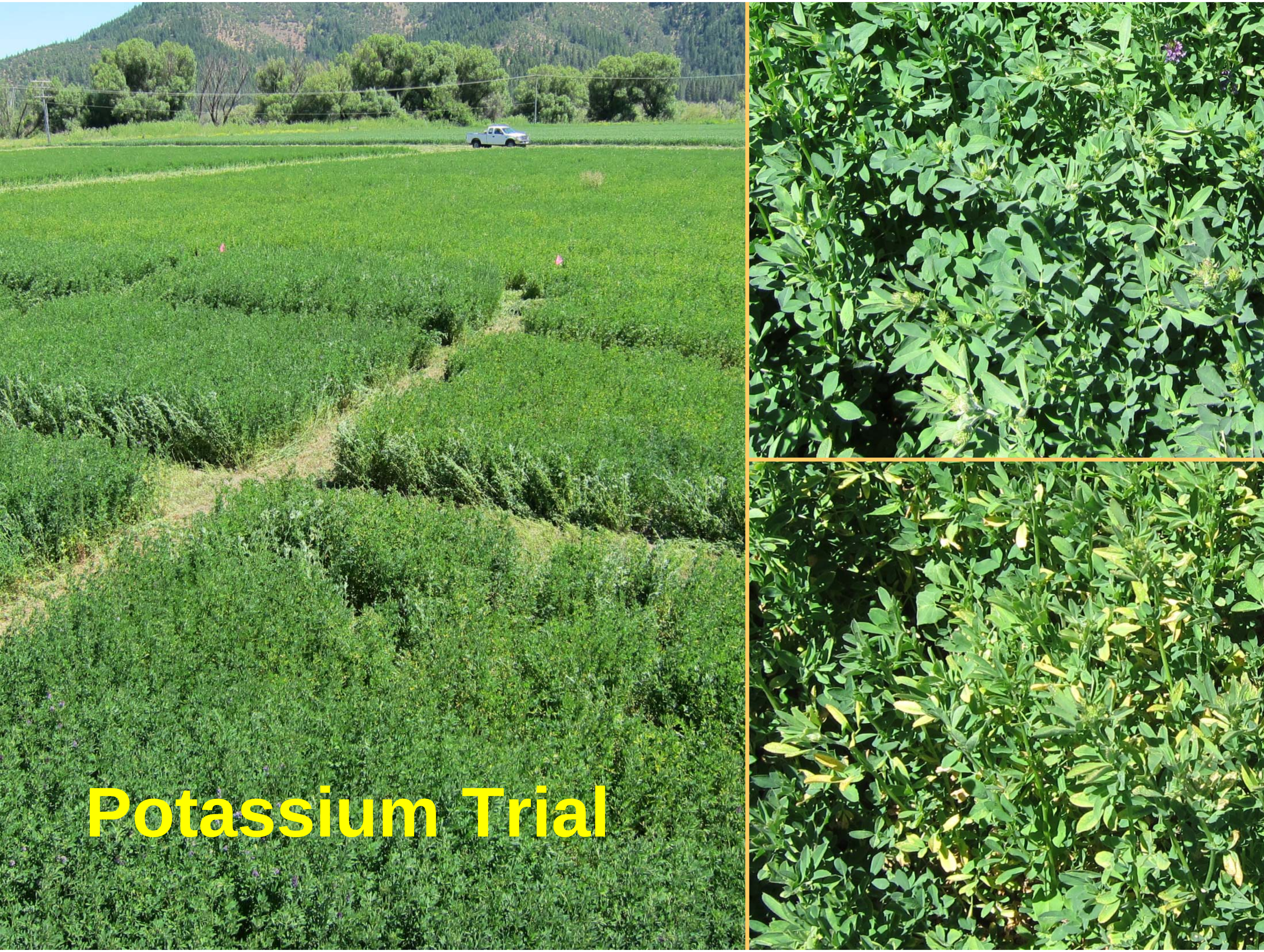

Effect of Growth Stage on
Nutrient Concentration

Research Protocol

- Sampled 3-5 fields in IM, CV, HD
- Sampled at early bud, late bud and 10% bloom
- 3 cuttings
- 3 different plant tissue protocols

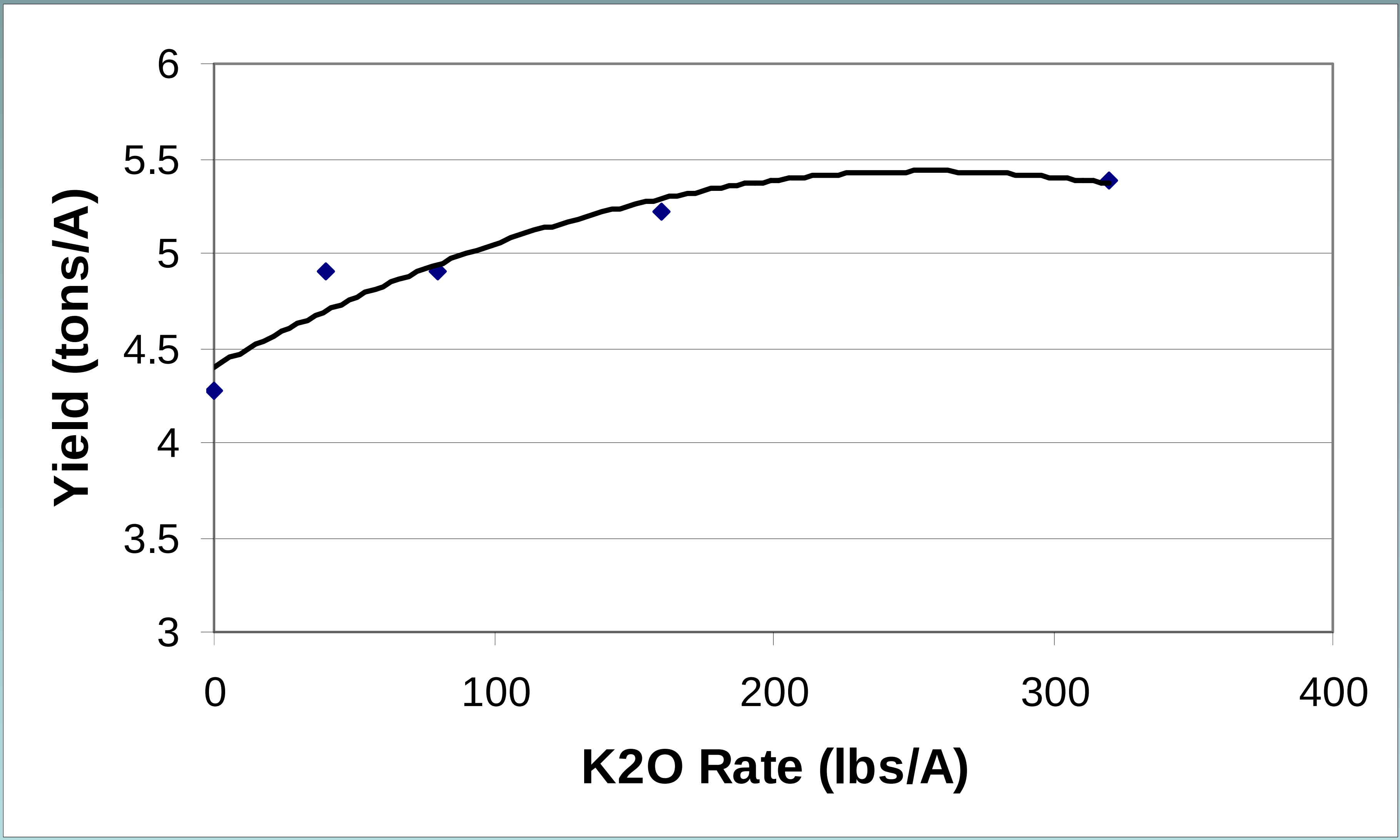
- Whole tops, fractionated plants, top 6”
- Analyzed for P, K, S, B and Mo


Phosphorus application rate studies to determine the effect of maturity and cutting on whole tops and mid stem phosphorus levels

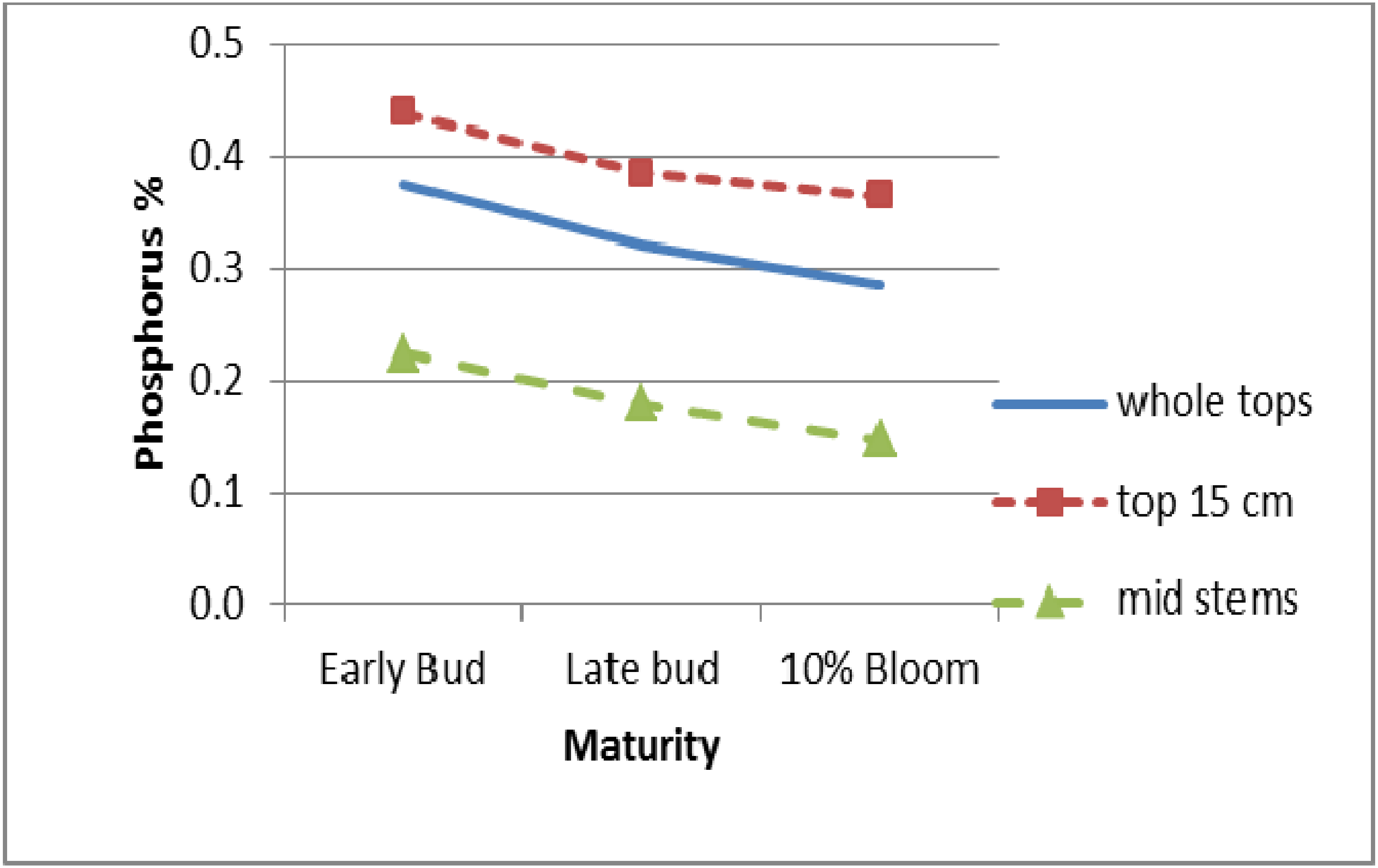

Potassium Trial

Effect of Potassium Fertilization Rate on Yield

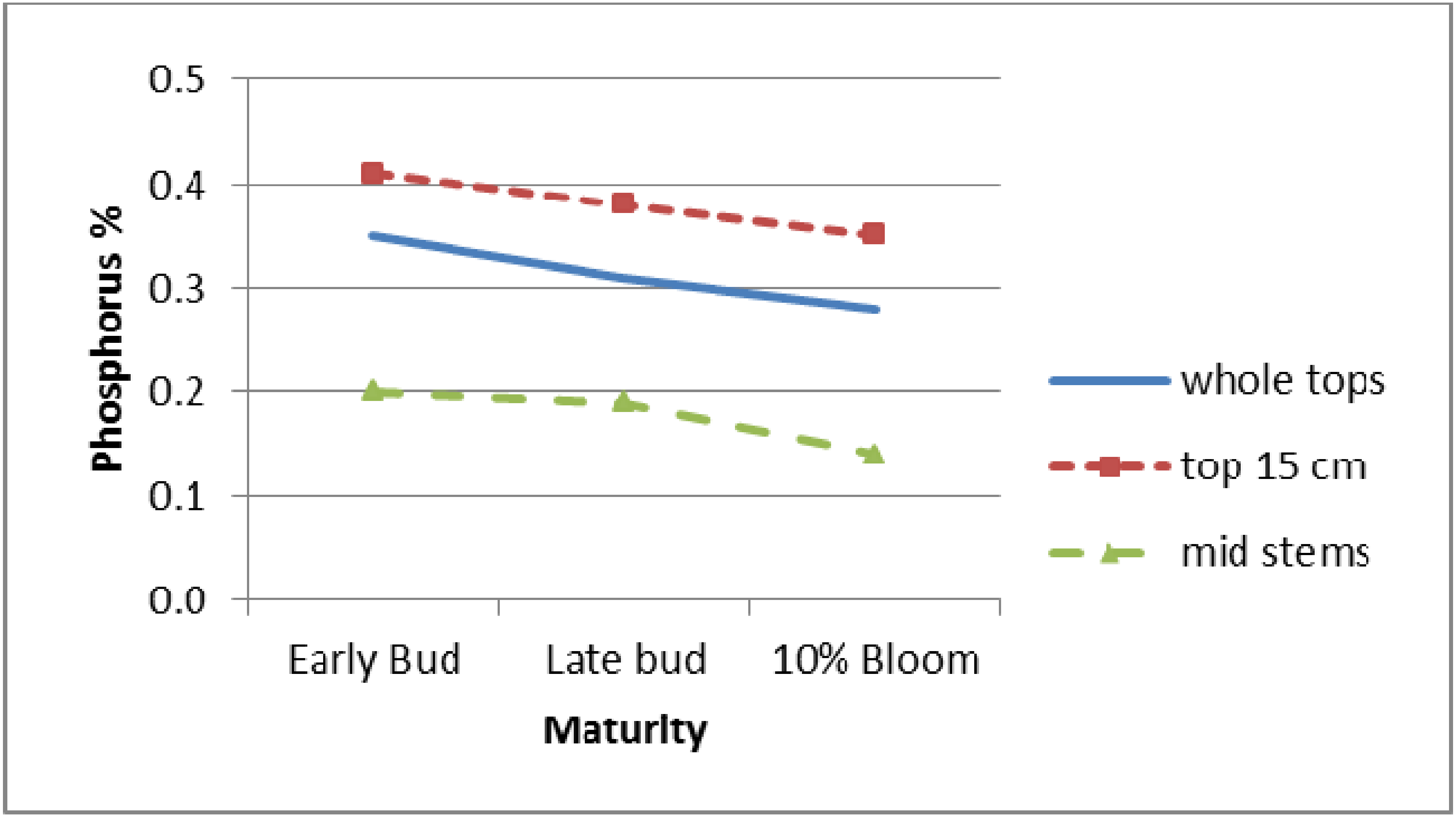
Scott Valley, Siskiyou County



Maturity Effects on P Concentration (2010)

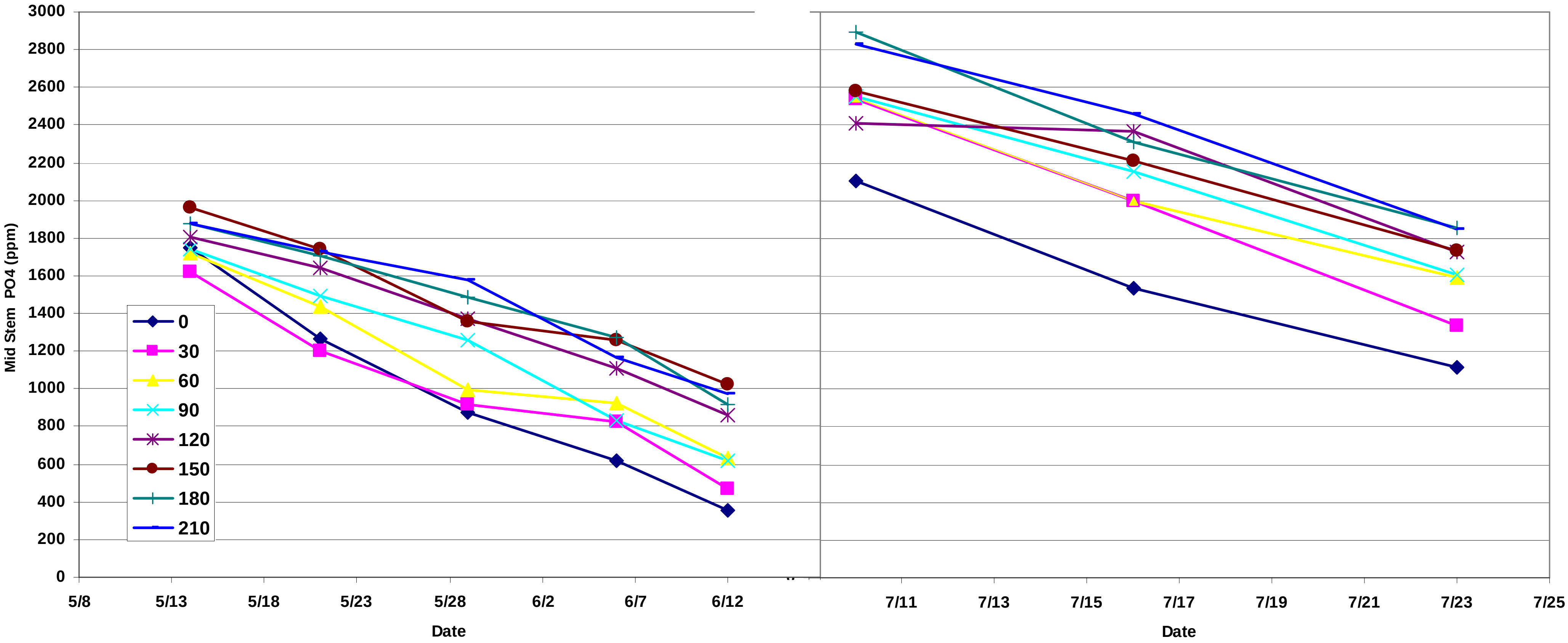


Maturity Effects on P Concentration (2011)



Effect of Maturity and Cutting on Mid-Stem PO_4-P

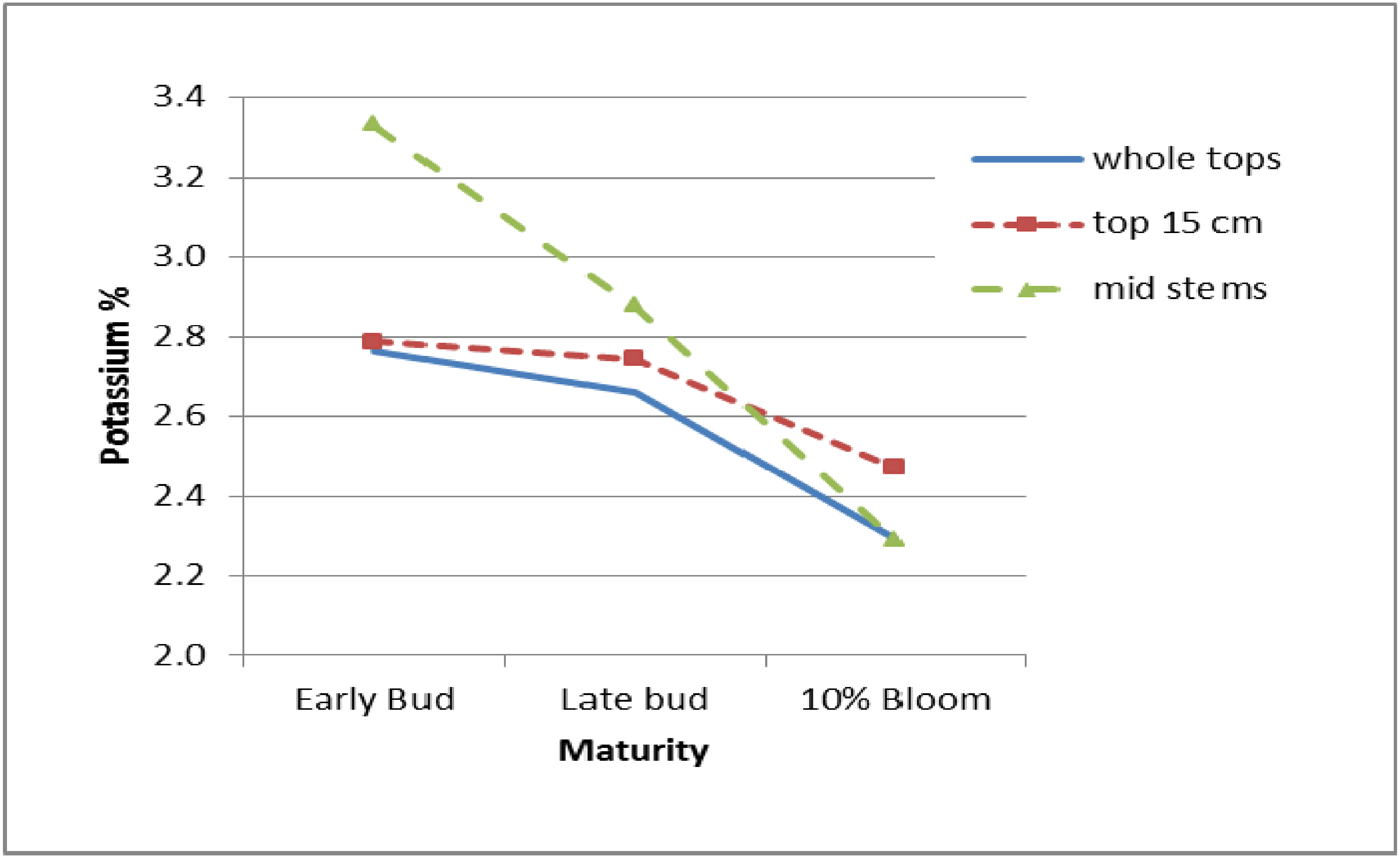
Could ADF be used as to quantify maturity?



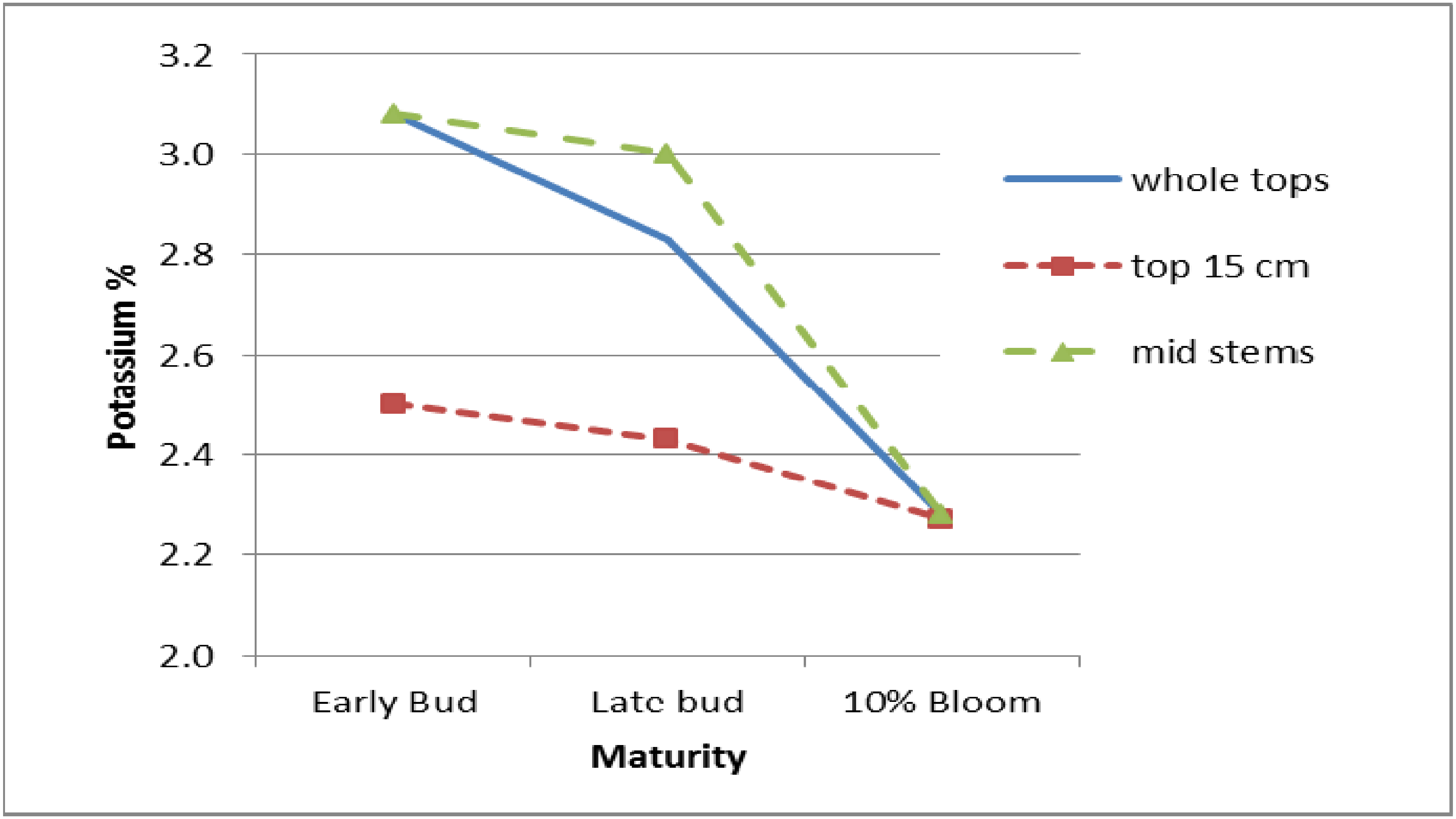
1st Cut

2nd Cut

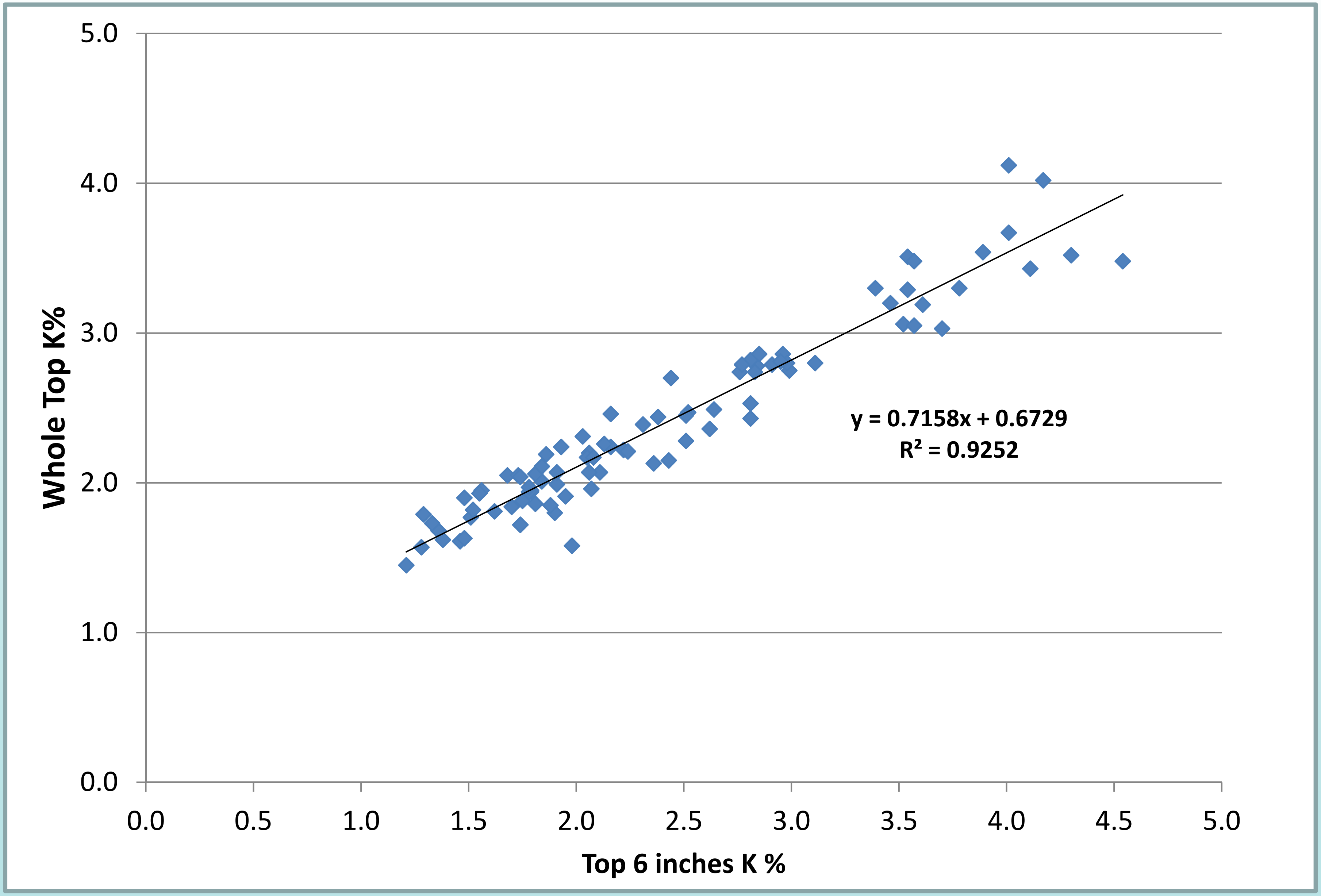
Maturity Effects on K Concentration
(2010)



Maturity Effects on K Concentration
(2011)



Relationship between Whole Top and Top 6 inch Sampling Protocols for K Concentration (All Regions). 2011



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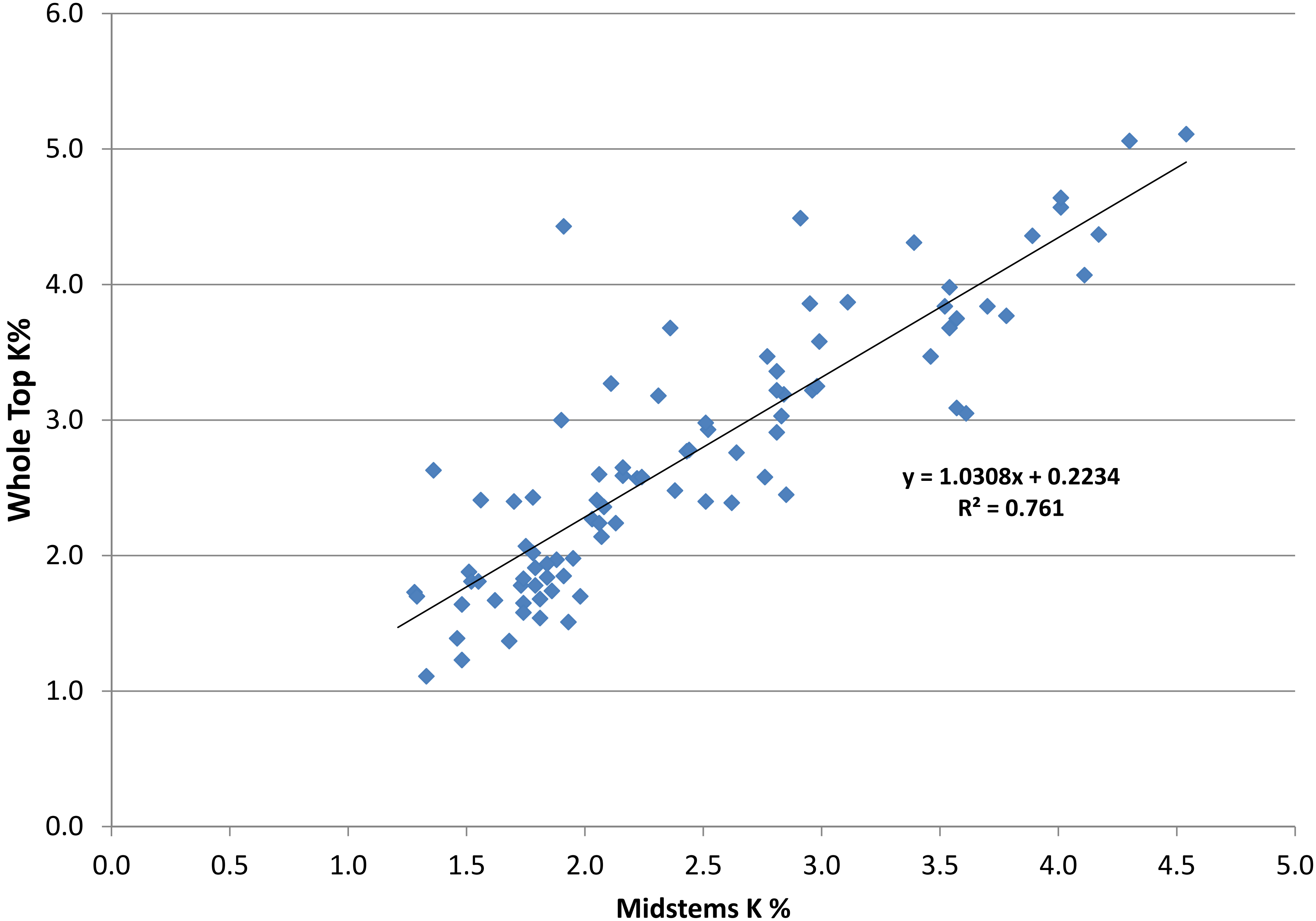
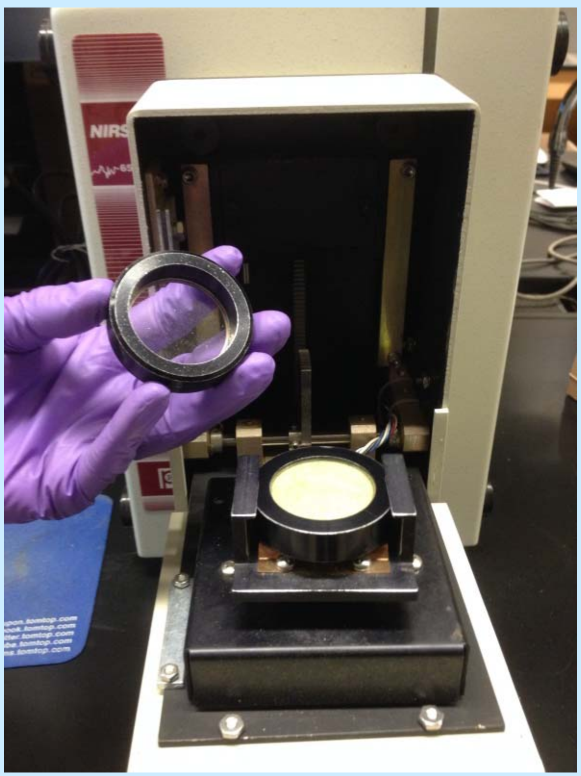
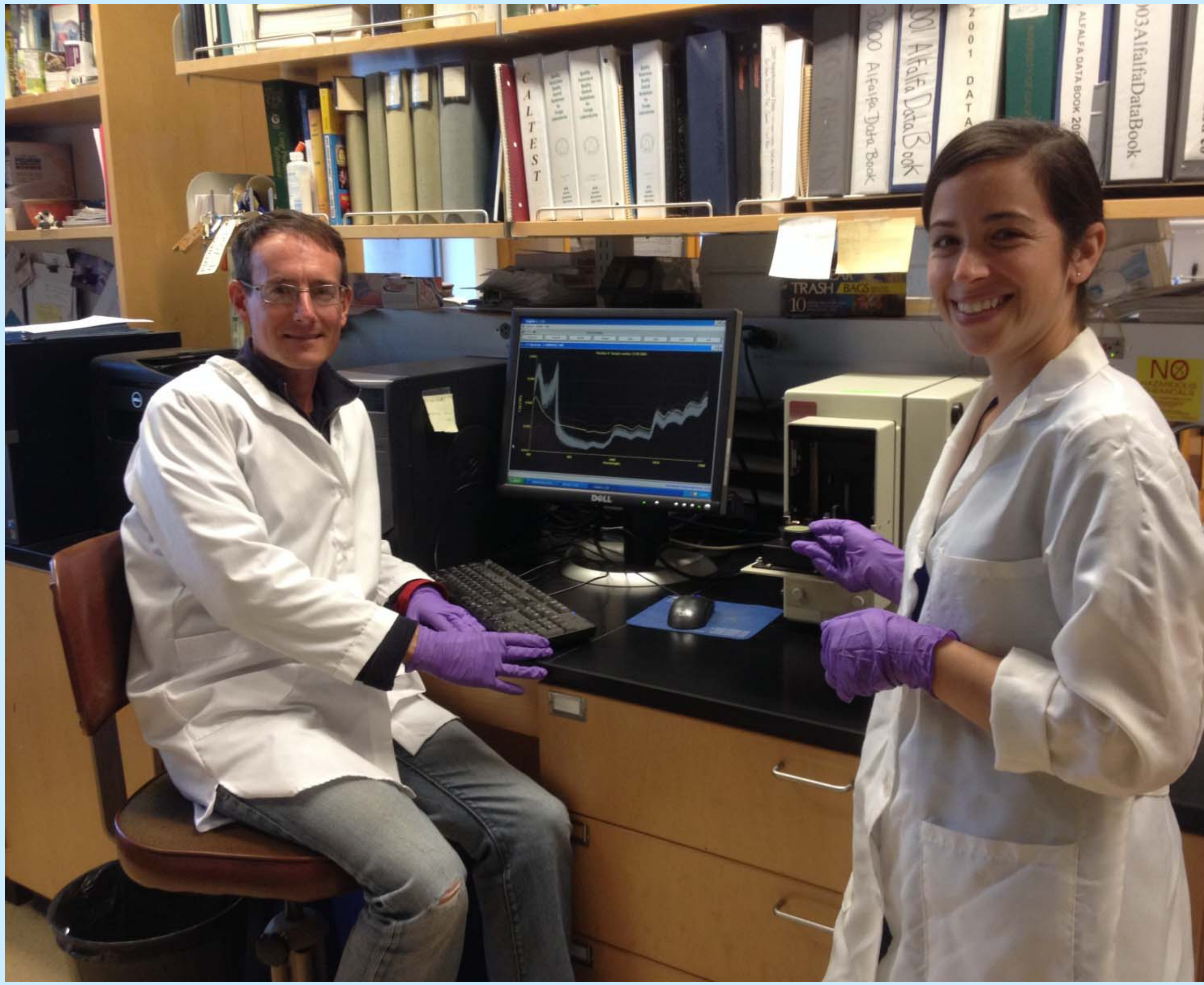


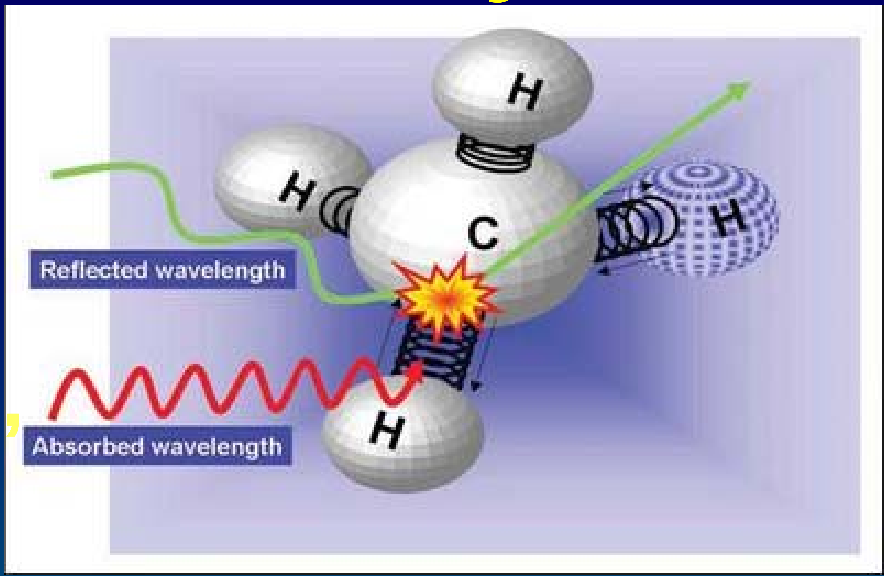
Near Infrared Spectroscopy (NIRS)

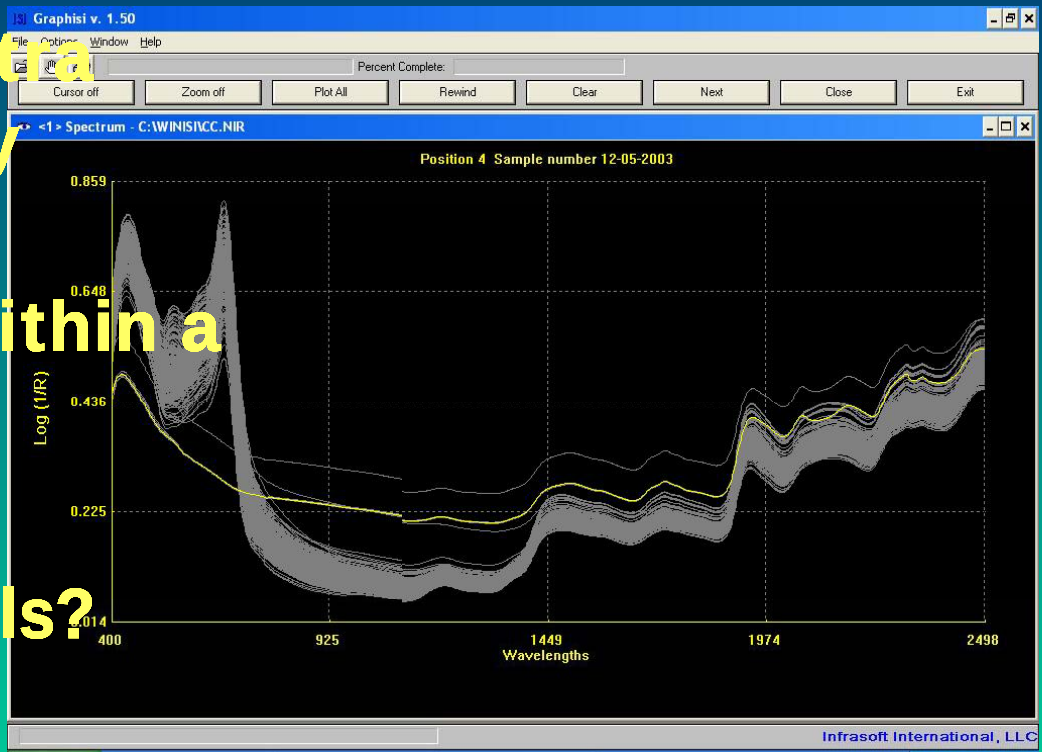




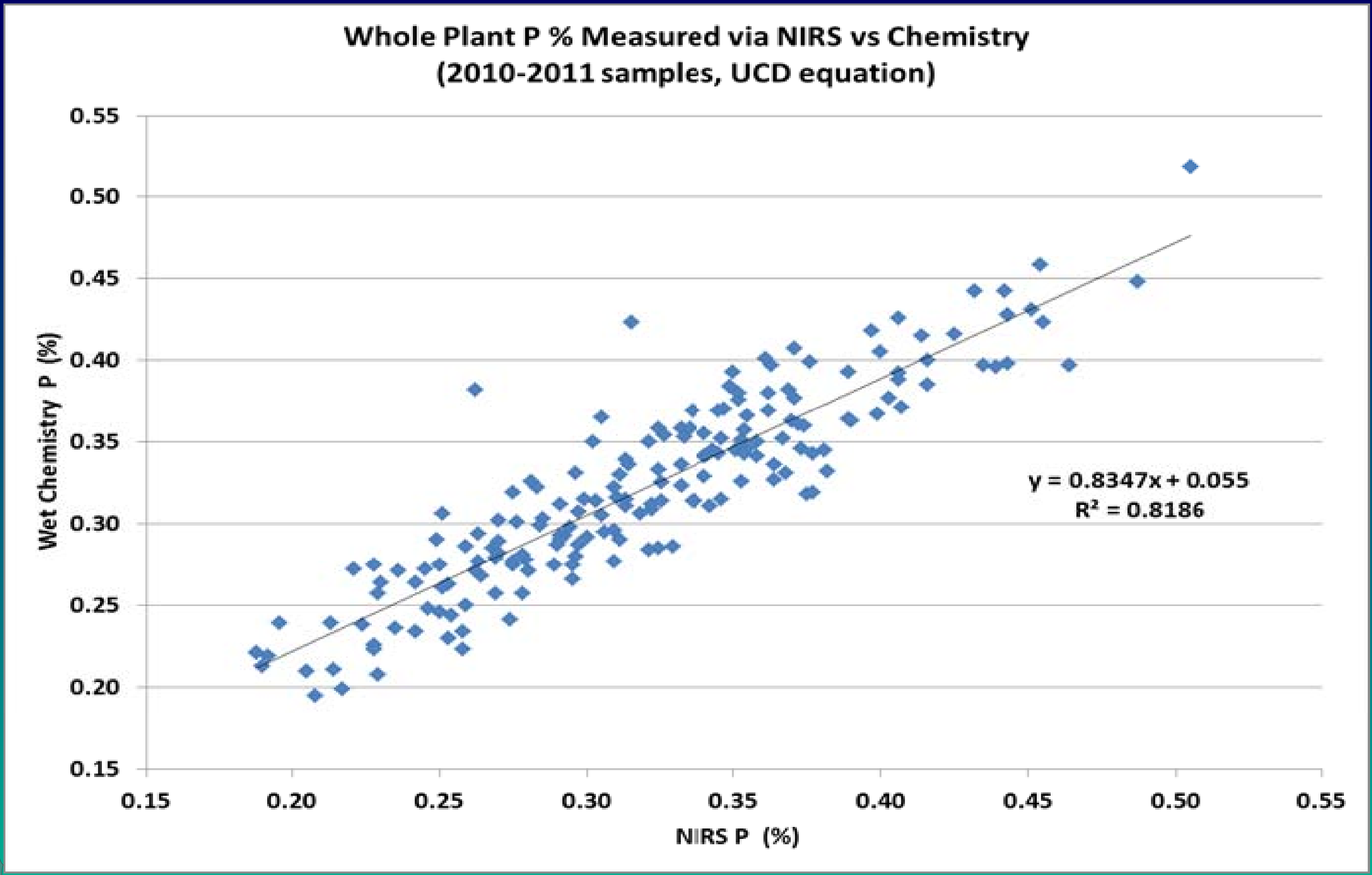
Near Infrared Spectrophotometry (NIRS)

- Specialized light source
- Reflectance from a sample creates a large data set
- Based upon ‘bending’ of OH, CH, and NH bonds
- ‘Fingerprint’ of sample is compared with NIRS spectra with known wet chemistry values
- New value is predicted (within a statistical tolerance)
- Fast and accurate
- What is its fit with minerals?

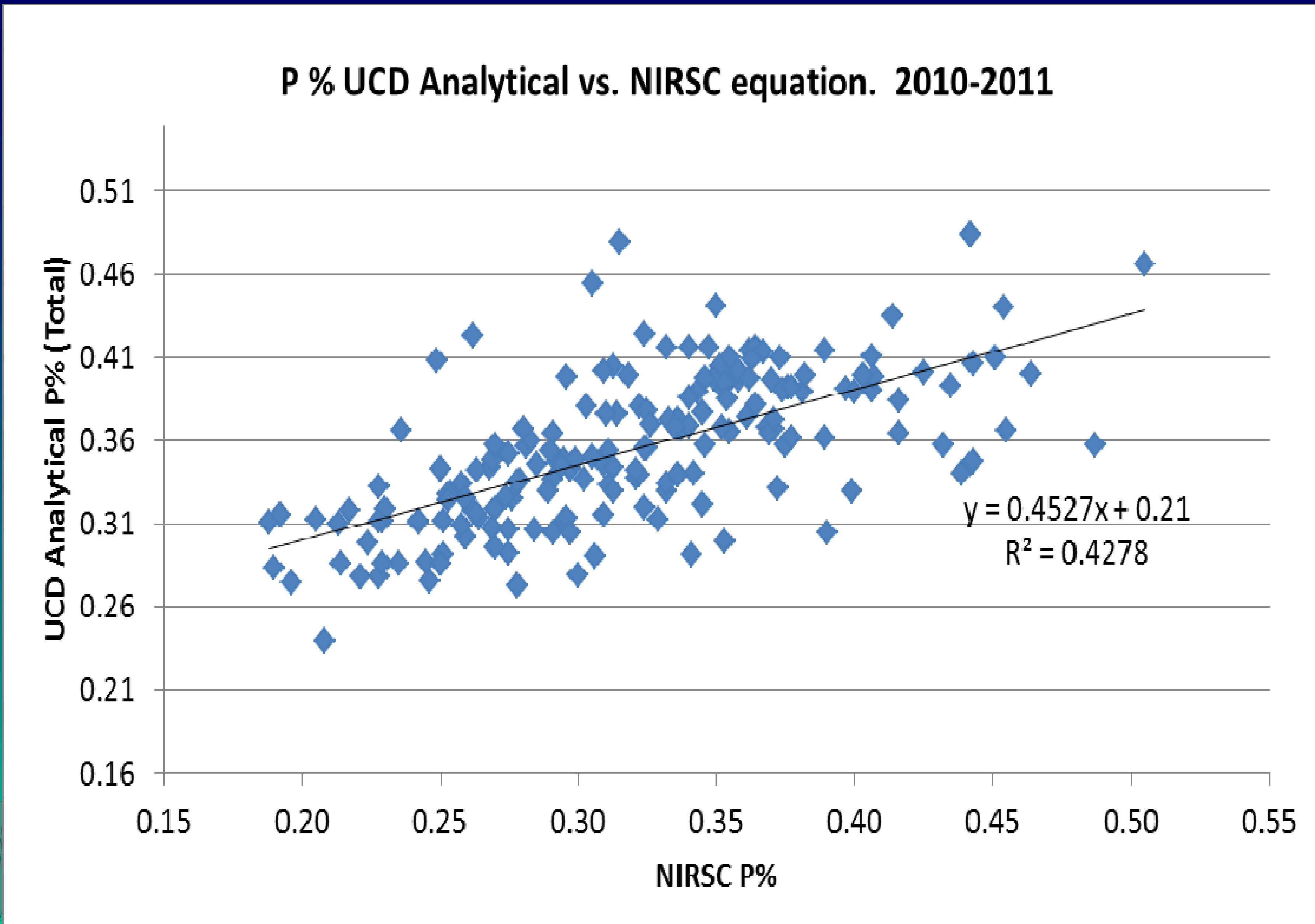




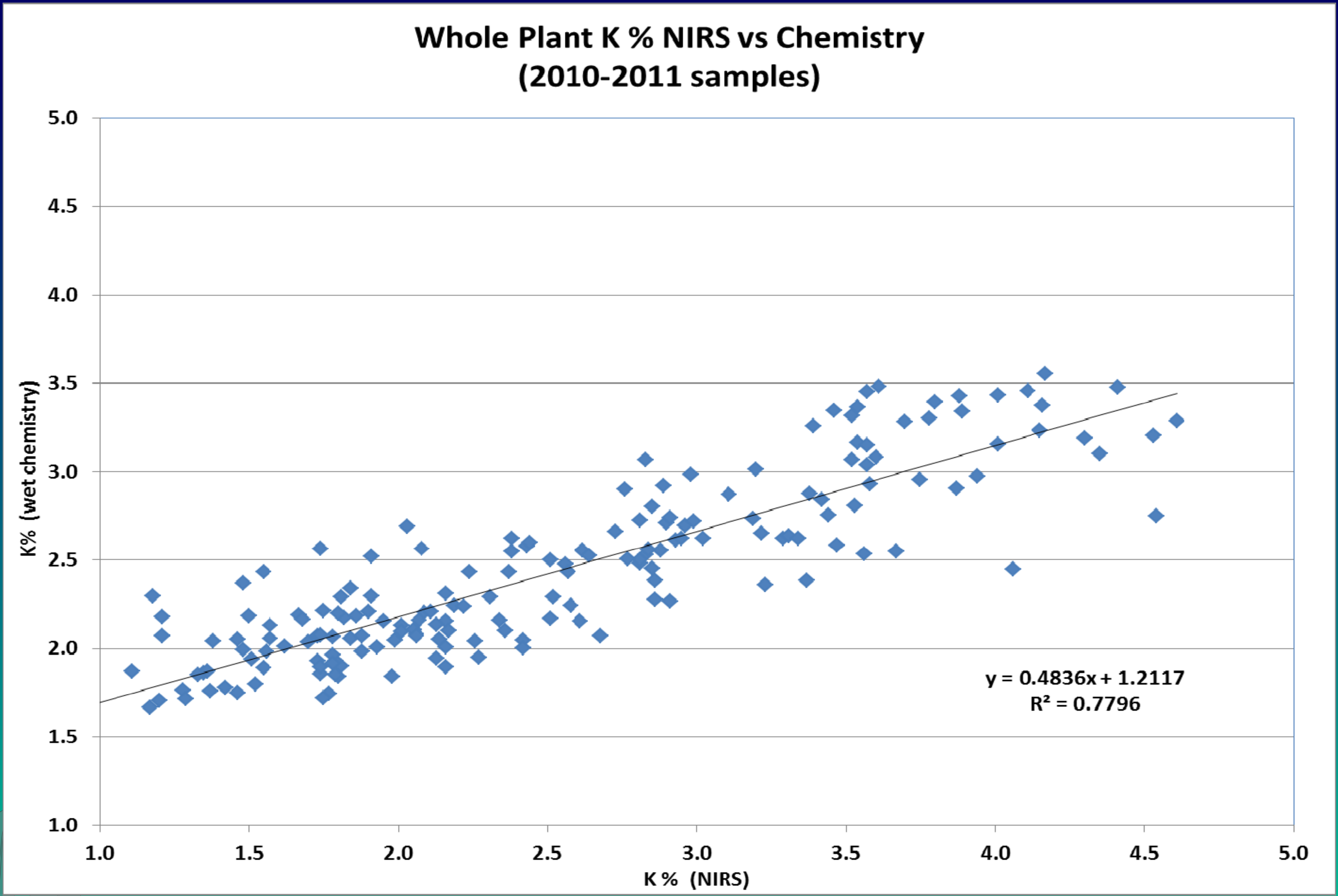
NIRS Phosphorus



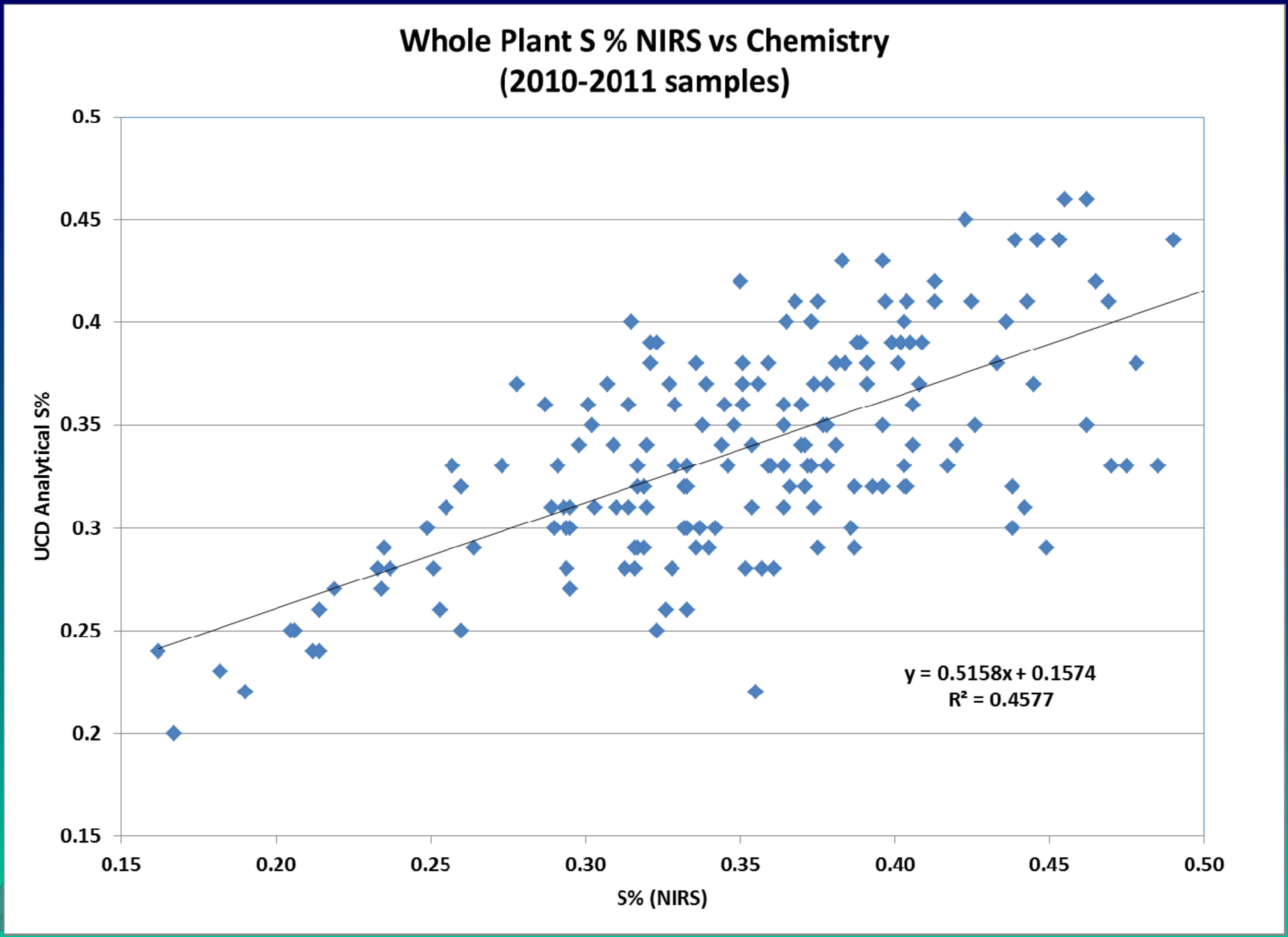
P-Different Equation:



NIRS Potassium



NIRS Sulfur



Whole Plant S % NIRS vs Chemistry
(2010-2011 samples)
UCD Analytical S%
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
S% (NIRS)
y = 0.5158x + 0.1574
R² = 0.4577

NIRS for tissue tests

- May work for P, K, not sure about S
- Not entirely sure why
- Consider high, med, low values – don't pay as much attention to absolute values (bias)
- Watch the different calibrations from different labs (lab-to-lab variation, chemistry used)
- Labs may need to improve calibrations further

Tentative Values to Interpret Cored Bale Samples

NUTRIENT	UNIT	PLANT TISSUE VALUE			
		DEFICIENT	MARGINAL	ADEQUATE	HIGH
Phosphorus					
Early bud	%	<0.26	0.27–0.29	0.30–0.39	>0.39
Late bud	%	<0.23	0.24–0.25	0.26–0.34	>0.34
10% bloom	%	<0.20	0.21–0.22	0.23–0.30	>0.30
Potassium					
Early bud	%	<0.91	0.92–1.24	1.25–1.60	1.60–3.42
Late bud	%	<0.87	0.88–1.19	1.20–1.53	1.53–3.27
10% bloom	%	<0.80	0.81–1.09	1.10–1.40	1.40–3.00
Sulfur					
Early bud	%	<0.23	0.23–0.26	0.27–0.35	>0.47
Late bud	%	<0.22	0.22–0.24	0.25–0.33	>0.44
10% bloom	%	<0.20	0.20–0.22	0.23–0.30	>0.40
Boron					
All stages	ppm	<15	16–20	21–80	>200
Molybdenum					
All stages	ppm	<0.3	0.4–1.0	1–5	5–10

Summary

- Large differences in fertility status
- Soil analysis good for pre-plant assessment
  - pH, salinity, P and K
- Plant tissue analysis more accurate in season
  - Evaluate most limiting nutrient then fertilize and resample
- Bale sampling for tissue testing practical
- Can use whole tops (bale), fractionated plant or top 6 inches
- Plant stage of development has a large influence on nutrient concentrations,
  - Especially for phosphorus and potassium
  - Standardization by maturity important
- Less than perfect system (soil and tissue don’t always agree)
- NIRS may be useful for first approximations
  - Link to Standard Forage Quality analysis
- Initial NIRS analysis should likely be followed up with more vigorous field testing


AP3162

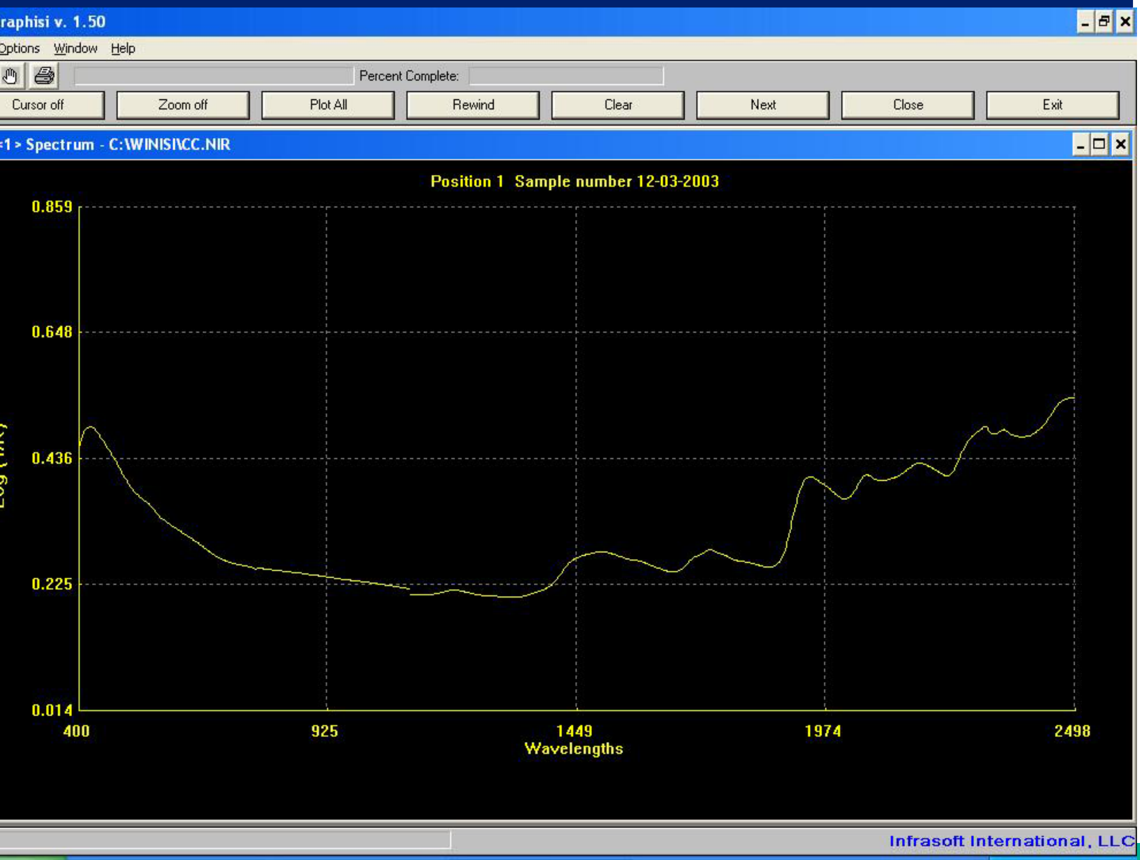
NIRS:

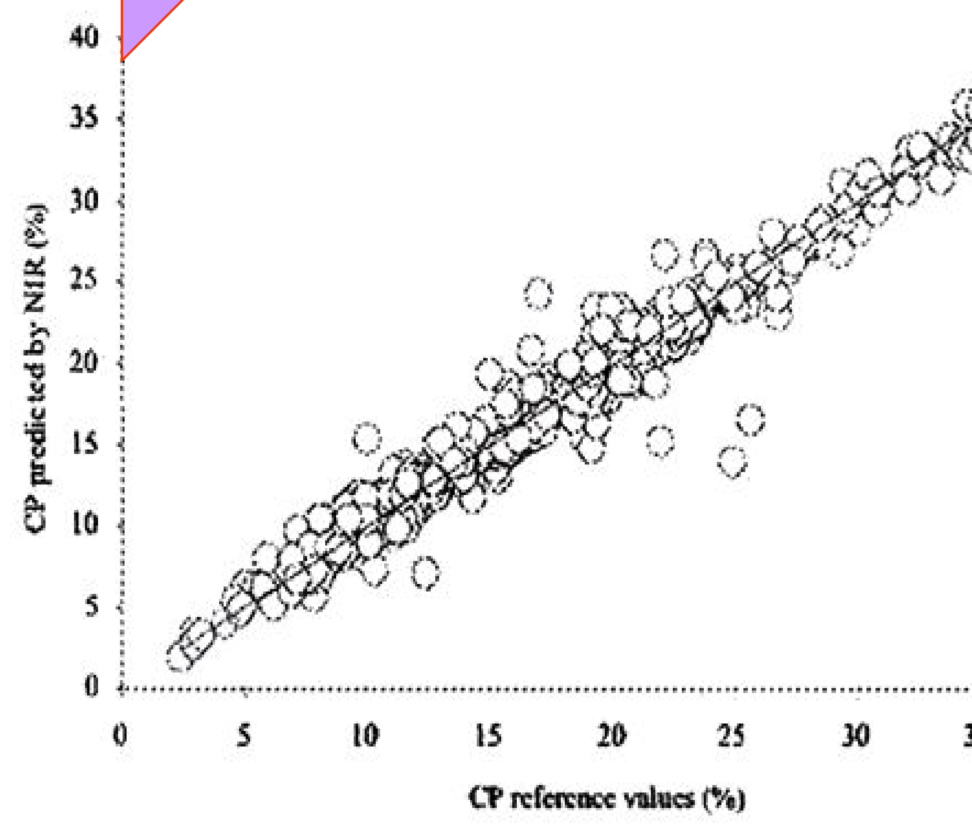
- .... has high repeatability and is widely used in forage testing

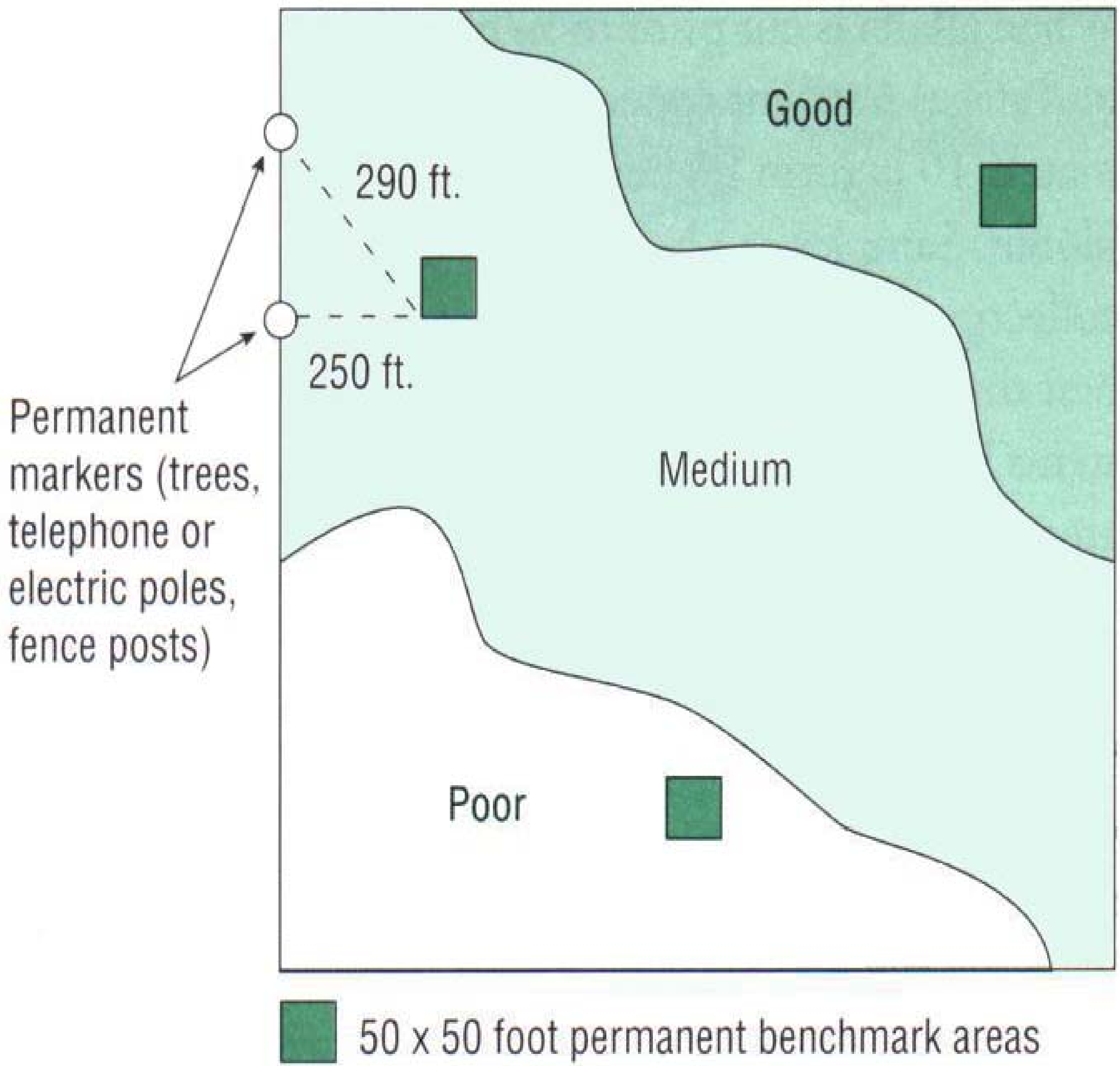
- Spectra:

Statistical techniques

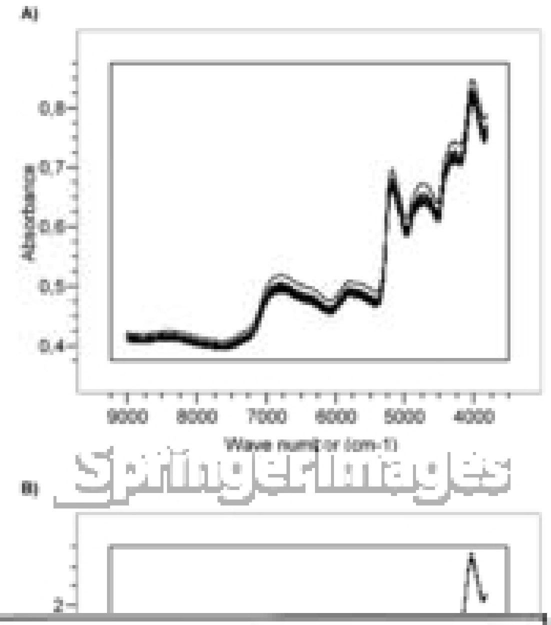
Crude Protein

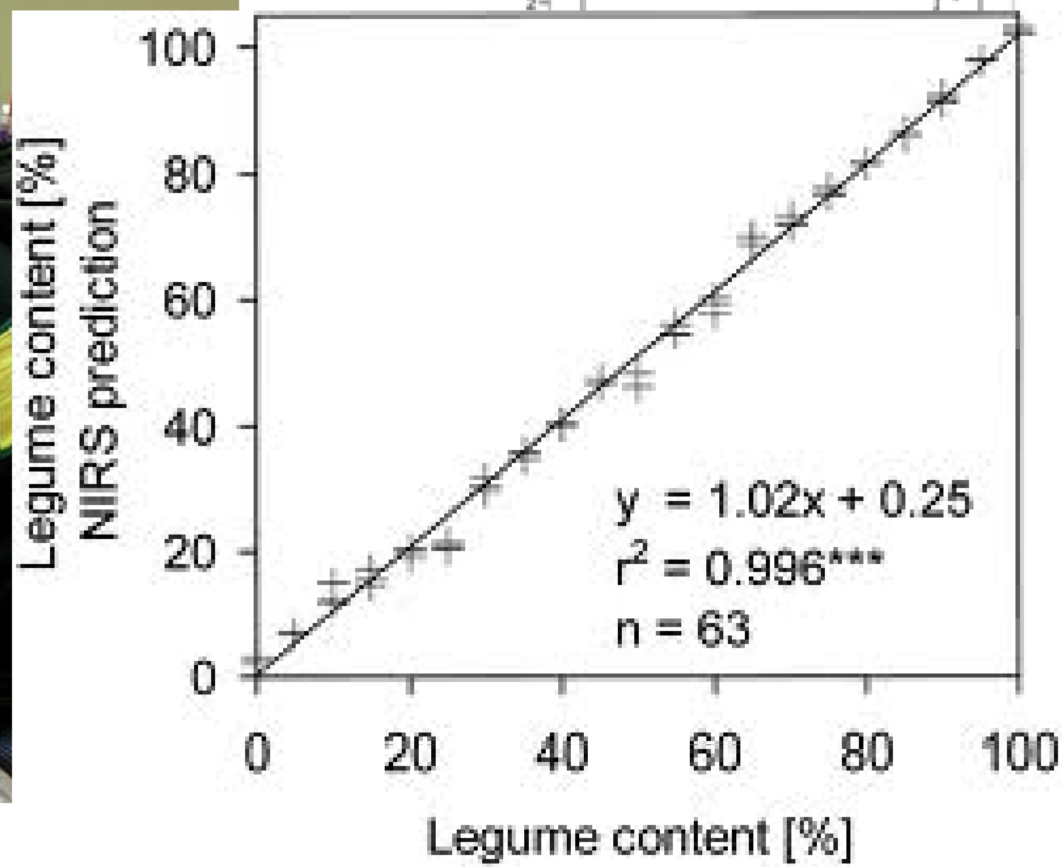




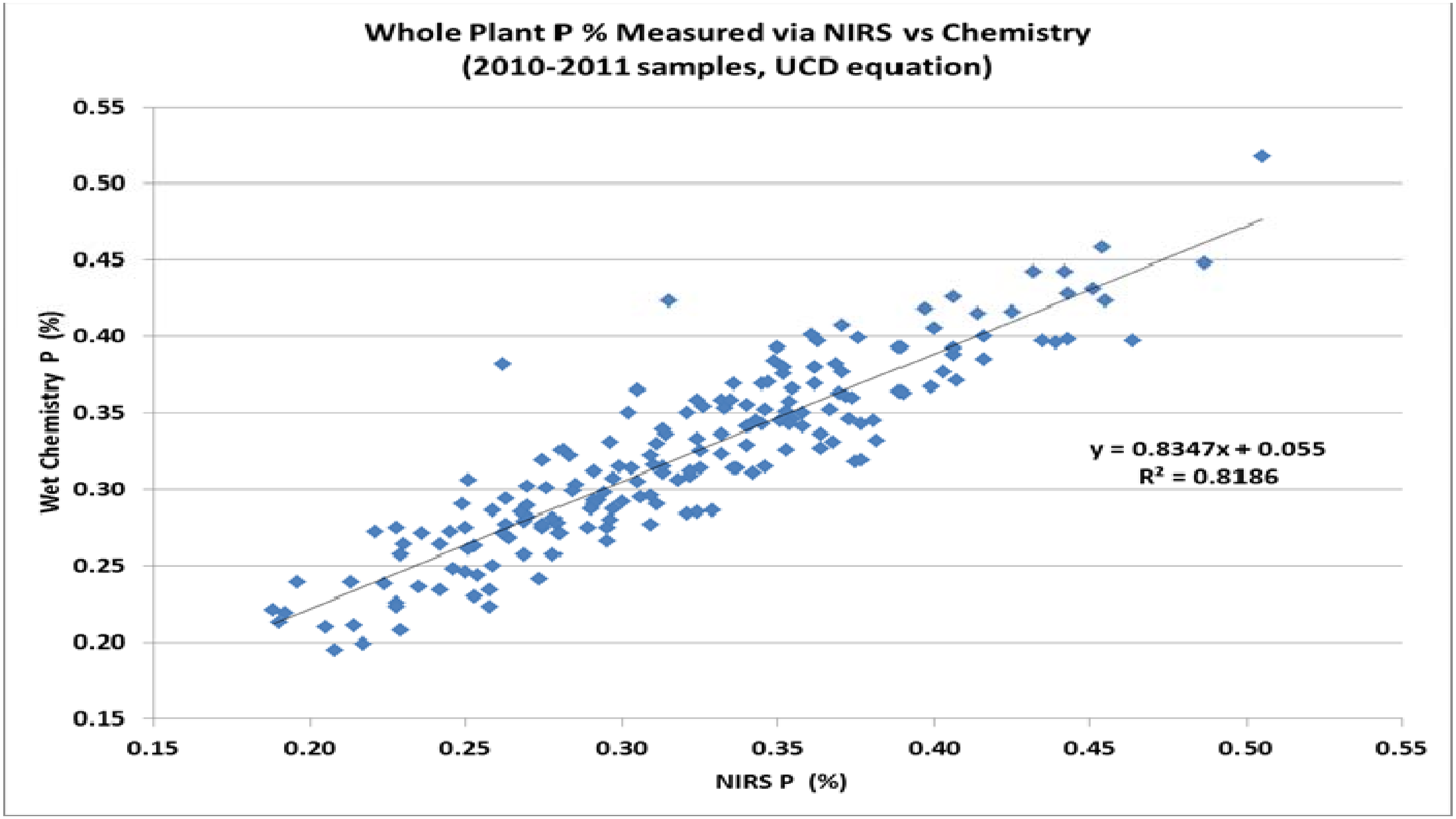

Good
290 ft.
250 ft.
Permanent markers (trees, telephone or electric poles, fence posts)
Medium
Poor
50 x 50 foot permanent benchmark areas

Near Infrared Spectrophotometry (NIRS)





Relationship Between NIRS and Wet Chemistry Values



The effect of phosphorus rate on alfalfa yield

Scott Valley, CA. (Olsen P 2.4 ppm)

Rate (lbs P_2O_5/A)	Cut 1 6/12	Cut 2 7/21	Cut 3 8/28	Total	Increase over Unfert.
Untreated	1.94	1.44	1.25	4.63	—
40	2.25	1.79	1.49	5.53	0.90
80	2.43	1.75	1.39	5.56	0.93
120	2.68	1.79	1.46	5.93	1.30
160	2.61	1.81	1.46	5.88	1.25

The effect of phosphorus rate on alfalfa yield

Butte Valley, CA. (Olsen P 8.4 ppm)

Rate (lbs P_2O_5/A)	**Cut 1 6/19**	**Cut 2 7/24**	**Cut 3 8/29**	**Total**	**Increase over unfert.**
Untreated	2.39	1.83	1.33	5.56	—
40	2.68	1.93	1.35	5.96	0.40
80	2.89	2.03	1.48	6.41	0.85
120	2.98	2.10	1.50	6.63	1.07
160	2.88	2.03	1.46	6.37	0.81