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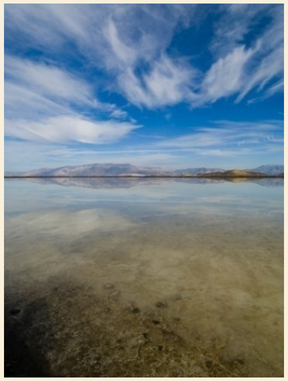
Alfalfa



April 2011

Sulfate of Potash (SOP)



Main goals

- General potash management
- Potash management in alfalfa
- Potash fertilizer consideration
- Sulfate of potash (SOP) where it might fit
- Sulfur the 4th macro nutrient?

General potash management

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Potassium (K) in a Corn / Soybean rotation

- Role of K in crop production
- Crop up take of K
- Soil K and soil testing
- K deficiencies
- Crop response to K
- K fertilizer

Role of K in crop production

- K activates enzyme reactions
- **K fosters nitrate-nitrogen (N) uptake and protein synthesis**
- **K controls water uptake and transpiration**
- K influences energy production in photosynthesis and respiration
- K supports photosynthate transport
- K is required for starch synthesis in seeds

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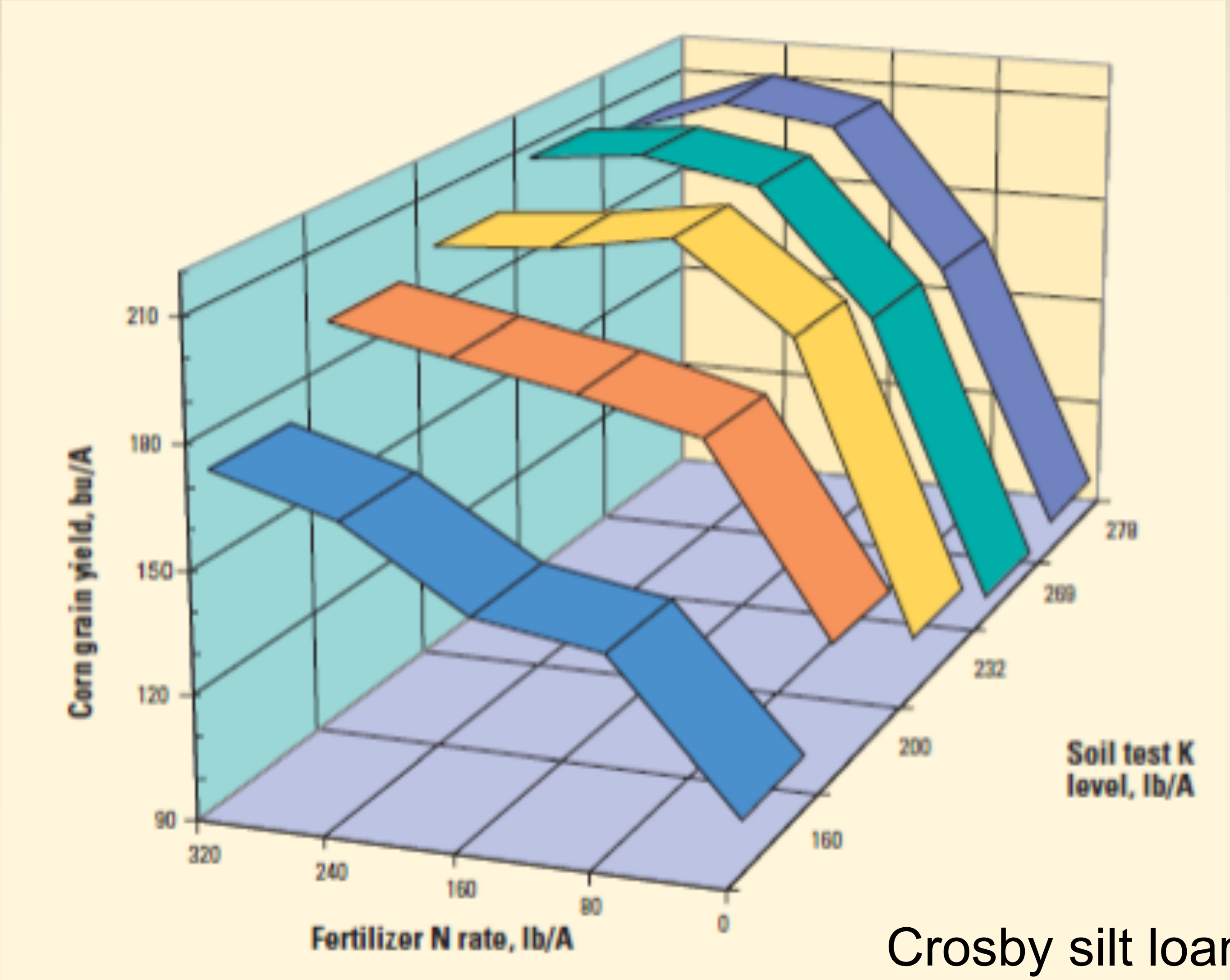
Role of K in crop N uptake

Crop grain yield response to fertilizer N rate and soil test K levels



Crosby silt loam soil near Springfiled, OH

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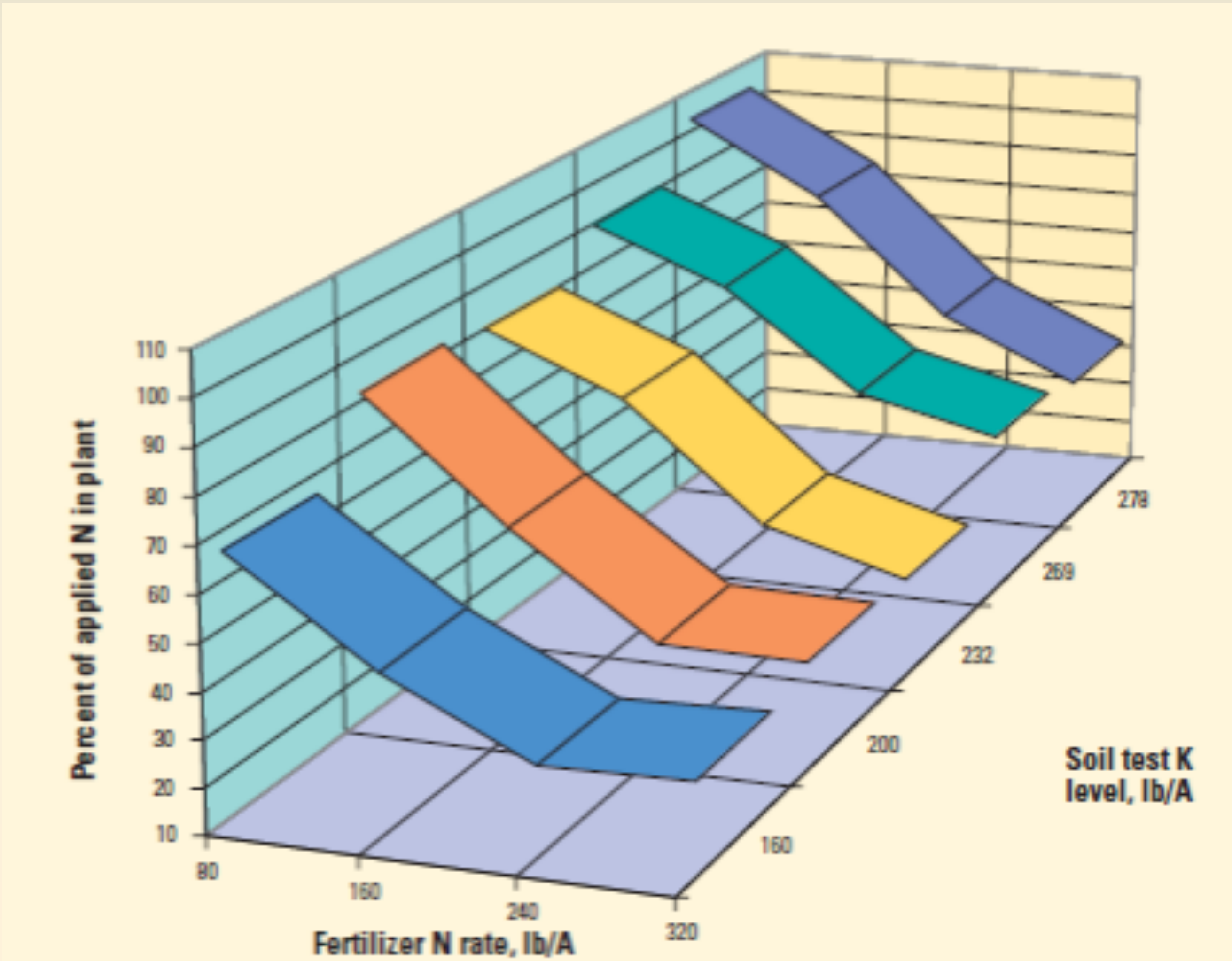
Role of K in crop N uptake

The effect of fertilizer N rate and soil test K levels on N uptake efficiency on a corn crop



Role of K in crop water use

- Plants depend on K to regulate the opening and closing of the stomates
  - Stomates are the opening though which gas and water vapor are exchanged
  - When water stress occurs the stomates close preventing water from being loss
  - When K is inadequate the stomates become sluggish and can take hours instead of minutes to close and closure can be incomplete
- K in the roots creates an osmotic pressure gradient which aids in drawing water into the roots
  - Plants deficient in K will be less able to absorb water and thus more susceptible to water stress

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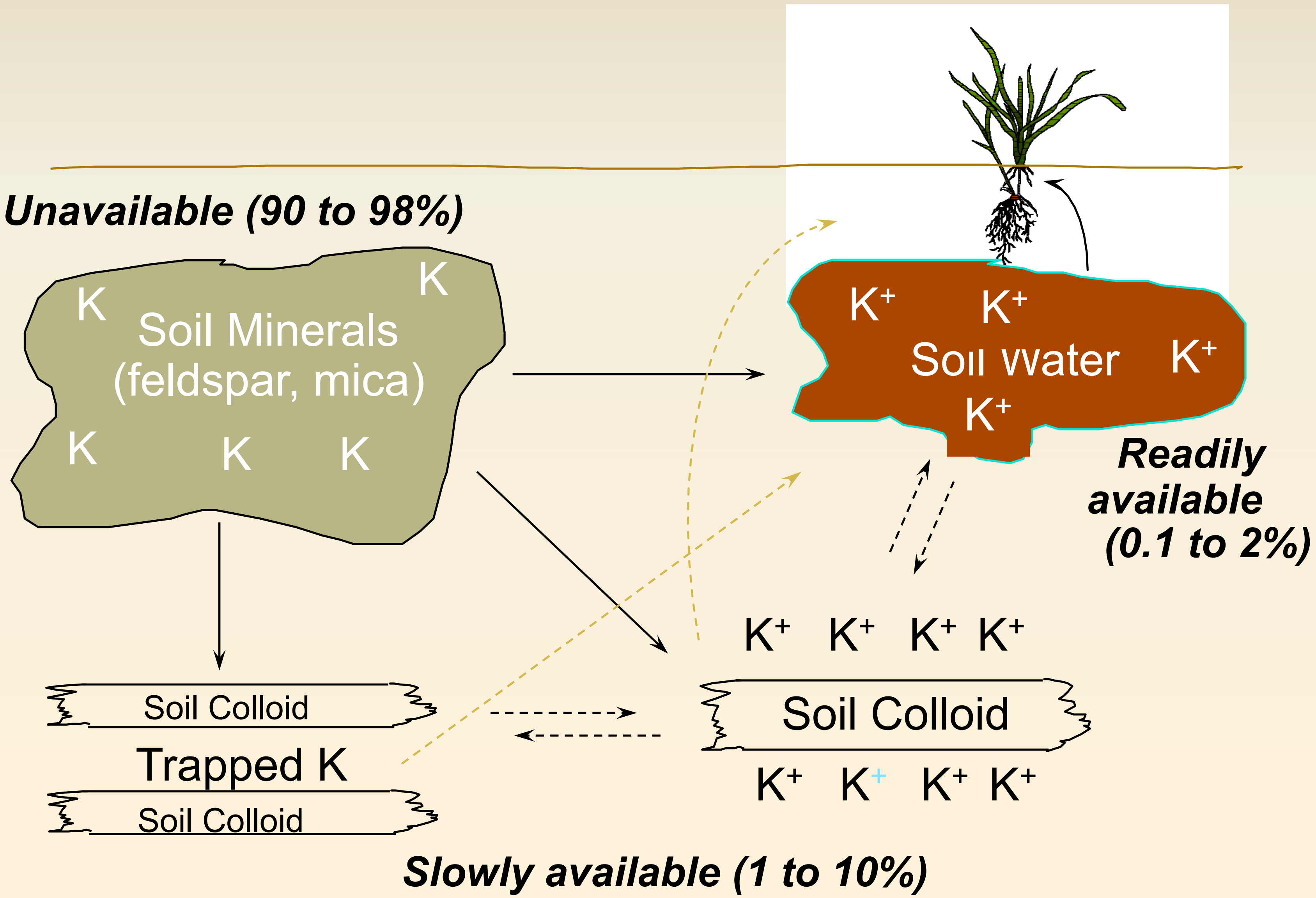
Potassium in the soil



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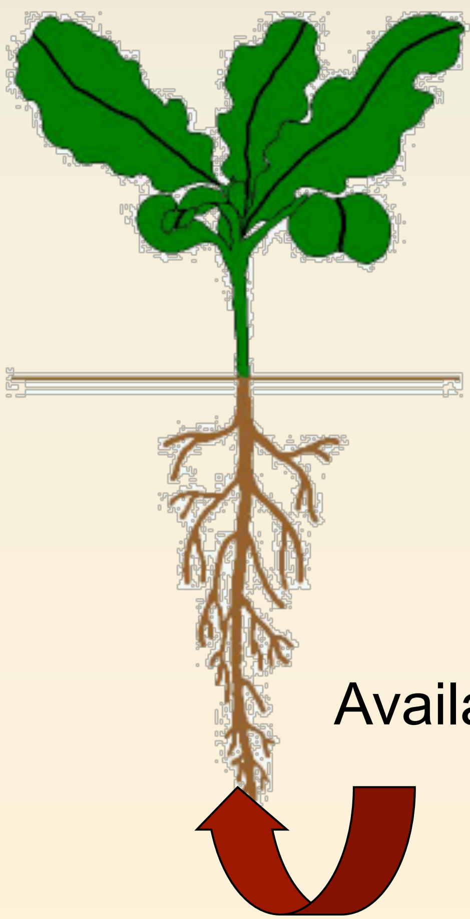
Crop Uptake

- Absorbed by crop in year 1:
  - 20 to 60% of applied K
  - Highest recovery on low K soils
- Slowly available K (future years):
  - Bulk of remaining K in most soil types
  - Future supply of K



Available K ↔ Slowly Available K ↔ Unavailable K

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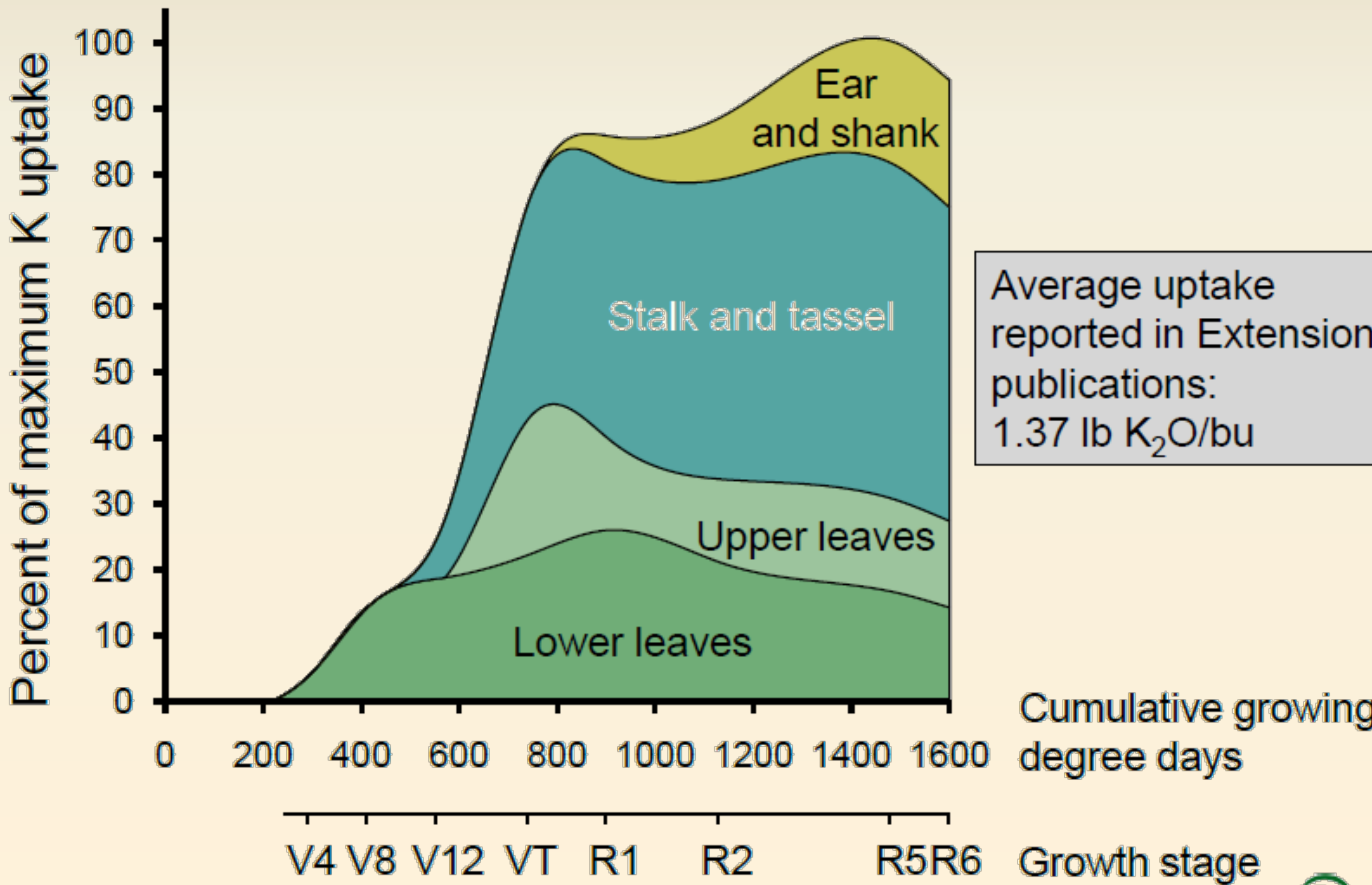
Crop uptake

- Poor soil Aeration
  - Oxygen is need for root uptake
  - Compaction
- Soil Moisture
  - To dry
  - To wet
- Soil Temp
  - Cool soil temp

Crop Uptake

Aerial partitioning of K in corn



Average uptake reported in Extension publications:
1.37 lb K_2O/bu

Karlen et al. 1988. Agron. J. 80:232

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Crop uptake

Crop	Yield/A	K uptake in total crop, lb K_2O/A
Corn	**250 bu**	**340(67.5)**
Soybeans	**60 bu**	**200(78)**
Wheat	40 bu	80 (19)*
Canola	35 bu	89 (20)
Peas	50 bu	150 (39)
Barley silage	4.5 tons	132
Alfalfa	**3 tons**	**180**

*K removed in grain in parenthesis.

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Soil Testing

- Most soil tests for K are based on either an ammonium acetate extraction or a similar extraction
- In some regions with low CEC soils, K rates are often based on the ratio of K relative to other bases, such as Ca and Mg
- Ion exchange membranes which measure the soil supply rate of K

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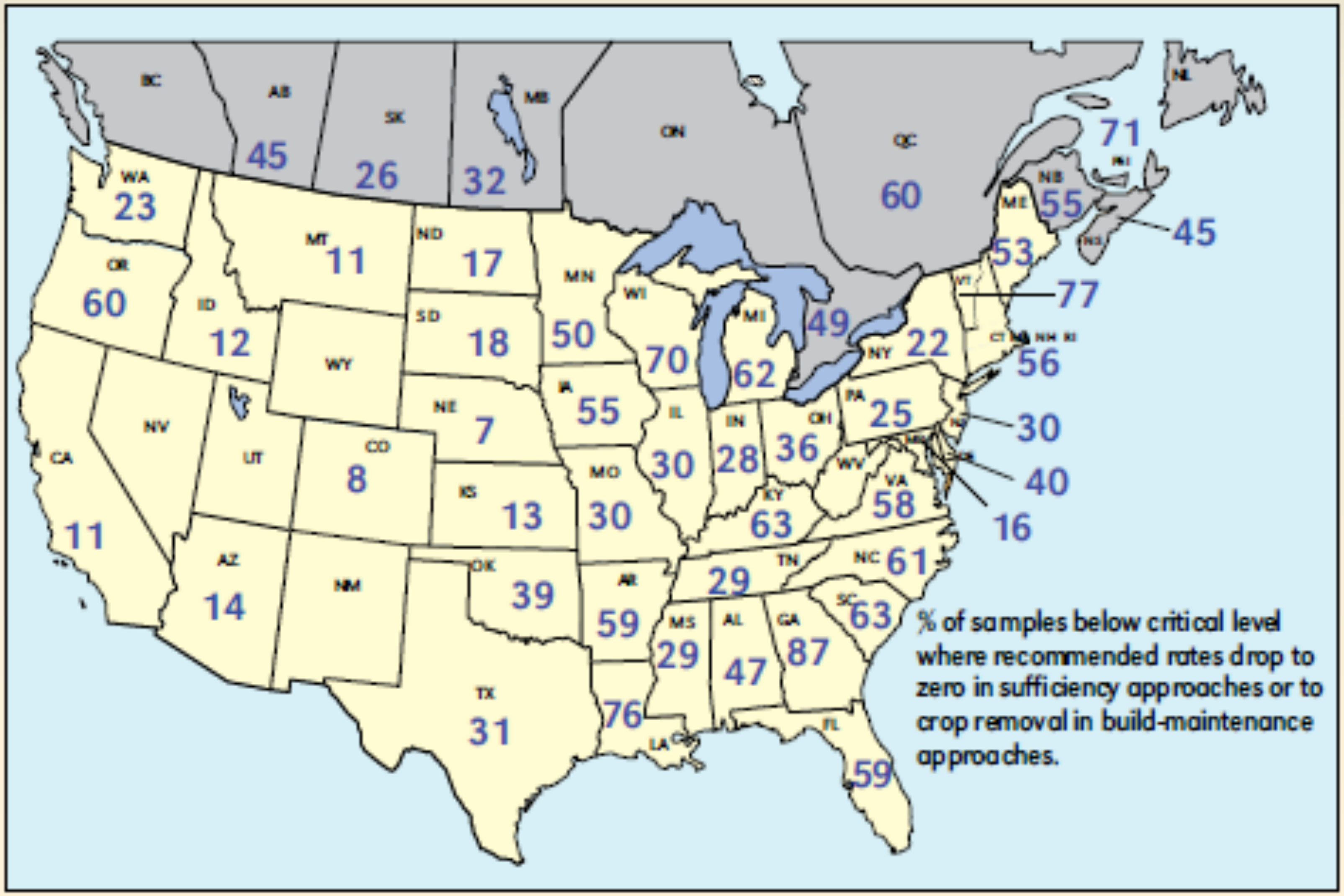
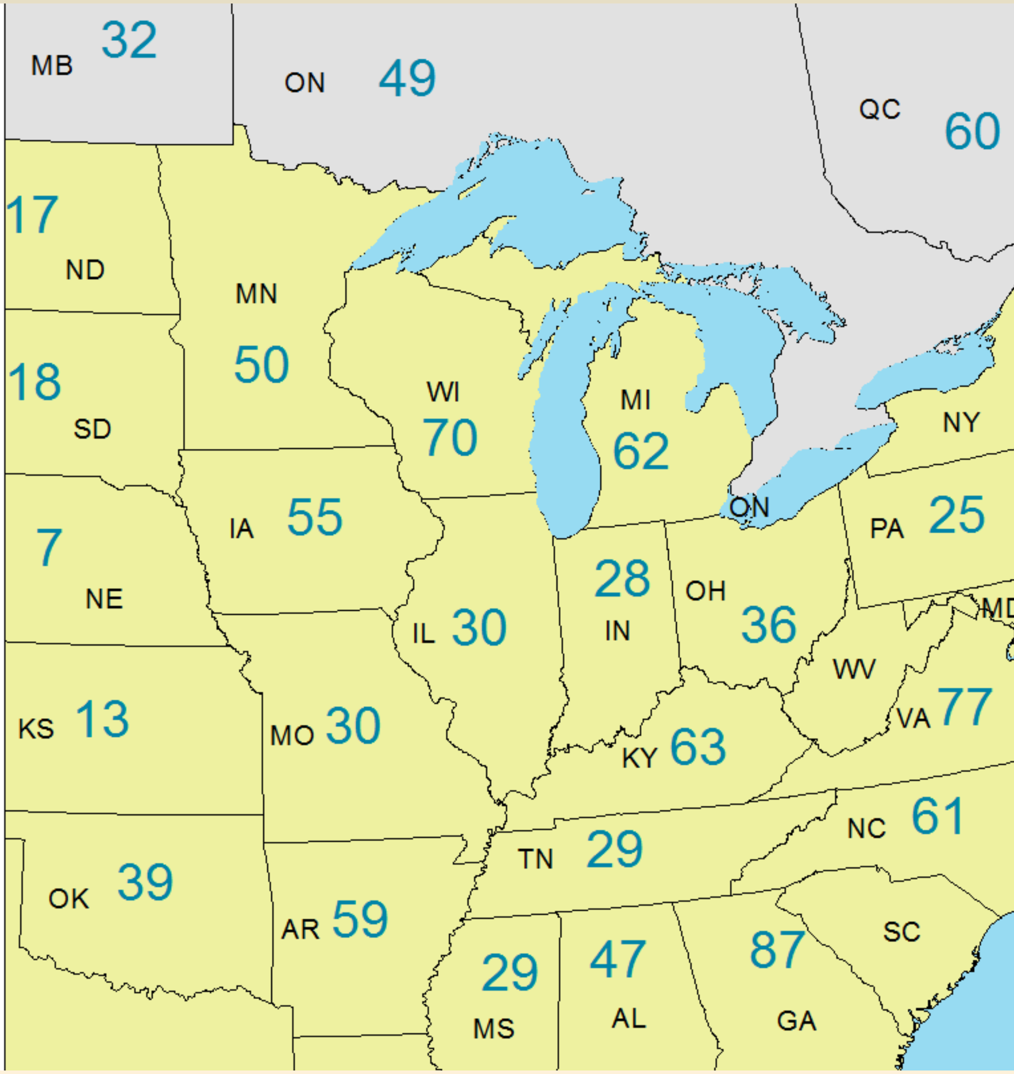
Soil test levels

Percent of samples testing below critical levels for K for major crops in 2010.



% Potassium Deficient Soils



Percent of samples testing below critical levels for K for major crops in 2010.

- Alfalfa K demand
  - Alfalfa has a high potash removal rate of 60 lb K_2O/t
  - Application rates of potash 150-300 lb K_2O/a

Alfalfa

- Alfalfa Facts
  - Perennial
  - Legume (fixes N)
  - Deep rooted (Taproot system)
  - Good drought tolerance
  - Optimal growth in 6.8-7.2 pH soils
- Alfalfa Forage Facts
  - High nutrient content protein, minerals
  - Good fiber digestibility
  - Rapidly digested
  - Supports high DM intakes
  - Supports high milk production

Neal Martin et al., USDA Dairy Forage Research Center

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Alfalfa Cultural Practices

- Alfalfa Planting
  - Most common spring planted (April time frame)
  - Some late summer planting (early to mid August)
  - Can be direct seeded (alfalfa only) or with a copanion crop like oats
- Alfalfa harvest
  - 3-4 time a year
  - Harvest starting in the first of June and occurring in 30 day intervals after that
  - Harvest as both Hay and Haylage
- Alfalfa stand
  - Can have a life span of 3-5 years
  - Average yields of 3-5 ton/a

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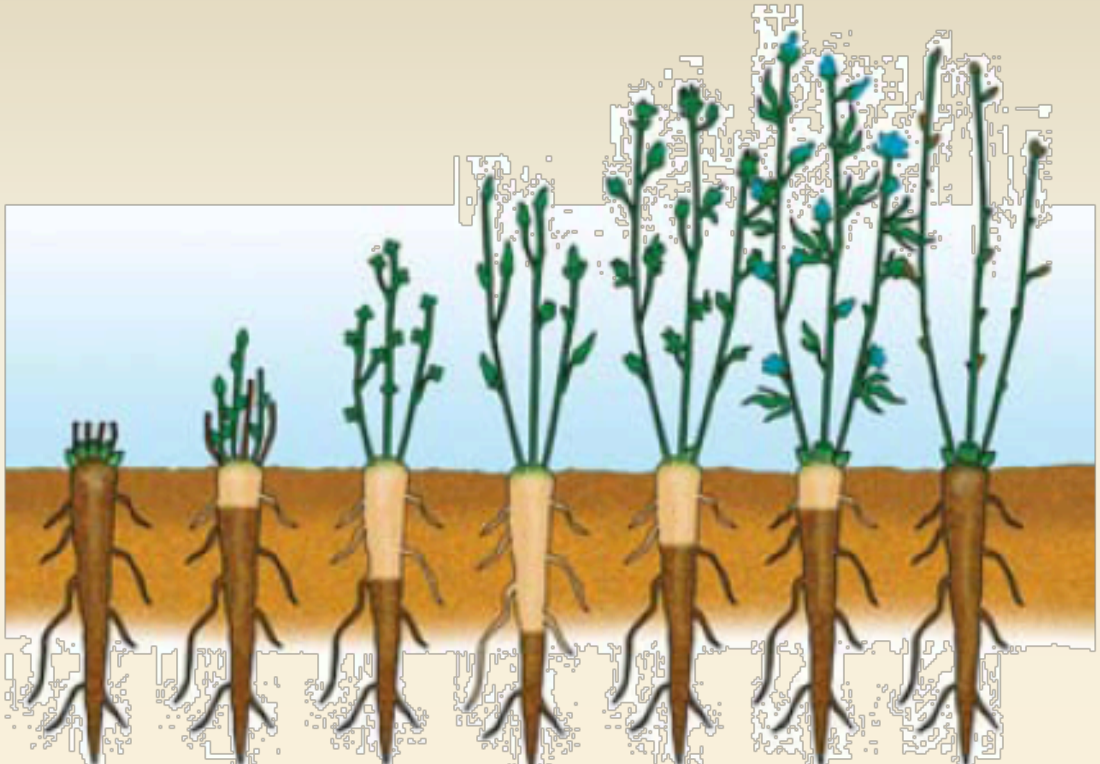
Alfalfa



Stored carbohydrates in taproots are necessary for rapid regrowth, winter survival, and root-rot resistance. This illustration shows the changes occurring as a result of regrowth after cutting. The darker area of the taproot represents the approximate carbohydrate level.

Source: NCR-184, Alfalfa Diseases in the Midwest

Alfalfa Nutrient Management

- Potassium Role in alfalfa
  - Optimizes yield
  - forage quality
  - disease resistance
  - overwinter survival
- Importance of managing potassium
  - Alfalfa is a luxury consumer of K (will take up more K than the plant needs)
  - To much K in transition cow’s (transitioning into lactation) diet is linked to milk fever
  - To much K will also reduce Ca and Mg availability

Alfalfa Nutrient Management

- 2010 Alfalfa plant K and S survey conducted by University of Wisconsin
  - 39 samples were collected across 17 counties
  - Samples were collected from the top six inches of new growth when the crop was in the bud to first flower stage
- Results
  - 51 were low in K
  - 64% were low in S
  - 31% were low in both K and S

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Potassium response Alfalfa

Effect of K fertilization on stand survival

K_2O Tmt	Lancaster (3)* soil K	Lancaster (3)* % stand	Manitowoc (7)* soil K	Manitowoc (7)* % stand	Barron (3)* soil K	Barron (3)* % stand	Arlington (4)+ soil K	Arlington (4)+ % stand	Madison (6) = soil K	Madison (6) = % stand
lb/a/yr	ppm	%	ppm	%	ppm	%	ppm	%	ppm	%
0	55	33	65	35	51	19	83	35	94	50
60	--	--	--	--	--	--	85	50	--	--
120	59	54	74	42	62	33	90	67	--	--
240	68	62	88	48	75	48	92	76	--	--
480	118	71	168	51	119	55	109	86	197	71
720	190	73	275	54	171	65	145	89	511	69
960	--	--	--	--	--	--	228	90	--	--
1200	--	--	--	--	--	--	--	--	462	72

K.A. Kelling and R.P. Wolkowski2 1992

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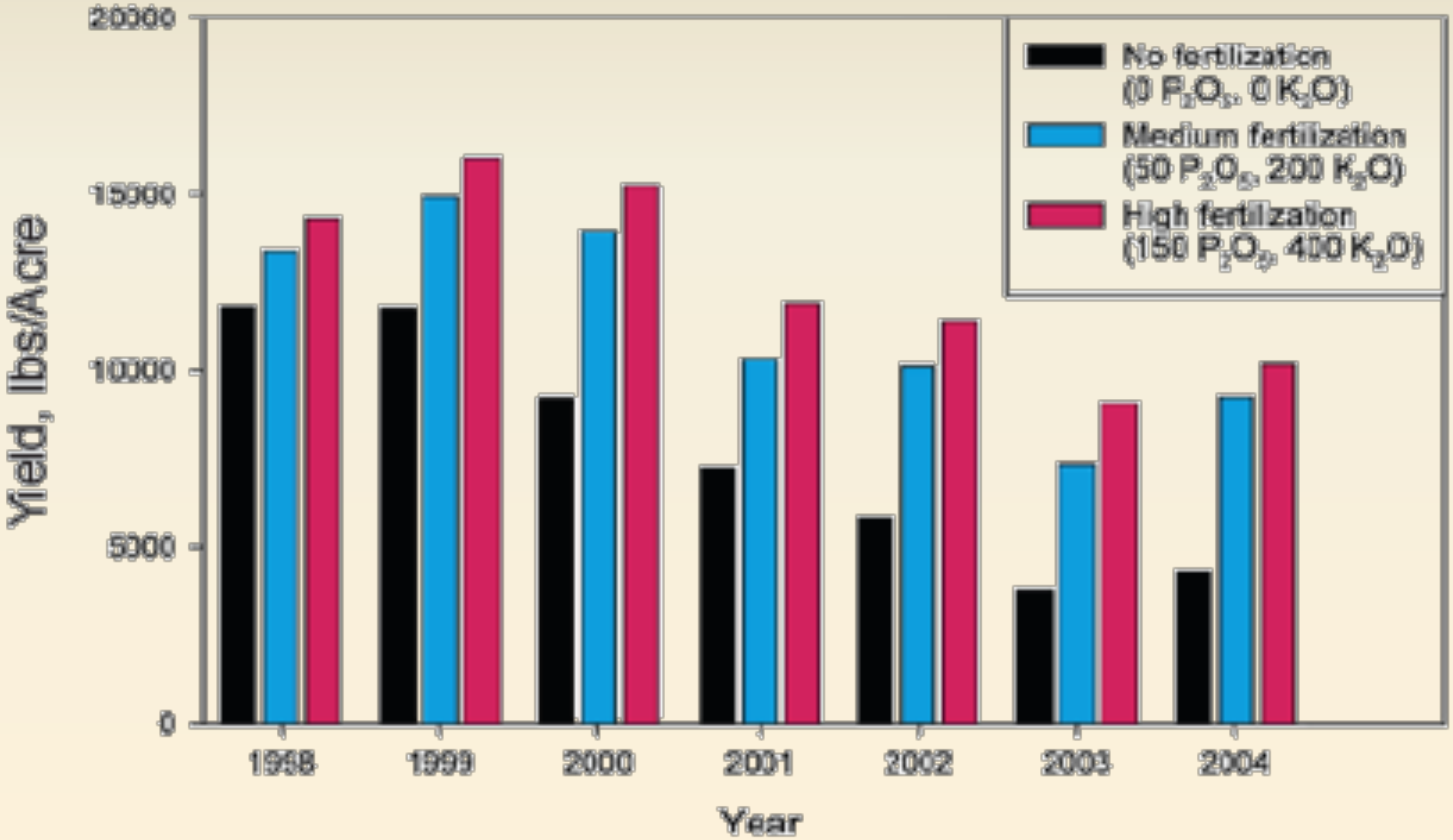
Potassium response Alfalfa



Purdue Extension AY-331-W

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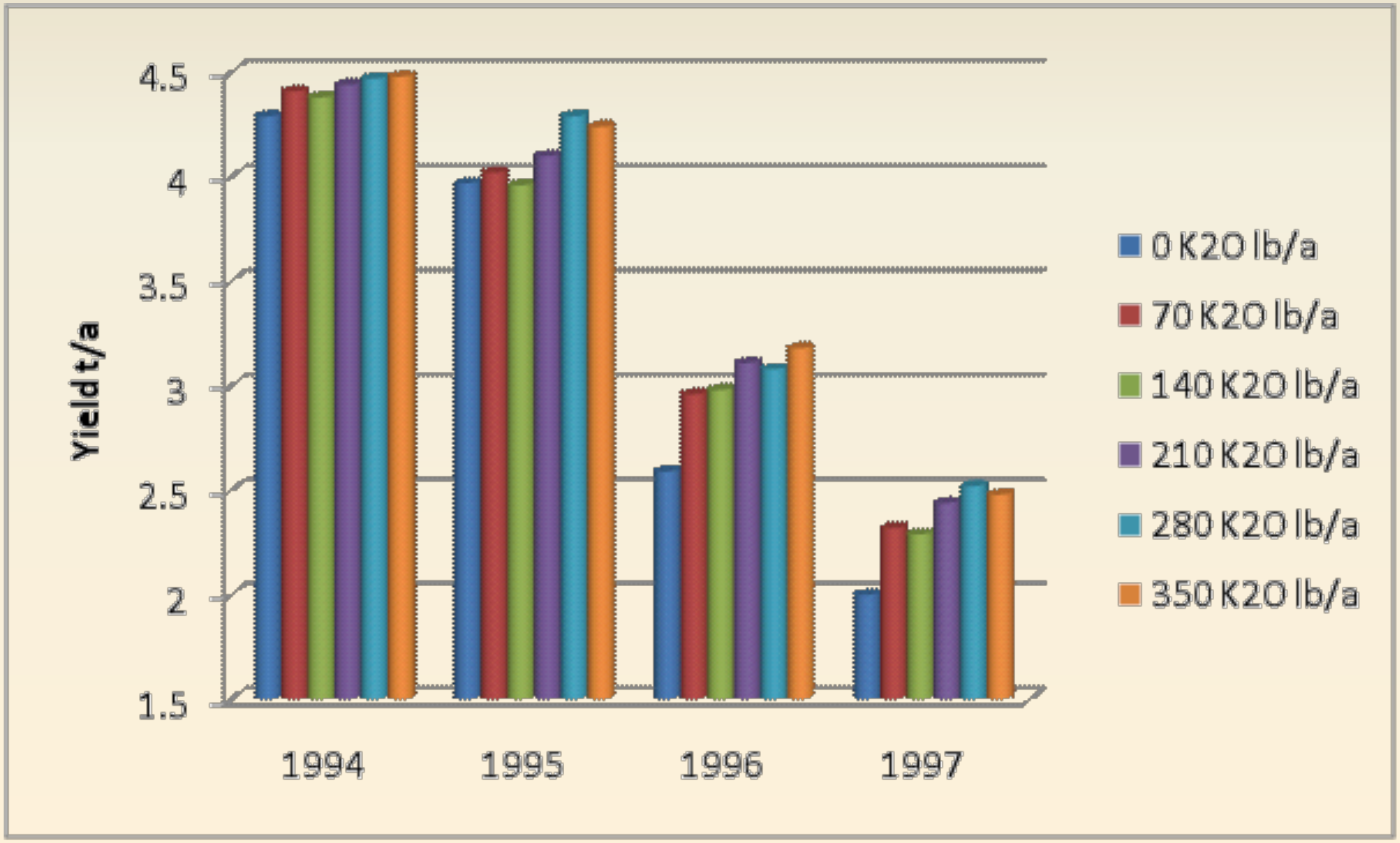
Potassium response Alfalfa

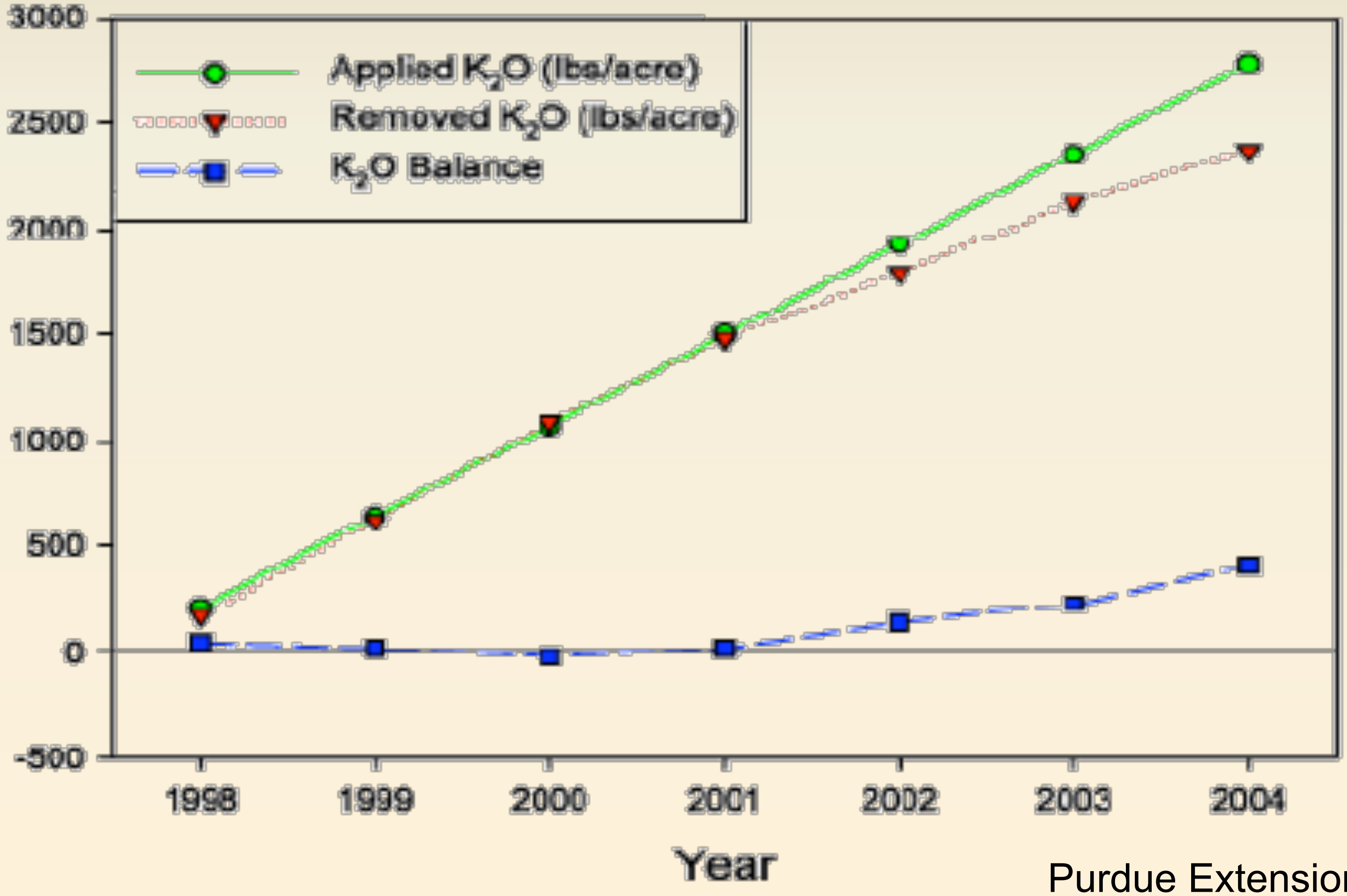
Alfalfa response to K rate



K.A. Kelling and P.E. Speth, 1998

Potassium response Alfalfa

K balance at 400lbs of K20/a/yr



Purdue Extension AY-331-W

Potassium response Alfalfa

Pounds of K20 removed to lower soil test by 1ppm

Cation Exchange Capacity	Lbs. of K_2O removed
6	5
12	9
18	13

- CEC = 12
- Yield = 5 tons per acre
- Potassium soil test level is 130 ppm at the beginning of the season.
- 5 tons/acre x 50 lbs. K2O per ton = 250 lbs. of K2O per acre removed by the crop.
- From Table 2, we see that it takes 9 lbs. of K2O of crop removal to change the soil test by 1 ppm. 250 ÷ 9 = 27.8 ppm decrease in the soil test level.

Michigan State University Extension Field crop News posted on May 20, 2010

Potassium deficient Alfalfa

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Potassium deficient Alfalfa

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Potassium deficient Alfalfa

http://landresources.montana.edu/soilfertility/kdeficiency.html

Potash fertilizer consideration

Potassium Fertilizers

Source	Analysis
Potassium sulfate, K_2SO_4 (SOP)	0-0-50 – 17
Potassium chloride, KCl (MOP)	0-0-60 (62)
Potassium-magnesium sulfate, (K-Mag) $K_2SO_4 \cdot 2MgSO_4$	0-0-22-22-11
Potassium nitrate, KNO_3	13-0-44
Potassium thiosulfate, $K_2S_2O_3$ (KTS)	0-0-25-17

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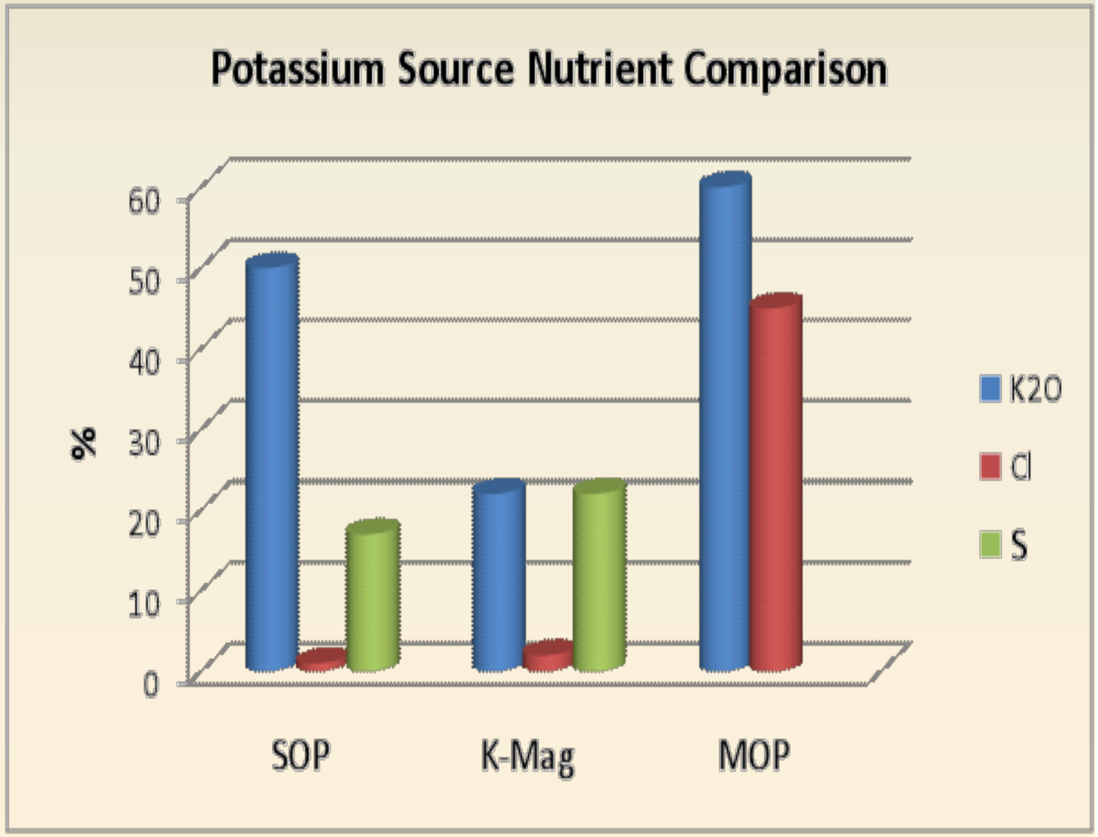
Potassium Fertilizers

- Many crops (e.g., almonds and potatoes) are chloride-sensitive
- SOP has lowest chloride among potassium fertilizers
- Our SOP is less than 1% chloride, guaranteed
- Minimized crop damage due to soil salt buildup



Potassium Fertilizers

- High salt levels can harm crops:
  - **Poor germination**
  - **Nutritional imbalances**
  - **Seedling injury**
  - **“Tip burn”**
  - **Stunted root and shoot growth**

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Potassium Fertilizers

- Gives an indication of the relative effect of a fertilizer on the soil solution

- Fertilizers are compared to Sodium Nitrate used as a standard

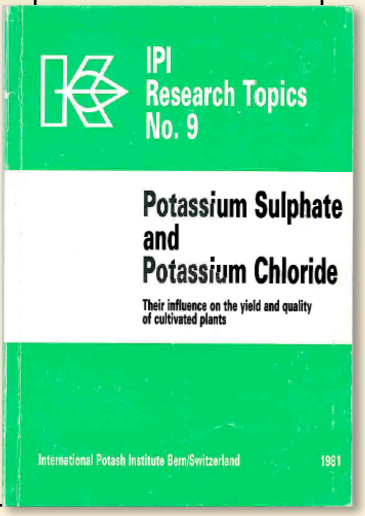
- Sodium Nitrate's salt index is 100

Salt Index		
Potassium Fertilizers	**Salt Index**	**Salt Index/unit of K_2O**
MOP (Potassium Chloride- 60%)	116.2	1.936 (K_2O)
Sodium Nitrate	100	6.06 (N)
Potassium Nitrate	73.6	1.58 (K_2O)
KTS (Potassium Thiosulfate)	64	2.56 (K_2O)
SOP (Potassium Sulfate)	46.1	0.88 (K_2O)
K-MAG (Sulfate of Potash Magnesia)	43.2	1.96 (K_2O)

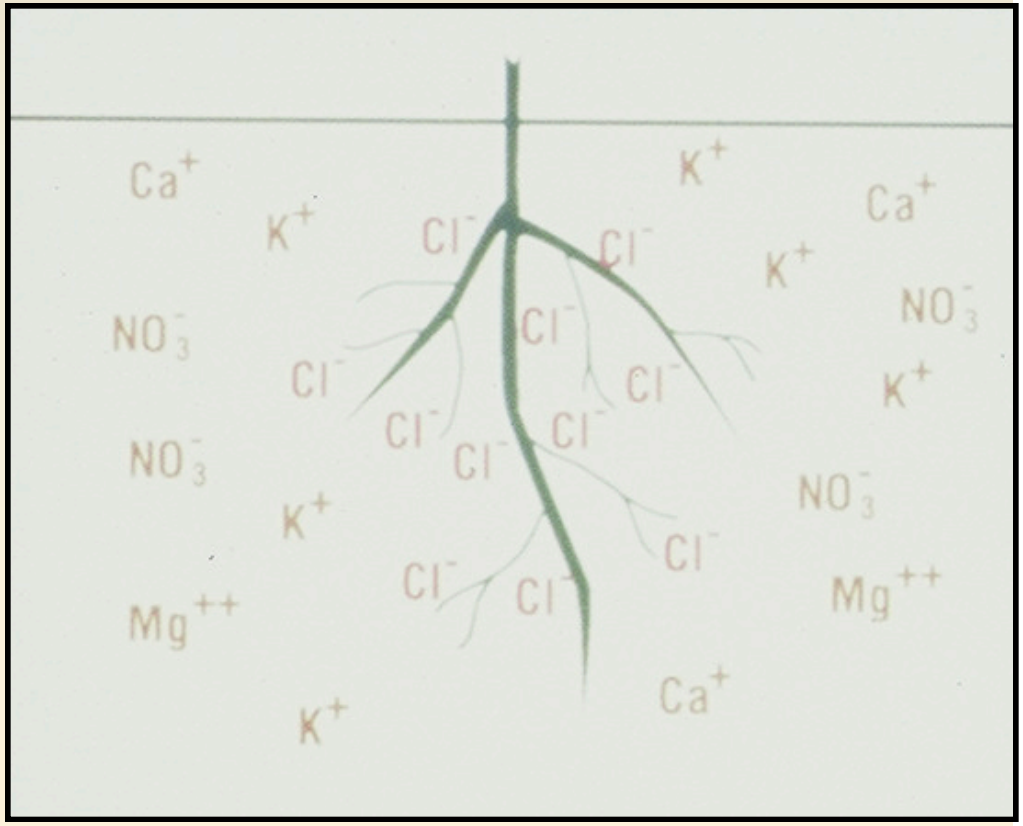
Potassium Fertilizers

- **Negative effect of Cl** more evident on light soils than on heavier soils.
- **Potassium Sulfate has the advantage** on low P soils since it improves P availability.
- When the P supply is high, **Cl reduces P uptake.**

Low	Moderate	High
Alfalfa	Barley	Asparagus
Apples	Cabbage	Bermudagrass
Apricots	Carrots	Cotton
Berries	Cucumbers	Spinach
Canola	Grapes	Date Palm
Celery	Melons	
Cherries	Peppers	
Corn	Pumpkins	
Lettuce	Wheat	
Oats		
Onions		
Peaches		
Potatoes		
Radish		
Tobacco		
Tomatoes		



- Excess chloride
  - Can accumulate and become toxic in the plant
  - Can accumulate in the soil and reduce nutrient uptake of
    - Nitrate
    - Sulfate
    - Phosphorus
    - Boron



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Potassium Fertilizers

Table 2.1. Chloride concentrations in some natural sources.

Source	Chloride (g kg^{-1})
Earth crust	1.50
Lithosphere	0.48
Basalt rocks	0.50
Syenite	0.98
Igneous rocks	0.23
Shale	0.16
Sandstone	0.02
Limestone	0.37
Dolomite	0.50
Soils	0.10
Ocean	19.0
Plants	1.0-10.0
Low to medium saline water	0.10-0.30[a]
High to very high saline water	0.30-1.20[a]
Table salt (NaCl)	607
Potassium chloride (KCl)	450-570

Compiled from Yaalon (1963); Flowers (1988). [a] Unit: kg m^{-3}

Sulfate of Potash (SOP)

where it might fit

0-0-50-17S

- High K2O analysis 50%
  - Alfalfa has a high potash demand removal rate of 60 lb K_2O/t
  - Application rates of potash 150-300 lb K_2O/a
- High S 17% i
  - Sulfur in the sulfate form, immediate plant available form
  - Alfalfa has a typical response to about 30lb S/a when deficient in the soil
- Low Cl less than 1%
  - Balanced plant nutrition total 67% potassium and sulfur everything you need and nothing you don’t
- Low salt index
  - Flexibility in application and timing
  - Safety for the plant and soil systems
- Lower potential for leaching
  - Less losses in sandy soils

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Potassium Response Alfalfa

ALFALFA RESPONSE TO K RATE, SOURCE AND TIME OF APPLICATION^'

K.A. Kelling and P.E. Speth

- K rate response
  - 0, 70, 140,210, 280, 350 lb K20/a
  - K source K2SO4
- K source response
  - K2SO4, KCl, KCl+S
  - 70, 210, 350 lb/a
- K application timing
  - Green up, after 1st cut, after 3rd cut, split 1st and 3rd cut
  - 350 lb K2O/a as K2SO4 or KCl

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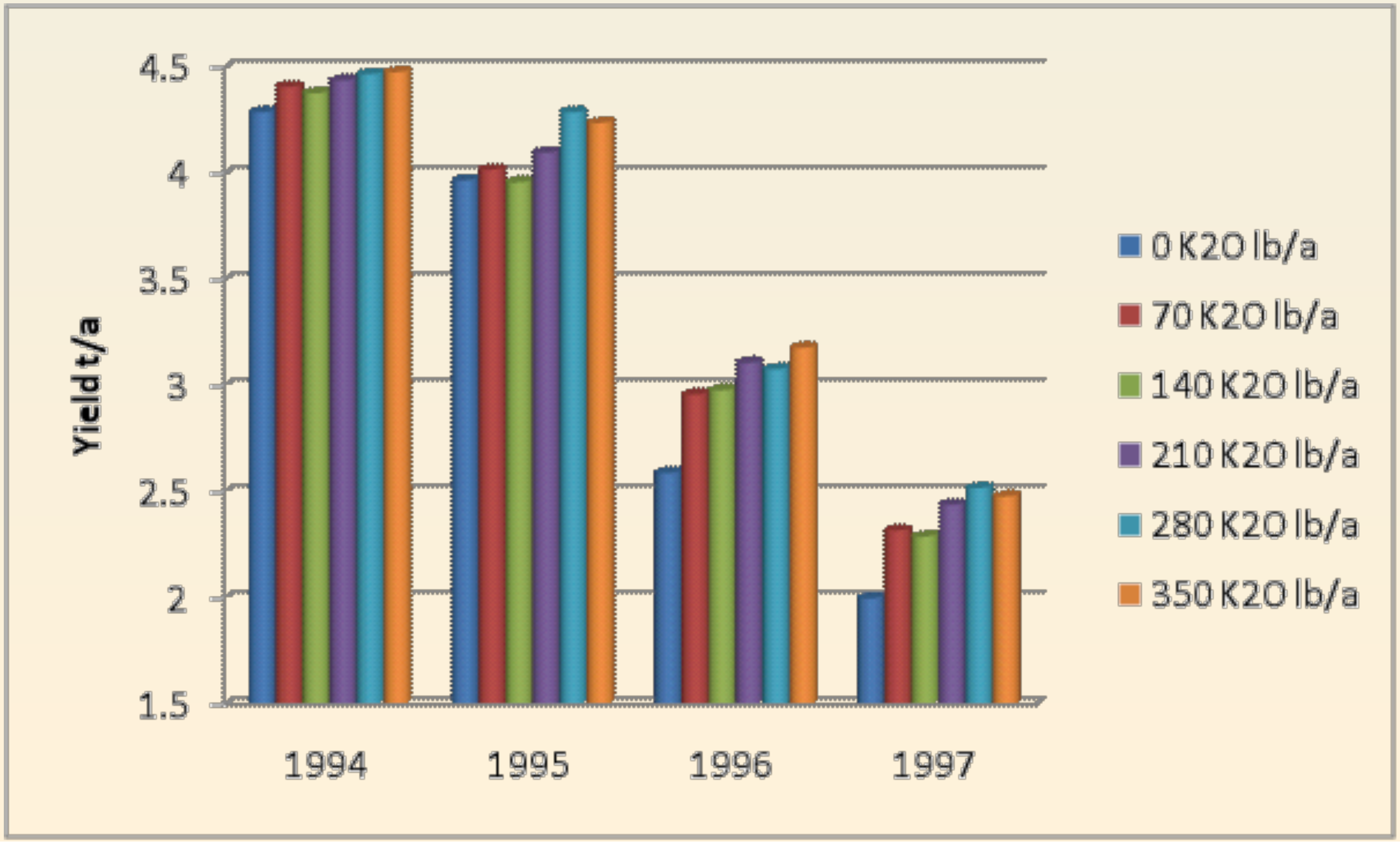
Alfalfa response to SOP rate

- Results
  - 210 lb K2O/a optimum rate of SOP
  - Increased stand productivity
  - Improved yield



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Effect of K Source Alfalfa Yields

- Results
  - SOP significantly increased yields 3 of 4 years
  - SOP significantly increased yields of KCl+S in 1994, however in subsequent year no difference was seen

K source	Alfalfa yields[1]			
	1994	1995	1996	1997
	(ton/acre (dry weight)			
K_2SO_4	4.63	4.21	2.98	2.39
KCl	4.40	4.16	2.76	1.95
KCl+S	4.29	4.28	2.99	2.40
$LSD_{0.05}$	0.23	NS	0.19	0.19

[1/]Averaged across 3 topdress rates and 2 initial soil test K levels.

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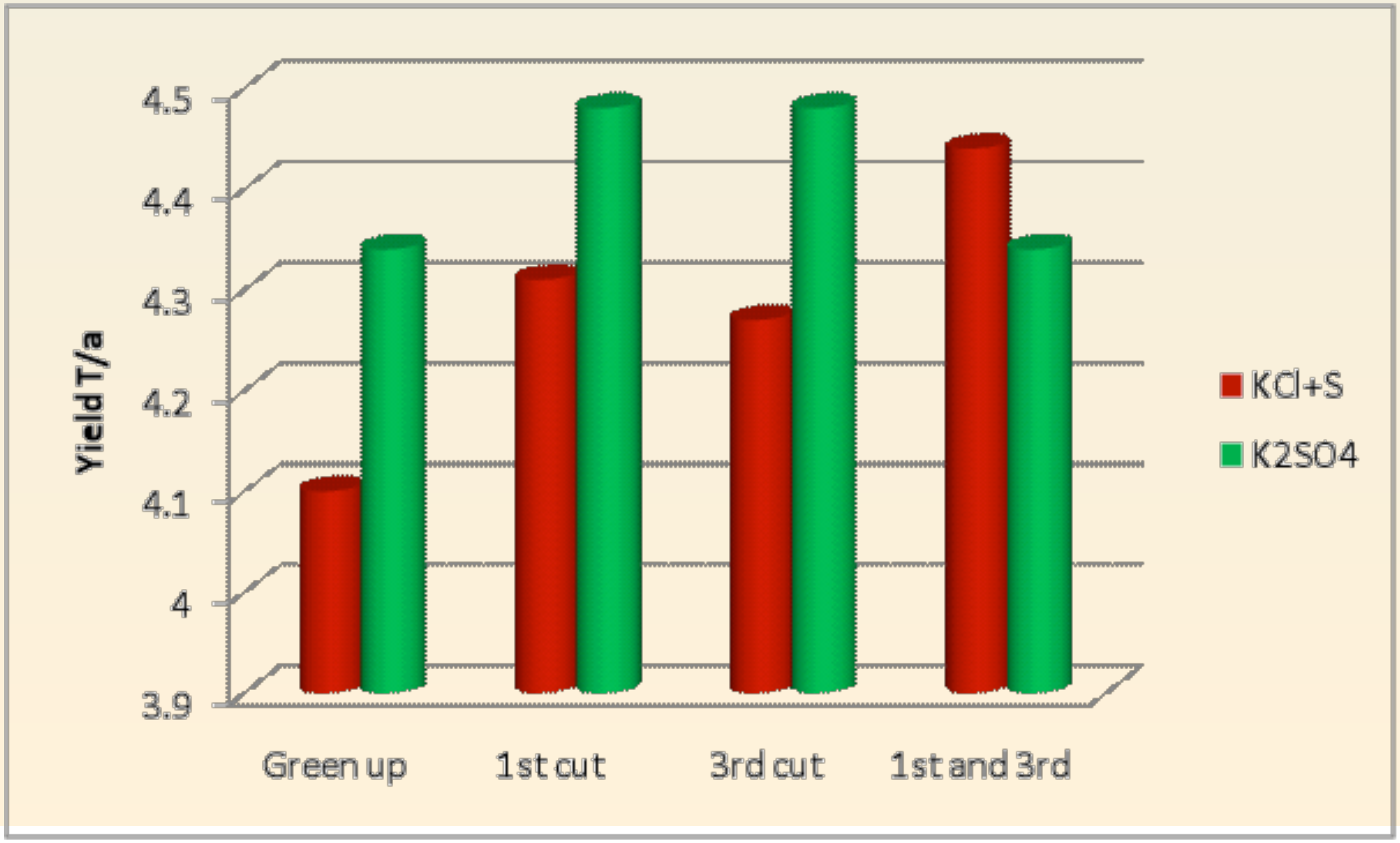
Interaction of K Source and Timing

- Results
  - SOP increased yields 3 of 4 application timings
  - SOP applications after the 1st or 3rd cutting resulted in the greatest yield



GSL is Investing in Research

- Not a tremendous amount of research has been done with SOP on alfalfa
- Research has plots were established in Wisconsin in spring 2010
- Opportunities
  - Greater yields with SOP
  - Enhanced nutrient use efficiency
  - Maximizing forage quality
  - Improved haylage production
  - Improved nodulation
  - Enhanced palatability

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Return of Using SOP

- How much is $15/a
  - 0.1t/a Alfalfa yield gain from SOP
  - 30 lb N/a gained in the rotation from increased nodulation
  - $15 of increased feed value

Alfalfa potassium cost 200 lb K2O/a 30 lb S/a

	K2O	S	Total
Application Rate lbs/Acre	200	30	
Cost Using MOP	$100	$25	$125
Cost Using SOP	$140	$0	$140
Difference			$15

Sulfur the 4th macro nutrient?

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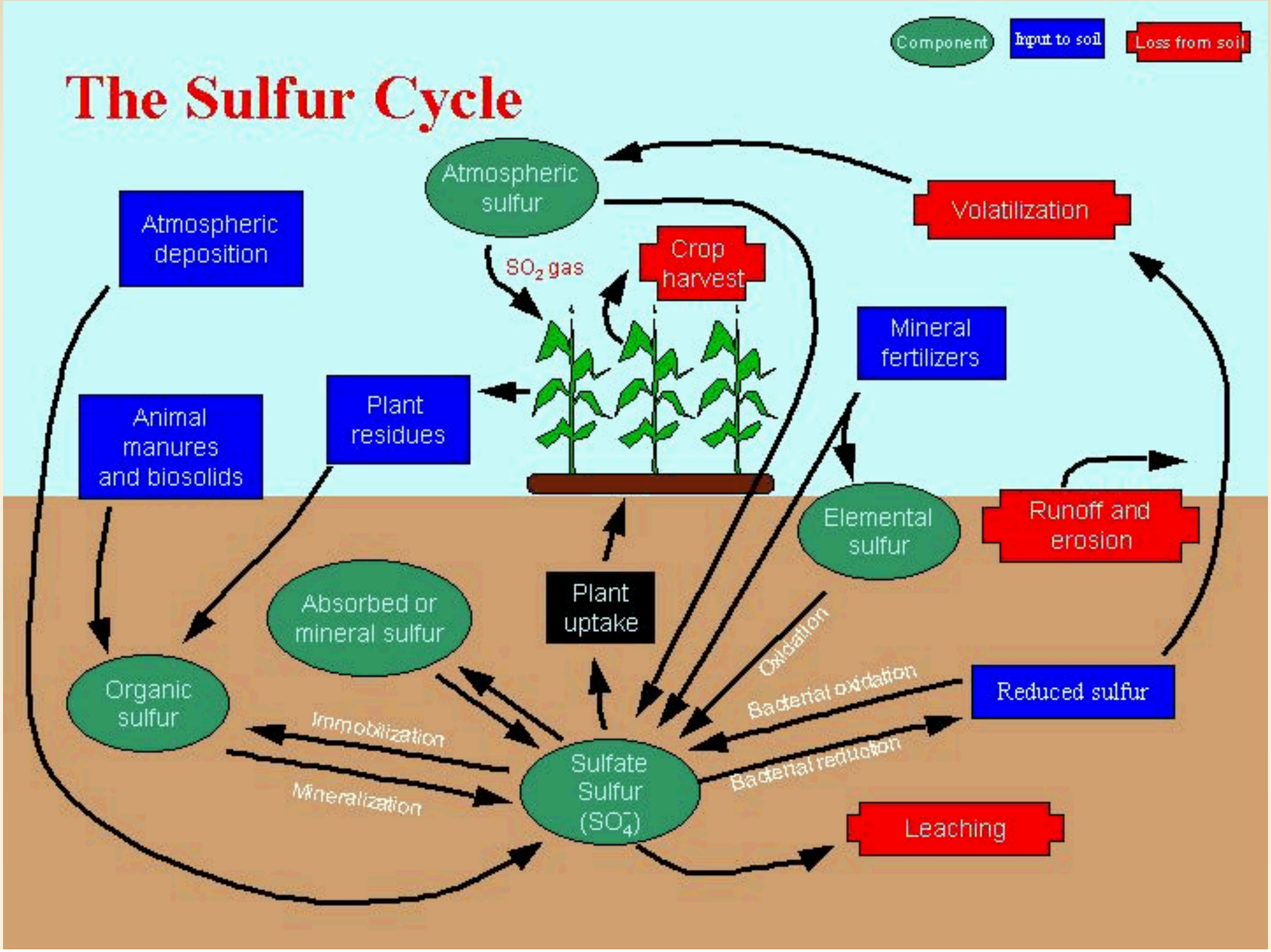
Sulfur



Sulfur function in the plant

- synthesis of amino acids
  - Amino acids are the building block of proteins
- Sulfur deficient plants
  - Accumulate more non protein N in the leaves increases the N:S ratio
  - It is important to maintain an N:S ration for proper microbial function in rumen animals
  - It can also effect food quality in vegetable production

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Sulfur Deficiencies

- Soil Properties and Climatic Conditions Aggravating Deficiency Symptoms
  - Coarse textured soils (sandy soils)
  - Low organic matter soils
  - Cold, wet soils
    - Slow release of S from organic matter
  - Low atmospheric deposition

- No application from
  - Manure
  - Other fertilizers

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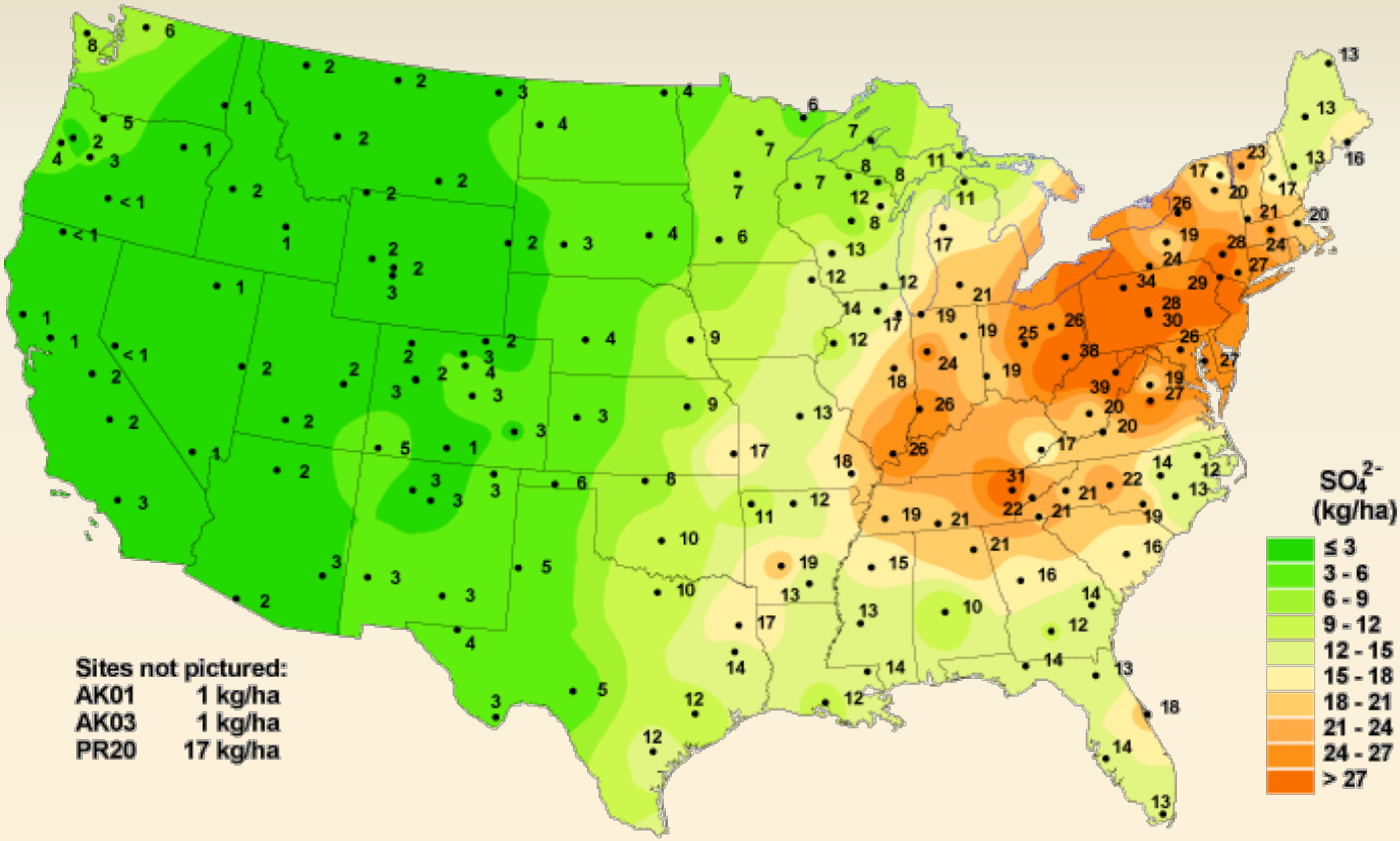
Sulfur

Sulfate ion wet deposition, 1994



National Atmospheric Deposition Program/National Trends Network
http://nadp.sws.uiuc.edu

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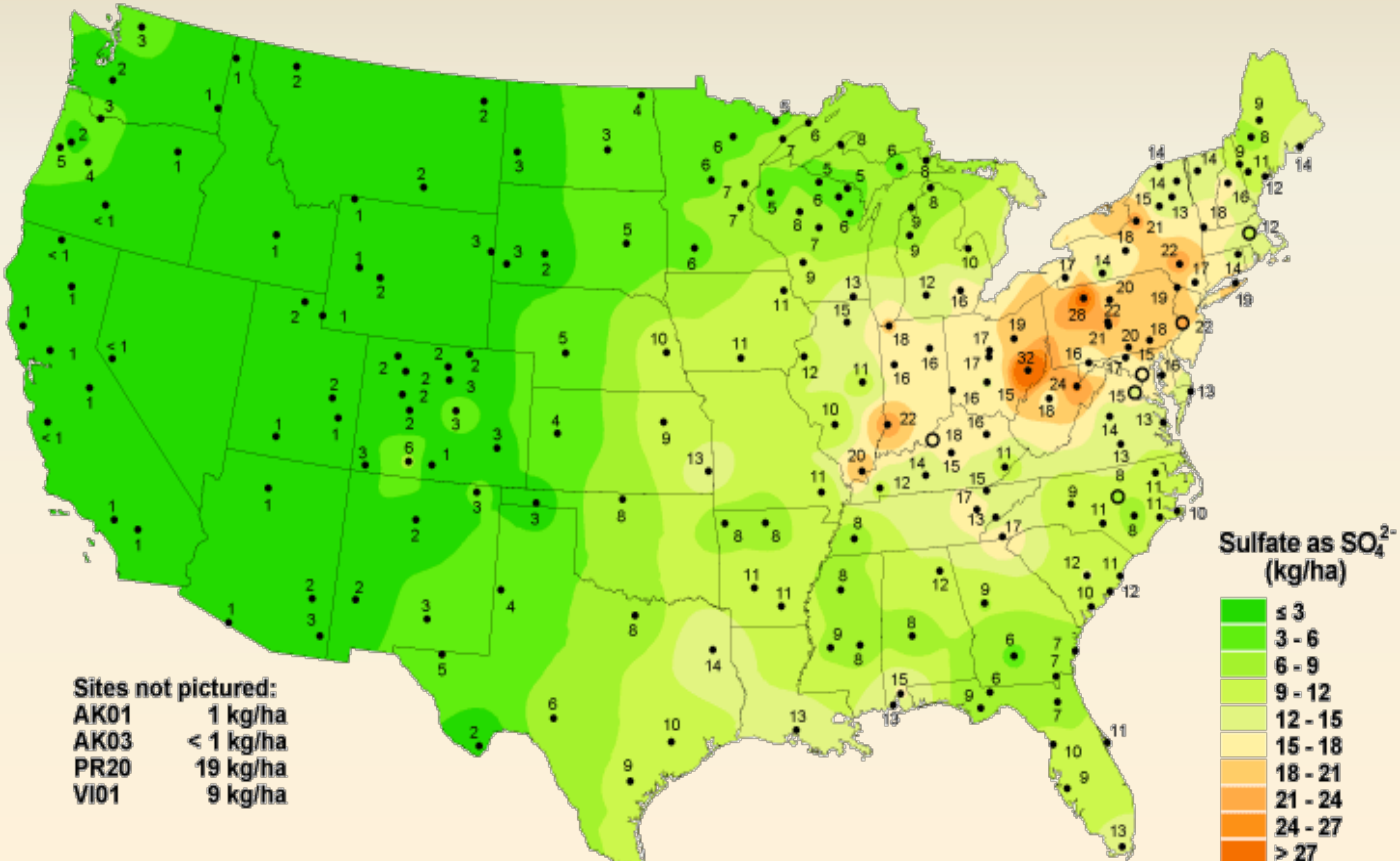
Sulfur

Sulfate ion wet deposition, 2007



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Sulfur

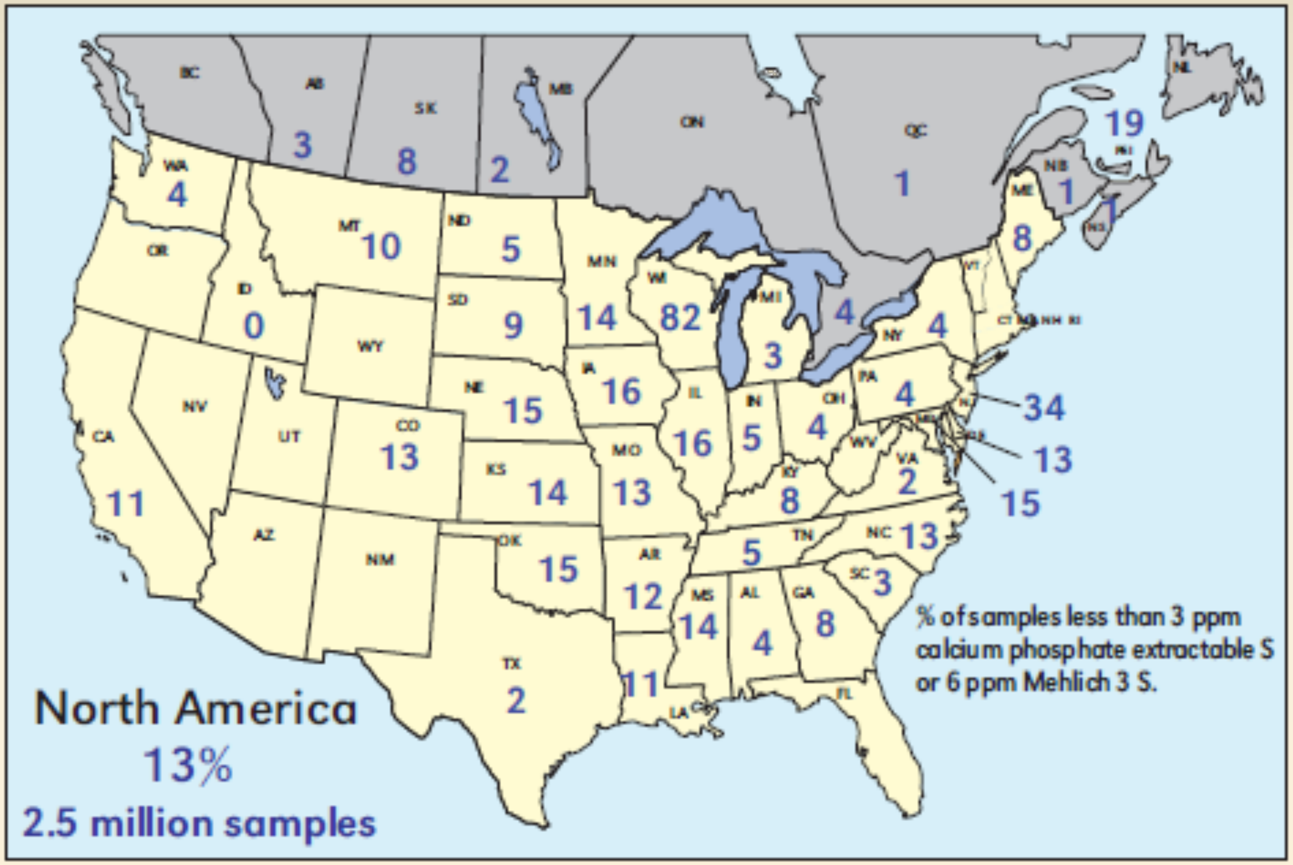

Figure 8. Percent of soils testing less than 3 ppm S in 2010 (for states and provinces with at least 2,000 S tests).

Sulfur deficient Alfalfa

Sulfur deficiency in alfalfa (right): short plants, thin stems, and light green color.

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Sulfur deficient Alfalfa

Stunting and yellowing of new growth caused by sulfur deficiency. Photo courtesy of Montana State University

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Sulfur Response in Alfalfa

- Results
  - 25 lb S/a optimum rate of sulfate
  - S increased stand productivity
  - Sulfate preformed better that elemental

Source	Rate	1997	1998	1999	2000
	lb S/a	———Dry matter yield ton/a———			
Check	0	0.74	4.08	4.33	3.3
Sulfate-s	25	0.97	4.27	5.09	3.74
	75	0.93	4.22	5.04	3.67
	225	1.03	4.28	5.25	3.85
Elemental S	25	0.66	4.4	4.96	3.43
	75	0.85	4.04	5.12	3.92
	225	0.95	4.37	4.96	3.76

K.A. Kelling, et, al 2002

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Carrying Effect of 1x75 lb S/a appl over 4 years

- Results
  - SOP and elemental performed similarly
  - S increased yield and tissue S%

Source	1997	1998	1999	2000
	———Dry matter yield ton/a———			
Check	0.74	4.08	4.33	3.3
K2SO4	0.87	4.2	5.23	4
CaSO4	0.87	4.04	5.01	3.96
Elemental S	0.91	4.39	5.48	3.79
	————Tiss S %————			
Check	0.25	0.2	0.15	0.19
K2SO4	0.33	0.27	0.2	0.23
CaSO4	0.34	0.28	0.21	0.23
Elemental S	0.25	0.26	0.24	0.28

K.A. Kelling, et, al 2002

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  - Improved nodulation
  - Enhanced palatability