Potassium & Potassium Management

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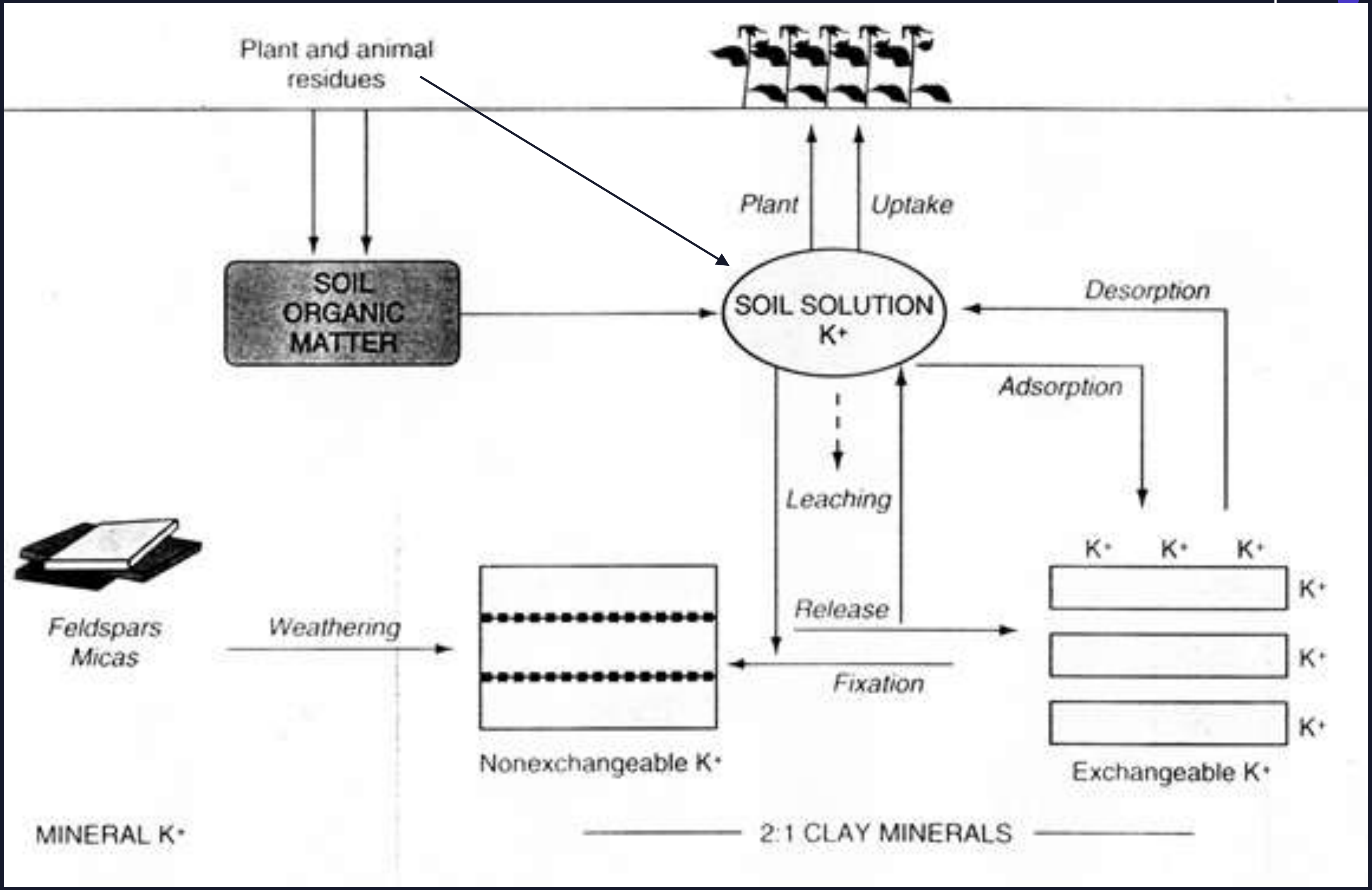
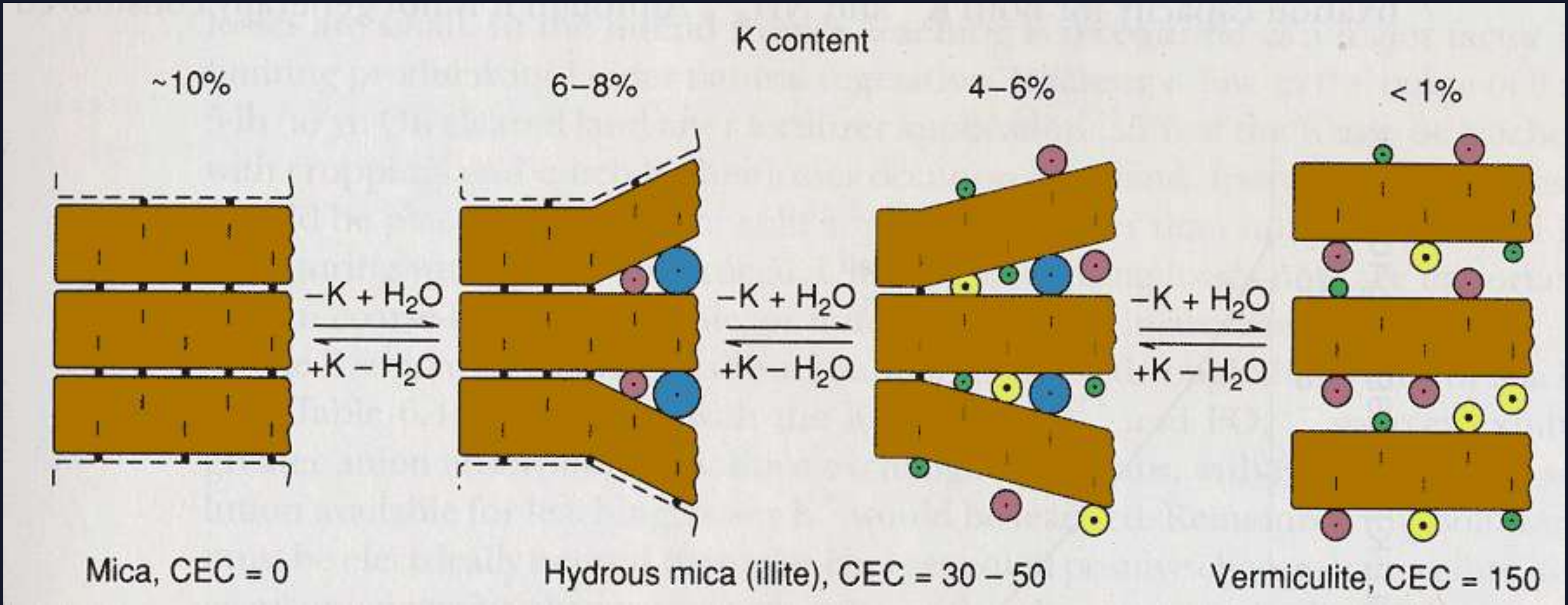
Potassium Cycle



Havlin et al., 2001

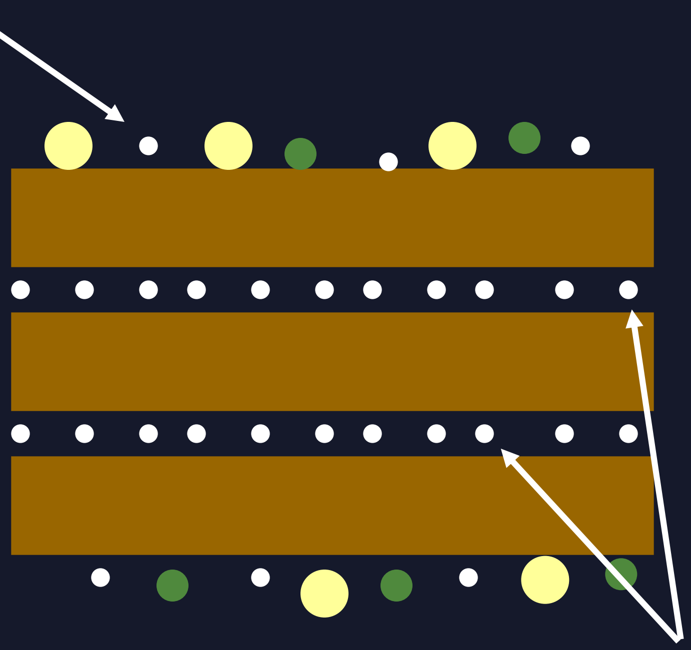
K release during mineral weathering



Recolored from Fig. 6.9 in Havlin et al. (1999)

Exchangeable vs. Non-exchangeable K

Exchangeable K
Readily buffers
soil solution K



Non-Exchangeable K
Slowly buffers
soil solution K

Soil tests measure exchangeable K

Factors Influencing Exchangeable K

- Wetting/drying
- Freeze/thaw
- Oxidation state of Fe

Wetting/Drying

- Exchangeable K can increase or decrease when soil is dried
  - Is dependent upon the clay minerals present
- K fixation can occur
  - Soils with high exchangeable K or recent K fertilizer applications are dried
  - Fixation is a result of K becoming trapped within clay sheets as they dry and collapse
- K release can occur
  - Soils low in exchangeable K are dried
  - The clay sheets roll back and release K

Wetting/Drying

- Net effect depends on whether fixation or release dominates
- Time of soil sampling in relation to field wetting and drying cycles may influence soil test K levels

Freeze/Thaw

- Fixed K released with freeze/thaw
  - Soils with considerable amount of mica
- K release/fixation not impacted by freeze/thaw
  - Soils with smaller amounts of mica & greater amounts of exchangeable K
- STK may be different in spring v. fall
  - Depending on clay minerals present & winter weather conditions

Oxidation State of Fe

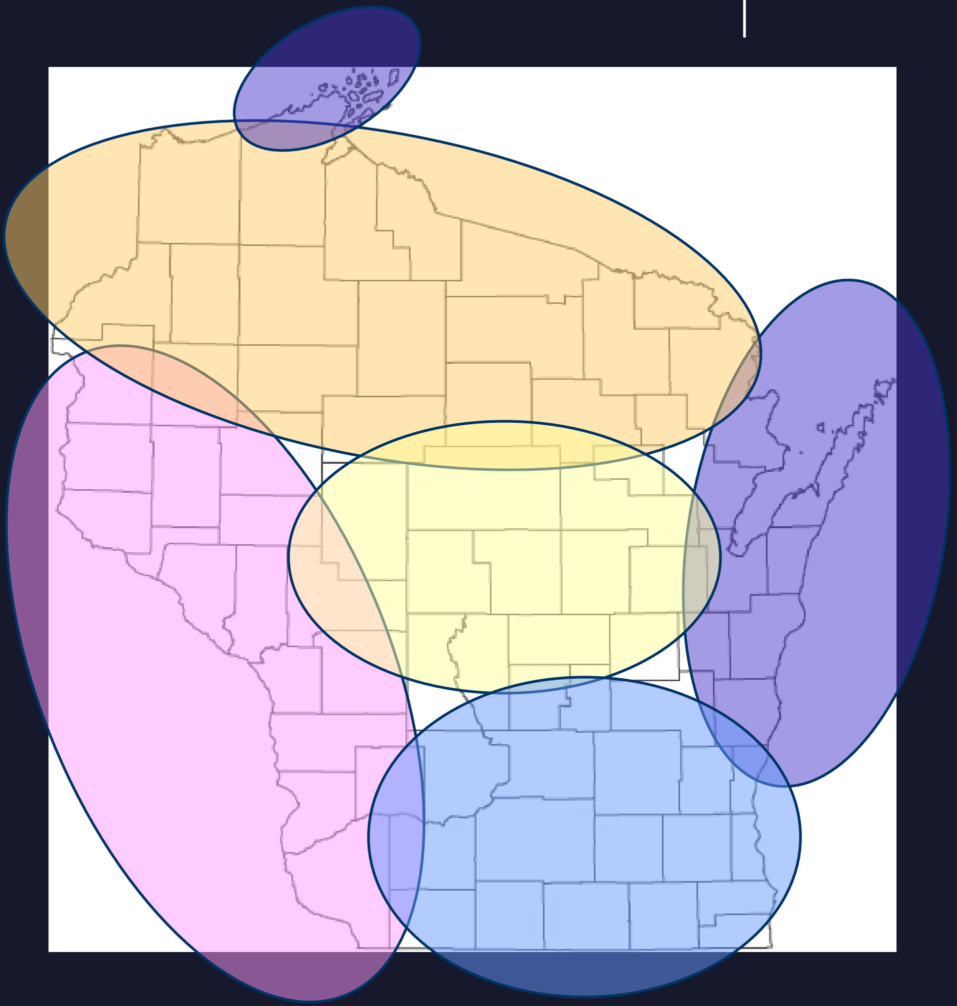
- Fe structural component in clay minerals
- Fe has different oxidation states
  - Fe^{3+} - oxidized
  - Fe^{2+} - reduced

- In smectites, as $Fe^{3+} \rightarrow Fe^{2+}$, K is fixed
- In illite, as $Fe^{3+} \rightarrow Fe^{2+}$, K is released

- In soils containing both illite & smectite, net effect of fixation/release depends on which clay mineral dominates

Clay Minerals in WI

- Composition of clay minerals varies
- Environmental impacts on STK may vary differently depending upon region



C. Stiles, personal communication (2004)

What does a soil test measure?

- Soil test K measures:
  - K in soil solution
  - Exchangeable K
- Seasonal variation in soil test K is known to exist
  - Sample at about same time each year to minimize this factor

Interpreting soil test K results

	Medium & fine soils		Course textured soils[†]	
Crop	Optimum	No response	Optimum	No response
	------------------ Soil Test K (ppm) ------------------			
Alfalfa	91 – 120	> 170	81 - 120	> 180
Corn	81 – 100	> 140	66 – 90	> 130
Soybean	81 – 100	> 140	60 – 80	> 120

[†] Not irrigated

Environmental Factors Affecting K Availability to a Plant

78 % of K supplied to root via diffusion

- Soil moisture
  - Low soil moisture results in more tortuou
    for K diffusion – takes longer to get to root
  - Increasing K levels or soil moisture will increase K diffusion
  - Increase soil moisture from 10 to 28 % can increase toatl K transport by up to 175 %
- Soil Aeration
  - High moisture results in restricted root growth, low O_2 and slowed K absorption by the root

Environmental Factors Affecting K Availability to a Plant

- Soil temperature
  - Low temperature restricts plant growth and rate of K uptake
  - Providing high K levels will increase K uptake at low temperatures
    - Reason for positive response to banded starter
- Soil pH
  - At low pH, K has more competition for CEC sites
  - As soils are limed, greater amount of K can be held on CEC and K leaching reduced.

Environmental Factors Affecting K Availability to a Plant

- Leaching
  - K leaching can occur on course textured or muck soils particularly if irrigated
  - Large fall K applications to sandy or muck soils discouraged

K Sources

K Sources – Inorganic

Fertilizer	Chemical Formula	Fertilizer Analysis	Salt Index
Potassium chloride (muriate of potash)	KCl	0-0-60 to 0-0-62	116
Potassium magnesium sulfate	$K_2SO_4 \cdot 2MgSO_4$	0-0-22	43
Potassium nitrate	KNO_3	13-0-44	74
Potassium sulfate	K_2SO_4	0-0-50	46

Red v. White Potash

- Both mined KCl
- Red potash produced by floatation, 0-0-60
- White potash produced by recrystallization, 0-0-62
- Color due to Fe and Mn impurities
- Use white for liquids
- No agronomic difference

K Sources - Organic

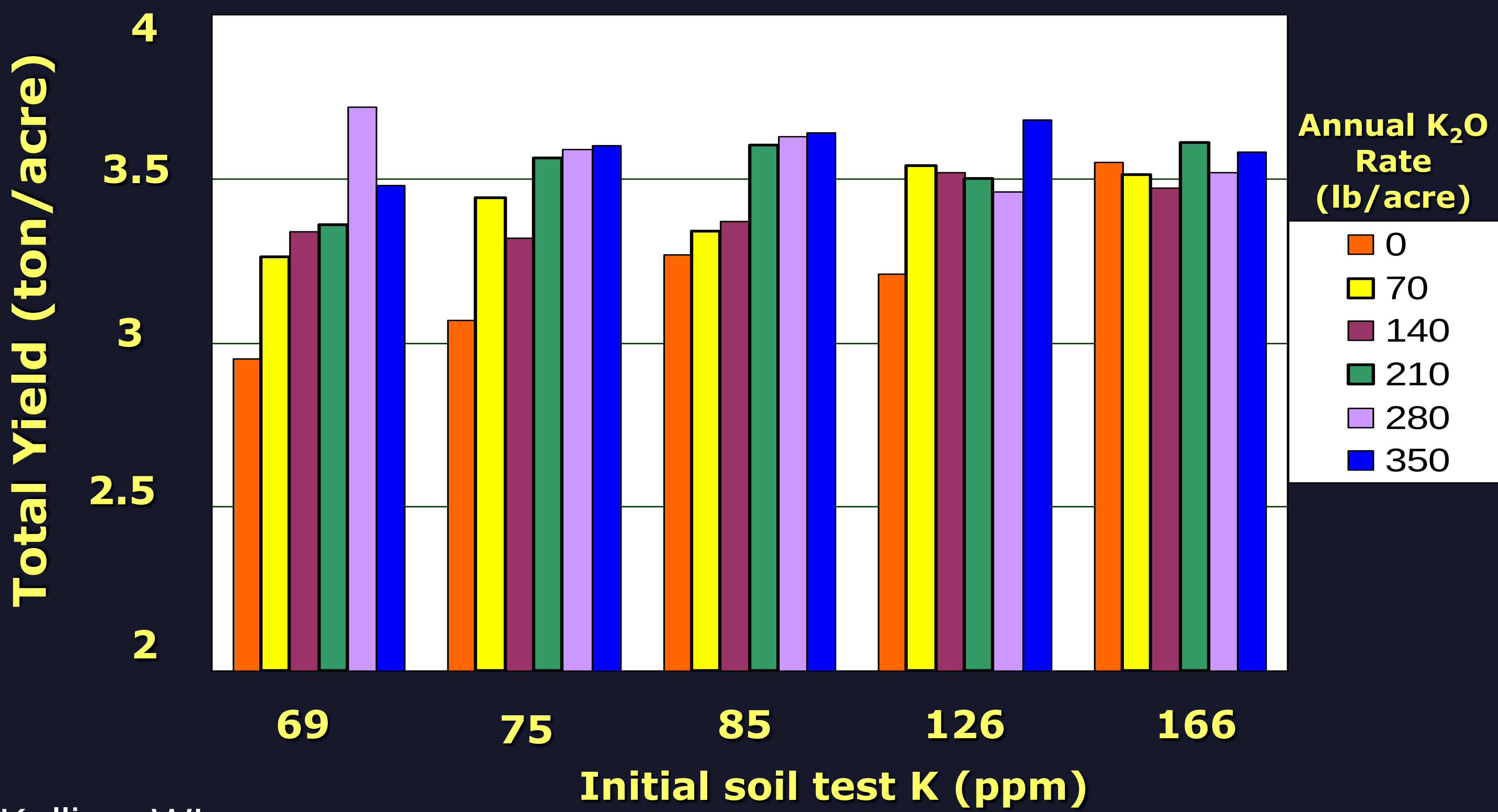
- Break down of crop residue
- Manures
  - Majority of K is soluble
    - 80 % of total K in manure available the year of application
    - 10 % of total K is available 2nd year after application
    - 5 % of total K is available 3rd year after application
  - Book values
    - Dairy solid – 9 lb K_2O/ton
    - Dairy liquid – 20 lb K_2O/1000 gal
- Biosolids

K Management

K Management in WI

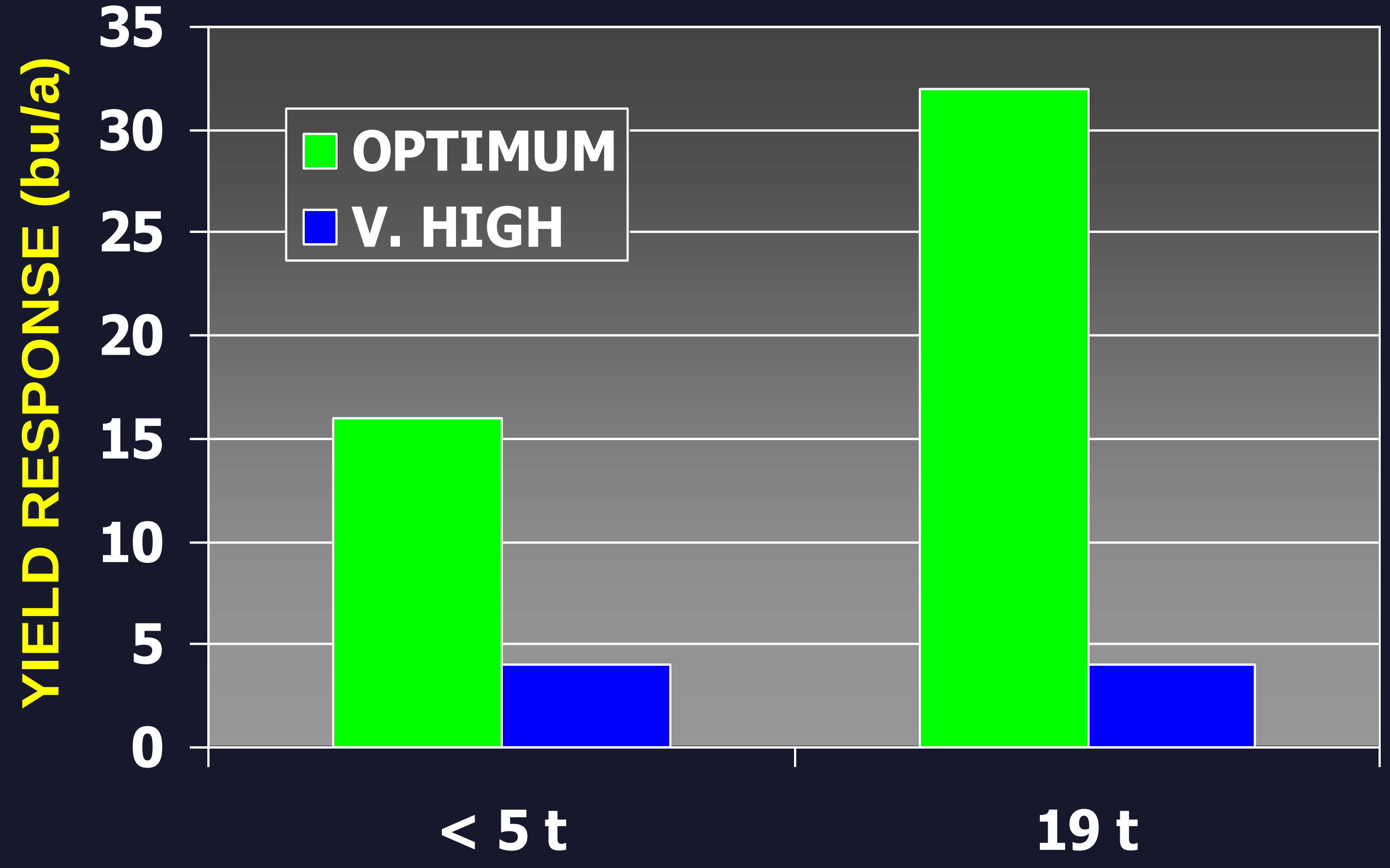
- Many soils deficient
  - Particularly alfalfa rotation
- K important in reduced tillage
- More liquid (low K) starter used
- Topdress K used as insurance
- Excessive K in some forages
- Timing relatively unimportant

Average interactions of soil test K levels and topdressed K_2O rate on alfalfa yields, Arlington, WI, 1994-1997



Kelling, WI

Response of corn to row-applied K on a silty clay loam soil (3 yr. avg.)



Oshkosh, Wis. (45 lb K_2O/a)
Wolkowski, WI

Broadcast vs. Band

K_2O applied (lb/acre)	Placement	Corn Yield (bu/acre)
0	-	114
40	Starter (band)	143
100	Broadcast	136
200	Broadcast	141

Soil test (0-6”) = 85 ppm; considered medium (optimum)
Goodhue County, Minnesota
From Rehm & Schmitt, 1997

Tillage and K Placement

Importance of K in Starter Fertilizers

- Response to deep-banded K at high soil tests
  - Ridge-till and no-till
- More frequent starter response at soil test K < 140 ppm
- Offset soil compaction effects
  - Restricted root volume
  - Poor aeration – limited K uptake
- More consistent starter response

Effect of tillage and soil test K on corn response to starter fertilizer

	Soil test K (ppm)		
Tillage	50-60	100-145	145-190
	------- Response, bu/acre -------		
Ridge-till	45	12	3
Chisel	13	7	8
Moldbrd.	20	5	7

Moncrief & Schulte; 8-48-12 starter fert.

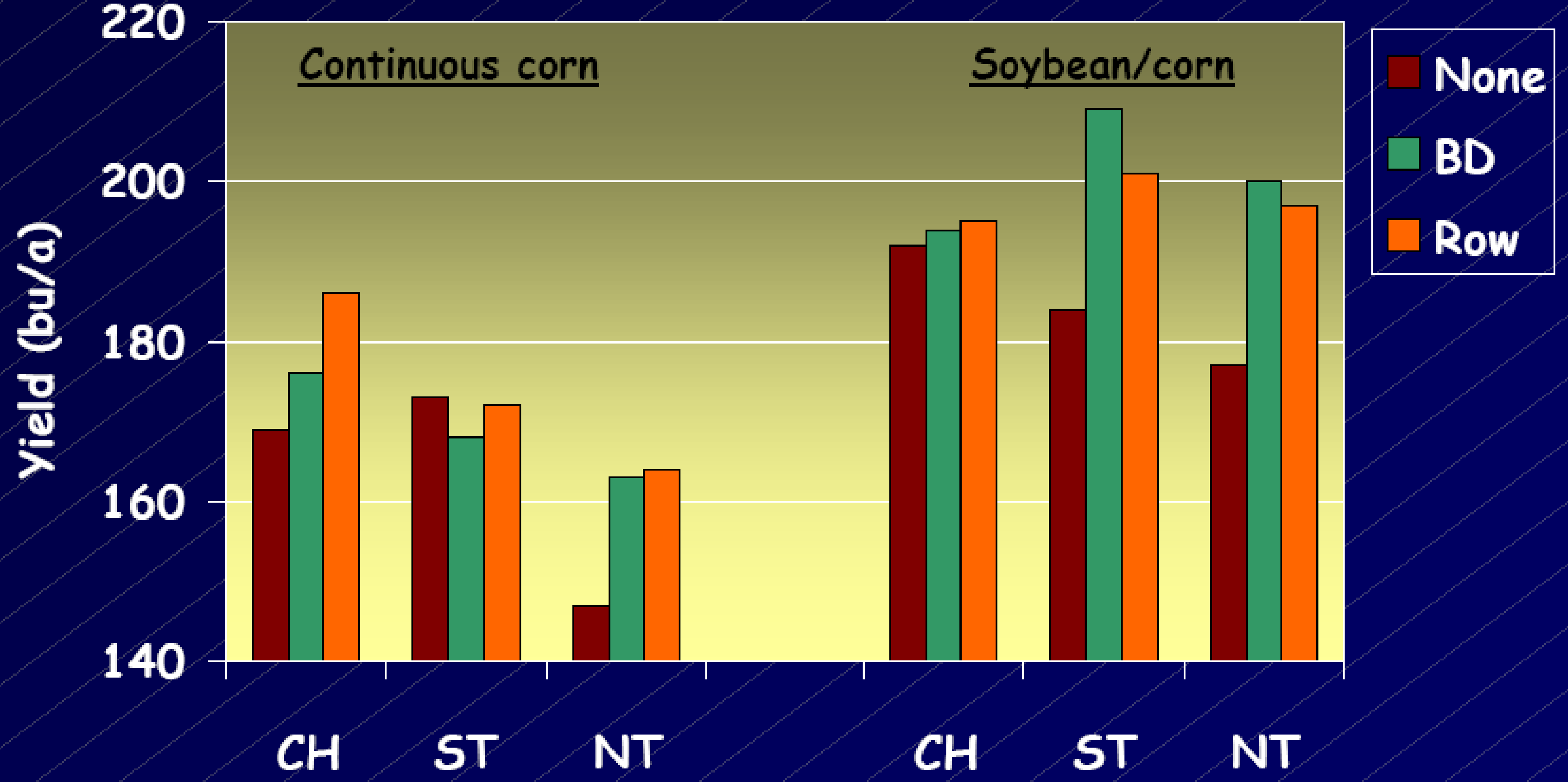
Arlington, WI

Corn yield advantage of deep-banded K over broadcast or planter-band K

Tillage System	Advantage
	bu/acre
Ridge-till	8
No-till	4-5
Chisel-disk	2

Mallarino, Iowa

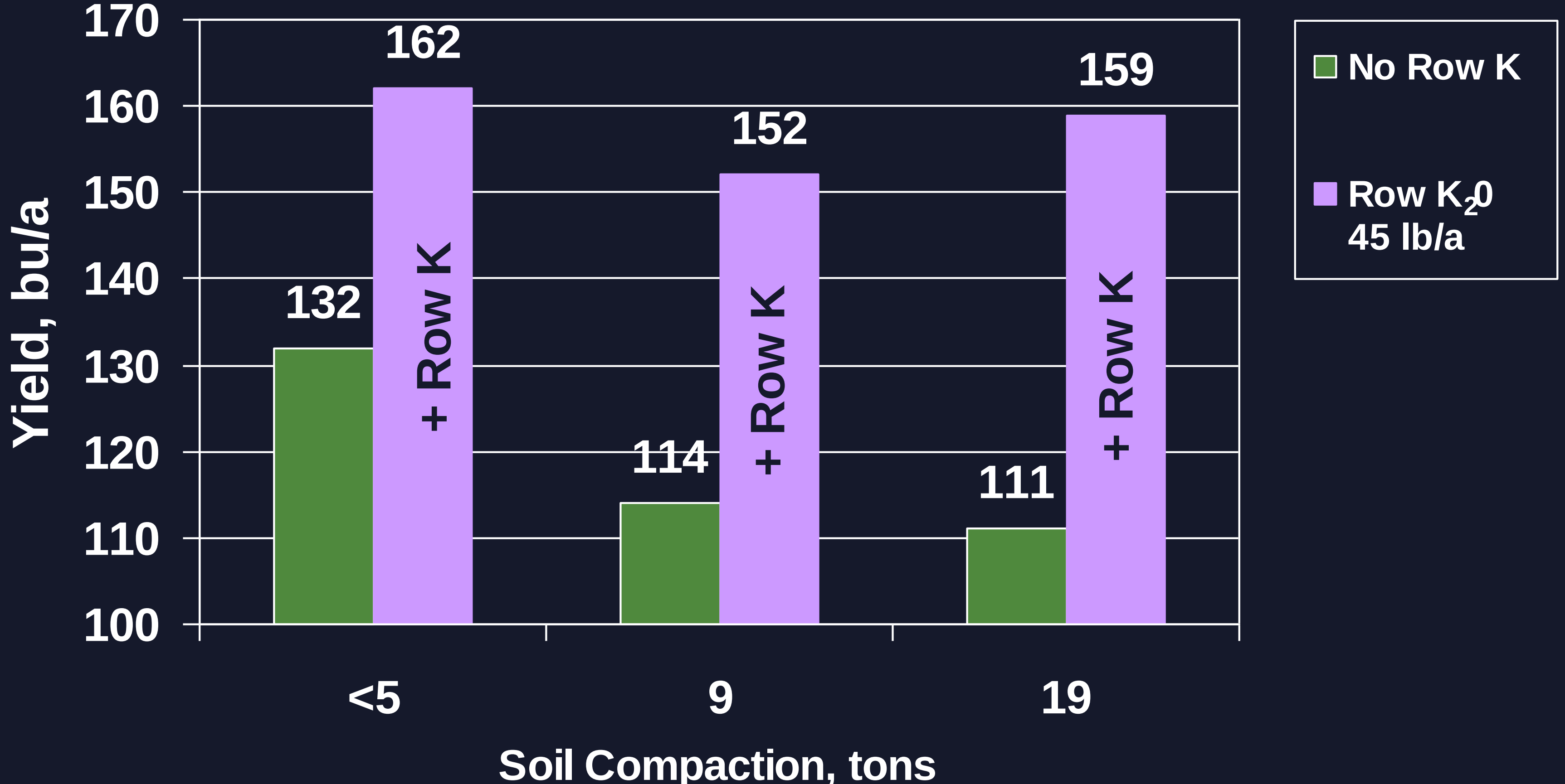
RESPONSE OF CORN TO TILLAGE AND FERTILIZER PLACEMENT, ARLINGTON, WIS. 2001-2003



200 lb 9-23-30/a

Initial soil test K was v. high
Wolkowski, WI

Row K Effects on Corn Yield with Increasing Soil Compaction



Initial K Soil test = 102 ppm (Optimum)
Wolkowski, WI

Effect of K Source

Effect of K source on alfalfa yield where fertilizer is applied in split applications

K source	Ashland*	Hancock+	Lancaster +	Manitowoc +	Marshfield*
		------------------------ Tons/acre ------------------------			
0	2.42	2.79	3.46	3.71	2.81
KCl	2.57	4.12	3.98	4.33	2.80
KCl + S	2.69	4.02	4.02	4.40	3.08
K_2SO_4	2.44	4.17	4.12	4.36	2.94
K-$MgSO_4$	2.46	4.05	4.15	4.48	2.89

* Average of 2 years

+ Average of 3 years

Adapted from Kelling, Erickson, and Schulte (unpublished). All plots received 50 lbs P and 400 lbs K/A/yr

K Source Conclusions

- If difference observed, likely due to associated ions
- No difference observed for most uses
- Salt or Cl ion problems avoided by splitting applications of rate more than 400-500 lbs/A
- Price, availability, & need for associated ion should determine which used

Timing Questions

- Preplant versus topdress?
- Frequency of topdress?
- Time of year to topdress?

Effect of rate and time of K topdress on alfalfa or alfalfa/orchardgrass yields, Maryland

	------- K_20 Rate (lb/a) -------		
K Timing	0	100	200
	---------- yield (T/a) ----------		
Fall	3.63	--	4.13
Fall/1st cut		--	4.13
Early spring		3.73	4.23
1st cut		3.90	4.23
Early spring/1st cut		4.10	4.27
Early spring/each cut		3.80	4.13

Adapted from Kresge and Younts, 1962.

Alfalfa response to time of topdress application

Applic. Time	1994	1995	1996	1997
	--------------- T/a DM ------------------			
Greenup	4.33	4.16	3.06	2.53
1st cut	4.46	4.35	3.17	2.65
3rd cut	4.48	4.27	3.06	2.47
1st & 3rd	4.44	4.35	3.08	2.61
Pr>F	*	0.20	0.78	0.33

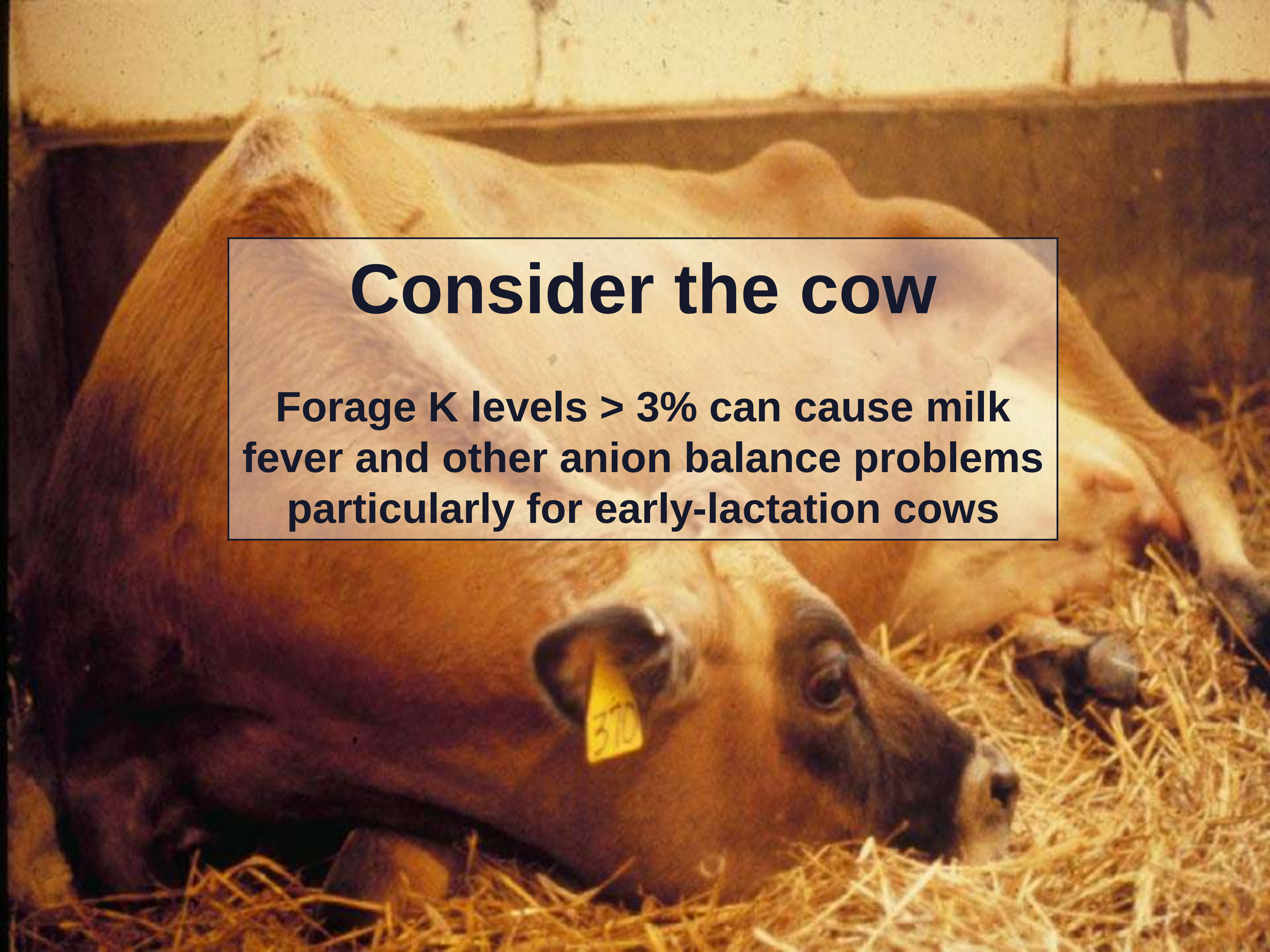
*Interaction between time and source significant at $Pr \geq 0.10$

Arlington, averaged across 2 soil test K levels and 2 K sources

Interaction between K source and application time, responsive years only

Application	KCl + S	K_2SO_4
	--------- T/a DM -----------	
Greenup	4.10	4.34
1st cut	4.31	4.48
3rd cut	4.27	4.48
1st & 3rd	4.44	4.34

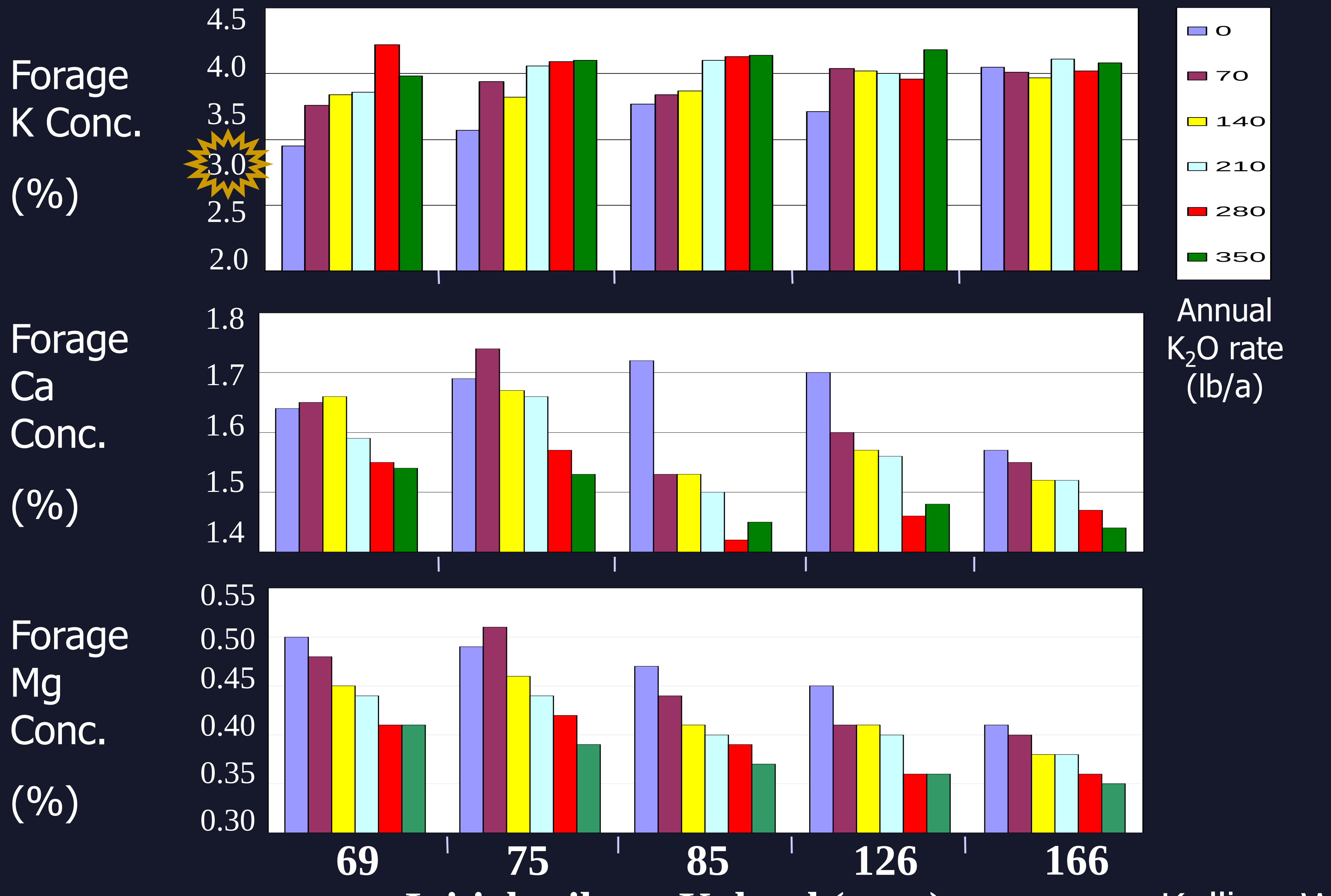
Average 1994-1995 across 2 soil K levels, Arlington



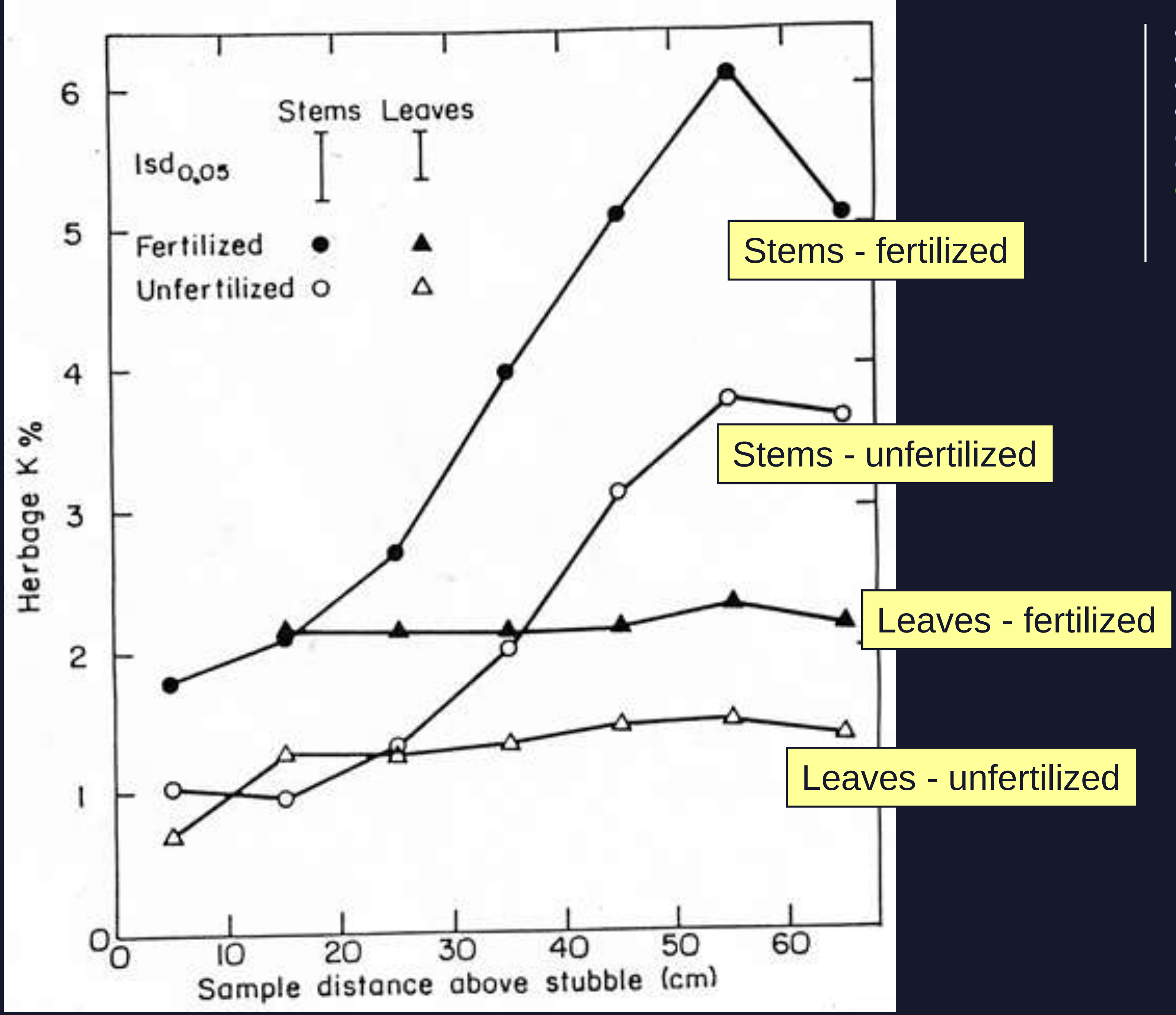
Consider the cow

Forage K levels > 3% can cause milk fever and other anion balance problems particularly for early-lactation cows

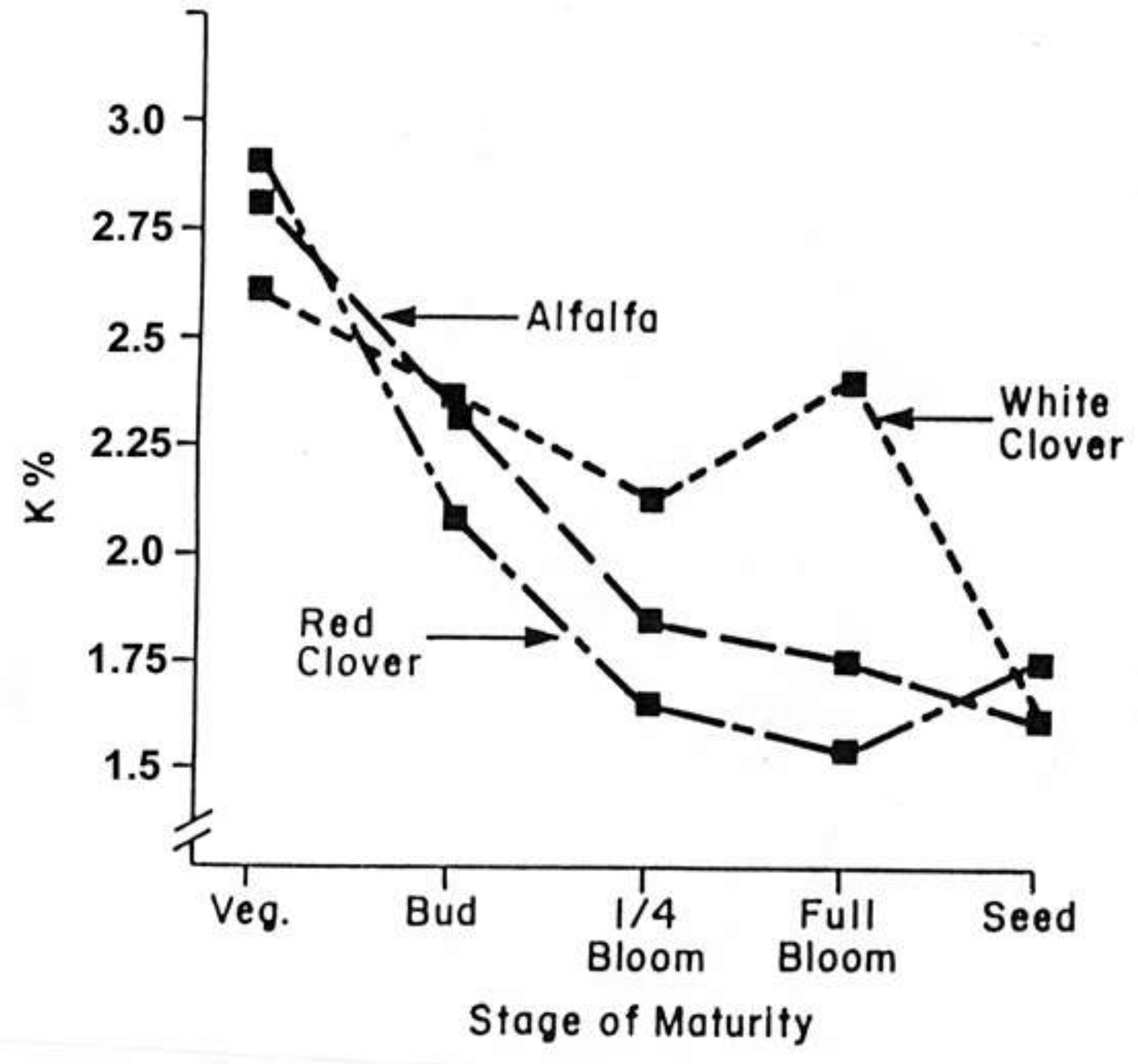
The average effect of soil test K and topdressed K_2O on third cutting forage cation concentrations, Arlington, WI 1994-1997



Kelling, WI



Rominger et al., 1975



Baker and Reid, 1977

Ways to reduce tissue K

- Soil test
  - Apply K only where needed
  - Credit manure K
- Clip low – retain leaves
- Cut later
- Allow K to drop on some fields
- Segregate low K forages for dry cows/heifers

Potassium BMP's

- Use soil test to guide K need
- Wisconsin recommendations call for 15 to 25 lb K_20 with high K soil
- Consider complete starter
- Avoid excessive build-up; distribute manure
- Avoid fall applications on sands and mucks
- Topdress as needed

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