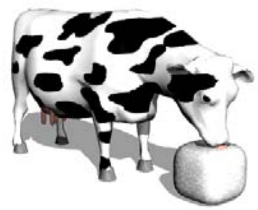
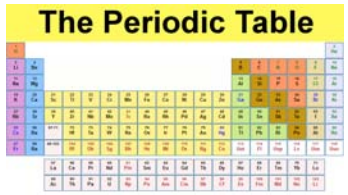
Update on Mineral Nutrition of Dairy Cows



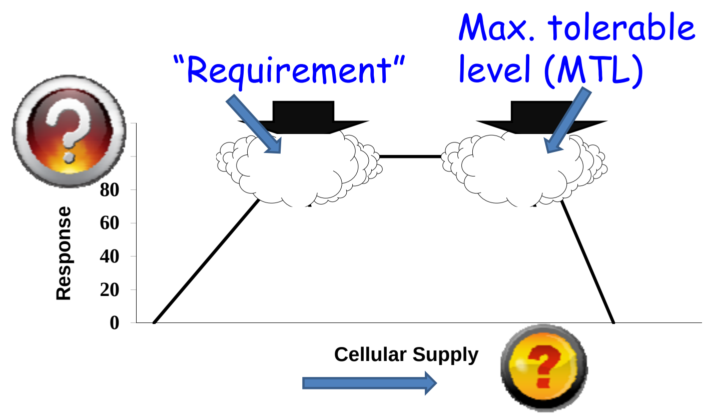


THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

Bill Weiss
Dept of Animal Sciences

Ohio Agricultural Research and Development Center   Ohio State University Extension

Establishing Mineral "Requirements"



NRC 2001 Factorial Approach

Inputs		Requirements
BW (DMI)	→	**Maintenance**
Days pregnant	→	Gestation
Age	→	Growth
Milk yield	→	Lactation

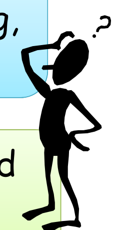
mg/d of absorbed mineral excreted, accreted in fetus, secreted in milk, and retained in new tissue

Effic. = 100%

Maintenance Requirements (~30-50% of total req't)

1. Amount of nutrient that is inevitably lost that must be replaced (nonlactating, not growing, not pregnant)

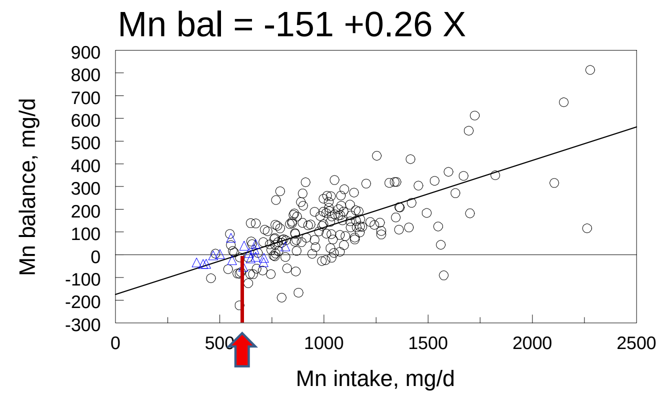
2. Minimum amount of a nutrient needed to maintain body functions and health without reducing body stores



Main Concerns with current factorial method

	Likely error
1. Maintenance requirement (optimal health?)	Under
2. Milk secretion vs milk synthesis	Under
3. Non-nutrient effects?	

Use of Mineral balance to estimate total requirement (diet, not TAR)



Weiss and Socha, 2005

'Requirement' estimated by balance method*

~625 kg cow, 35 kg milk

Total Mineral

	Balance method	NRC
Cu:	360 mg	250 mg
Mn:	580 mg	310 mg
Zn:	840 mg	870 mg

* Data from digestibility studies by OSU

NRC 2001 Factorial Approach

Inputs

Feedstuffs
Mineral concentration

→ Absorption coefficients

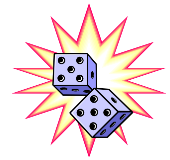
→ TAS: mg/d of mineral that is available for use

The AC is a weak link in formulating for available TM

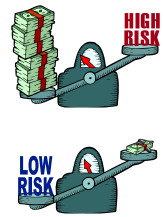
1. Very difficult to measure
2. Diet and source dependent
   - e.g., high S diet and Cu
   - e.g., organic vs inorganic
3. Animal status dependent

Uncertainty increases risk
Formulation must consider risk

For Minerals (and vitamins) substantial uncertainty exists



- *requirements*
- *absorption*



You must evaluate: risk/reward

If you are wrong does it cost more to over or underfeed???

Trace Minerals Recommendations

Think mg/day, not ppm

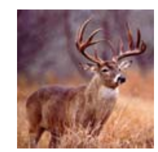
	Dry cow	80 lbs milk
Cu reqt	175 mg	250 mg
Diet conc	14 ppm	10 ppm

45 vs 60 lbs DMI: 410 vs 550 mg/d (20 ppm)

Concentrations may be higher for dry cows but lower for high yielding cows

Trace Minerals Recommendations

Basal feeds provide TM



Problems with the data
- Variable
- High sampling error
- Non-normal distribution

Get enough samples

Use median

Problems do not justify ignoring basal supply

Cu in Corn Silage

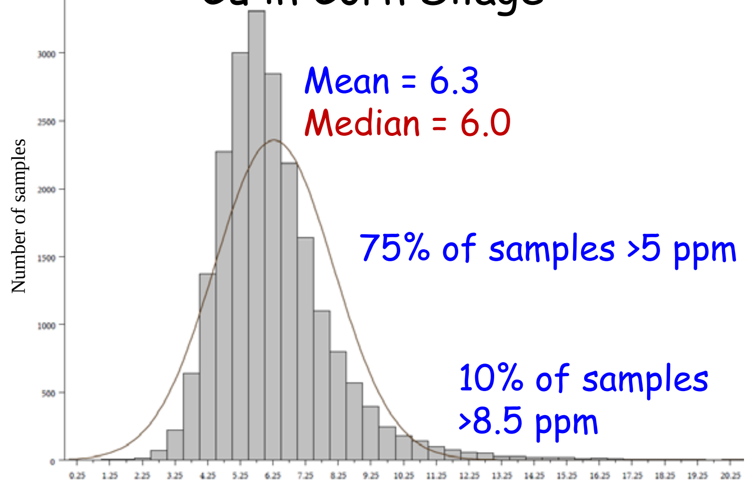
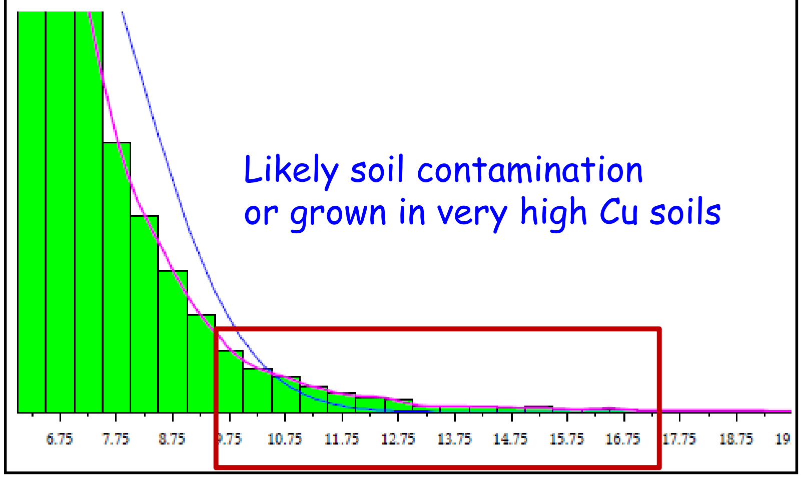


Figure courtesy J. Knapp

Cu in Corn Silage

Figure courtesy J. Knapp



High TM in Basal Feeds

With high ash/and Fe
- likely soil contamination
- availability probably low

Without high ash
- could be interior metals
- availability may be similar to inorganic supplements

Trace Minerals Recommendations

Capture value from high availability TMs

Need 6 mg absorbed Cu to meet reqt

Copper sulfate = 25% Cu; AC = 0.05

Product X® = 25% Cu; Relative AC = 2X

(6/0.05)/0.25 = 480 mg $CuSO_4$ *or*

(6/(0.05 X 2)/0.25 = 240 mg of Product X®

Relative Availability

1. Feed a standard mineral (e.g., $CuSO_4$)
2. Feed test mineral (same amount)
3. Measure response and report ratio

$$\frac{\text{Liver Cu when fed source Y}}{\text{Liver Cu when fed Cu sulfate}}$$

1. Diet specific
2. Animal specific
3. Everything is relative

Are differences between organic and inorganic TM due to bioavailability?

Organic Zn reduced the pathogen associated with digital dermatitis in feces (inorganic did not)

Faulkner et al., 2017

Intestine is a very important immune organ

⇕

Microbiome affects immunity

Potassium (NRC = ~1.1%)

The Good

1. Can improves milk fat (DCAD, not K)
2. Helps with heat stress (K)
3. Some data: optimal is >NRC

The Bad

1. Reduces Mg absorption (K)
2. Increases manure and manure (K)

Higher K (DCAD) improves fat and FE

Diet K% (DCAD)

Cont: 1.3 (32)

K carb: 2.1 (53)

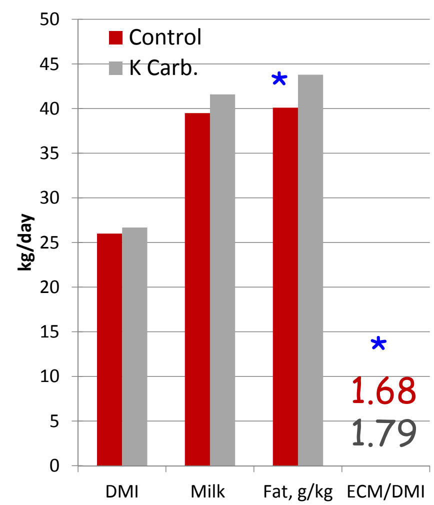
Both diets

34% forage

6% DDG

Early lact. cows

Harrison et al., 2012

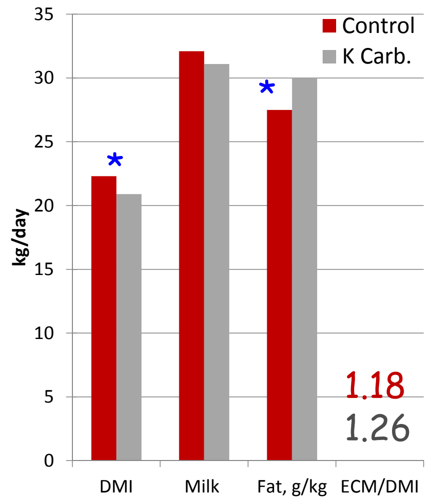


Higher K (DCAD) improves fat and FE

Diet K% (DCAD)
Cont: 1.2 (2)
K carb: 2.2 (30)

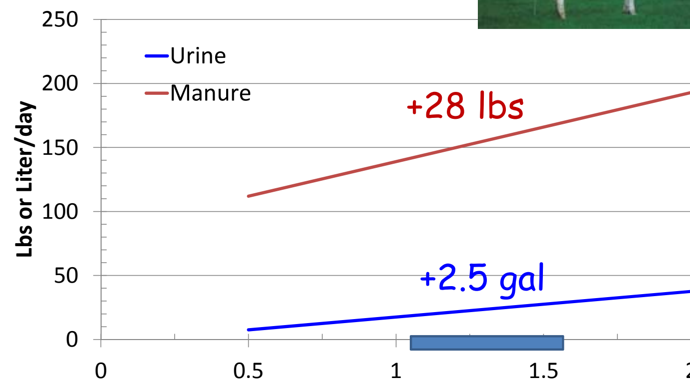
All diets
27% DDG
4.2 or 5.8% Fat

No K x fat INT



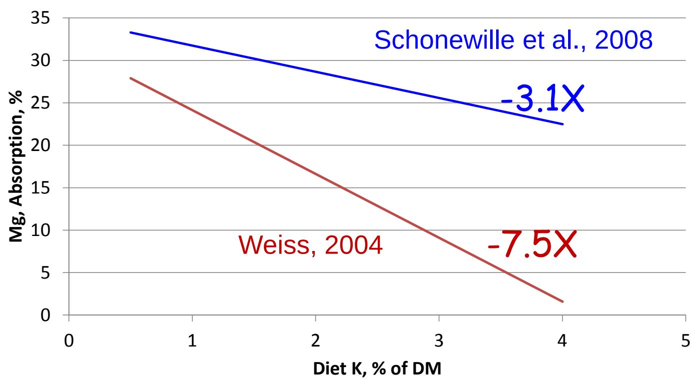
Lamar and Weiss, 2013

Higher Diet K = More Manure



Weiss et al., 2009

K and Mg Absorption in Dairy Cows



0.45 vs 0.25% Mg

Magnesium

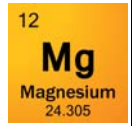
12
Mg
Magnesium
24.305

1. Absorbed from rumen

2. Real world antagonists
   - K (linear)
   - LCFA (probably not big)
   - Rumen ammonia (RDP)
     Acute vs. chronic

3. Minimal homeostatic control of absorption

Magnesium

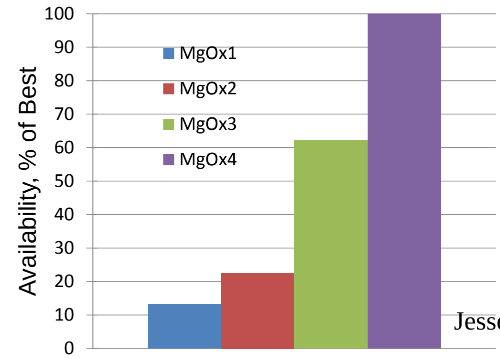


	NRC 2001	'Correct'
Basal feeds	0.16	0.30* ±0.16
Good MgO	0.7 or 0.5	0.20 to 0.25
$MgSO_4$	0.9 or 0.7	0.35 to 0.40

* @1.2%K

Feeds are better than we thought
Supplements are worse than we thought

Mg Availability from4 sources of MgO



Jesse et al., 1981

Uncertainty increases risk
Formulation must consider risk

Sulfur (NRC = 0.2%)

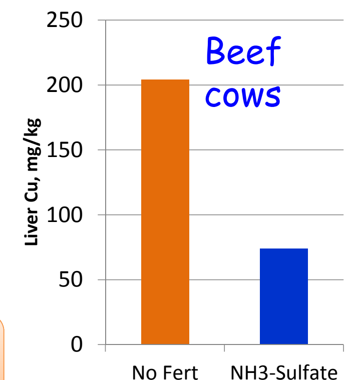
No reason to exceed NRC

1. Reduces copper availability
2. Reduces selenium availability
3. Reduces DCAD (milk and DMI)

Higher S diets may be cheaper ($/lb)
because of DDG inclusion

High S forage = Reduced Copper Stores

- Grass fertilized with
  - Nothing
  - NH3-Sulfate
- Forage S
  - 0.2%
  - 0.5%

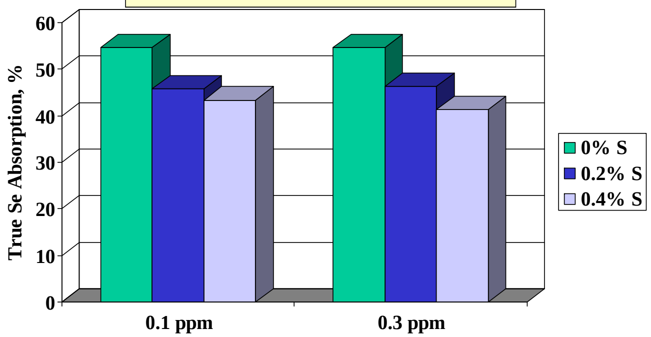


High S + normal Mo
reduces Cu status

Arthington et al., 2004

Se and Sulfur

-3% units/0.1% added S



Ivancic and Weiss, 2001

Remember Water

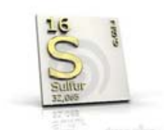
Water with 250 ppm Sulfate-S

= +0.1% dietary S

Water with 700 ppm Sulfate-S

= +0.3% dietary S

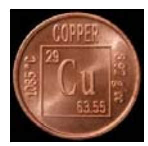
Take water samples occasionally



Sulfur (NRC = 0.2%)

Watch total S (diet + water)

1. Reduces copper availability
2. Reduces selenium availability
3. Reduces DCAD (milk and DMI)



Absorbed Cu = ~9-12 mg/d
Total Cu*: 200 to 270 mg/d

Feed Enough !

Reduced mastitis
Improved immunity
Reduced RP

Don't feed too much !

Real world toxicity (i.e., death)
Accumulation of liver Cu

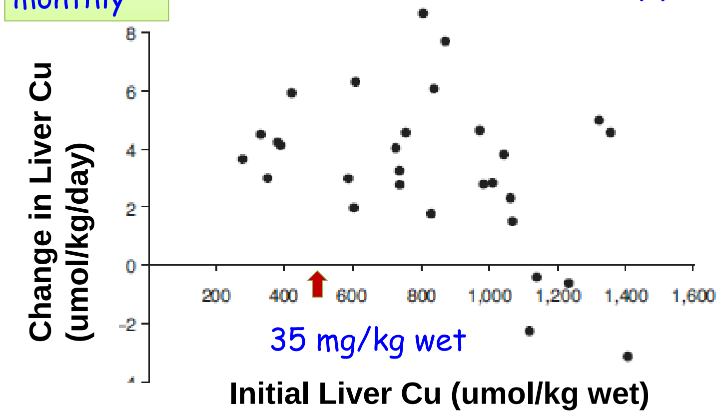
Copper: Lots of Real World Antagonists

1. High Sulfur (Forage, DDG, water)
2. High reduced Fe (water)
3. Grazing (soil ingestion)
4. High Mo

NRC assumes minimal antagonism:
Real world situations justify increased Cu

+4 to 7 mg/kg monthly

Liver Cu continues to accumulate (diet = ~20 ppm)



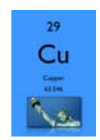
Balemi et al., 2010 (NZVJ)

Cu Recommendations

No DDG, good water:

- **1.2** to 1.5X NRC (12 to 17 ppm **TOTAL** Cu when using $CuSO_4$)
- If using high bioavailability sources, feed less (i.e., no safety factor)

Lifetime moderate overfeeding of Cu may be causing problems !



Cu Recommendations

With Antagonists (eg. DDG, bad water …)

- Maybe 2 to 3X NRC (20 to 30 ppm)
- Use proven 'High available' Cu
- Evaluate status (liver Cu from cull cows, biopsies)

Lifetime moderate overfeeding of Cu may be causing problems !

Se: All animals: 0.3 ppm added

Lactating cows, normal situation

- all or predominantly inorganic

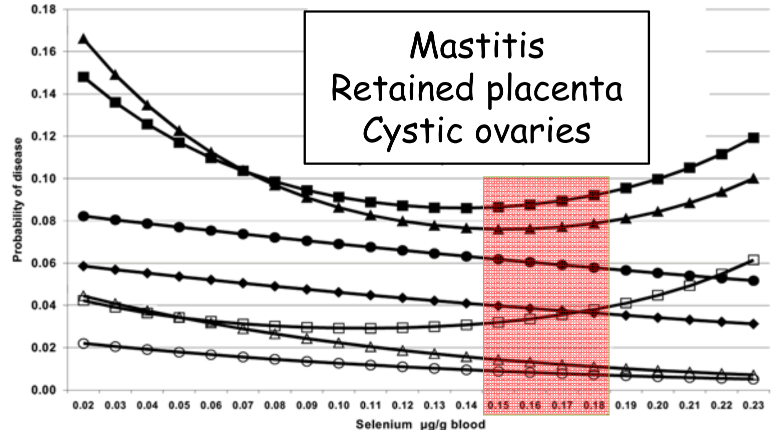
Lactating cows, antagonists (e.g. S)

- substantial amount from Se-yeast

Late gestation cows and heifers

- mix of inorganic and Se-yeast

Probability of Disease vs Blood Se



Kommisrund et al., 2005

Whole blood = 0.16 – 0.18 ug/ml

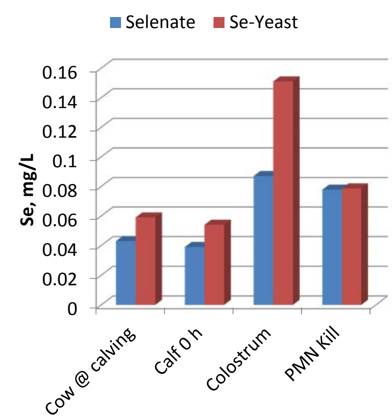
Selenium Yeast

Benefits:

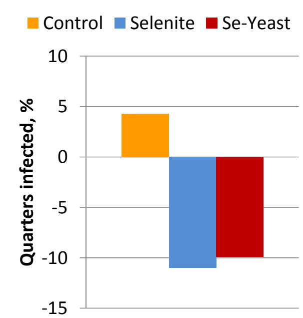
- 1.2 to 1.3 X more available
- Builds up body Se reserves
- Increases milk Se (humans)
- Transfer to fetus and colostrum
- Limited absorption antagonists

Disadvantage: Cost

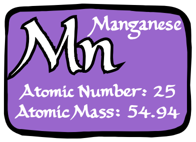
Relative Response: Selenite vs Se-yeast



Weiss and Hogan, 2006



Malbe et al., 1995



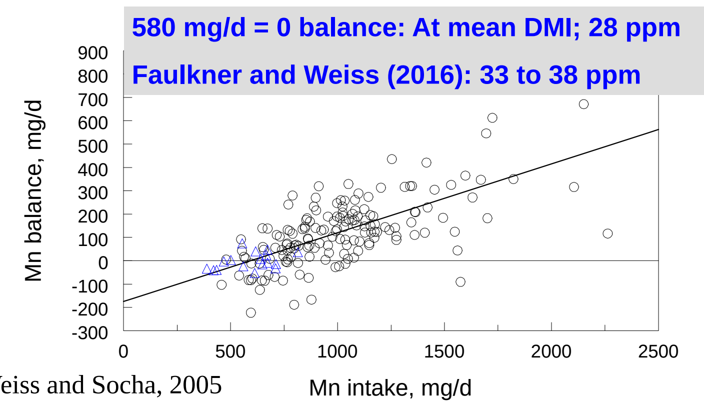
NRC (2001): ~14 - 18 ppm

Beef cows fed 18 ppm produced calves with signs of clinical Mn deficiency (Hansen et al., 2006)

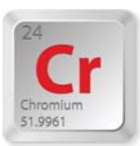
Dairy cow balance data suggests 30-40 ppm

Use of Mineral balance to estimate maintenance requirement (diet, not TAR)

Mn bal = -151 +0.26 X



Weiss and Socha, 2005



Chromium (No NRC requirement, FDA max = 0.5 ppm from Cr prop)

- Part of Glucose Tolerance Factor (GTF)
- Enhances insulin sensitivity (early lactation cows are insulin resistant)
- Reduces lipolysis and lowers NEFA which can stimulate DMI in early lactation
- Enhances cellular immunity (↓ cortisol?)

Production Responses

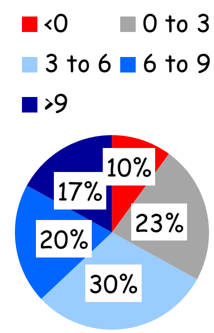
12 studies, 30 trt

Typical rate:
~1 ppm dry
0.5 ppm lactating

Typical duration
-3 wk to +4 WOL

Multiple Cr sources

Lb/d increase from control



~2/3 of trt comp. >3 lb/d increase

Summary

1. Uncertainty and risk management justifies **moderate** overfeeding of MANY minerals

   Moderate = +20 to 50% of NRC

2. Safety factors should be farm, mineral, and mineral source specific

3. Consider long term effects of overfeeding

Summary

4. Do **not** ignore minerals in basal ingredients (use means or medians for TM)

5. Supplemental Mg is not as good as you thing but feed Mg is better than you think

http://dairy.osu.edu

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