Feeding recommendations regarding reduced lignin alfalfa

- Neither improved NDFd or milk production should be anticipated if grower is using delayed harvest to increase tons.
- Improved NDFd (and possibly milk production) is anticipated only when grower is using his normal (or early) cutting schedule.

Does increasing NDFd increase energy content of alfalfa?

- YES, but only in small amounts

  - 10 lbs alfalfa DM x 1.0 mcal ME/lb DM x 42% NDF x 10% improvement = 0.42 mcal of ME
  - If we assume that all this ME goes to milk production you would get about 0.8 lbs of milk
The energy response seems small. So, why feed alfalfa of higher NDFd?

- To reduce rumen fill and increase DM intake
  - The greater impact of higher alfalfa NDFd on milk production is from increasing DM intake, rather than increasing energy concentration

Intake Potential increases with increases in NDFd

- A one unit increase in in-vitro digestibility of NDF was associated with a 0.37 lb/day increase in dry matter intake (DMI) and a 0.55 lb/day increase in 4% fat corrected milk yield per cow (Oba and Allen, 1999)
- Greater DMI responses are observed with early lactation, higher producing cows that are more bulk fill limited.
  - Less noticeable with lower producing cows
If I feed alfalfa of a higher NDFd, will I always see an improvement in DM intake?

• No (only when)
  – Rumen fill is excessive
    • Forage levels are greater than 55% and/or
    • Digestibility of forages is below average
When rumen fill is not excessive, will I see a response in DM intake?

• NO
  – When forage levels in the diet are low (less than about 45%) and/or
  – Digestibility of forages is above average, rumen fill is not limiting intake

Does a improvement in DM intake always lead to higher milk production?

• Not always. If cows are in poor body condition or in later lactation, the increased energy intake will be used for tissue growth and not milk production.
Milk response expectation with feeding highly digestible alfalfa

It will depend on intake improvements, body condition and stage of lactation

Chances for more milk are better if:
- DM intake increases
- Body condition is good
- Cows are in early lactation (<150 DIM)

One pound increase in DM intake provides enough energy potential for

- 2.5 lbs of additional milk production
- or
- 0.35 lbs of body weight gain

If I substitute alfalfa of higher NDFd into the diet and rumen fill is high and body condition is good (>BCS of 3.5) and cows are in early lactation, should I see an improvement in DMI intake and milk production?

Very likely. For every 1 lb. increase in DM intake, you should expect a 2.5 lbs increase in fat corrected milk (FCM)
• Q: Why would a grower ever want to grow alfalfa of higher NDFd, particularly if he doesn’t own any cows?

• A: To sell hay of higher quality for a premium price

• Q: So, alfalfa hay of a higher NDFd will have a greater RFV (Relative Feed Value) or TDN (Total Digestible Nutrients), which commands a premium price?

• A: Unfortunately not. Neither of these indexes will reflect the higher NDFd.
RFQ vs. RFV?

- What do the numbers tell me?
- Do they provide pertinent information?
- Feed quality of alfalfa depends to a great extent on maturity of the stand.
- With increased maturity, plant structural carbohydrates, as measured by the ADF and NDF fractions, increase.
- Relative Feed Value (RFV) has been used for years to compare the quality of legume and legume/grass hay and silages.
- Having one index to price hay and predict animal performance has been very useful for both sides.
- RFV estimates forage DM digestibility and filling capacity. Relative Feed Quality improves on RFV by accounting for NDF digestibility.

Relative Feed Value (RFV)

- RFV estimates the digestibility dry matter from the ADF (cellulose and lignin), and calculates the DM intake potential (as % of BW) from NDF (total cell wall portion ADF + hemicellulose).
- This index ranks forages relative to the digestible DMI of full bloom alfalfa (assuming 41% ADF and 53% NDF). The RFV index at this growth rate is 100.
- Example:
  - Alfalfa hay or haylage with 32% ADF and 40% NDF
  - DigDM = 88.9 – (0.779 x 32) = 63.97
  - DMI = 120/40=3
  - RFV = (63.97 x 3) / 1.29 = 149

Limitations of RFV:
1) DigDM and DMI are assumed constants for all forages.
2) ADF and NDF are the only laboratory values used.
3) CP concentration of forages is not used.
4) RFV cannot be used in ration formulation or evaluation.
Relative Forage Quality (RFQ)

- Fiber from grass and legumes naturally differs in digestibility, as it also when grown under different ambient temperatures.
- RFV of first-cutting alfalfa will be similar to that of second and third cutting harvested at similar stages of maturity.
- However, fiber fraction digestibility could vary as it is influenced by ambient temperature at the time of growth and development.
- RFQ was therefore designed to account for fiber digestibility to estimate intake as well as the total digestible nutrients (energy) of the forage.
- RFQ index is and improvement over RFV index for those that buy and sell forages because it better reflects the performance that can be expected from the cattle (it also differentiates legumes from grasses).

RFV and RFQ are closer for alfalfa when fiber digestibility is average. They differ primarily as fiber digestibility varies from average.
The handoff between agronomy and nutrition

**Agronomy concerns (seed seller, grower)**
- Yield (tons/acre)
- RFQ (alfalfa)
- RFV (alfalfa)
- TDN
- Milk/ton (corn silage)

* Did it test correctly????

**Nutrition concerns (nutritionist, dairy producers)**
- NDF/NDFd
- RDS
- RUNDF
- DM
- Protein

* Are the cows going to perform better????

What should we use?

- TTNDFD

- %ADL – acid detergent lignin

- NDFom/uNDFom – om or ash free – 30/120/240 to calculate rate of fiber digestion (kd)
Summary

• Should I expect increased milk production?
  – “It depends” Chances are better if:
    • Alfalfa is harvested for quality (normal cutting schedule)
    • DM intake increases
    • Body condition is good (>3.5)
    • Cows are in early lactation (<150 DIM)
  – Can’t always expect a milk production response!

Summary

• Is there anything that we need to do to the diet to feed highly digestible alfalfa?
  – Not really. Formulation similar to that used with high NDFd alfalfa
  – If rumen fill amounts are low, there is opportunity to increase forage levels in the diet
  – Do not fall prey to the “add wheat straw” reaction
Take Home

- Crossroads between agronomy and nutrition
- Analysis of forage digestibility
- Will we be ready to maximize new technologies/climate
- Dairy feeding studies still limited
"Coordinating DCAD and the Electrolytes; It’s More Important than you Think?"

Rich Erdman
Department of Animal & Avian Sciences
erdman@umd.edu

Dietary Cation Anion Difference (DCAD)

DCAD Represents the Relative Difference in (mEq/kg) in the primary dietary electrolytes:

\[
\text{DCAD} = \text{mEq K} + \text{mEq Na} - \text{mEq Cl} \\
\text{DCAD-S} = \text{mEq K} + \text{mEq Na} - \text{mEq Cl} - \text{mEq S}
\]

Uses of DCAD:
• Dry cows-Low DCAD-preventing milk fever
• Lactating Cows-High DCAD
  • Intake, Milk Production, Rumen pH, Milk Fat, Acid Base Balance
DCAD is a relative Difference in Electrolytes, Not an amount!

<table>
<thead>
<tr>
<th>Diet</th>
<th>K%</th>
<th>Na%</th>
<th>Cl%</th>
<th>S%</th>
<th>DCAD, mEq/kg</th>
<th>DCAD-S, mEq/kg</th>
<th>Electrolytes %</th>
<th>g/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal (Corn Silage)</td>
<td>1.20</td>
<td>0.25</td>
<td>0.40</td>
<td>0.25</td>
<td>303</td>
<td>147</td>
<td>1.85</td>
<td>426</td>
</tr>
<tr>
<td>Basal + 0.5% Salt</td>
<td>1.20</td>
<td>0.45</td>
<td>0.70</td>
<td>0.25</td>
<td>303</td>
<td>147</td>
<td>2.35</td>
<td>541</td>
</tr>
<tr>
<td>Alfalfa/Small Grain + 0.5% Salt</td>
<td>1.53</td>
<td>0.25</td>
<td>1.00</td>
<td>0.25</td>
<td>303</td>
<td>147</td>
<td>2.98</td>
<td>685</td>
</tr>
</tbody>
</table>
Assumes 51 lb DMI

Three diets can have the same [DCAD] but be very different in amounts of electrolyte fed..

*Extra electrolytes have to eliminated by the kidney*

The Electrolytes (Na, K, Cl) are Strong Ions?

The term “Strong Ion” coined by Peter Stewart (Canadian Physiologist) in paper:

- “Strong Ion Theory of Acid-Base Balance”
  (Respiration Physiology (1978) 33, 9-26)

- Strong ions are completely dissociated in biological fluids
  - Cations: Sodium (Na), Potassium (K) Magnesium (Mg)
  - Anions: Chloride (Cl), Sulfate, Lactate, Volatile Fatty acids, Beta-hydroxy butyrate.

- Dietary K, Na, and Cl are the principal dietary strong ions.
4 Characteristics of Strong Ions?

- **Primary Functions:**
  - Active Transport of Nutrients (glucose, amino acids)
  - Neural Transmission
  - Osmoregulation: Water balance across tissues
    - Digesta vs intestine, intracellular vs. extracellular, fecal water, etc.

- **Minimal reserves**
  - Deficiencies manifest themselves quickly (1-2 days)
  - Share common deficiency symptoms:
    - Decreased feed and water intake, dry manure

- **Highly available:** Nearly 100% absorbed from diet

- Excess Strong Ions are excreted in the urine, Not in the feces

---

The Strong Ion’s Role in Osmoregulation
(Normal Osmotic Pressure: ~300 mOsm)

<table>
<thead>
<tr>
<th>Ion</th>
<th>Intra-cellular</th>
<th>Blood</th>
<th>Rumen Fluid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na⁺</td>
<td>12</td>
<td>145</td>
<td>84</td>
</tr>
<tr>
<td>K⁺</td>
<td>139</td>
<td>4</td>
<td>27</td>
</tr>
<tr>
<td>Cl⁻</td>
<td>4</td>
<td>116</td>
<td>8</td>
</tr>
<tr>
<td>HCO₃⁻</td>
<td>12</td>
<td>29</td>
<td>6</td>
</tr>
<tr>
<td>Amino acids &amp; proteins</td>
<td>138</td>
<td>9</td>
<td>(VFA's) 105</td>
</tr>
<tr>
<td>Mg²⁺</td>
<td>0.8</td>
<td>1.5</td>
<td>4.2¹</td>
</tr>
<tr>
<td>Ca²⁺</td>
<td>&lt;0.0002</td>
<td>1.8</td>
<td>3.5¹</td>
</tr>
<tr>
<td>Osmoles</td>
<td>290</td>
<td>290</td>
<td>315³</td>
</tr>
</tbody>
</table>

¹Adapted from Bennick et al. (JDS, 1978)
**Ruminants Evolved on Forages**

<table>
<thead>
<tr>
<th>Forage</th>
<th>% of DM</th>
<th>mEq/kg DM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K</td>
<td>Na</td>
</tr>
<tr>
<td>Corn Silage</td>
<td>1.20</td>
<td>0.01</td>
</tr>
<tr>
<td>Alfalfa Haylage</td>
<td>3.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Grass Silage</td>
<td>2.81</td>
<td>0.05</td>
</tr>
<tr>
<td>Barley Silage</td>
<td>2.42</td>
<td>0.13</td>
</tr>
<tr>
<td>Rye Silage</td>
<td>3.34</td>
<td>0.05</td>
</tr>
<tr>
<td>Orchardgrass</td>
<td>3.58</td>
<td>0.04</td>
</tr>
</tbody>
</table>

**Comments:**
- Nutritional environment: High K, Low Na, and Moderate Cl
- Ruminant are equipped to get rid of excess K
- Forages are high DCAD feeds

**Dietary Electrolytes are not Expensive to Supplement**

The Relative Costs of Increasing Diet K, Na, and Cl by 100mEq/kg (98, 58, and 89 g/d, respectively)

<table>
<thead>
<tr>
<th>Mineral Supplement</th>
<th>Added Cost, $ per Cow/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt</td>
<td>K</td>
</tr>
<tr>
<td></td>
<td>$0.02</td>
</tr>
<tr>
<td>Potassium Chloride</td>
<td>$0.10</td>
</tr>
<tr>
<td>Potassium Sesquicarbonate</td>
<td>$0.25</td>
</tr>
<tr>
<td>Sodium Bicarbonate</td>
<td>$0.13</td>
</tr>
<tr>
<td>Sodium Sesquicarbonate</td>
<td>$0.09</td>
</tr>
</tbody>
</table>

1Cow consuming 25 kg (55 lb) DM per day
2Dietary K, Na, and Cl increase by 0.39, 0.23, and 0.35%, respectively
Dairy Cows Like to Operate with an Alkaline Urine (pH=7.5 to 8)

- Peak DMI occurs when urine pH is about 8
- That point is reached with DCAD of ~ 37.5 mEq/100 g
- Dry Matter Intake (DMI) falls off rapidly as urine pH drops to 7 or below.
- Low DCAD diets reduce urine pH (dry cows)
- Don’t feed lactating cows for low urine pH!

Mongin DCAD (K + Na –Cl)
Adapted from Hu and Murphy, 2004, J. Dairy Sci. 87:2222

What Regulates Urine pH?

- Strong Ion intakes in excess of requirements
  - Excreted in the urine
- SID (Strong Ion Difference) = Na⁺ + K⁺ - Cl⁻
  - DCAD is a Proxy for Urinary SID
- Urinary Strong Ion Excretion (Eq. Basis)
The cations must equal the anions:

\[
\text{Cations: } \quad \text{Na}^+ + \text{K}^+ + \text{H}^+ + (\text{NH}_4^+) = \text{Cl}^- + \text{OH}^- (\text{HCO}_3^-)
\]

\[
\text{Anions: } \quad \text{Cations} = \text{Anions}
\]
**Alkaline Urine pH**

When there are Excess Cations (K, Na)

\[ \text{Na}^+ + \text{K}^+ + \text{H}^+ (\text{NH}_4^+) = \text{Cl}^- + \text{OH}^- (\text{HCO}_3^-) \]

↑ Urinary Bicarbonate, ↑ urine pH

Results in an alkaline urine: This is normal for ruminants

---

**Acid Urine pH**

When there are Excess Anions (Cl)

\[ \text{Na}^+ + \text{K}^+ + \text{H}^+ (\text{NH}_4^+) = \text{Cl}^- + \text{OH}^- (\text{HCO}_3^-) \]

↑ Urinary NH\(_4^+\), ↓ Bicarbonate, ↓ pH

Too much Cl in relation to K and Na results in an Acid Urine  (This is abnormal in ruminants)

Remember: Dairy cows like to operate with an alkaline urine (pH=7.5 to 8)
DCAD is strongly related to Urine pH

M. Spanghero/Animal Feed Science and Technology 98 (2002) 153–165

- In low sulfur diets each DCAD equation fits well, but given a different number with each equation.
- DCAD-S may overestimate S effects in diet.

Excess Strong Ions Drive Cows to Drink!!
(OK, Not that kind of drink)

Erdman is a German name.
For those of you who do not know, beer is an important food group for all Germans
Beer is also an Excellent Source of Water!!
(That must be eliminated)

Mechanism

\[ \text{Beer} + \text{NaCl} = \text{PUSH} \]

\[ \text{NaCl} = \text{PULL} \]

The same holds true with cows!
“With Strong Ions, Not Beer”

Electrolyte (Strong Ion) Intake
Drives Urine Output in Dairy Cows

\[ \text{Urine Volume, kg} = 0.115 \times \text{Na Intake, g/d} + 0.058 \times \text{K Intake, g/d} \]

\( R^2 = 0.848, SE = 5.16 \)

From Bannink et al., 1999, J. Dairy Sci 82:1008

Is this the:
• Push Mechanism?
• Pull Mechanism?

1 Liter Extra Urine

9 g/day Excess Na
or
17 g/d Excess K
There is a Limit to how Concentrated Urine can be

In Bannink et al. 1999
The projected urine conc.
K = 881 mOsm
Na = 756 mOsm
This suggests that the cow is minimizing the amount of water lost in order to get rid of excess K and Na

Add First Glance, Added K Appears to Improve N Use (lower MUN)

<table>
<thead>
<tr>
<th>Added Potassium, mEq/kg DM</th>
<th>0</th>
<th>125</th>
<th>250</th>
<th>375</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>1143</td>
<td>1174</td>
<td>1158</td>
<td>1124</td>
</tr>
<tr>
<td>MUN, mg/dL</td>
<td>15.5</td>
<td>14.0</td>
<td>13.6</td>
<td>12.0</td>
</tr>
<tr>
<td>Protein %</td>
<td>2.95</td>
<td>2.99</td>
<td>2.95</td>
<td>2.92</td>
</tr>
<tr>
<td>Protein, g/d</td>
<td>2.95</td>
<td>2.99</td>
<td>2.95</td>
<td>2.92</td>
</tr>
</tbody>
</table>

K+ 39.1
Cl− 35.5
Na+ 23

• Don’t be fooled: Milk MUN went down because urine volume went up to get rid of excess K.
• Same amount of Urea-N was excreted in a larger urine volume

1Iwaniuk et al., 2015 J. Dairy Sci. 98:1950
Summary: Strong Ion Effects on Water Intake, Urine Output and pH

- Excess K and Na, Increases
  - Water Intake
  - Urine Output
  - Urine pH
- If you want cows to drink more, increase diet K and Na
  - More Water Intake, More Watering Space
- Excess Cl:
  - Decreases urine pH (Cows like an alkaline, NOT AN ACID Urine)
  - Increases urine output
  - Requires more K and Na that will also increase water intake

Dumping extra electrolytes (strong ions) in the diet has consequences
Pay attention, especially to Cl!

Cow Manure is 85% Water
(Something has to hold that water)

- Just like other body fluids:
  - Fecal water is related to osmotic pressure
  - Strong ion (K, Na, and Cl) contents
- Implied Strong Ion Osmotic Effect
  - 170 mOsm (more than 50% of total 300)
  - Other Fecal Minerals (Ca, P, Mg), VFA, bicarbonate contribute
- This suggests a metabolic fecal strong ion requirement to maintain a constant fecal water

\[ y = 5.87x + 15.82 \]
\[ R^2 = 0.76 \]
122 Cow Obs.
Cow Manure is 85% Water

Preliminary Lucas Plot (Regression) Analysis
Apparently Absorbed Ion = Dietary Ion (both as g/kg Diet DM)

<table>
<thead>
<tr>
<th>Strong Ion</th>
<th>Intercept (Met. Fecal) g/kg DM</th>
<th>Slope (Abs. Coeff.)</th>
<th>RMSE g/kg DM</th>
<th>P &lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>-2.48</td>
<td>1.02</td>
<td>0.27</td>
<td>0.001</td>
</tr>
<tr>
<td>Na</td>
<td>-1.45</td>
<td>0.98</td>
<td>0.53</td>
<td>0.001</td>
</tr>
<tr>
<td>Cl</td>
<td>-1.11</td>
<td>0.92</td>
<td>0.52</td>
<td>0.001</td>
</tr>
</tbody>
</table>

• Implied Absorption Coefficients—Very High
  • ~100% for K and Na, 92% for Cl
• Most Fecal K, Na, and Cl is Metabolic
  • 2.48, 1.45, and 1.11 g/kg Diet DM, respectively
• Consistent with maintaining constant fecal H₂O

What Do Cows Need for?  
Milk production

<table>
<thead>
<tr>
<th>Strong Ion</th>
<th>2001 NRC</th>
<th>Castillo et al., 2013¹</th>
<th>Difference, g/kg</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>K, g/kg milk</td>
<td>1.50</td>
<td>1.54</td>
<td>+0.04</td>
<td>+2.6</td>
</tr>
<tr>
<td>Na, g/kg milk</td>
<td>0.65</td>
<td>0.41</td>
<td>-0.24</td>
<td>-37.1</td>
</tr>
<tr>
<td>Cl, g/kg milk</td>
<td>1.15</td>
<td>1.03</td>
<td>-0.12</td>
<td>-10.4</td>
</tr>
</tbody>
</table>

¹Castillo et al., 2013. J. Dairy Sci. 96:3388; 39 herds averaging 787 cows per herd

• Potassium concentrations seem fine
• More recent data suggests Na = 0.40 and Cl = 1.0
  • Lower than current 1989 NRC
• Why is milk Cl and especially Na so much lower now?
Why are milk Na and Cl so much lower today?

<table>
<thead>
<tr>
<th>Strong Ion</th>
<th>2001 NRC</th>
<th>Normal Milk(^1)</th>
<th>High SCC(^1)</th>
<th>% of Normal</th>
</tr>
</thead>
<tbody>
<tr>
<td>K, g/kg</td>
<td>1.50</td>
<td>1.73</td>
<td>1.54</td>
<td>91</td>
</tr>
<tr>
<td>Na, g/kg</td>
<td>0.65</td>
<td>0.57</td>
<td>1.05</td>
<td>184</td>
</tr>
<tr>
<td>Cl, g/kg</td>
<td>1.15</td>
<td>0.91</td>
<td>1.47</td>
<td>161</td>
</tr>
</tbody>
</table>

\(^1\)From Review by Harmon, 1994, J. Dairy Sci 77:2103

- 2001 NRC values based on 1965 British estimates
- Mastitis increases milk Na and Cl
- Milk SCC has declined rapidly during the last 50 years?

---

What Do Cows Need?
2001 NRC Maintenance Req.

<table>
<thead>
<tr>
<th>Strong Ion</th>
<th>Endogenous Fecal &amp; Urinary, g/kg BW</th>
<th>Metabolic Fecal (g/kg Diet DM)</th>
<th>Severe Heat Stress g/100 kg BW</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>0.038</td>
<td>6.1 (2.6)</td>
<td>0.40</td>
</tr>
<tr>
<td>Na</td>
<td>0.038</td>
<td>--</td>
<td>0.50</td>
</tr>
<tr>
<td>Cl</td>
<td>0.0225</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Comments:
- Endogenous Urinary Excretion-Impossible to Measure
  - Dependent on the relative excess of other strong ions
- Metabolic fecal minerals, usually expressed per unit diet DM
- Heat stress values not large nor well defined
What Do Cows Need? 2001 NRC Maintenance + Milk Requirements (g/d)\(^1,2\)

<table>
<thead>
<tr>
<th>Ion</th>
<th>End. Fecal</th>
<th>Urinary</th>
<th>Met. Fecal</th>
<th>Heat Stress</th>
<th>Total Maint</th>
<th>Milk</th>
<th>Total</th>
<th>% Diet DM</th>
<th>DCAD, mEq/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>29</td>
<td>153</td>
<td>3</td>
<td>185</td>
<td>83</td>
<td>268</td>
<td>1.07</td>
<td>273</td>
<td></td>
</tr>
<tr>
<td>Na</td>
<td>29</td>
<td>--</td>
<td>4</td>
<td>32</td>
<td>64</td>
<td>0.26</td>
<td>113</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cl</td>
<td>16</td>
<td>--</td>
<td>--</td>
<td>58</td>
<td>72</td>
<td>0.29</td>
<td>81</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\)1540 lb (700 kg) cow consuming 55 lb (25 kg) DMI producing 110 lb (50 kg) milk

\(^2\)Assumes true absorption coefficient of 90% for each strong ion

How many people feed diets with those concentrations of K, Na, and Cl?

The ratios of SI in feed are not the ratio that ends up in urine

<table>
<thead>
<tr>
<th>Ion</th>
<th>g/d</th>
<th>Eq/d</th>
<th>K:Na:Cl</th>
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Minus

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Minus

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<tr>
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<td>1.7</td>
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<td>Cl</td>
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Equals

<table>
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<td>K</td>
<td>162</td>
<td>4.1</td>
<td>36.7</td>
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<tr>
<td>Na</td>
<td>19</td>
<td>0.8</td>
<td>7.3</td>
</tr>
<tr>
<td>Cl</td>
<td>4</td>
<td>0.1</td>
<td>1.0</td>
</tr>
</tbody>
</table>
If we increased diet Cl to 0.6%

0.35% Dietary Cl
Urinary Bicarbonate:
= Urinary (K + Na – Cl)
= 4.1 + 0.8 – 0.1
= 4.8 equivalents (288 g HCO₃⁻)

0.60% Dietary Cl (+63 g, +1.8 Eq)
Urinary Bicarbonate:
= 4.1 + 0.8 – 1.9
= 3.0 equivalents (188 g HCO₃⁻)
Small change in Cl, Big impact on urinary HCO₃⁻ and pH

If we increased diet Cl to 0.6%

1540 lb Cow, 55 lb DMI,
110 lb milk,
Diet K, Na, Cl:
1.2, 0.3, and 0.35%
DCAD = 340 mEq

Feces
Milk
Urine

Urine

Again: Milking Cows Like an Alkaline Urine

• Alkaline pH requires excess urinary cations, (K + Na) vs anions (Cl)
• Overfeeding Cl will lower DCAD and urine pH
Always Remember: Excess Strong Ions Drive Cows to Drink!!

Summary: Coordinating DCAD and the Electrolytes

Feed for an alkaline urine (pH ~ 7.5 to 8)
- Remember High DCAD is only a proxy for Urinary SID
- Cows need much more urinary K/Na than Cl
- Adding more NaCl or KCl to diet won’t help you!

Watch Cl, Do Feed Analysis!
- Feed enough to meet milk and maintenance needs
- Not too much in excess, leads to lower urine pH
- Small grain and grass silages, can be fairly high in Cl
- If Cl is too high
  - Add Na or K Carbonate/Sesquicarbonate instead of NaCl or KCl
Summary: Coordinating DCAD and the Electrolytes

Water Intake
- 9 grams extra Na, 17 grams extra K increase H2O by 1L.
- If want to increase H2O intake:
  - Add dietary K, Na
  - Make sure that you have good quality water, adequate watering space

Finally, Pay Attention:
“Dumping extra strong ions in the diet has consequences. The cow can handle extra K and Na, but not Cl.”
Fiber Analysis and Application in Modeling

Lynn Gilbert, PAS - Ag Model and Training Systems (AMTS) LLC
Sarah E. Fessenden, PAS - Dairy One Forage Laboratory
Let’s start with the basics
Current status: fiber digestion
3-pool model
(Mertens, 1977; Raffrenato and Van Amburgh, 2010; Cotanch et al., 2014)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Complete digestion</th>
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<tr>
<td>NDF</td>
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<tr>
<td>pdNDF</td>
<td>Variable kd</td>
</tr>
<tr>
<td>iNDF₂</td>
<td>Kd = 0</td>
</tr>
<tr>
<td>F-NDF</td>
<td>Variable k_{Fast}</td>
</tr>
<tr>
<td>S-NDF</td>
<td>Variable k_{Slow}</td>
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<tr>
<td>iNDF₃</td>
<td>Kd = 0</td>
</tr>
<tr>
<td>uNDF240</td>
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</table>

NDS Complete digestion
NDF - Relations to Digestibility

From Van Soest, 1996
- Lignin highest in primary wall & moves into secondary wall as plant matures
  - ML and 1° wall often indigestible (for fiber particles)
To Lignin or Not to Lignin

Lignin itself does NOT correlate well with NDF digestibility.

- It is all about the cross-linkages between lignin and hemicellulose and cellulose that dictate digestibility.

There will no longer be a need to determine lignin.

- Makes labs happy as NIR calibrations for lignin are difficult.
2.4 factor to calculate CHO C is NOT constant

- BMR corn silage hybrids, 3 to 5
- Conventional hybrids 2 to 7
- Alfalfa 1.9 to 3.2
  - (with 80% between 2.2 and 2.8)
- Grasses 1.5 to 5.5
  - (with immature grasses varying from 1.9 to 7.5).
Some papers call it iNDF to represent indigestible NDF.

Mertens has pushed for us to call it uNDF for undigestible NDF and uNDF is becoming the *de facto* standard term.
This has massive potential impact on formulation, procurement, and manufacturing thinking.

- uNDF and intake appear to be very highly correlated
  - It appears in Holsteins that the cow will reach a steady-state uNDF rumen level
    - 4-5 kg or 8.8 to 11 lbs.
  - For her to consume more feed, an equal amount of uNDF must escape the rumen first
    - uNDF has 0 kd so completely regulated by passage rate
  - This has massive potential impact on formulation, procurement, and manufacturing thinking
uNDF vs Lignin x 2.4 in Select Feeds
pNDF = aNDFom - uNDF

uNDF is determined with different time points for forages vs. non-forages
Corn silage example: uNDF

Rate = 0%,
unDF = 9.9% NDF

For comparison:
2.4*3 lignin/42% NDF = 17% unavailable NDF
Corn silage example: slow pool

Larger Slow and uNDF pools:
- More “ballast”
- Greater chewing and rumination
- Lower intake
- Slower eating speed

Rate = 2%,
P2 = 18.1% NDF
Corn silage example: fast pool

Larger fast pool appears to result in:
- Faster eating
- Faster ruminal disappearance
- Higher intakes
- More ruminal buoyancy

Rate = 11% / hr
P1 = 72% NDF
### Use uNDF for CHO-C

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>dNDF Disappeared - 30 HR (% NDF)</td>
<td>57.8</td>
</tr>
<tr>
<td>dNDF Disappeared - 120 HR (% NDF)</td>
<td>68.9</td>
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<td>dNDF Disappeared - 240 HR (% NDF)</td>
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<tr>
<td>CHO-C (%NDF, 240 hr in-vitro method)</td>
<td>26</td>
</tr>
<tr>
<td>CHO-B3 kd (%/hr)</td>
<td>5.11</td>
</tr>
</tbody>
</table>

#### aNDFom Digestion

![Graph showing aNDFom Digestion](image)

- **Predicted**
- **Observed**
Neutral Detergent Fiber (NDF)

- Procedure used to describe the total fiber content of feed
  - Collectively cellulose, hemicellulose, and lignin
- Sample is boiled in ND solution for 1 hour to dissolve the unwanted nutrients leaving the fibrous residue behind
- Various chemicals are employed to dissolve the unwanted nutrients
  - Sodium dodecyl sulfate - protein and fats
  - EDTA (ethylene diamine tetra acetic acid) - Ca, Mg, Zn, and pectins
  - Triethylene glycol - starch
  - Sodium borate - buffer
  - Sodium phosphate dibasic - buffer
Neutral Detergent Fiber (aNDF)

- Procedure modified in the 90s to clear more of the noise
  - Amylase - enzyme to breakdown starch
  - Sodium sulfite - protein
Neutral Detergent Fiber (aNDFom)

- Now encouraged to use “organic matter” or “ash free” basis for NDF
- Contamination of ash comes from large harvesting equipment, flood irrigation, and other sources
- Elevated total ash content of some feeds can sometimes contribute to elevated NDF values
- Can lead to an underestimation and underfeeding of fiber and the problems associated with low fiber diets.
Neutral Detergent Fiber (aNDFom)

- Ash free fiber involves taking the fiber residue remaining after ND extraction and “ashing” it at 550°C for 2 hours.
- The NDF value is then corrected for the ash content.
- The organic matter (om) or ash free NDF is reported as aNDFom.
## Forage Statistics 2015-2018

<table>
<thead>
<tr>
<th></th>
<th>Haylage</th>
<th>n</th>
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<th>aNDFom</th>
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Corn Silage NDF Digestibility by NDF and Lignin Content

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<tr>
<th>NDF, %DM</th>
<th>Lignin, %DM</th>
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</table>

Courtesy M. Van Amburgh, Cornell University
### Corn Silage NDF Digestibility by NDF and Lignin Content

<table>
<thead>
<tr>
<th>NDF, %DM</th>
<th>Lignin, %DM</th>
<th>NDFD% (30hr)</th>
<th>Est. NDF kd, %hr</th>
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<tbody>
<tr>
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Courtesy M. Van Amburgh, Cornell University
<table>
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<th>Herd Demographics</th>
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<tr>
<td>Days In Cycle</td>
</tr>
<tr>
<td>Age (months)</td>
</tr>
<tr>
<td>Days Pregnant</td>
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<tr>
<td>Days Since Calving</td>
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<tr>
<td>Calving Interval</td>
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<tr>
<td>Lactation Number</td>
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<tr>
<td>Calf Birth Weight (lbs)</td>
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<tr>
<td>Age of First Calving (months)</td>
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<tr>
<td>Milk Production (lbs/day)</td>
</tr>
<tr>
<td>Milk Fat</td>
</tr>
<tr>
<td>Milk True Protein</td>
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<tr>
<td>Milk Crude Protein</td>
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<td>Milk Lactose</td>
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<td>BCS (1-5)</td>
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<td>Additive</td>
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<tr>
<td>Hair Depth (inches)</td>
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<tr>
<td>Corn Silage Processed 40 DM 45 NDF Coarse</td>
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<tr>
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<tr>
<td>Alfalfa Silage 20 CP 37 NDF 17 LNDF</td>
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<tr>
<td>Alfalfa Silage very good</td>
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<td>Alfalfa Silage semi good</td>
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<td>Alfalfa Silage poor</td>
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<td>Corn Grain Ground Fine</td>
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<td>Soybean Meal 47.5 Solvent</td>
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<td>MinVix</td>
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<td>Magnesium Ox</td>
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<td>Salt White</td>
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<tr>
<td>Parameter</td>
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<tr>
<td>Dry Matter Intake (lbs/day)</td>
</tr>
<tr>
<td>IOFC</td>
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<tr>
<td>Cost/hd</td>
</tr>
<tr>
<td>Forage (%DM)</td>
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<tr>
<td>Forage NDF (%BW)</td>
</tr>
<tr>
<td>DM (%)</td>
</tr>
<tr>
<td>ME Allowable Milk (lbs/day)</td>
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<tr>
<td>MP Allowable Milk (lbs/day)</td>
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<tr>
<td>ME (%Rqd)</td>
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<tr>
<td>MP (%Rqd)</td>
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<tr>
<td>Rumen NH3 (%Rqd)</td>
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<td>NFC (%DM)</td>
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<td>NpND (%DM)</td>
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<td>Sugar (%DM)</td>
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<tr>
<td>Ferm. Starch (%DM)</td>
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<td>EE (%DM)</td>
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Good Quality and Good Digestibility
Good Quality- Semi-Digestible
<table>
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<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>dNDF Disappeared - 30 HR (%NDF)</td>
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<td>dNDF Disappeared - 120 HR (%NDF)</td>
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<td>dNDF Disappeared - 240 HR (%NDF)</td>
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<td>CHO-C (%NDF, 240 hr in-vitro method)</td>
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<tr>
<td>CHO-B3 kd (%/hr)</td>
<td>4.64</td>
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</tbody>
</table>

**Graph:**

- **Title:** In-vitro Incubation Time (Hours)
- **Y-axis:** ADP/Ins gap remaining (% of ADP/Ins)
- **X-axis:** In-vitro Incubation Time (Hours)

**Legend:**

- Solid line represents the ADP/Ins gap remaining percentage over time.
- The shaded area indicates the concentration range.
The size of the uNDF pool doesn’t correlate with the rate AND the non forages don’t have values in the model

NOW WHAT?!?
It’s very important to test all your feeds with the time points.

Tests have come a long way and we’re still learning things from this.
Open Discussion: What are you seeing in the field?
Thank you
The heifer paradigm: know your future generation

Dr. Jud Heinrichs & Rob Goodling
Dept. of Animal Science, Penn State University
1. Know a herd’s inventory
   - Is there excess heifers?
   - What should the herd track?
2. Identify their opportunities
   - Cull cows play a part in the decision, too
   - Does it help feed inventories
3. Address the next steps
   - Costs to raise heifers
   - Too many heifers, who stays, who goes
IDENTIFY 2: Opportunity Cost

KNOW 1: Inventory

ADDRESS 3: Heifer Management
PA Reproductive Metrics

(Dairy Records Management Systems, 2018)
Where Will Herds Go?

What are the goals next year
3 years down the road
8 years down the road

MAINTAIN

EXPAND

SHRINK
Is it measured?

Pumpkin Problems

3. Estimate how many seeds are in your group’s pumpkin: 30

4. Actual amount of seeds counted in my group’s pumpkin was: 505

(really) (wrong)
KNOW 1: Animal Inventories

• What is your herds growth pattern?

• Do you have enough heifers?
  o What do I track
  o Where can I find it

• Tools that can help
Break into 2 equations

• Filling available slots (heifers needed)
  o (heifers entering vs. heifers and cows leaving)
  o Cull rate, non-completion rate, age first calving, herd size

VS

• Expected number of heifer calves annually
  o Calving interval, calf mortality, calf sex ratio, age first calving, herd size
A Case of Two Farms

Farm A
- Consistent culling
- Heifer Changes in 2015
  - Sexed semen
  - Improved heat detection
- Good reproduction

Farm B
- Sporadic culling
- Inconsistent Heifer Mgmt
  - Varied age at first calving
  - Waves of freshenings
- Moderate Reproduction
# Front Page 202 Summary

## Production, Income & Feed Cost Summary

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
<th>%</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cows in Milk (All Cows)</td>
<td>205</td>
<td>214</td>
<td>82</td>
<td>96</td>
</tr>
<tr>
<td>Milk Lbs</td>
<td>66.8</td>
<td>25</td>
<td>68</td>
<td>88</td>
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<tr>
<td>Fat Lbs</td>
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<td>2</td>
<td>992</td>
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<tr>
<td>Fat %</td>
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<td>3</td>
<td>976</td>
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<tr>
<td>Protein Lbs (All Cows)</td>
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<td>706</td>
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<tr>
<td>Protein %</td>
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<td>73</td>
<td>723</td>
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<tr>
<td>Silage Lbs Consumed</td>
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<tr>
<td>Other Succulents or Blended Rations Lbs Consumed</td>
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<td>1</td>
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<td>Cost of Concentrates $</td>
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<td>Income Over Feed Cost $</td>
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<td>Feed Cost per CWT Milk $</td>
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## Reproductive Summary Of Current Breeding Herd

<table>
<thead>
<tr>
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<td>Voluntary Waiting Period (VWP)</td>
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<td>Days to 1st Service</td>
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## Reproductive Summary Of Total Herd

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## Birth Summary

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<td>Females</td>
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## Cows To Be Milking, Dry, Calving By Month

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<tr>
<th>Month</th>
<th>Cows to Calve</th>
<th>Heifers to Calve</th>
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<tr>
<td>Oct</td>
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<td>44</td>
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<tr>
<td>Nov</td>
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<td>Dec</td>
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<td>Jan</td>
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<td>Feb</td>
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## Yearly Reproductive Summary

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<th>Test Date</th>
<th>% Heifers Ov.</th>
<th>Conception Rate</th>
<th>Prog Rate</th>
<th>Number Services</th>
<th>Number Calving</th>
<th>Number Pregnant</th>
<th>Total Prog Core</th>
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<tr>
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## Bulk Tank Summary

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<th>Bulk Tank</th>
<th>% Fat</th>
<th>% Pro</th>
<th>SCC</th>
<th>MUN</th>
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<td>3.2</td>
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## Totals

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### Stage Of Lactation Profile

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<th>Stage of Lactation (Days)</th>
<th>Number of Animals</th>
<th>Avg Age (in Mnths)</th>
<th>Avg Days Dry</th>
<th>Avg Days in (Milk Cow)</th>
<th>Avg Days LAT</th>
<th>Avg Days Milk</th>
<th>Avg Days P</th>
<th>Avg Days</th>
<th>Avg Days Cols</th>
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### Identification And Genetic Summary

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<th>Age Group</th>
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<th>Num. Identified By</th>
<th>No. Of Animals with Ident.</th>
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<th>Hard Mert $</th>
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### Production By Lactation Summary

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<th>Lactation</th>
<th>Avg Age (in Mnths)</th>
<th>Peak Milk</th>
<th>Summ Milk</th>
<th>Prog 305 Day Act</th>
<th>Difference From Homesteads</th>
<th>Ash Body Ur</th>
<th>% Cows SCC Score</th>
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### Somatic Cell Summary

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<th>% Cows SCC Score</th>
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### Dry Cow Profile

|牛 Number | Average Days | Number Dry Days | Number Dry Days | Number DRY | Number Enter 
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### Yearly Summary Of Cows Entered And Left The Herd

| Yearly Production And Mastitis Summary
<table>
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<td>56</td>
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---

Weighted SCC ACT (Nearest 1,000)
Calving Interval, Calf Sex Ratio

Herd Cull Rate

Age at First Calving

Overall Herd Size

Mature milk cows

First-calf heifers

Dry cows

Replacement Heifers

Calf Mortality Rate

Non-Completion Rate

What's Missing?
Non-Completion Rate

- Not easily identified
- % of heifers enter system but do not calve in
  - Typical start after first 48 hrs. old
  - Number heifers left (for any reason)
  - Essentially a heifer cull rate
- Case Farms (Last 12 mo)
  - $\frac{\text{# Heifers Culled}}{\text{Avg # Heifers}} = \text{Rate}$
  - Farm A: $\frac{23}{284} = 8\%$
  - Farm B: $\frac{4}{170} = 2\%$
Are They Achieving…

• <13.3  Mo. Calving Interval
• 22-24  Mo. Age at First Calving
• 50    % Heifer Calves
• <5    % Calf Mortality Rate

Stresses on Heifer System
Are They Achieving

- <8 % Non-completion
- 22-24 Mo Age at First Calving
- 33-35 % Cull Rate**
PSU Herd Metrics App

- [https://extension.psu.edu/penn-state-dairy-herd-metrics](https://extension.psu.edu/penn-state-dairy-herd-metrics)
- Enter Your herds 7 key metrics
- Save scenarios
  - Test “What if” scenarios
- Enter economic values
  - culled cows or heifers to see impact of a herd’s status
Monthly % Herd 1st Lact Freshening

Case Farm A: Monthly 1st Lact Freshening

Case Farm B: Monthly 1st Lact Freshening
You decide

• What is the average % left herd for each farm

• What would the average + 1 Deviation be?
Monthly % Left Herd

Case Farm A: Monthly Left Herd

Case Farm B: Monthly % Left Herd
1st lact fresh with % left controls
IDENTIFY 2: Opportunity Cost

KNOW 1: Inventory

ADDRESS 3: Heifer Management
Replacement Rate

Case Farm A: Replacement Rate

Case Farm B: Replacement Rate
Heifer Distribution by Age Group

Case Farm A: Heifer Group Distribution

Case Farm B: Heifer Group Distribution
Why too much culling may be counter productive
Same herd, 35% L1, pro-rated to L2 & L3+
% Cows Left Herd, PA DHI Herds >50 cows

(Dairy Records Management Systems, September, 2018)
• Average Herd Turnover is ~40% in PA (and nationally)

• Think about this a bit differently

• After calving, how many years will they stay in the herd
  o 1 year ÷ 40% = 2.5 years in herd before culling (i.e. productive life)

  o What if that was 3.5 years, or 1 year?
What areas drive cull rate

- Genetics
  - Heifers “should” be genetically superior

- Maturity
  - Mature cows net more milk per lactation

- Costs
  - Heifer rearing cost
  - Salvage income
Value of a Mature Herd

(De Vries, A., 2018)
KNOW 1: Inventory

IDENTIFY 2: Opportunity Costs

ADDRESS 3: Heifer Management

Data
Costs to Raising Heifers
Rearing cost by heifer weights

Cost per day ($)

- Fixed
- Labor/mgt
- Variable
- Feed

Heifer weight (lbs.)

Hoffman et al., 1999
Feed costs are the largest cost input for heifer production (>60%).
Heifer feed costs >12% of total farm expenses.

Gabler et al., 2000
## Costs to Raise Heifers, birth to freshening
### survey of 44 PA herds, winter 2011/spring 2012

<table>
<thead>
<tr>
<th>$/heifer</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feed</td>
<td>1,318</td>
<td>281</td>
<td>819</td>
<td>1,980</td>
</tr>
<tr>
<td>Labor</td>
<td>203</td>
<td>99</td>
<td>66</td>
<td>436</td>
</tr>
<tr>
<td>Bedding</td>
<td>90</td>
<td>81</td>
<td>10</td>
<td>392</td>
</tr>
<tr>
<td>Repro</td>
<td>49</td>
<td>22</td>
<td>13</td>
<td>122</td>
</tr>
<tr>
<td>Health</td>
<td>17</td>
<td>13</td>
<td>3</td>
<td>66</td>
</tr>
<tr>
<td>Total</td>
<td>1,808</td>
<td>339</td>
<td>1,129</td>
<td>2,505</td>
</tr>
<tr>
<td>Total/day</td>
<td>2.38</td>
<td>0.41</td>
<td>1.50</td>
<td>3.24</td>
</tr>
</tbody>
</table>

Heinrichs et al., JDS 2014
Average heifer rearing costs
Pennsylvania survey, 2011

Heinrichs et al., 2014
2017-18 Planned Heifer Feed Cost/Cow

Reduction:
66 of 109 plans impacted
Average savings: $55/cow
Effect of age at calving on heifer numbers
Simulation for 100-cow herd

- ≤ 2 months
- 3 to 6 months
- ≥ 7 months, not pregnant
- pregnant

Assumptions: 47% heifer calf birth rate, 7% stillbirth rate, 8.5% cull rate before first lactation, 30% cow replacement rate, 13 month calving interval

Projected herd size

After 2 Years

Herd Structure Simulation Model, University of Wisconsin, Cabrera & Meyer
Looked at Efficiency of Heifer Raising

- Costs at all time points
- Nutrition/feeding rates at all time points/groups
- Growth at weaning, breeding, calving
- Age at calving
- DHI records- milk (total, fat, protein), reproduction, culling; all compared total herd averages

Heinrichs et al., 2013
# Efficient farms compared to Inefficient farms

Data envelopment analysis of 44 PA herds, winter 2011/spring 2012

<table>
<thead>
<tr>
<th></th>
<th>Efficient</th>
<th>Inefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>9</td>
<td>35</td>
</tr>
<tr>
<td>Feed costs ($/heifer)</td>
<td>1,137</td>
<td>1,364</td>
</tr>
<tr>
<td>Labor costs ($/heifer)</td>
<td>141</td>
<td>218</td>
</tr>
<tr>
<td>Milk produced by first lactation heifers (% of mature herd mates)</td>
<td>88%</td>
<td>82%</td>
</tr>
<tr>
<td>Age at calving (mo)</td>
<td>23.7</td>
<td>25.3</td>
</tr>
</tbody>
</table>

Heinrichs et al., 2014
A little more about the efficient farms...

<table>
<thead>
<tr>
<th>Farm #</th>
<th>Feed, $/head</th>
<th>Labor, $/head</th>
<th>AFC, mo.</th>
<th>Heifer milk production, % of mature herd mates</th>
</tr>
</thead>
<tbody>
<tr>
<td>41</td>
<td>912.87</td>
<td>116.97</td>
<td>23.5</td>
<td>81.93</td>
</tr>
<tr>
<td>7</td>
<td>849.76</td>
<td>120.41</td>
<td>23.8</td>
<td>82.88</td>
</tr>
<tr>
<td>34</td>
<td>1,042.10</td>
<td>138.13</td>
<td>23.0</td>
<td>85.99</td>
</tr>
<tr>
<td>21</td>
<td>819.12</td>
<td>124.95</td>
<td>25.0</td>
<td>87.95</td>
</tr>
<tr>
<td>30</td>
<td>1,608.63</td>
<td>88.20</td>
<td>24.5</td>
<td>92.14</td>
</tr>
<tr>
<td>10</td>
<td>1,230.77</td>
<td>317.62</td>
<td>23.9</td>
<td>94.56</td>
</tr>
<tr>
<td>33</td>
<td>1,179.01</td>
<td>66.25</td>
<td>22.5</td>
<td>87.97</td>
</tr>
<tr>
<td>38</td>
<td>1,020.01</td>
<td>210.56</td>
<td>25.0</td>
<td>99.32</td>
</tr>
<tr>
<td>32</td>
<td>1,574.30</td>
<td>82.47</td>
<td>22.2</td>
<td>83.02</td>
</tr>
</tbody>
</table>

Heinrichs et al., 2014
Efficiency was attained by herds with the lowest input costs (21, 7, and 41).

But, herds with higher input costs also attained efficiency if they had low AFC or high milk production of heifers compared to the other cows in the herd (10, 30, and 32).

Herds with the highest input costs must lower AFC and increase milk production of heifers to recoup the money they invest in heifers and increase efficiency.

Heinrichs et al., 2014
Major issues statewide that lead to higher heifer costs

- Weaning too late; high feed costs
- Breeding too late
- Bedding
- Age at calving #1
Age at Calving and Cost of Rearing

Italian Holsteins, calved from 1992-97

- AFC average 28 mo, SD 3.16
- Most profitable AFC 23 to 24 mo

Pirlo et al., 2000
What affects the costs of raising replacement dairy heifers:
A multiple component analysis  (Tozer and Heinrichs, 2001)

• Herd culling rate
  o ↓ 20%  →  ↓ costs 24.6%
  o ↑ 25%  →  insufficient heifers

• Age at first calving
  o ↓ 1 mo AFC  →  ↓ costs 4.3%
Costs of Age at First Calving

Tozer and Heinrichs, 2004
Herd Average Age at First Calving, PA Holsteins, last 5 years

Age of 1st Lact Cows

DRMS Dairy Metrics, 1/19/18
Distribution of age at first calving in PA Holsteins, 2002 v. 2017

Heifers with AFC of 21 – 24 mo
2002 – 31.1% 2017 – 63.4%

DRMS data
Distribution of age at first calving in PA Holsteins, 2015 v. 2017

Heifers with AFC of 21 – 24 mo
2015 – 58.6%  2017 – 63.4%

DRMS data
Comparison of actual 305-d milk by age at first calving in PA Holsteins, 2010 v. 2017

Actual 305-d milk yield, lbs.

Age at calving, months

2010  2017

DRMS data
Heifer Health Events are Critical
Effects of bovine respiratory disease (BRD) experienced before first calving

- Dark bars = accumulated DIM
- Light bars = productive life
Survivorship throughout first lactation as influenced by the number of bovine respiratory (BRD) episodes experienced before first calving

- Solid black line = 0 cases BRD
- Solid gray line = 1 case BRD
- Dotted black line = 2 cases BRD
- Dotted gray line = 3 cases BRD
- Dashed black line = ≥ 4 cases BRD

Bach, 2011
Calf health impacts ADG of heifers

- Diarrhea, septicemia, and respiratory disease can affect heifer growth

- Passive transfer of IgG affected health and indirectly height and weight

Donovan et al., 1988
Calf health and survivorship and age at calving

- Heifers treated for pneumonia – 2.5X more likely to die
- Heifers treated for diarrhea 2.5X likely to be sold
- Heifers treated for diarrhea 2.9X more likely to calve >30 mos.

Waltner-Towes et al., 1986
Summary

• Goal of raising dairy heifers is to minimize costs without sacrificing future productive potential
  o Age at first calving 22-24 mo

• Several management systems can work well
  o Choice depends on individual farm facilities, resources, and management preferences
What is needed

• Beef crosses (which ones, market value)
• “don’t put eggs in 1 basket”
• Back calculate needs in age groups
In Summary

• Need to know the numbers
  o Cost to raise heifers at various stages
  o Current metrics impacting cow flow
  o Current metrics impacting available heifers

• Current and future goals
  o Plan for possible bumps in the road

• No single answer fits every farm
Credits

“cow-calf-mama-farm-animal-beef-2125856” by maryconnealy Pixabay.com cc0.
“problem-analysis-solution-hand-67054” by geralt. Pixabay.com cc0.
“question-mark-important-sign-1872634” by qimono. Pixabay.com cc0.
“brown-eggs-breakfast-nutrition-food-3217675” by jill111. Pixabay.com cc0.
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Food production must increase by >50% by 2050

http://www.restlessbeings.org/images/child_malnutrition_on_the_map.jpg
http://www.census.gov/ipc/www/idb/worldpopgraph.php
Sustainable Food Production

Income – Expenses = Profit


- Agriculture: 40%
- Urban: 11%
- Mixed Open: 7%
- Forest: 15%
- Point Source: 22%
- Septic: 4%
- Non-Tidal Water Deposition: 1%

Agriculture: 40%
Mixed Open: 7%
Forest: 15%
Urban: 11%
Non-Tidal Water Deposition: 1%
Point Source: 22%
Septic: 4%
N Conversion Efficiencies are Relatively Poor for the Ruminant

↑ efficiency = ↑ food/ac and ↓ environmental loading!

Bequette et al., 2003
## Ohio Dairy Nutrient Prices

November 28, 2017 Evaluation  
Buckeye Dairy News: Vol 10, Issue 6

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Cost/Unit</th>
<th>Daily Supply*</th>
<th>Cost/cow/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEL (3X, NRC 2001)</td>
<td>$0.0664</td>
<td>35.4 Mcal</td>
<td>$2.35</td>
</tr>
<tr>
<td>Metabolizable Protein (NRC)</td>
<td>$0.4375</td>
<td>5.44 lbs</td>
<td>$2.38</td>
</tr>
<tr>
<td>Effective NDF (forage NDF)</td>
<td>$0.0321</td>
<td>10.4 lbs</td>
<td>$0.33</td>
</tr>
<tr>
<td>Non-effective NDF (Total NDF – Forage NDF)</td>
<td>-$0.0591</td>
<td>7.3 lbs</td>
<td>-$0.43</td>
</tr>
<tr>
<td>Total Cost for Energy, Protein and Fiber</td>
<td></td>
<td></td>
<td>$4.63</td>
</tr>
</tbody>
</table>

* 1600 lb cow, 80 lbs milk/d, 3.0% protein, 3.5% fat

NRC 2001 Least Cost Rations
Balanced to NRC 2001 Requirements (MP & RDP)

Ration Cost, $/c/d

36 kg milk, 3.0% protein, 3.6% fat, 23.6 kg DMI

Dietary CP, % of DM

- Pigs can capture up to 80% of absorbed AA in tissue. Baker et al. (1986)
- Low CP + select AA

Mar, 2013 Ingredient Prices
ST-Pierre, Progressive Dairyman

Used Formulate2©
Milk Protein vs Metabolizable Protein

650 g / 454 x $0.44/lb = $0.63/c/d

For this much protein
Feed this much MP

Lapierre et al., 2007
Milk Protein Responses to Digestible Lysine and Methionine

- Based on MP
- NO forward progress

NRC, 2001
Protein is a String of Amino Acids

Amino Acids are Required

Amino Acids

Protein

Regulation
AA, Energy, Hormones
Metabolic Representation of AA

Single Limiting Nutrient Theory

Water Barrel Analogy

- **Lowest Stave** determines the water level in the barrel
- **Mitchell and Block, 1946**
  - Order of limitation
  - Barrel with staves
- **Based on Constant Efficiencies of Conversion**
  - No regulation
  - No Adaptation
Lactational Responses to Individual Essential AA in Mice

Liu et al., 2017
Responses to EAA

15.2% CP, 38% N Efficiency

<table>
<thead>
<tr>
<th>Effect (P-values)</th>
<th>MKH</th>
<th>IL</th>
<th>MKH*IL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MKH</td>
<td>0.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IL</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MKH*IL</td>
<td>0.89</td>
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</table>

<table>
<thead>
<tr>
<th>Effect (P-values)</th>
<th>MKH</th>
<th>IL</th>
<th>MKH*IL</th>
</tr>
</thead>
<tbody>
<tr>
<td>MKH</td>
<td>0.002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IL</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MKH*IL</td>
<td>0.500</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Yoder et al., 2018
Real Facts: A Leaky Barrel

- Leaks define Efficiency
- $\uparrow$ level $\Rightarrow$ $\uparrow$ leaks
- Size of each leak depends on the mix of nutrients
- Plugging ANY leak helps!
- Additive, independent responses
### Predicted AA Outflow

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Observed mean</th>
<th>Predicted mean</th>
<th>RMSE (%)</th>
<th>Mean bias (% of MSE)</th>
<th>Slope bias (% of MSE)</th>
<th>CCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>NANMN, g/d</td>
<td>236</td>
<td>212</td>
<td>197</td>
<td>37.2</td>
<td>3.97*</td>
<td>0.02</td>
<td>0.35</td>
</tr>
<tr>
<td>MiN, g/d</td>
<td>236</td>
<td>294</td>
<td>290</td>
<td>24.0</td>
<td>0.20</td>
<td>0.11</td>
<td>0.68</td>
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<tr>
<td>Arg, g/d</td>
<td>229</td>
<td>120</td>
<td>138</td>
<td>31.8</td>
<td>23.9*</td>
<td>2.2*</td>
<td>0.44</td>
</tr>
<tr>
<td>His, g/d</td>
<td>234</td>
<td>57.9</td>
<td>60.9</td>
<td>31.0</td>
<td>2.8*</td>
<td>0.6</td>
<td>0.44</td>
</tr>
<tr>
<td>Ile, g/d</td>
<td>234</td>
<td>122</td>
<td>138</td>
<td>31.4</td>
<td>16.1*</td>
<td>1.3</td>
<td>0.45</td>
</tr>
<tr>
<td>Leu, g/d</td>
<td>234</td>
<td>227</td>
<td>228</td>
<td>28.2</td>
<td>0.0</td>
<td>1.4</td>
<td>0.54</td>
</tr>
<tr>
<td>Lys, g/d</td>
<td>232</td>
<td>158</td>
<td>190</td>
<td>40.6</td>
<td>25.9*</td>
<td>3.2*</td>
<td>0.34</td>
</tr>
<tr>
<td>Met, g/d</td>
<td>233</td>
<td>49.1</td>
<td>55.5</td>
<td>32.1</td>
<td>16.2*</td>
<td>1.4</td>
<td>0.53</td>
</tr>
<tr>
<td>Phe, g/d</td>
<td>234</td>
<td>131</td>
<td>143</td>
<td>28.0</td>
<td>10.4*</td>
<td>0.2</td>
<td>0.51</td>
</tr>
<tr>
<td>Thr, g/d</td>
<td>234</td>
<td>125</td>
<td>138</td>
<td>26.8</td>
<td>15.1*</td>
<td>0.0</td>
<td>0.55</td>
</tr>
<tr>
<td>Val, g/d</td>
<td>234</td>
<td>140</td>
<td>152</td>
<td>30.6</td>
<td>7.6*</td>
<td>0.6</td>
<td>0.44</td>
</tr>
</tbody>
</table>

Myers Thesis, 2018
Predicting Milk Protein Output

Milk Protein \( (g/d) = 328 - 0.831(DIM) - 62.6(MilkFat\%) + 9.42(DEI) + 4.95(Arg) \)
\[-0.021(\text{Arg})^2 + 1.28(\text{His}) + 0.687(\text{Ile}) + 1.63(\text{Leu}) - 0.003(\text{Leu})^2 + 0.393(\text{Lys}) + 1.024(\text{Met}) - 4.34(\text{Val}) + 0.009(\text{Val})^2\]
How Low Can We Go?

\[
Milk\ Protein\ (g\ /\ d) = 328 - 0.831(DIM) - 62.6(MilkFat\%) + 9.42(DEI) + 4.95(\text{Arg}) - 0.021(\text{Arg})^2 + 1.28(\text{His}) + 0.687(\text{Ile}) + 1.63(\text{Leu}) - 0.003(\text{Leu})^2 + 0.393(\text{Lys}) + 1.024(\text{Met}) - 4.34(\text{Val}) + 0.009(\text{Val})^2
\]

Assumptions: 23 kg DMI, MP ~ 0.6 * CP, MP = $0.4375/lb, Milk Prt = $2/lb

<table>
<thead>
<tr>
<th></th>
<th>16.5% CP</th>
<th>14.5% CP</th>
<th>12.5% CP</th>
<th>12.5% + rpAA</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP, g/d</td>
<td>2280</td>
<td>2000</td>
<td>1725</td>
<td>1885</td>
</tr>
<tr>
<td>EAA, g/d</td>
<td>1170</td>
<td>1025</td>
<td>885</td>
<td>1007</td>
</tr>
<tr>
<td>Milk Prt, g/d</td>
<td>1080</td>
<td>1064</td>
<td>1042</td>
<td>1114</td>
</tr>
<tr>
<td>Abs His, g/d</td>
<td>56</td>
<td>49</td>
<td>42</td>
<td>56 (+14)</td>
</tr>
<tr>
<td>Abs Leu, g/d</td>
<td>214</td>
<td>188</td>
<td>162</td>
<td>214 (+52)</td>
</tr>
<tr>
<td>Abs Lys, g/d</td>
<td>179</td>
<td>157</td>
<td>135</td>
<td>179 (+44)</td>
</tr>
<tr>
<td>Abs Met, g/d</td>
<td>54</td>
<td>47</td>
<td>41</td>
<td>54 (+13)</td>
</tr>
</tbody>
</table>

* MP cost is nonlinear vs reduced dietary CP.
Going Forward

**We**

- Complete Model Evaluations
  - Cow trial
- Formulation System
  - Repeatable solutions
  - Reasonable solutions
  - Change in ingredient use
  - Value of EAA
  - Solution speed

- Feeding trial test of the solutions

- Incorporation into Commercial Software
  - AMTS
  - NDS
  - ??

**You**

- Embrace optimization of diets
  - Starch, sugars, NDF, eNDF, dNDF
  - Fat, fatty acids
  - Arg, Leu, Lys, Met, Phe, Thr, Val
  - Vitamins
  - Minerals
  - ~ 28 nutrients to balance

- TRULY OPTIMIZE 28 NUTRIENTS BY HAND?!
  - Linear in AMTS is a step forward
  - Nonlinear takes longer, but better
  - $0.20 to $0.80/c/d on the table
  - Allocate time to master.
Acknowledgements and Questions

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• Perdue Ag Solutions
• Papillon
• Adisseo
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• Virginia Agricultural Council
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• John Sutton, U. Reading
• Diane Wray-Cahen, U. Reading
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• Larry Reutzel, Purina
• Helene Lapierre, Ag Canada
• Alex Hristov, Penn State Univ.
• Jeffery Escobar, VT/Novus
• Mike Akers, VT
• Mike McGilliard, VT
• Ondrej Becvar, VT
• Hollie Schramm, VT
• Danijela Kirovska, Univ. of Belgrade
• Lin Xueyan, Shandong Ag Univ.
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• Ning Jiang, Heilongjiang Bayi Ag. Univ

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• Ashley Bell
• Sebastian Arriola
• Michelle Aguilar
• Juan Castro
• Kari Estes
• Adelyn Myers
• Robin White
• Xinbei Huang
• Ashley Felock
• Rebecca Garnett
• Guimei Liu
• Xin Feng
• Veridiana Daley
• Meng Li
• Peter Yoder
• A herd of undergraduate students
Understanding and Using MUN

Mark D. Hanigan
Professor
Department of Dairy Science
Virginia Tech
## Ohio Dairy Nutrient Prices

July 25, 2018 Evaluation  
Buckeye Dairy News: Vol 20, Issue 4

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Cost/Unit</th>
<th>Daily Supply*</th>
<th>Cost/cow/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEL (3X, NRC 2001) MCal</td>
<td>$0.0704</td>
<td>35.4 Mcal</td>
<td>$2.49</td>
</tr>
<tr>
<td>RDP (NRC) Lbs</td>
<td>$0.162</td>
<td>5.07 lbs</td>
<td>$0.82</td>
</tr>
<tr>
<td>RUP (NRC) Lbs</td>
<td>$0.385</td>
<td>~2.4 lbs</td>
<td>$0.92</td>
</tr>
<tr>
<td>Effective NDF (forage NDF) Lbs</td>
<td>$0.150</td>
<td>10.4 lbs</td>
<td>$1.56</td>
</tr>
<tr>
<td>Non-effective NDF (Total NDF – Forage NDF) Lbs</td>
<td>-$0.043</td>
<td>7.3 lbs</td>
<td>-$0.32</td>
</tr>
<tr>
<td>Total Cost for Energy, Protein and Fiber</td>
<td></td>
<td></td>
<td>$5.47</td>
</tr>
</tbody>
</table>

* 1600 lb cow, 80 lbs milk/d, 3.0% protein, 3.5% fat
N Conversion Efficiencies are Relatively Poor for the Ruminant

↑ efficiency = ↑ food/ac and ↓ environmental loading!

Bequette et al., 2003
Effects of Dietary Protein (RDP) on Intake and Milk Yield

Cyriac et al., 2006

NRC 2001 RDP Requirement

DMI: \( P = 0.01 \) (Lin)
Milk yield: \( P = 0.09 \) (Lin)
What is Urea

Feed Protein -> Animal Protein

Amino Acids

CO₂

H₂O

NH₃

CO₂

H₂N-CO-NH₂ (Urea)
RDP = Ruminally Degraded Protein
RUP = Ruminally Undegraded Protein
CP = RDP + RUP
MP = Digestible (Microbial Protein + RUP)
What Goes In MUST Come Out!
MUN and Urinary N Output

Milk Urea (mg/dl) = \( \frac{\text{MUN (mg/dl)}}{0.467} \)

Burgos et al., 2007
Effects of Dietary Protein on MUN and N Efficiency

Cyriac et al., 2006
RDP/RUP and MUN

- Effect of more RDP?
- Effect of more RUP?

Can you tell which is a problem?

RDP = Ruminally Degraded Protein
RUP = Ruminally Undegraded Protein
CP = RDP + RUP
MP = Digestible (Microbial Protein + RUP)
Effects of Varying RDP and RUP

Cows averaged 40 kg/d at the start of the study. Milk Protein, kg/d, $P_{RDP} = .06$

Aguilar et al. 2012
Low CP plus EAA

15.2% CP

<table>
<thead>
<tr>
<th>Effect (P-values)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MKH</td>
</tr>
<tr>
<td>0.31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Effect (P-values)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MKH</td>
</tr>
<tr>
<td>0.001</td>
</tr>
</tbody>
</table>

Milk Production, kg/d

- Control
- MKH
- IL
- MKH+IL

Milk Protein, g/d

- Control
- MKH
- IL
- MKH+IL

MUN
- Control
- MKH
- IL
- MKH+IL

N Efficiency
- Control
- MKH
- IL
- MKH+IL

Yoder et al., 2018
Increased Starch?
Dietary Crude Protein and Fiber

Milk, $P_{CP} < .05$

- 13% CP 30% NDF
- 13% CP 40% NDF
- 17% CP 30% NDF
- 17% CP 40% NDF

MUN or Milk

Kaufman and St-Pierre., 2001

NEL: 30% NDF – 1.66 mcal/kg
40% NDF – 1.63 mcal/kg
Plasma Urea vs Conception Rate

\[ y = 0.3321x + 49.357 \]

\[ R^2 = 0.0236 \]

## Effect of Salt on MUN

High NaCl = 1.29% Na  
Low NaCl = 0.31% Na

<table>
<thead>
<tr>
<th></th>
<th>Low protein</th>
<th>High protein</th>
<th>Low NaCl</th>
<th>High NaCl</th>
<th>Low NaCl</th>
<th>High NaCl</th>
<th>SE</th>
<th>Protein</th>
<th>NaCl</th>
<th>Protein × NaCl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na-intake (g/d)</td>
<td>58</td>
<td>273</td>
<td>62</td>
<td>244</td>
<td>10.2</td>
<td>0.263</td>
<td>&lt;0.001</td>
<td>0.110</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMI (kg/d)</td>
<td>19.2</td>
<td>19.3</td>
<td>19.6</td>
<td>20.0</td>
<td>0.28</td>
<td>0.068</td>
<td>0.383</td>
<td>0.507</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk yield (kg/d)</td>
<td>22.4</td>
<td>22.0</td>
<td>24.7</td>
<td>26.5</td>
<td>1.03</td>
<td>0.028</td>
<td>0.285</td>
<td>0.126</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein (%)</td>
<td>3.34</td>
<td>3.45</td>
<td>3.48</td>
<td>3.29</td>
<td>0.142</td>
<td>0.961</td>
<td>0.691</td>
<td>0.162</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MUN (mg of N/dL)</td>
<td>5.29</td>
<td>3.66</td>
<td>9.29</td>
<td>7.45</td>
<td>0.342</td>
<td>&lt;0.001</td>
<td>0.002</td>
<td>0.314</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Spek et al., 2013 JDS
Wet Chemistry vs Infrared Analyses of MUN

Table 1. Percent recovery of urea nitrogen among analytical methods.

<table>
<thead>
<tr>
<th>Method</th>
<th>Recovery(%)¹</th>
<th>SE(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bentley</td>
<td>92.1a</td>
<td>2.76</td>
</tr>
<tr>
<td>CL-10</td>
<td>85.0b</td>
<td>2.76</td>
</tr>
<tr>
<td>Foss4000</td>
<td>47.1c</td>
<td>9.88</td>
</tr>
<tr>
<td>Foss6000</td>
<td>95.4a</td>
<td>10.1</td>
</tr>
<tr>
<td>Skalar</td>
<td>95.1a</td>
<td>7.61</td>
</tr>
</tbody>
</table>

¹Recovery = (Treated MUN - Control MUN)/4 mg/dL.

a,b,cMeans within a column with unlike superscripts differ (P < 0.05).


United DHIA - Bentley
$0.25 / cow for full test
$10 for a single bulk tank sample
## Genetics and MUN

<table>
<thead>
<tr>
<th>Effect</th>
<th>Estimate</th>
<th>SE</th>
<th>P&lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-166</td>
<td>26</td>
<td>0.002</td>
</tr>
<tr>
<td>Dietary CP, % of DM</td>
<td>5.4</td>
<td>1.1</td>
<td>0.0001</td>
</tr>
<tr>
<td>Dietary NDF, % of DM</td>
<td>2.84</td>
<td>0.45</td>
<td>0.0001</td>
</tr>
<tr>
<td>Milk Yield, kg/d</td>
<td>0.66</td>
<td>0.12</td>
<td>0.0001</td>
</tr>
<tr>
<td>Milk Protein, %</td>
<td>37.7</td>
<td>7.3</td>
<td>0.0001</td>
</tr>
<tr>
<td>CP x NDF</td>
<td>-0.038</td>
<td>0.018</td>
<td>0.03</td>
</tr>
<tr>
<td>CP x Milk Yield</td>
<td>-0.0194</td>
<td>0.0057</td>
<td>0.001</td>
</tr>
<tr>
<td>CP x Milk Protein</td>
<td>-0.73</td>
<td>0.24</td>
<td>0.003</td>
</tr>
<tr>
<td>NDF x Days in Milk</td>
<td>-0.00005</td>
<td>0.00002</td>
<td>0.009</td>
</tr>
<tr>
<td>NDF x Milk Protein</td>
<td>-0.65</td>
<td>0.11</td>
<td>0.0001</td>
</tr>
<tr>
<td>Milk x Milk Protein</td>
<td>-0.073</td>
<td>0.023</td>
<td>0.002</td>
</tr>
</tbody>
</table>

### Random Effects

<table>
<thead>
<tr>
<th>Effect</th>
<th>P&lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herd</td>
<td>0.08</td>
</tr>
<tr>
<td>Cow(Herd)</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Aguilar et al., 2012
Monitor MUN to Achieve Optimum Return

1. Establish a baseline for your herd
   - Some genetic variation
   - Dietary salt effects
   - Balance ration to NRC 2001 or equivalent
   - Feed ration for 2 weeks and Measure MUN (~11 mg/dl)

2. Systematically reduce RUP (0.25% units at a time)
   - For example, CP from 16.5% to 16.25% via RUP ($0.04/c/d)
   - Keep RDP and energy constant
   - Feed for 3 weeks; Monitor MUN and milk yield
   - MUN should ↓ by ~0.5 mg/dl
   - Any milk loss will be half of NRC predicted loss
   - Calculate Income/Feed Cost (IOFC)
   - If greater, retain reduction and lower another 0.25%

3. Reduce RDP by 0.5% of Diet DM while holding RUP constant
   - Same approach as for RUP, e.g. 16% to 15.5% ( $0.08/c/d)
   - RDP ≥ 9% of DM is safe
   - ↓ DMI is first sign of deficiency

4. MUN at maximal IOFC is target for the herd
   - Can operate at 8 or below
   - May require RPAA → IOFC
Bay Restoration = ↑$
Bridging the Gap in Client Communications

Lisa A. Holden

It takes two to speak truth - one to speak and another to hear.

--Henry David Thoreau
Retain, retain, retain

Acquiring a new customer is 5 to 25 times more costly than retaining an old one.

Increasing retention rates by 5% increased profits from 25 to 95%.

Today’s Session

A little communication
A little personality/generations
A few examples

**Action steps** – to BRIDGE the GAPS!
Activity

For the next 40 seconds...

Communicate with the person beside you.
A.S.A.P.

WHAT DOES THIS MEAN???
The Communication Cycle

Sender
- Intent
- Content

Message
- Verbal
- Nonverbal

Feedback
- Noise
  - environmental
  - physiological
  - psychological
  - social
  - syntax, semantics

Receiver
- Interprets
  - experience
  - context
Communication

Sender – The one with the ball
  ◦ Pitcher
  ◦ Quarterback

Receiver – The one who wants the ball
  ◦ Catcher
  ◦ Wide Receiver
  ◦ Dog
Don’t drop the message!
Think about what you mean?
Communicate what you mean.
Consider this . . .

**Manager:** Tom I need you to move that heifer to Pen 6.

**Tom:** Sure thing, Boss.

Possible outcomes:
- Correct heifer moved to correct pen in timely fashion.
- Wrong heifer moved.
- Correct heifer moved . . . Eventually.
- Other??
What about... 

**Manager:** Tom I need you to move heifer #355 to Pen 6 in the next hour.

**Tom:** OK, Boss.

**Manager:** Will you be able to do that? Do you need any help?

**Tom:** I’ll get Bill to help me right after he is done pushing up feed.

Possible outcomes:
- Correct heifer moved to correct pen in timely fashion.
- Wrong heifer moved.
- Correct heifer moved... Eventually.
Understanding Why Communication Breaks Down

People misunderstand one another.
Speakers often assume.
Too little information is given.
How about this . . .

Worker: Uh, there’s a cow in Pen 3 that looks a little off.

Manager 1: What is her number? Can you describe what you mean by a little off?

Manager 2: Does she need treated?
Understanding Why Communication Breaks Down

Information is given too fast.

Listeners are unwilling to ask questions.

Background noise, distractions.
The Communication Cycle

- Sender
  - Intent
  - Content
  - Message
  - Verbal
  - Nonverbal
  - Feedback
  - Noise
    - environmental
    - physiological
    - psychological
    - social
    - syntax, semantics

- Receiver
  - Interprets
    - experience
    - context

Responsibility tracks:
- Message flow
- Feedback loop
Action Steps

Think about what you want to communicate.

- Ask questions.

- NOT: Do you understand?

- BUT: I’m not sure I am being clear. Can you confirm for me . . .

Coach your clients to be better at COMMUNICATING!
What is Nonverbal Communication?
The Power of Nonverbals
Communication involves a number of choices

More than just WORDS.
The tone of voice.
Inflection or variation in voice.
Pace or speed of speaking.
Volume or loudness.
Nonverbal: Such as body stance, eye contact, facial expression, physical distance, gestures.
Action Steps

Pay attention to YOUR nonverbals

WATCH the nonverbal of others
Improving Your **Communication**

1. Simplify the content.
2. Speak at a reasonable rate.
3. Give details in order.

4. **EXAMPLE:** Milker meetings. Change from quarterly with lots of information to weekly 20 minute “updates”.

[Image of London Bridge]
Improving Your Communication

1. Highlight important points.
2. Use more than one communication channel.
3. Seek feedback.

Milking practices
Wet towels spread bacteria. Make sure towels are dry.
Put a sign up on the dryer.
Check at the next milker meeting.
Action Steps

Think about what you want to communicate.
◦ Ask questions.
◦ NOT: Do you understand?
◦ BUT: I’m not sure I am being clear. Can you confirm for me . . .

Pay attention to “power gradient”.

PennState
Questions?
### The age of communication

<table>
<thead>
<tr>
<th>Traditionalists</th>
<th>Baby Boomers</th>
<th>Generation X</th>
<th>Millennials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Being Respected, security</td>
<td>Being valued, money</td>
<td>Freedom, fewer rules, time off.</td>
<td>Working with bright people, time off.</td>
</tr>
</tbody>
</table>
Personality “TESTS” ???

Myers-Briggs
Kiersey
DISC
Others?
Four “types”

1. Driver
2. Analytical
3. Amiable
4. Expressive
So what . . .
Conversations: Texts, emails, phone calls, -- communication is constant.
Establish expectations

- Time lines
- Performance
- Payments
- Communication boundaries

Chalking the Field
People vs. Problem

Consider this conversation with a feeder

- Three times this week the fresh pen ran out of feed. The pen average has dropped by six pounds. Peak milks are being compromised and we are losing money.

- Implied?
People vs Problem

• The implied YOU

• Covey – Seek first to understand.

• Solve PROBLEMS together
People vs. Problem

Consider another conversation with a feeder

◦ I wanted to talk with you about a problem that I noticed this week. You know its important to have the fresh pen feed delivered on time since intakes will greatly impact peaks. In looking at the data, I noticed that feed was late three times on the datasheet. Do you know what has changed and why this is happening?

◦ Implied?
Situation One
Situation Two
Start off with a question
How do you ask great questions?

<table>
<thead>
<tr>
<th>SENTENCE STARTERS</th>
<th>TIPS TO REMEMBER</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHO?</td>
<td>Don’t be afraid of a delay or a break in the conversation!</td>
</tr>
<tr>
<td>WHAT?</td>
<td>Silence creates magic!</td>
</tr>
<tr>
<td>WHEN?</td>
<td>Focus only on what the person is saying, formulate next question after they’ve finished responding.</td>
</tr>
<tr>
<td>WHERE?</td>
<td>Try not to be invested in the outcome, or ask questions that lead.</td>
</tr>
<tr>
<td>HOW?</td>
<td>Tell me more about that.</td>
</tr>
</tbody>
</table>
Action Steps

Be aware of differences
  ◦ Adjust when needed.

  ◦ Clarify expectations
    ◦ Time and money

  ◦ Start the conversation
    ◦ Ask good questions
Questions?

Lisa A. Holden
lah7@psu.edu
Subtitle: Increasing production from each acre
... beyond what is possible from corn silage and alfalfa

• Why consider small grain forages?
• Key considerations: opportunities and challenges
• Opportunities to increase output/reduce risk of forage systems
• Paying attention to the agronomics
• Performance of recent small grain/cover crop trials
• Other possible crops/systems
→ NOT advocating abandonment of corn silage OR alfalfa
Alternatives- why now?

- Variable feed costs, variable milk prices → tight margins
- Periodic droughts
- Improving no-till planting equipment
- New seed options
- Better understanding of utilization
- Soil/nutrient mgt management

Alternatives- an agronomist’s view

- Precipitation issues
  - Summer droughts
  - Unused fall + spring
- Make use of possibly “wasted” fall and spring solar energy
- Improve on-farm cycling of nutrients
Small grain crops as double-crops

- “spring-planted”
  - Oats
  - Some triticales
- “fall-planted”
  - Barley
  - Wheat
  - Rye
  - Triticale

Key considerations for adding small grain crops to the rotation:
- Management
  - Animals that will consume these
  - Storage considerations
  - Soil/weather
  - Timeliness:
    - enough labor?
    - Enough equipment?
  - Fertility needs
Double cropping basics

- Follow corn silage with a small grain for forage
- Harvest fall and/or spring
- Several basic options
  - Spring oats
  - Ann. ryegrass
  - Clovers
  - Winter rye
  - Winter wheat
  - Winter triticale
  - Winter barley

Current production model ... and potential of winter double crops to increase seasonal dry matter production

Missed opportunities to use early spring and late-season sunshine for photosynthesis and dry matter production

Source: A.H. Heggenstaller
Biomass production in winter double crop systems

**Tradeoff:** Missed opportunity for early season photosynthesis and dry matter production for the full season crop

Reduced losses

Source: A.H. Heggenstaller

Double cropping considerations

- Is there enough growing season in the fall and spring to justify the investment?
- Will harvesting the spring crop impact the yield of the full season crop?
- Are some acres of the full season crop planted late anyway?
Double cropping considerations

• Newcomers don’t have to start with drilling all acres available
• Start small and “grow” the acreage
• Increasing crop diversity should result in increasing productive potential for farm... **but will require increased management**!
Double cropping advanced topics

- Mixtures of multiple species
  - Fall/spring mixes
    - Oats/wheat
    - Oats/triticale
  - Spring mixes
    - Ann rye/triticale
    - Ann rye/crimson clover
    - ??
- Relay cropping
  - Triticale in alfalfa
‘Hercules’ oats + ‘Aroostook’ rye vs ‘Everleaf’ oats + ‘Aroostook’ rye

Do I stay with a grain type?  Do I consider a forage type?

Why double cropping?
1. Need more forage...for cows and heifers
2. Opportunity to use manure nutrients → comply with Nutrient Management Plan
3. Erosion control
4. Improve soil health via crops growing during most of the year
5. Help reduce soil compaction
6. Maximize crop production on expensive farmland → reduce cost per unit of feed by spreading land costs over more tons
### Ryelage forage analysis

<table>
<thead>
<tr>
<th>Sample Date</th>
<th>DM</th>
<th>CP</th>
<th>ADF</th>
<th>NDF</th>
<th>TDN</th>
<th>NEL</th>
<th>RFV</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 19, 2011</td>
<td>32.2</td>
<td>16.2</td>
<td>34.6</td>
<td>56.5</td>
<td>62</td>
<td>0.64</td>
<td>102</td>
</tr>
<tr>
<td>Oct 6, 2011</td>
<td>27.6</td>
<td>11.5</td>
<td>32.7</td>
<td>56.2</td>
<td>61</td>
<td>0.63</td>
<td>105</td>
</tr>
<tr>
<td>Sept 26, 2012</td>
<td>38.0</td>
<td>13.0</td>
<td>36.5</td>
<td>58.3</td>
<td>61</td>
<td>0.63</td>
<td>96</td>
</tr>
<tr>
<td>May 22, 2013</td>
<td>34.2</td>
<td>14.6</td>
<td>35.7</td>
<td>57.6</td>
<td>62</td>
<td>0.64</td>
<td>97</td>
</tr>
</tbody>
</table>

Skyview Laboratory, INC

### On farm small grain forage analyses

<table>
<thead>
<tr>
<th>Type</th>
<th>DM</th>
<th>Crude Protein</th>
<th>NDF</th>
<th>NEL</th>
<th>Potassium</th>
</tr>
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<tbody>
<tr>
<td>Rye</td>
<td>40.5</td>
<td>14.1</td>
<td>51.7</td>
<td>0.68</td>
<td>2.73</td>
</tr>
<tr>
<td>Wheat</td>
<td>32.1</td>
<td>13.3</td>
<td>53.8</td>
<td>0.63</td>
<td>2.61</td>
</tr>
<tr>
<td>Triticale</td>
<td>36.8</td>
<td>13.6</td>
<td>52.7</td>
<td>0.68</td>
<td>3.89</td>
</tr>
<tr>
<td>Triticale</td>
<td>45.3</td>
<td>14.9</td>
<td>45.5</td>
<td>0.68</td>
<td>2.91</td>
</tr>
<tr>
<td>Triticale</td>
<td>47.6</td>
<td>11.4</td>
<td>51.2</td>
<td>0.66</td>
<td>2.86</td>
</tr>
</tbody>
</table>

Courtesy: Agri-Basics
Paying attention to the agronomics

- Small grains often need **more**, not less mgt...
  - Weeds controlled?
  - Timely planting (earlier vs. later)
  - Soil tested, fertility appropriate
    - Adequate N and other nutrients, exp. K
  - Species, *variety* selection critical
  - Is quality seed being used?

- Avoid the cover crop “plant and forget” mentality
Penn State Extension

5.5 inch row spacing vs 7.5 inch row spacing

Drilled: Oct. 21 vs Sept. 30

Importance of timely planting

Photo taken Dec. 27, 2013

Photo credit: Eric Risser
## Production of cereal rye for no-till mulch: effect of fall planting date on spring growth

Steven Mirsky Ph.D. dissertation research

<table>
<thead>
<tr>
<th>Planting Date</th>
<th>Sampling Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>August 25</td>
<td>May 01</td>
</tr>
<tr>
<td>September 05</td>
<td>May 10</td>
</tr>
<tr>
<td>September 15</td>
<td>May 20</td>
</tr>
<tr>
<td>September 25</td>
<td>May 30</td>
</tr>
<tr>
<td>October 05</td>
<td></td>
</tr>
<tr>
<td>October 15</td>
<td></td>
</tr>
</tbody>
</table>

(seeded rye @ 120 lb/A in 7.5 in. rows)

---

Spring (April 1) Rye Biomass increases with earlier fall planting

Photo credits: Steven Mirsky
Cereal Grain Phenology

<table>
<thead>
<tr>
<th>Feekes</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>10.1</th>
<th>10.2</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zadoks</td>
<td>10</td>
<td>21</td>
<td>26</td>
<td>30</td>
<td>36</td>
<td>31</td>
<td>32</td>
<td>37</td>
<td>39</td>
<td>45</td>
<td>50</td>
<td>60</td>
<td>90</td>
</tr>
</tbody>
</table>

- Better forage quality
- Better yields

Cereal Grain Phenology: Zadoks scale

<table>
<thead>
<tr>
<th></th>
<th>May 01</th>
<th>May 10</th>
<th>May 20</th>
<th>May 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug-25</td>
<td>45</td>
<td>55</td>
<td>60</td>
<td>72</td>
</tr>
<tr>
<td>Sep-05</td>
<td>40</td>
<td>53</td>
<td>58</td>
<td>71</td>
</tr>
<tr>
<td>Sep-15</td>
<td>40</td>
<td>50</td>
<td>56</td>
<td>71</td>
</tr>
<tr>
<td>Sep-25</td>
<td>38</td>
<td>47</td>
<td>54</td>
<td>70</td>
</tr>
<tr>
<td>Oct-5</td>
<td>36</td>
<td>41</td>
<td>53</td>
<td>68</td>
</tr>
<tr>
<td>Oct-15</td>
<td>33</td>
<td>40</td>
<td>51</td>
<td>66</td>
</tr>
</tbody>
</table>
Tillering encouraged by:
- Moisture
- Warm temperatures
- Fertility (esp. N)
- Time (earlier planting)

→ Possible to reduce seeding rates when conditions for tillering are ideal

Spring (April 1) Rye Biomass increases with earlier fall planting

Aug 25 | Sept 5 | Sept 15
Sept 25 | Oct 5 | Oct 15

Photo credits: Steven Minsky
Certified rye seed  v  farm-grown seed

Fall-harvested Crop Mgt Challenges
• Delaying planting past mid-Sept. will reduce yields
• Time management: Plant immediately following silage harvest for best soil conditions and yield potential
• Plant/harvest traffic + Wet fall = Soil compaction
• Delayed harvest: Cool temps, forage difficult to dry
• Oats alone → no cover for fields by spring
• Species mixtures: Seed segregation → patchy stands
Spring-harvested Crop Mgt Challenges

- Harvest traffic + wet spring = soil compaction
- High labor requirements (harvest, manure spreading after harvest, and planting of next crop)
- Good planning and access to custom operators beneficial
- Delayed harvest or N def. reduces forage quality
- Delayed harvest can impact yield of next crop
- Small grains harvested at soft dough can develop mycotoxins
Fall or Spring Crop Opportunities

- Make use of sunlight otherwise “wasted”
- Cover crop benefits: erosion control, increase soil OM, improved soil structure, better no-till
- Sequester nutrients from manure that “has to be spread”
  - Nutrient management plan benefits
  - Reduce amount of purchased fertilizer
- Manure following planting can help with cover crop germination

1. “±bars” represent minimum and maximum values measured for a specie or mixture
2. Fall growth was somewhat below average due to several weeks of cloudy and wet weather beginning in mid-September (low light, loss of N)
2010-11 Penn State On-Farm Cover Crop Trial

Spring Cover Crop Nitrogen Capture

Captured N (lbs/acre)

(averaged across locations)

- Reduced potential
- Higher potential

- Crimped Cover + Ryegrass
- Triticale + Ryegrass
- Oats + Rye
- Rape + HVetch + Rye
- Till Rad + HVetch + Rye
- Till Rad + Rye
- Rye
Forage Dry Matter of Cover Crops
Sampled mid-April 2013 from 6 SE Counties

Aboveground Biomass DM (lbs/acre)

Vertical bars indicate minimum and maximum values for a treatment.
Forage Quality of Cover Crops
Sampled mid-April 2013 from 6 SE Counties

- Crude Protein
- ADF
- NDF

Annual Ryegrass + Crimson clover vs Triticale + Crimson clover
photo: 16 April 2012   Location: Blair County, PA
Aroostock Rye @ late boot/early head
Photo: 16 April 2012      Location: Blair County, PA

Cumulative DM Yields of Cool-Season Cover Crops
PSU Rock Springs Research Center (2011-2012)

Cumulative Forage Dry Matter (T/ac)

* All entries seeded 19 September 2011
Forage Quality of Cover Crops
Sampled late April/early May 2012

Cumulative DM Yields of Cool-Season Cover Crops
PSU Rock Springs Research Center (2012-2013)

* All entries seeded 24 September 2012
Assessing the Economics

- Yield potential of corn and winter crops
- Impact of delayed planting on corn yields
- Availability of manure to offset increased fertility costs
- Increased use of fixed assets like land and machinery
- Potential value of the alternative forages
  - Replacement for corn silage or medium quality hay

Other Examples

Direct cut barley @ Soft dough
  - 3-4 tons DM possible
  - Rapid harvest possible
  - Nearly full season double cropping
  - Good substitute for CS
  - Environmental benefits

<table>
<thead>
<tr>
<th>Sample</th>
<th>DM</th>
<th>CP</th>
<th>ADF</th>
<th>NE/Lact</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>35.3</td>
<td>7.6</td>
<td>29.9</td>
<td>0.68</td>
</tr>
<tr>
<td>2</td>
<td>35.0</td>
<td>8.3</td>
<td>30.5</td>
<td>0.69</td>
</tr>
<tr>
<td>3</td>
<td>37.0</td>
<td>9.8</td>
<td>34.0</td>
<td>0.69</td>
</tr>
<tr>
<td>Corn sil'g</td>
<td>41.7</td>
<td>8.0</td>
<td>23.4</td>
<td>0.75</td>
</tr>
</tbody>
</table>
Fall Grazing

**Summary**

- Small grain forages can fill gaps in the cropping season and improve seasonal DM yields
- Small grains able to use moisture when plentiful!
- Alternatives can improve nutrient balance and soils
- Management is critical...both in the field and barn
- Careful assessment of economics is important
- New focus on management details
Discussion/Questions?
Who We Are

- John and Diane
  - Children
    - Peter & Katy
    - Granddaughter
    - Ava
- 100 Milking cows
  - RHA 27000 milk
  - 4.0 Fat 1075 Fat
• Why Am I Farming?
• Is It Fun?
• What is The Future?
• Am I Scared?

The most dangerous phrase in the language is "we've always done it this way."

• Have a Plan- At Least an Idea.
• The Highest Yield is My Goal #1
• Cutting Costs is Second #2
• Learn From Others, Successes and Failures.
• Attend Many Meetings- Great Advice and Free Food.
• Every Failure is a Great Learning Experience.
• Can I Seed Two things at Once.
• Take Many Photos for Your Records.
• Write it Down- Paper and Pen or Tablet.
• Grow Cow Quality Feedstuff.

Technology
Machinery and Equipment Developed from the Application of Scientific Knowledge.
One Size Doesn’t fit all...

New Tools For Greater Efficiency

Economic Reality 101

Rocket Fuel
Dairy Quality
Heifer Feed
Mulch Hay

How do You Expect Me to Formulate a Ration With This?

My First Corn Planter
Examine the Soils and Native Vegetation on Your Farm. It Will Tell You What You Can or Can’t do in any Given Location.

Double Crop Nitrogen Study
http://nmsp.cais.cornell.edu/

On Farm Research,
Cornell University
Nutrient Management Spear program

N Rate Study: Locations
62 trials across NY
- 5 Regions
- 39 Soil types
Three species
- 21 Cereal rye
- 37 Triticale
- 4 Wheat

Cornell Fertilizer Trials
Manure Storage Is Extremely Important in a No-Till System Due to the Timeliness and Adequate Field Conditions. (Compaction and Ruts are Very Costly)
Applied manure at the time of covercrop seeding allows the covercrop to store nutrients for future crops. And to prevent leaching.

Where Did My Covercrop Go?

100% ground cover. 100% of the Time. This is Very Important to Our Success.
One Martin Spike and One Rubber Closing Wheel Has Worked Very Well
Planting Into Living Rye
2015

BEST WEED CONTROL EVER!
FERTILIZER

The Most Important Thing You Can Put In Any Field is Yourself.

First Things First. Always Take a Soil Test

All Grass Field Are Topdressed Four times

• Adding Lime Regularly Can Yield Big Returns
• I Believe This Is One of the Biggest Drawbacks on Many Farms

Add Lime Regularly in Smaller Amounts
Corn Fields Receive Top-dressed Protected Urea at V6

No-Till Alfalfa Has Always Been a Challenge
Alfalfa is Cut Every 28 days
Yielding 4-5 Cuttings
Alfalfa Grown on Well Drained or Gravel Fields Only

Grass is grown on 200 acres and harvested 4 or 5 times per year.
Always A Great Sense of Pride
When You Can Bale Beautiful
Hay on Memorial Day

Pre-Cut Cereal Rye (Head Straw)
This is Four (Tons/Acre) Yield

Grass Hay Harvest 2017

<table>
<thead>
<tr>
<th>Cutting</th>
<th>Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>2.3</td>
</tr>
<tr>
<td>2nd</td>
<td>1.8</td>
</tr>
<tr>
<td>3rd</td>
<td>1.5</td>
</tr>
<tr>
<td>4th</td>
<td>1.1</td>
</tr>
<tr>
<td>5th</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>6.7</td>
</tr>
</tbody>
</table>
Sudangrass and Red Clover after Rye Harvested for Straw

SudanGrass At 45 Days Post Planting

One cut BMR Sudangrass

SudanGrass At 45 Days Post Planting
Interseeding with Festulolium and Orchardgrass after fourth cutting.

Interseeded with Festulolium and Orchardgrass on 9-15-14.

Sudangrass and Cowpeas.

Greenspirit Italian Ryegrass instead of Growing Corn.
Seeding Italian Ryegrass At 45 Lbs./Ac

10 Days Post Seeding

20 days post seeding

25 days post seeding

Italian Ryegrass at 35 Days Post Planting
45 Days Post Seeding

Italian Ryegrass Harvest 2017

1st Cut 2nd Cut 3rd Cut Total 6.2

Third Cutting
GreenSpirit
Italian Ryegrass
Haylage 2017
**Corn Grain following Corn-2016 (No-Till)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost 1</th>
<th>Cost 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Cost</td>
<td>$125.00</td>
<td>$125.00</td>
</tr>
<tr>
<td>Spraying</td>
<td>$ 17.00</td>
<td>$ 17.00</td>
</tr>
<tr>
<td>Apply Fertilizer</td>
<td>$ 17.00</td>
<td>$ 17.00</td>
</tr>
<tr>
<td>Plant/Seed</td>
<td>$ 30.00</td>
<td>$ 30.00</td>
</tr>
<tr>
<td>Seed Cost/Seed</td>
<td>$100.00</td>
<td>$ 75.00</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>$120.00</td>
<td>$130.00</td>
</tr>
<tr>
<td>Interest / 5.2%/ 8 months</td>
<td>$12.44</td>
<td>$12.95</td>
</tr>
<tr>
<td>Herbicide/Insecticide</td>
<td>$ 48.00</td>
<td>$ 8.00</td>
</tr>
<tr>
<td>Crop Insurance</td>
<td>$ 12.00</td>
<td>$ 0000</td>
</tr>
<tr>
<td>Time/Revenue</td>
<td>$ 8.00</td>
<td>$ 8.00</td>
</tr>
<tr>
<td>Harvest Forage $60/ac X 3 cuts</td>
<td>$180.00</td>
<td></td>
</tr>
<tr>
<td>Corn/bean/ Root/ Starchy</td>
<td>$ 88.71</td>
<td>$180.00</td>
</tr>
<tr>
<td></td>
<td>$571.15</td>
<td>$745</td>
</tr>
</tbody>
</table>

**Italian Ryegrass Following Corn-2016 (No-Till)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost 1</th>
<th>Cost 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicide/Insecticide</td>
<td>$ 48.00</td>
<td></td>
</tr>
<tr>
<td>Crop Insurance</td>
<td>$12.00</td>
<td>$ 0000</td>
</tr>
<tr>
<td>Lime Miscellaneous</td>
<td>$ 8.00</td>
<td>$ 8.00</td>
</tr>
<tr>
<td>Harvest Forage $60/ac X 3 cuts</td>
<td></td>
<td>$480.00</td>
</tr>
<tr>
<td>Combine/ Haul/ Drying/Shrink</td>
<td>$ 88.71</td>
<td>$180.00</td>
</tr>
<tr>
<td></td>
<td>$571.15</td>
<td>$745</td>
</tr>
</tbody>
</table>

**Total/Corn** $640.00

**Total Italian Ryegrass $1,150.00**

**Profit/ Acre** $ 38.85 $405.00

---

**Corn Silage Harvest 2018**

**91 day**

**2200 GDD**

**220 BPA**

**82 Day Corn Hybrid**

Planted after First Cut Hay, on May 31, 2018

26 Ton Silage, 187 Bu/ Acre Grain Yield
When seeding pastures it is best to use a mixture of many different grasses and legumes. Some start earlier in the spring, some handle drought and heat better, and some provide nitrogen and high protein.
Seed To Soil Contact Is An Absolute Necessity To Good Germination And To Your Success!

New 65’ x 144’ Dry Cow Heifer Barn. 2018
Wildlife Plot Seeded
10 Days Post Planting

Keeping a Watchful Eye on the Crops
Although Not Fancy. Our Ability to Spray When Conditions are Right is Very Important.
If You No-Till, it Will Grow.

Crop Scouting is Very Important. We Have Always Made it A Family Affair.

Responsible Nutrient Management Award 2016- NNTC

World Dairy Expo Forage Analysis Super Bowl 2015 Grand Champion Grass Hay

“Never get so busy making a living, that you forget to make a life.”
Always Carry a Camera. Hey, You Never Know

Some Of My Neighbors in Disbelief (Dog, Tick, and Woim)

This really happens more often than you would think.

I would like to thank Penn State, its employees and the Nearby Farm Support Community for Inviting Me, and the Opportunity to Speak at This Nutrition Conference about our Farm. It is Always a Pleasure.

John K
Reaping the Benefit of Higher Quality Alfalfa Genetics

Tom Kilcer, CCA
Advanced Ag Systems LLC
www.advancedagsys.com
Where do You Start,

What reaches the Mouth of the Cow

At Field Time of Harvest

Harvest losses

Storage Losses

Feed-out Losses
At Field Time of Harvest

- Harvest losses
- Storage Losses
- Feed-out Losses
Highly Digestible Alfalfa Genetics
Not a Magic Bullet
But a critical tool to increase 
or get profitability
Field at the Time of Harvest

When was Last Soil Samples?
pH : This is not magic alfalfa
It Makes A Difference - Alfalfa

Seed Costs the Same
Results are Very Different
Was Great Alfalfa Beginning of Year

pH: 5.8
Field at the Time of Harvest

When were the last soil samples?
pH: This is not magic alfalfa
Sulfur: Critical for protein
Sulfur deficiency in alfalfa.

Dr. Ketterings, Cornell University
Quality Forage

When You Harvest
680 GDD = 38%NDF(alfalfa) (GDD=Base 40)
Great indicator for grass/alfalfa fields
**2016 numbers based on 2 week forecast**

Winchell,
Java, NY
### Harvest Decision

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa Height</td>
<td>12</td>
</tr>
<tr>
<td>% Grass</td>
<td>50</td>
</tr>
<tr>
<td>Target NDF</td>
<td>45</td>
</tr>
<tr>
<td>Maturation Rate</td>
<td>Normal</td>
</tr>
<tr>
<td>Current NDF</td>
<td>34</td>
</tr>
<tr>
<td>Target Height</td>
<td>25.5</td>
</tr>
<tr>
<td>Days To Harvest</td>
<td>13.5</td>
</tr>
</tbody>
</table>

---

**Graph:**

- **Target NDF:** Orange line
- **Projected NDF increase:** Green dashed line
- **Current NDF:** Green circle

**Axes:**

- **Y-axis:** NDF (%)
- **X-axis:** Days until harvest
Quality Forage

How You Harvest
Minimum Tillage Haylage

Where is alfalfa regrowth when you start to mow

Sid Bosworth, UVM
Cutting Height: Directly Impacts Ash
Tilted Knives and Mowing Close
9% vs 11% Ash

• you lose **1.9 lbs of milk** compared to the same forage without that much ash

• in 305 days with 1000 cows is 5795 cwt @ $15/cwt = **$86,920**

• It can be made up by more grain, at a price and by money leaving your farm unnecessarily.
Many Farms Have +72 NEL Haylage

Why is Your Haylage 54 - 61 NEL?
Non-structural carbohydrates (NSC) (sugars & starch)

25-35%

Structural carbohydrates
(NDF: cellulose, hemicellulose, & lignin;
ADF: cellulose & lignin)

30-50%

Proteins
(soluble & bound)

15-25%

Fats (lipids)

2-3%

Ash (minerals)

8-13%
Sunshine Produced Dry Matter

+50

Respiration lost Dry Matter

-20

+30 **Net Gain**
Sunshine Produced Dry Matter

-20 Net Loss

- Shade or Nighttime
- Respiration lost Dry Matter
Biology: Photosynthetic Drying

CO₂ + H₂O = CHO + O₂

In the presence of Sunshine

Increasing Energy In Forage
Relationship between overnight DM loss and minimum night temps

Knapp et al. 1973
# Ration Ingredient Analysis

**Milk cow 650 35 4.0-**

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Ration</th>
<th>PR. Corn</th>
<th>Sil-BU</th>
<th>2nd Cut</th>
<th>Haylage</th>
</tr>
</thead>
<tbody>
<tr>
<td>As fed level</td>
<td>121.20</td>
<td>62.50</td>
<td>31.30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry matter, %</td>
<td>42.81</td>
<td>36.00</td>
<td>48.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crude protein, %</td>
<td>16.3</td>
<td>6.9</td>
<td></td>
<td>22.4</td>
<td></td>
</tr>
<tr>
<td>Soluble Protein, % CP</td>
<td>42.0</td>
<td>43.0</td>
<td>61.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RDP, % CP</td>
<td>67.7</td>
<td>71.0</td>
<td>77.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RUP, % CP</td>
<td>32.2</td>
<td>29.0</td>
<td>23.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDN, %</td>
<td>73.2</td>
<td>75.0</td>
<td>67.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NE, lactation, Mc/lb</td>
<td>0.76</td>
<td>0.77</td>
<td>0.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forage, %</td>
<td>74.1</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Windrows are Compost Drying

- 100% humidity in windrow = No drying
- No sunlight = No photosynthesis energy/drying
- Respiration reduces energy level
- Sugar reduced 19%
- Starch (concentrated energy) reduced 92%
- No substrate for rapid fermentation which burns off more energy

Drying Reduced

10 – 100X

Harris & Tullberg 1980
Compost Drying 80%

Photosynthetic Drying 20%

Compost Drying 30%

Photosynthetic Drying 70%
Varieties of Alfalfa

- A
- B
- C
- D

% Dry Matter

- Start
- 1.5 hours
- 2.5 hours

Advanced Ag Systems LLC
### 1st Cut Harvest Window

<table>
<thead>
<tr>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>19</td>
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<tr>
<td>17</td>
<td>20</td>
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<tr>
<td>18</td>
<td>21</td>
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<td>23</td>
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<td>24</td>
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<td>8</td>
<td>11</td>
</tr>
<tr>
<td>9</td>
<td>12</td>
</tr>
</tbody>
</table>

- **Light rain**
- **Heavy rain**
- **No rain**
Dr. Undersander, U of Wisconsin

Traffic Applied, days after harvest

Hay Yield, Tons acre^{-1}

25% reduction in yield

r^2 = 0.57

Traffic Applied, days after harvest

0 1 2 3 4 5
Width Matters More Than Conditioning – Alfalfa- Swath Not Moved

% Moisture Lost

% of cutterbar width

NHC40%  NHC59%  NHC73%  NHC83%  SB 94%

- 2 hour

4.00%  6.00%  8.00%  10.00%  12.00%
Figure 2. Effect of wide swath vs. narrow swath drying rate, Arlington, Wisconsin, July 2007

Representative of drying curves for narrow and wide swath widths.
Vemeer TM 1200
Dave Schwantes, Minnesota
92.8% of Cutterbar
Biology of Drying Forages

Photosynthetic Drying
Dries from stem base upward
Conditioning reduces water movement through the stem-inhibits drying.

Intermediate Phase
Air entering now exits thru the stem sidewalls
Conditioning speeds up this phase 10 X slower drying

Final Phase
Dry Hay

<60% Moisture

Moisture

Time
2002; 350 cows, average leaf loss
average protein loss = $15000
Mergers run to fast for material or run to close to the ground – vacuums everything up.
**USE AN INOCULANT!!!**

<table>
<thead>
<tr>
<th>Inoculant</th>
<th>NDFd 30</th>
<th>Lignin/NDF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inoculant 1</td>
<td>67.05 a</td>
<td>7.49 c</td>
</tr>
<tr>
<td>Inoculant 2</td>
<td>67.78 a</td>
<td>7.87 b</td>
</tr>
<tr>
<td>No Inoculant</td>
<td>63.13 b</td>
<td>8.25 a</td>
</tr>
</tbody>
</table>

= to 2.3 pounds of milk/cow/day
Hooray!, I think he is finally going to be quiet.

Thank God for that, I was ready to throw myself off this rock.