Hay Quality as Related to Storage and Precision Nitrogen

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1. STORAGE COSTS/SAVINGS
2. NITROGEN MGT. IN GRASS HAY
3. AERIAL IMAGERY FOR N MGT?
4. CONCLUSIONS

Assume this is a 5x4 hay bale (WxD)

What percentage of the bale is in the outer 6 inches?

a) 15%  b) 25%  c) 35%  d) 45%

Assume this is a 5x4 hay bale (WxD)

What percentage of the bale is in the outer 2 inches?

a) 3%  b) 5%  c) 10%  d) 15%
Assume this is a 5x4 hay bale (WxD)

What percentage of the bale is in the outer 2 inches?

- a) 3%
- b) 5%
- c) 10%
- d) 15%

Bale DW loss from weathering

<table>
<thead>
<tr>
<th>Weathered Layer Depth, inches</th>
<th>Bale Diameter</th>
<th>% of Bale in Outer Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>4 ft</td>
<td>16.0%</td>
</tr>
<tr>
<td>4</td>
<td>4 ft</td>
<td>30.6%</td>
</tr>
<tr>
<td>6</td>
<td>4 ft</td>
<td>43.8%</td>
</tr>
<tr>
<td>8</td>
<td>4 ft</td>
<td>55.6%</td>
</tr>
<tr>
<td>2</td>
<td>5 ft</td>
<td>12.9%</td>
</tr>
<tr>
<td>4</td>
<td>5 ft</td>
<td>24.9%</td>
</tr>
<tr>
<td>6</td>
<td>5 ft</td>
<td>36.0%</td>
</tr>
<tr>
<td>8</td>
<td>5 ft</td>
<td>46.2%</td>
</tr>
<tr>
<td>2</td>
<td>6 ft</td>
<td>10.8%</td>
</tr>
<tr>
<td>4</td>
<td>6 ft</td>
<td>21.0%</td>
</tr>
<tr>
<td>6</td>
<td>6 ft</td>
<td>30.6%</td>
</tr>
<tr>
<td>8</td>
<td>6 ft</td>
<td>39.5%</td>
</tr>
</tbody>
</table>

Losses as a function of storage conditions

![Graph showing DM loss as a function of storage conditions](image)

- Gravel
- Ground
- Pallet
- Pallet w/cover
- Tires
- In barn

Based on models developed from Verma and Nelson (1983) data.

Investment Cost for Different Storage Options

<table>
<thead>
<tr>
<th>Storage System</th>
<th>System cost per sq ft</th>
<th>System Cost per 100 bales</th>
<th>System Life Yrs</th>
<th>Storage Cost $/bale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Shed</td>
<td>3.50</td>
<td>3948.5</td>
<td>20</td>
<td>$5.14</td>
</tr>
<tr>
<td>Pole shed with plastic roof on pad</td>
<td>1.20</td>
<td>1866.5</td>
<td>20</td>
<td>$3.21</td>
</tr>
<tr>
<td>Reusable tarp on pad</td>
<td>0.15</td>
<td>300</td>
<td>1</td>
<td>$3.18</td>
</tr>
<tr>
<td>Plastic wrap on ground</td>
<td>0.29</td>
<td>550</td>
<td>1</td>
<td>$5.78</td>
</tr>
<tr>
<td>Elevated stack on pad</td>
<td>0.40</td>
<td>933.5</td>
<td>20</td>
<td>$0.95</td>
</tr>
<tr>
<td>Net wrap on ground</td>
<td>0.08</td>
<td>150</td>
<td>1</td>
<td>$1.58</td>
</tr>
<tr>
<td>Twine on ground</td>
<td>0.04</td>
<td>75</td>
<td>1</td>
<td>$0.79</td>
</tr>
</tbody>
</table>

From Collins et al. (1997); Verma and Nelson (1983)

<table>
<thead>
<tr>
<th>Storage System</th>
<th>6 Month DM Loss</th>
<th>6 Month Value Loss + Storage Cost</th>
<th>12 Month DM Loss</th>
<th>12 Month Value Loss + Storage Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Shed</td>
<td>4%</td>
<td>$2.00</td>
<td>8%</td>
<td>$4.00</td>
</tr>
<tr>
<td>Pole shed with plastic roof on pad</td>
<td>4%</td>
<td>$2.00</td>
<td>8%</td>
<td>$4.00</td>
</tr>
<tr>
<td>Reusable tarp on pad</td>
<td>8%</td>
<td>$4.00</td>
<td>13%</td>
<td>$6.50</td>
</tr>
<tr>
<td>Plastic wrap on ground</td>
<td>11%</td>
<td>$5.60</td>
<td>17%</td>
<td>$8.40</td>
</tr>
<tr>
<td>Elevated stack on pad</td>
<td>4%</td>
<td>$2.23</td>
<td>8%</td>
<td>$4.22</td>
</tr>
<tr>
<td>Net wrap on ground</td>
<td>24%</td>
<td>$12.00</td>
<td>32%</td>
<td>$16.00</td>
</tr>
<tr>
<td>Twine on ground</td>
<td>26%</td>
<td>$13.00</td>
<td>35%</td>
<td>$17.50</td>
</tr>
</tbody>
</table>

From Collins et al. (1997)
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Clemson hay yield monitor operation (Patent Pending)

- Tongue/throat mounted sensors measure windrow height on-the-go
- Windrow height multiplied by distance traveled to calculate windrow volume
- Windrow volume correlated to mass flow feeding into the baler

Hay YM Accuracy: 2016 All Bales

![Hay YM Accuracy Graph]

Accuracy by Grass/Forage Type

- **ALFALFA**
  - 9.73% Error
  - Predicted Mass Flow kg/s
- **BERMUDA MIX**
  - 10.40% Error
  - Predicted Mass Flow kg/s
- **RYEGRASS**
  - 10.80% Error
  - Predicted Mass Flow kg/s
- **TIFTON 85**
  - 7.35% Error
  - Predicted Mass Flow kg/s

Storage Costs + Dry Matter Loss Costs (per bale)

- From Collins et al. (1997); Verma and Nelson (1983)

- **$0.00**
- **$5.00**
- **$10.00**
- **$15.00**
- **$20.00**
- **$25.00**

- 6 Month
- 12 Month
Nitrogen Strip Test Design – Tifton 95 Bermudagrass

N Rate, lb/ac
- 93
- 90
- 89
- 63
- 43

Harvest dates in test
- 2016
  - Cut 3: August 17th
  - Cut 4: October 3rd
- 2017
  - Cut 1: May 28th
  - Cut 2: July 14th
  - Cut 3: September 5th

Yield Response to Nitrogen Across all Cuttings

<table>
<thead>
<tr>
<th>Yield, ton/ac @ 15% MC</th>
<th>40lbN</th>
<th>60lbN</th>
<th>80lbN</th>
<th>100lbN</th>
<th>120lbN</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>2.40</td>
<td>2.50</td>
<td>2.59</td>
<td>2.66</td>
<td>2.68</td>
</tr>
</tbody>
</table>

Profit Response to Nitrogen Across all Cuttings

<table>
<thead>
<tr>
<th>Returns Above N Costs, $/Ac</th>
<th>40lbN</th>
<th>60lbN</th>
<th>80lbN</th>
<th>100lbN</th>
<th>120lbN</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>334.351</td>
<td>349.28</td>
<td>360.943</td>
<td>372.493</td>
<td>376.477</td>
</tr>
</tbody>
</table>

Profit Response to Nitrogen By Cutting

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>400</td>
<td>500</td>
<td>450</td>
<td>500</td>
<td>450</td>
</tr>
<tr>
<td>2017</td>
<td>450</td>
<td>500</td>
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<td>450</td>
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Profit Response to Nitrogen By Cutting

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<td>450</td>
<td>500</td>
<td>500</td>
<td>450</td>
<td>500</td>
</tr>
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Mean Crude Protein Content for each Cutting by N-Rate

Clemson’s Directed Prescriptions (D-Rx) System

Shallow EC

Uniform Rate Nitrogen Strips

Clemson’s Directed Prescriptions (D-Rx) System

Directed Prescriptions (D-Rx) System

N Rate for Max Profit as vs. Shallow EC by Cutting
Profit Comparisons: Uniform N Rates and D-Rx by Cutting

Variable Rate N Potential Benefit, $/ac (By Cutting)

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Potential for use of UAVs in Hay and Forage

- Harvest timing
- Protein/yield assessment
- Weed location/identification
- Input prescription
- Problem identification
USE OF AERIAL IMAGE FOR PREDICTING YIELD

Dry Yield Actual
Dry Yield Predicted

2017 Aug 30
2017 Sept 5
NDVI_{EST} from Aerial

Tifton 85
Tifton 85

3200 3400 3600 3800 4000 4200 4400 4600 4800
Dry Yield Predicted P=0.001 MSE=0.15
RMS=285.00

All image data layers exported by SID®

RGB Image
R
G
B
BRT
NDVI

2017 Aug 30
2017 Sept 5
NDVI_{EST} from Aerial

Tifton 85
Tifton 85

Dry Yield
Actual
Predicted

2017 Aug 30
2017 Sept 5
Actual Dry Yield
Predicted Dry Yield
USE OF AERIAL IMAGE FOR PREDICTING PROTEIN

Conclusions – Hay Storage

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4. CONCLUSIONS

- Investments in storage cost less than the dry matter value loss from lack of storage
  - Over its lifetime, storage can cost more than $5 per bale
  - 6-12 month value savings can amount to $12-15 per bale
Conclusions – Yield Monitoring

- Hay yield monitors not available yet
- What questions would you like answered?
  - Yield monitors are powerful tools for conducting tests on your fields

Conclusions – N Management in Tifton 85

- Response to N varies depending on time of year
  - Largest N response for first cutting
  - Optimum N rate for profit/yield may decrease during growing season
  - Optimum N rate for profit may decrease with GDD
- Variable rate N prescription requires more research
  - Hay yield monitor availability is a hindrance
  - VRN may be profitable mid-season only
  - Optimum N rate by zone difficult to predict
  - Yield response to N was inconsistent

Conclusions – Aerial Imagery

- Primary current application as scouting tool
  - Not currently anywhere near capable of replacing boots in the field
- Pre-harvest yield estimation
  - May be useful for planning harvest logistics and timing
  - May be useful for insurance documentation
- Protein mapping
  - May be inexpensive alternative to constituent sensing options

Questions? kirk2@clemson.edu