Humidity, Hay Moisture & Harvest Management

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- Alfalfa Growing Season
  - Intense Sunlight
  - High Temperatures
  - Low Humidity
  - Winds?

- Harvest Challenges
  - High Drying Rates
  - Low Moisture Hay
    - Leaf Loss
    - Rehydration Challenge
    - Night Hay Operations
Losses During Haymaking
Accelerate With Lower Moisture Hay

Estimated Harvest Losses of 20-25%
Humidity & Hay Moisture

- **Equilibrium Moisture**
  - Hay Placed in Constant Humidity Environments
  - Allowed to Equilibrate
  - Measure Moisture Content

- **Purpose**
  - Storage Conditions
  - Quality
  - Trade

- Moisture increases with humidity
- Moisture decreases with temperature

Source: Pitt, 1990; Hill et al., 1976
Relevance to Arizona Hay

- Lab testing indicates good agreement
- Leaves & stems similar
- Low humidity extension
Baling Moisture

AZ Baling Moisture Range

RH: ~50-70%
The Challenge!

- Maximum relative humidity barely makes this range in May & June
- Some nights this humidity range is not attained
Relative Humidity

Saturation level of air varies with temperature.

Air water content changes minimally during most days.

Relative Humidity: relative saturation level

- 68°F (Sunrise): 70% (2.34 kPa)
- 86°F (10 am/pm): 39% (4.24 kPa)
- 104°F (3 pm): 22% (7.37 kPa)
Hay Meteorology: Night

Inversion

Warmer Temperatures
Lower Relative Humidity

Cool Temperatures
Higher Relative Humidity

RH ~50%

Surface Cools Due Radiative Loss

Windrow

RH ~60-70%
Good Baling

Slow Moisture Movement

Slow Moisture Movement
Wind mixes warmer and drier air aloft down to the surface replacing the cooler, moist air. This leads to high surface temperatures and lower surface relative humidity and much drier hay.
Does This Really Happen??

Temperature & Humidity
At 5’ & in Windrow

Mohave Valley: June 2013

![Graph showing temperature and humidity changes in Mohave Valley.]
How Fast Can Hay Respond to Change in Humidity?

Oven Dried Hay Transferred to Environment With 75% Relative Humidity

--Leaf Moisture Increased to 10% in ~35 Minutes
--Stem Moisture Increased to 10% in ~75 Minutes
Can We Measure This in Field??

- Hay Scales
  - Screen Trays
  - Load Cells
  - Weather Sensors
  - Data Logger
- Constant Output
  - Weight
  - Temperature
  - Humidity
  - Wind (If Required)

Small Capacity Hay Scale
Output From Scales
September Cutting, Harquahala, AZ

Alfalfa Moisture Following Cutting

- Rapid drying during daytime
- Rehydration at night
A Closer Look at Night Rehydration

Hay moisture responds rather quickly to change in humidity at night.
Peak Overnight Hay Moisture

Similar to Equilibrium Moisture Curve if some form of humidity averaging is used.
Self Humidification

Hay Moisture: ~40%

<table>
<thead>
<tr>
<th>Component</th>
<th>Moisture</th>
<th>Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaves</td>
<td>18%</td>
<td>47%</td>
</tr>
<tr>
<td>Stems</td>
<td>64%</td>
<td>92%</td>
</tr>
</tbody>
</table>

Early in dry down process, slower drying stems will humidify swath/leaves at night. Raking in early morning may produce less leaf loss.
Possible Management Options

• Humidity Monitoring
  • When to Bale

• Cultural Practices
  • Soil Moisture
  • Windrow Management

• Artificial Humidification
  • Light Water Applications
  • Steam System

Early Windrow Steam System
Portable Humidity Monitors
Remote Field Assessment

- Humidity Sensor

Spectrum Technologies

Peak Hay Moisture

AZ Baling Range

45-60%

Hay Moisture, %

Average Overnight Relative Humidity, %

Item 3451H
- Water vapor escaping from soil helps humidify near surface atmosphere.

- Adjust irrigation prior to cutting and achieve measureable improvement in humidity?
Humidity Profile Near Surface at Night

Bermudagrass

Standard Measurement Height
Relative Humidity = ~55%

Surface to 1’ Above Ground
Relative Humidity = 70-82%
Windrow Structure

Short & wide during dry season
Tall & skinny during the wetter season

[Diagram showing windrow structure in warm, dry and cool, moist conditions, with moisture movement indicated.]
Artificial Humidification
Spraying Water on Windrow

- **Water Application**
  - CA: 40-50 Gal/A
  - AZ: 50 Gal/A
  - UT: 2-4 Gal/100’

- **Lag Time for Baling**
  - 5-30 Minutes
    - Moisture Penetration
    - Humidity & Wind
    - Time of Day
  - Manual Assessment

Artificial Humidification

- Steam Injection
  - Humidify Hay
- Baling Period
  - Flexible/Longer
  - Eliminates Balers
- Improves Quality
  - Reduce Leaf Loss
  - Higher RFV
- Expensive

http://www.staheliwest.com

http://www.harvesttec.com
Concluding Comments

• Humidity vs Hay Moisture
  • Equilibrium Moisture Curves are Relevant
  • More Field & Lab Work Required
    – To Fully Understand Relationship

• Hay Management vs Humidity
  • Just Getting Started
  • Field Monitors
    – RH~50% @ Ground Level
  • Cultural Practices
    – Do They Work?
    – Can They Be Implemented?