HAY MOISTURE & WEATHER: IMPLICATIONS FOR HAY HARVEST

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Harvest Losses vs. Moisture

From Collins & Owens, 1995
# Losses During Haymaking

## Table 4. Alfalfa losses of DM and leaves during various haymaking operations.

<table>
<thead>
<tr>
<th>Operation</th>
<th>% of DM Lost</th>
<th>% of Leaves Lost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mowing</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Mowing/conditioning:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>reciprocating mower, fluted rollers</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>disc mower, fluted rollers</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>disc mower, flail conditioner</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Raking:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>at 70% moisture</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>at 60% moisture</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>at 50% moisture</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>at 33% moisture</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>at 20% moisture</td>
<td>12</td>
<td>21</td>
</tr>
<tr>
<td>Tedding:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>at 70% moisture</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>at 60% moisture</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>at 50% moisture</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>at 33% moisture</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>at 20% moisture</td>
<td>12</td>
<td>21</td>
</tr>
<tr>
<td>Baling, pickup + chamber</td>
<td></td>
<td></td>
</tr>
<tr>
<td>at 25% moisture</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>at 20% moisture</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>at 12% moisture</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Baling at 18% moisture:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>conventional rectangular baler</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>with ejector</td>
<td></td>
<td></td>
</tr>
<tr>
<td>round baler, variable chamber</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>round baler, fixed chamber</td>
<td>13</td>
<td>21</td>
</tr>
</tbody>
</table>


## Figure 3. The effect of forage moisture on dry matter loss during raking of alfalfa hay (Collins and Moore, 1995.)
Heating, Heat Damage, Fire

**Fig. 19.4.** As a general trend, heating during hay storage increases as hay moisture increases. Using larger or denser hay packages increases heating at any given moisture level.

From Collins & Owens, 1995
Evaporation

Liquid (Water) → Energy Required → Gas (Water Vapor)
EVAPORATION

Liquid
Tightly Packed Molecules Held By Polar Attraction

Gas (Humidity)
Isolated, Free Molecules Moving in Air

Evaporation
EVAPORATION FROM VEGETATION/HAY

Weather Regulates/Supplies Energy

Solar Radiation, Wind, Temperature, Humidity
HAY DRYING

Fig. 19.2. A typical pattern of moisture loss during hay curing. Initial moisture at cutting is usually near 80%.

From Collins & Owens, 1995
# Seasonal Drying Trends & Weather

Drying related to available energy & vapor transport along with yield (amount of water)

<table>
<thead>
<tr>
<th>Month</th>
<th>Solar Radiation W/m*(m)</th>
<th>Vapor Gradient kPa</th>
<th>Wind Speed m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>February</td>
<td>160</td>
<td>0.68</td>
<td>1.8</td>
</tr>
<tr>
<td>April</td>
<td>264</td>
<td>1.44</td>
<td>2.5</td>
</tr>
<tr>
<td>June</td>
<td>347</td>
<td>3.55</td>
<td>2.4</td>
</tr>
<tr>
<td>August</td>
<td>302</td>
<td>3.14</td>
<td>2.3</td>
</tr>
<tr>
<td>October</td>
<td>231</td>
<td>2.48</td>
<td>1.8</td>
</tr>
<tr>
<td>December</td>
<td>139</td>
<td>0.70</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Compare June to any other month. The challenges of winter drying are obvious!
EQUILIBRIUM MOISTURE CONTENT

The moisture content of a material that is stabilized at a given temperature and humidity.

Graph: Moisture content of shelled corn at 50°F as a function of relative humidity.
Equilibrium Moisture Content
Alfalfa Hay

Can we predict hay moisture from humidity data?
Does This Work in Arizona?

Can we better use relative humidity in harvest management??

Allow alfalfa moisture equilibrate to various humidity levels developed using saturated salt solutions.
Equilibrium Moisture Content

Alfalfa Hay

From: Collins & Moore, 1995
HAY MANAGEMENT

![Graph showing the relationship between moisture and relative humidity for different hay types at 95°F and 77°F. The graph indicates that moisture levels should be maintained within the 70-80% range for optimal hay management. The graph also highlights the moisture content for Small Square, Large Round, and Large Square hay types at different relative humidity levels.](image-url)
HAY MOISTURE vs. HUMIDITY

Challenging Period: April-July

Optimum Relative Humidity for Haymaking: ~70%
Maximum Relative Humidity Commonly Stays Below 70% From April-June
HAY METEOROLOGY: NIGHT

Relative humidity (RH) at surface increases due to moisture movement from soil to air and surface cooling (due to radiation loss) which increases the saturation level (RH) of the air.

- **Warmer Temperatures, Lower Relative Humidity**
- **Cool Temperatures, Higher Relative Humidity**

**Inversion**

- **Windrow**
  - Increasing Hay Moisture
  - Good Baling: 70% RH

**Surface Cools Due Radiative Loss**

Slow Moisture Movement
WHERE DOES DEW COME FROM?

Dew forms when water vapor from warm moist soils moves upward into the vegetation which is chilled below the dew point.
HAY METEOROLOGY: NIGHT

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**Windrow**

- **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.
WINDROW HUMIDITY

Graph showing the change in windrow humidity over time, with arrows indicating the effects of wind and sunset.
WIND EFFECT: LAST NIGHT

Parker Rovey Weather: Past 24 Hours

Air Temperature, Dew Point & Relative Humidity

Most Recent Data
03/25 09:46 AM
Temperature 77.3 F  Dew Point 37.8 F  Humidity 24.1 %

Wind Speed & Direction

Most Recent Data
03/25 09:46 AM
Speed 7.2 mph  Direction 321 deg
Moisture vs Overnight Weather

Measure Temperature & Humidity
- 50 cm
- 100 cm
- 150 cm
- 200 cm
- Surface temperature (IRT)

Hay Placed at Different Levels
- Measure increase in moisture
Calm Night

Dormant Bermudagrass

22 March

Peak Humidity: 76%
Moisture increased 9.4%
Windier Night
Note Lower Humidity!

Dormant Bermudagrass
24 March

Peak Humidity: 60%
Moisture increased 5%

Peak Humidity: 82%
Moisture increased 11%
Windrow Structure

Short & wide during dry season
Tall & skinny during the wetter season
When weather station humidity approaches 50% and winds are light, humidity at surface should approach levels supporting good baling conditions (70%).
WATCHDOG HAY CELLULAR ALERT

- Humidity Sensor
- Small Datalogger
- Cell Phone
  - GSM
  - CDMA
- At Selected Humidity
  - Calls/Texts
    - Four Numbers
- Cost
  - $1125-$1375
  - Phone Charges

Spectrum Technologies

Need to Determine Proper Humidity Setting – 50%??
WHERE DOES DEW COME FROM?

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Water Management

We need to encourage higher levels of soil moisture during the dry season to enhance vapor transfer to the surface. Irrigation management may be a tool. Subsurface drip irrigation may offer significant benefits.

Vapor transfer is diminished when soils are dry and much of the vapor is reabsorbed in the dry surface soil.

Irrigation management may be a tool. Subsurface drip irrigation may offer significant benefits.
QUESTIONS?

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Phone: 520-419-2991
Fig. 4. Day and night stem relative growth rates for stressed and irrigated alfalfa during 1979 with $S_x$ included as error bars. Nighttime denoted by heavy bars on the abscissa.
Equilibrium Moisture Content
Alfalfa Hay

From: Collins & Moore, 1995