

# ***Using Propionic Acid to Preserve More Hay***

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**Riley, KS – 1991**  
**100°F, 20 mph winds**



**Unfortunately, harvests of alfalfa or other hays are frequently complicated by poor drying conditions, or unexpected rainfall events.**



**Therefore, hay producers often must choose between subjecting their valuable hay crops to rain damage, or accepting inadequate desiccation and spontaneous heating.**



**Fayetteville, AR - 2003**



**Marshfield, WI - 2006**

# Spontaneous Heating

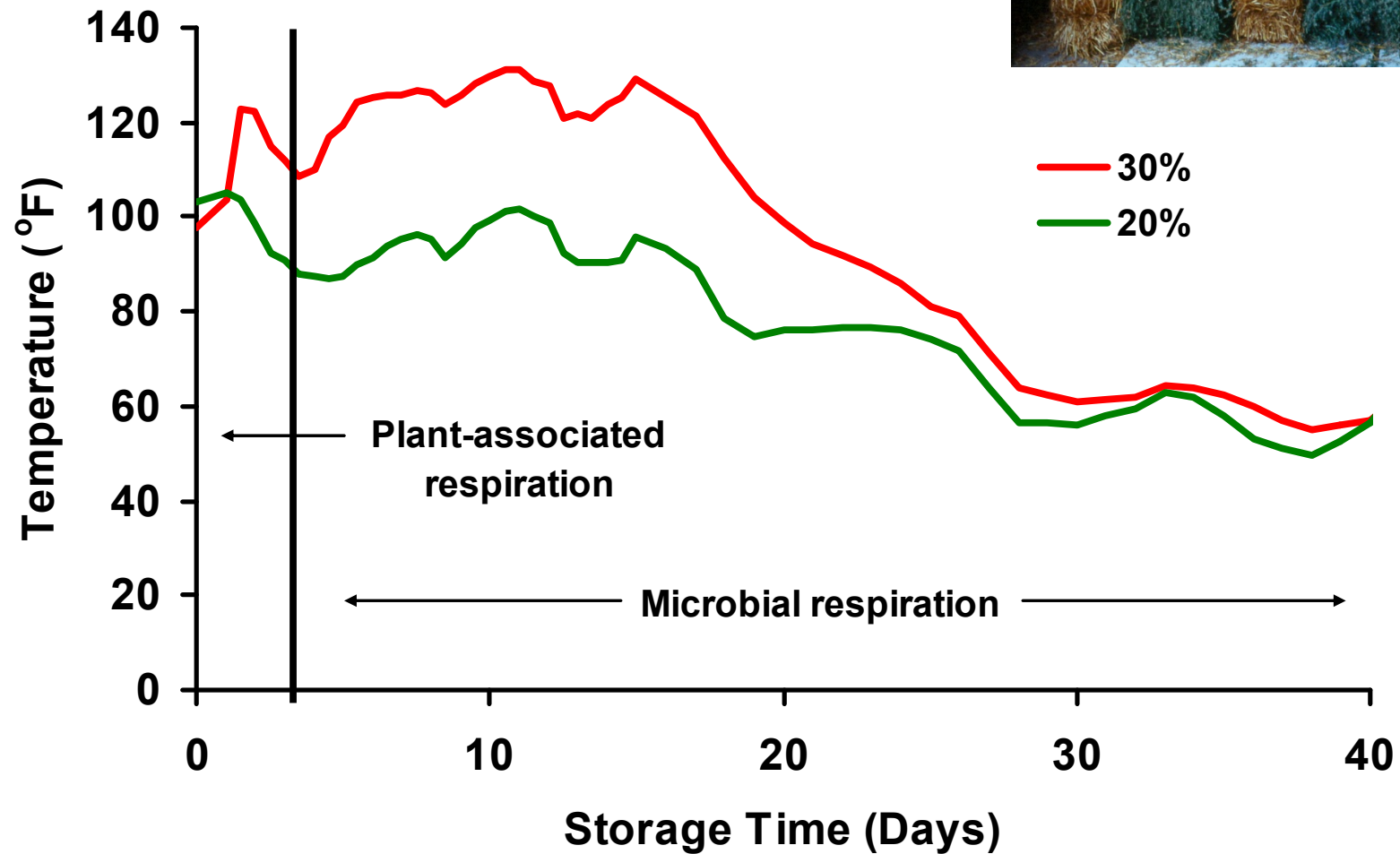
- result of plant and microbial respiration
- occurs in consistent patterns across forages
- many contributing factors
  - moisture
  - bale density and/or size
  - environmental factors
  - storage site
  - preservatives
- *good predictor of changes in forage quality !*



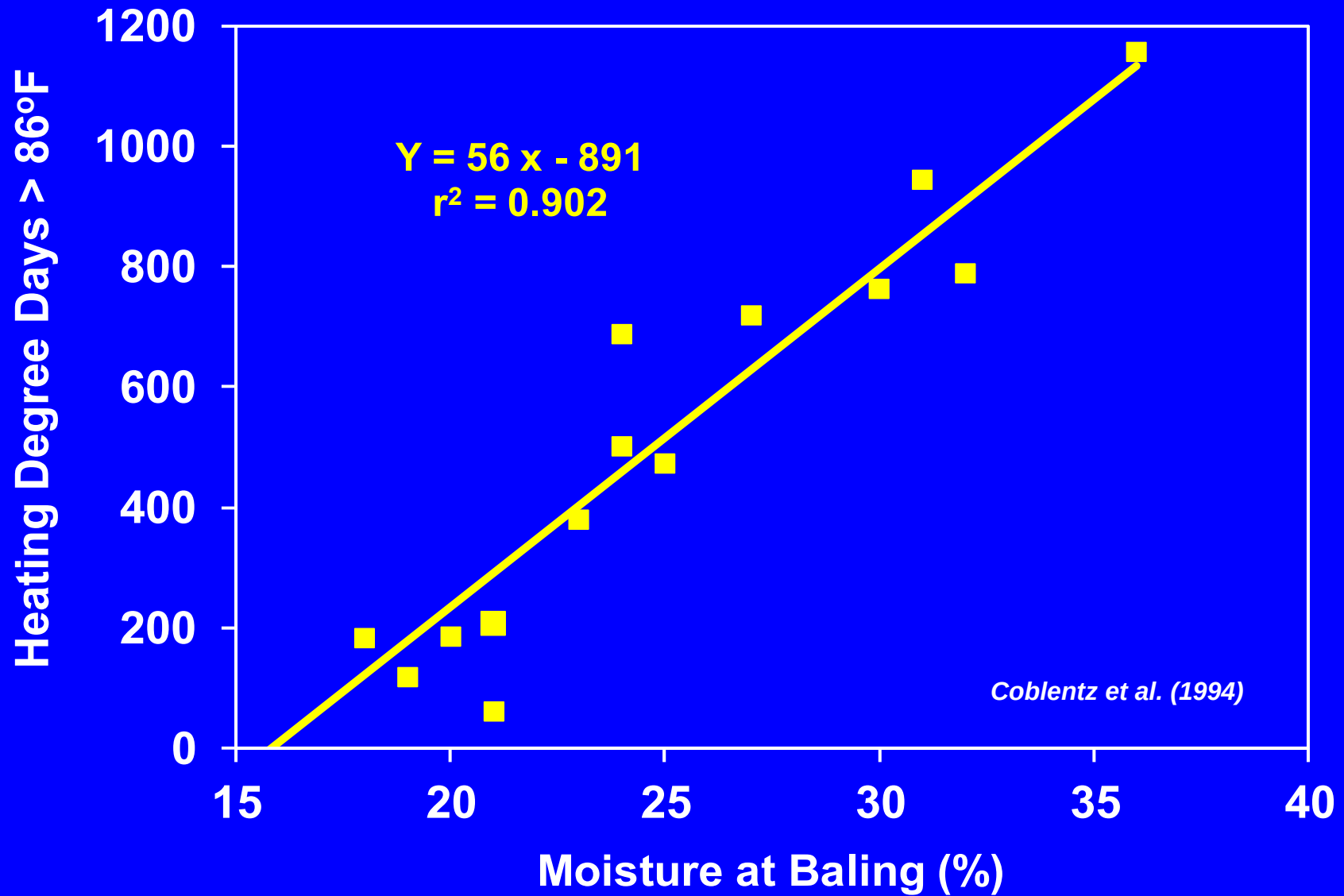
# Patterns of Spontaneous Heating in Alfalfa Hay (45-kg bales)



*Coblentz et al. (1996)*



## Heating Degree Days vs. Initial Bale Moisture Alfalfa Hay (Small Rectangular Bales) - 1991

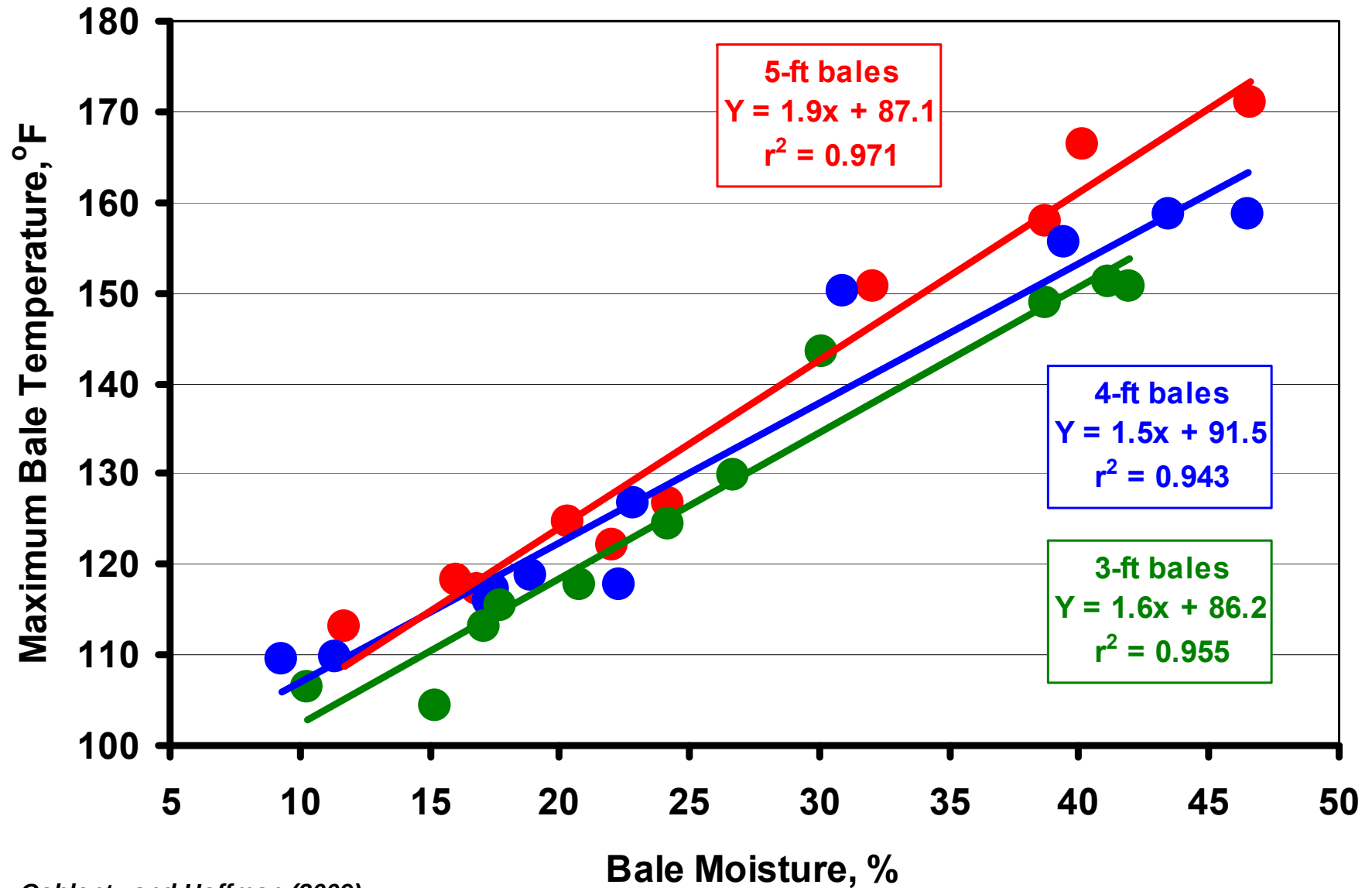


# Wisconsin Round-Bale Studies



- alfalfa- orchardgrass hays from 3 harvests
- 3 bales/interactive treatment (3, 4, or 5-ft diameter)
- storage was outdoors on wooden pallets
- bales were monitored daily until internal bale temperatures indicated no further spontaneous heating
- bales were sampled rigorously on a pre- and post-storage basis

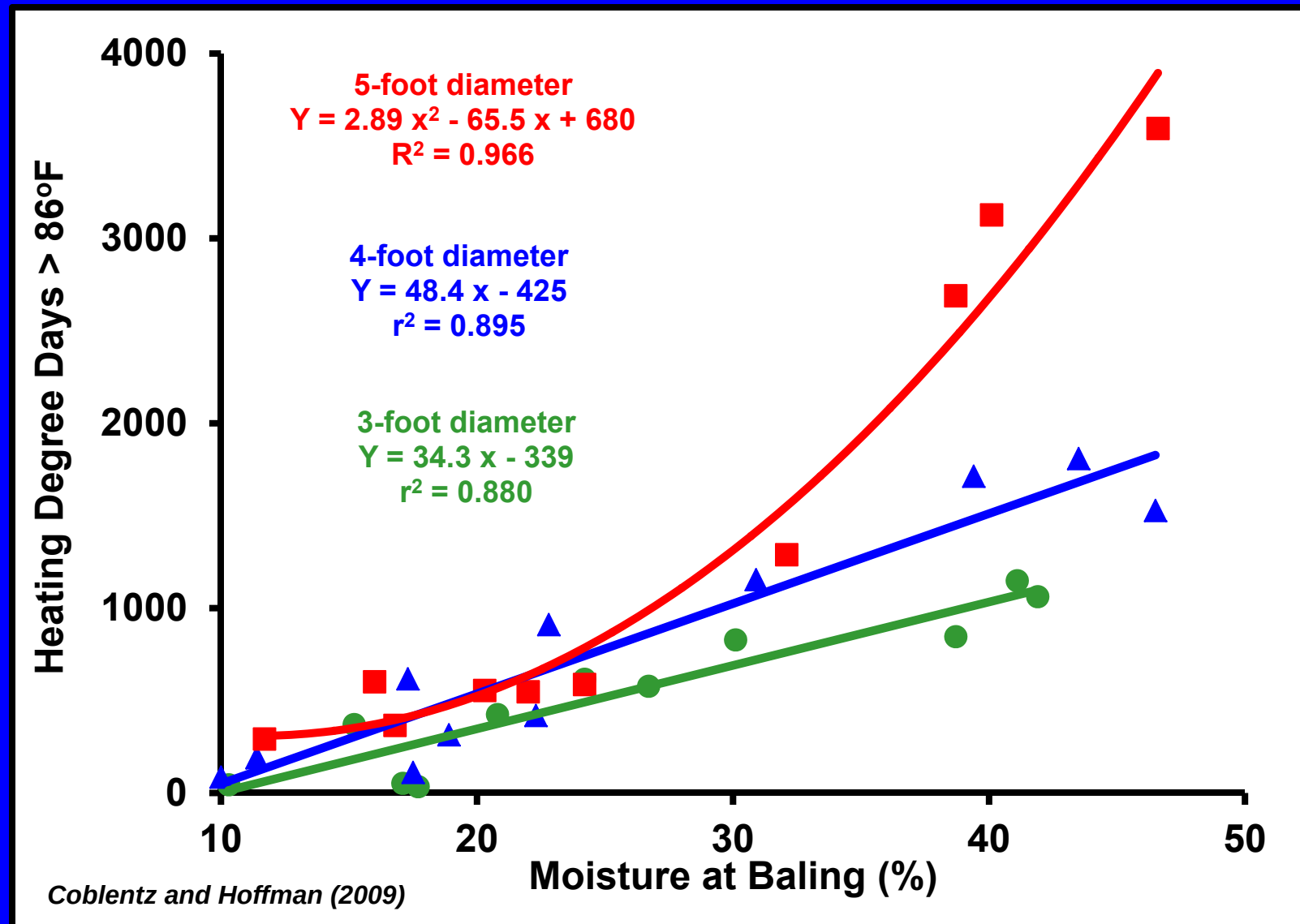
## Maximum Internal Bale Temperature (Coblentz and Hoffman, 2009)



Coblentz and Hoffman (2009)



**Cost and availability of labor has forced the dairy and hay industries towards larger hay packages, and these bales are far more likely to exhibit spontaneous heating.**

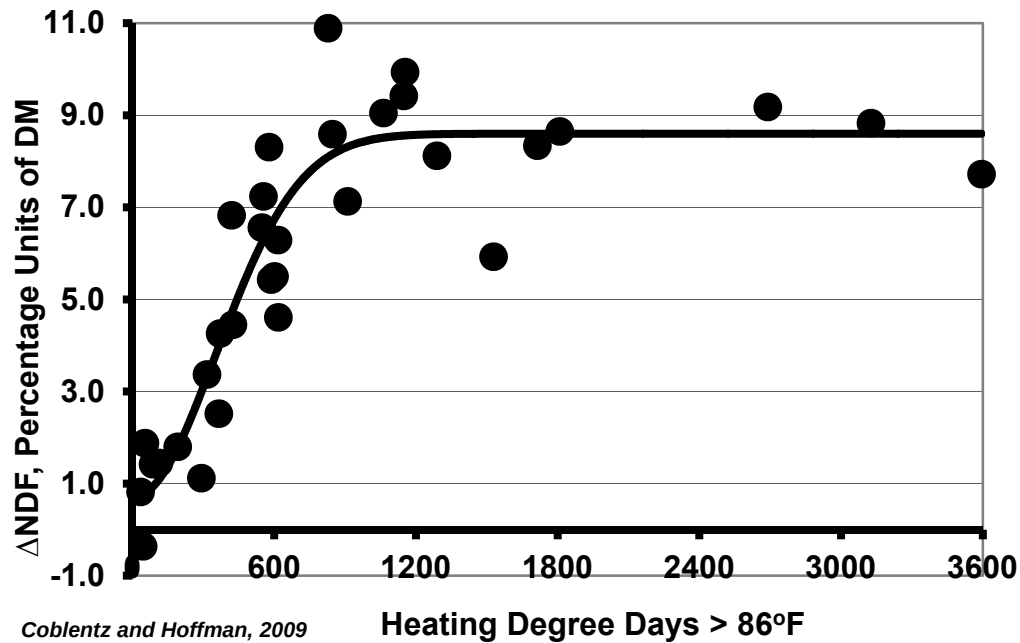


## Wisconsin Round Bale Study (2006-07)

### NDF

N = 32 baling treatments

Initial = 46.5%, which corresponds generally to  $\Delta\text{NDF} = 0$  on the y-axis

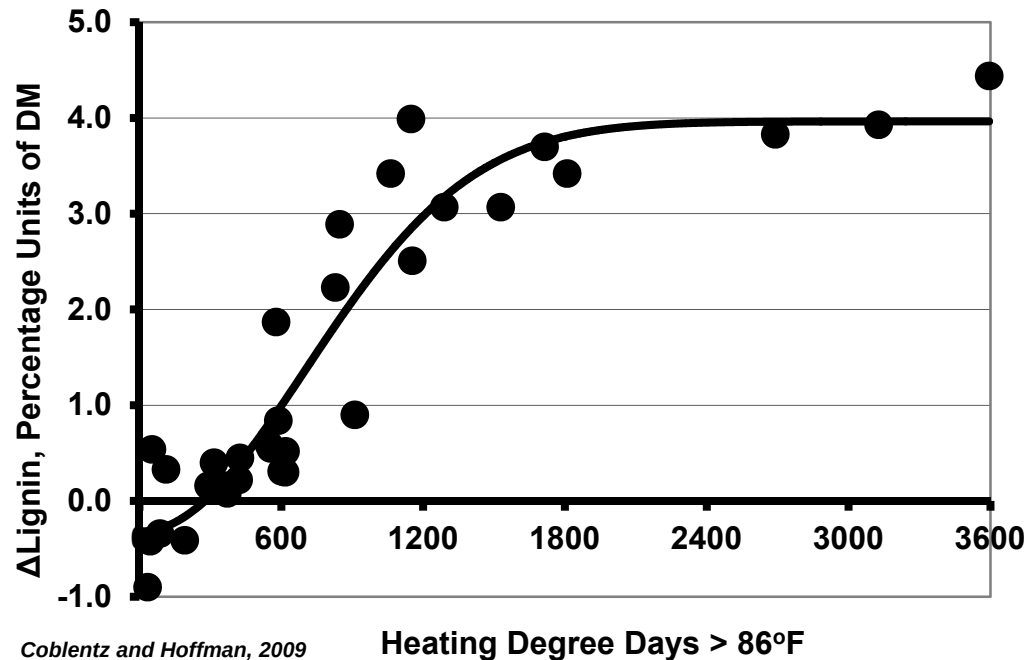


### Fiber Components

#### Acid-Detergent Lignin

N = 32 baling treatments

Initial = 5.54%, which corresponds generally to  $\Delta\text{LIG} = 0$  on the y-axis



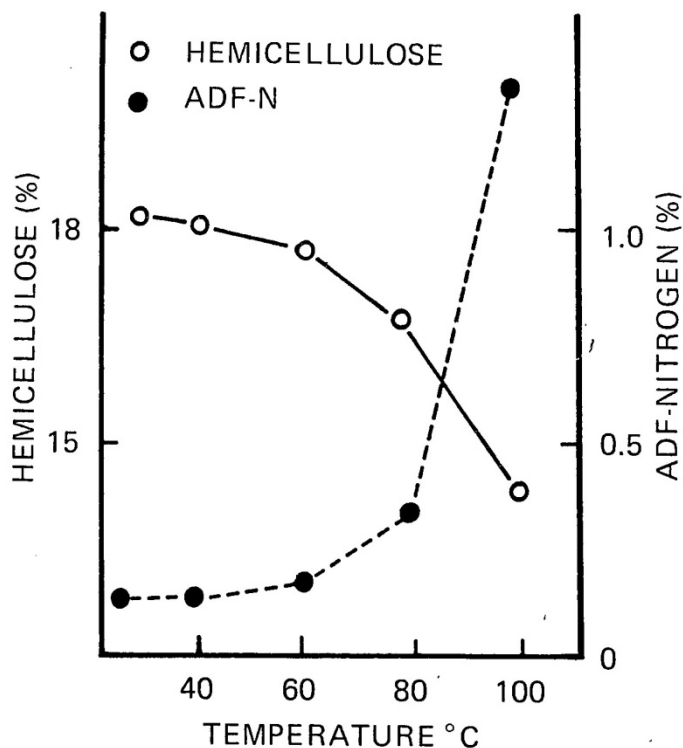
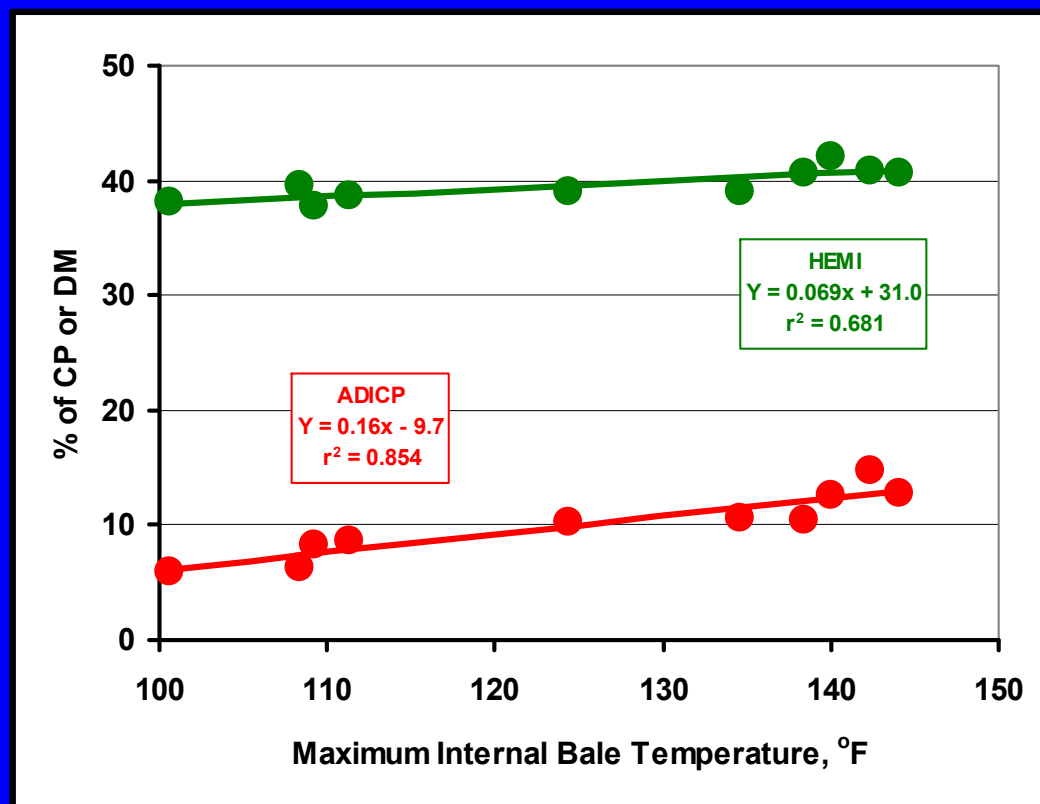


Figure 7.12. The relationship between the hemicellulose content of orchardgrass and the extent of the Maillard reaction. Hemicellulose declines as it is used in the heat damage reaction (Goering et al, 1973). Damaged carbohydrates no longer analyze as such and appear in the lignin fraction.

**Van Soest, 1982**

## Heat Damaged Protein (ADICP)



**Bermudagrass Hay**  
(Coblentz et al., 2000)

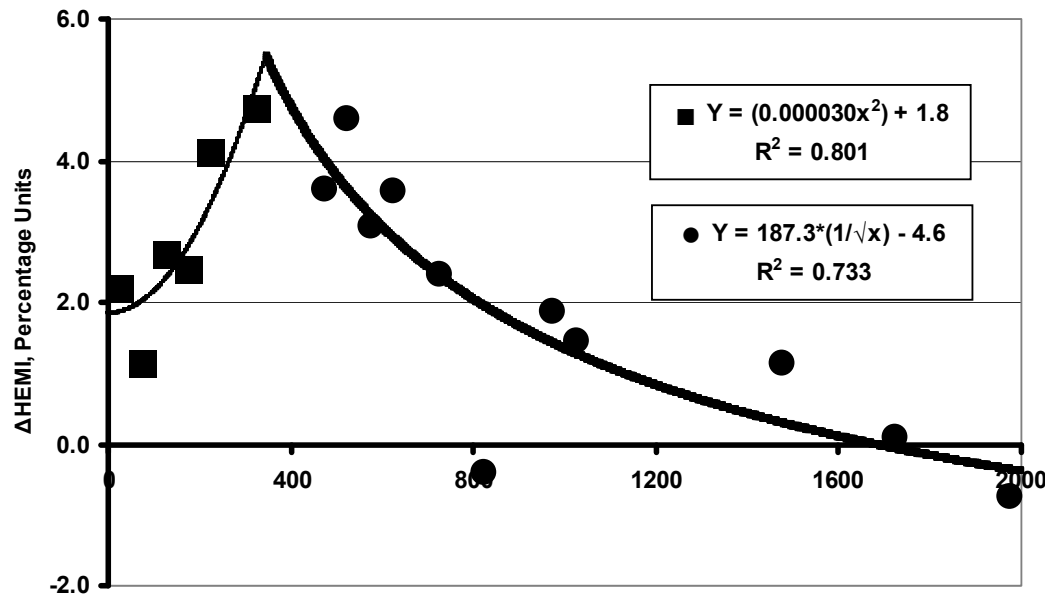
# Wisconsin Round Bale Study (2006-07)

## Hemicellulose

N = 32 baling treatments

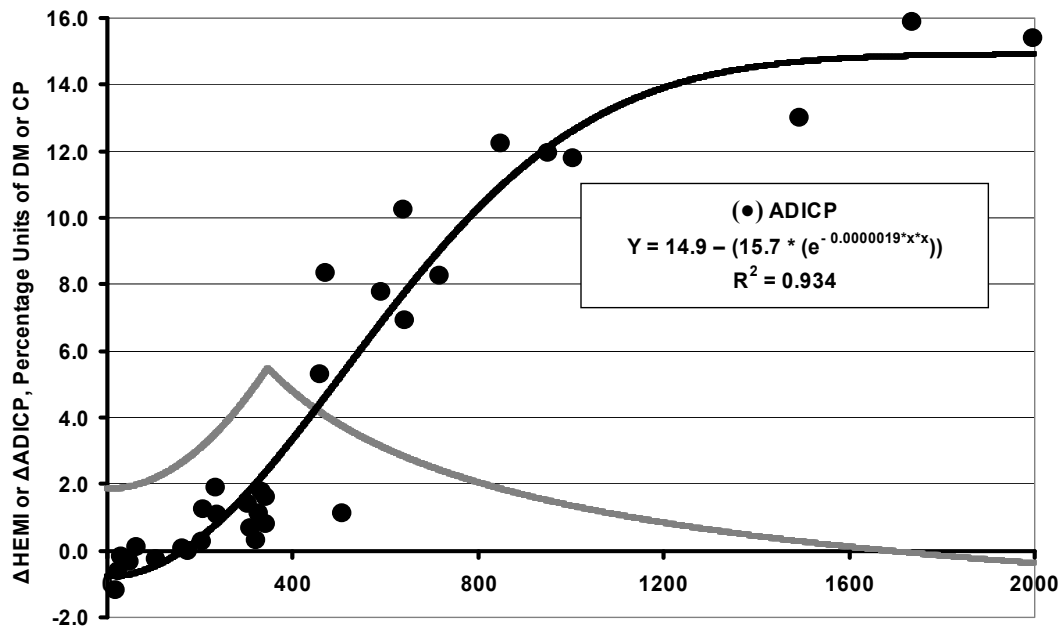
Initial = 15.1%, which corresponds generally to  $\Delta\text{HEMI} = 0$  on the y-axis

Intersection of regression lines occurred at 347 HDD > 30°C



Coblentz and Hoffman, 2009

Heating Degree Days > 30°C



Coblentz et al., 2010

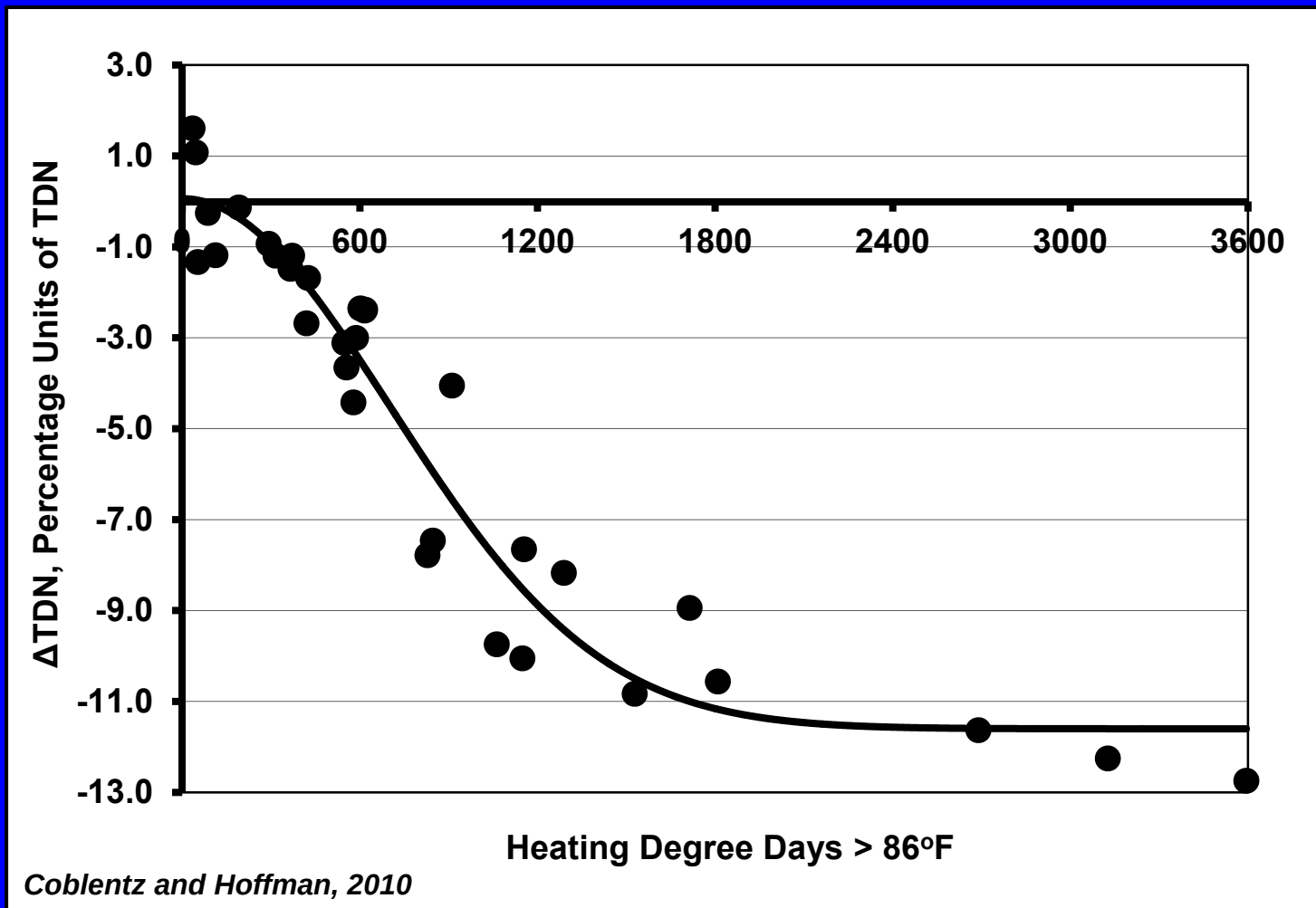
Heating Degree Days > 30°C

## Acid Detergent Insoluble Crude Protein (ADICP)

N = 32 baling treatments

Initial = 6.3% of CP and 15.1% of DM, which correspond generally to  $\Delta\text{ADICP} = 0$  and  $\Delta\text{Hemicellulose}$  (gray line) = 0, respectively, on the y-axis





## TDN

**N = 32 baling treatments**

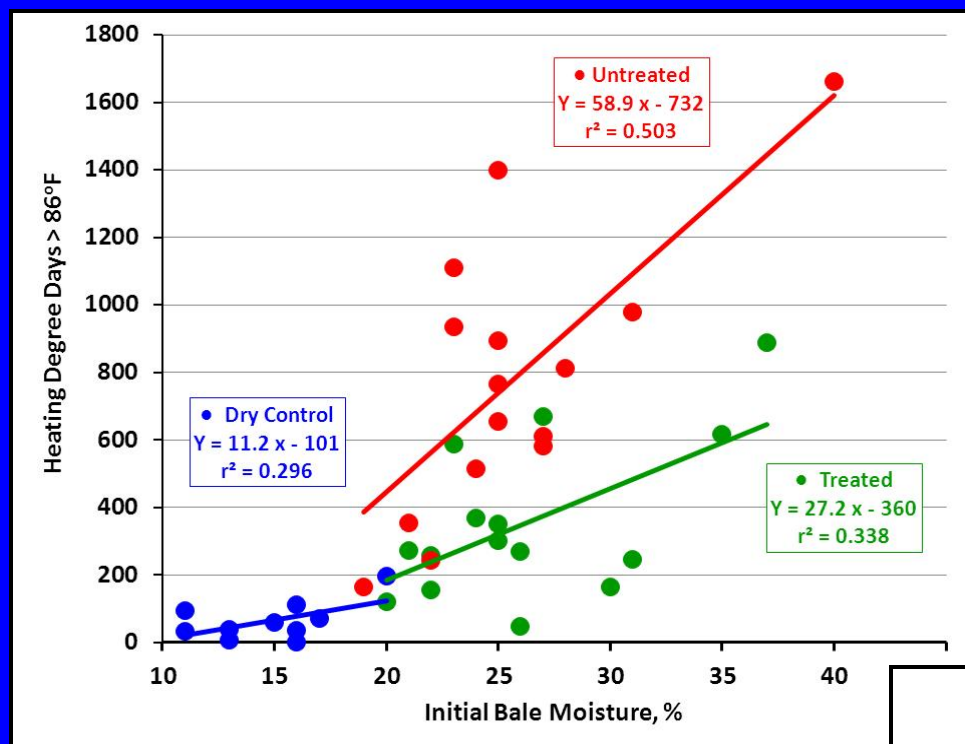
**Initial = 57.9%, which corresponds generally  
to  $\Delta\text{TDN} = 0$  on the y-axis**

# Use of Propionic Acid-Based Preservatives



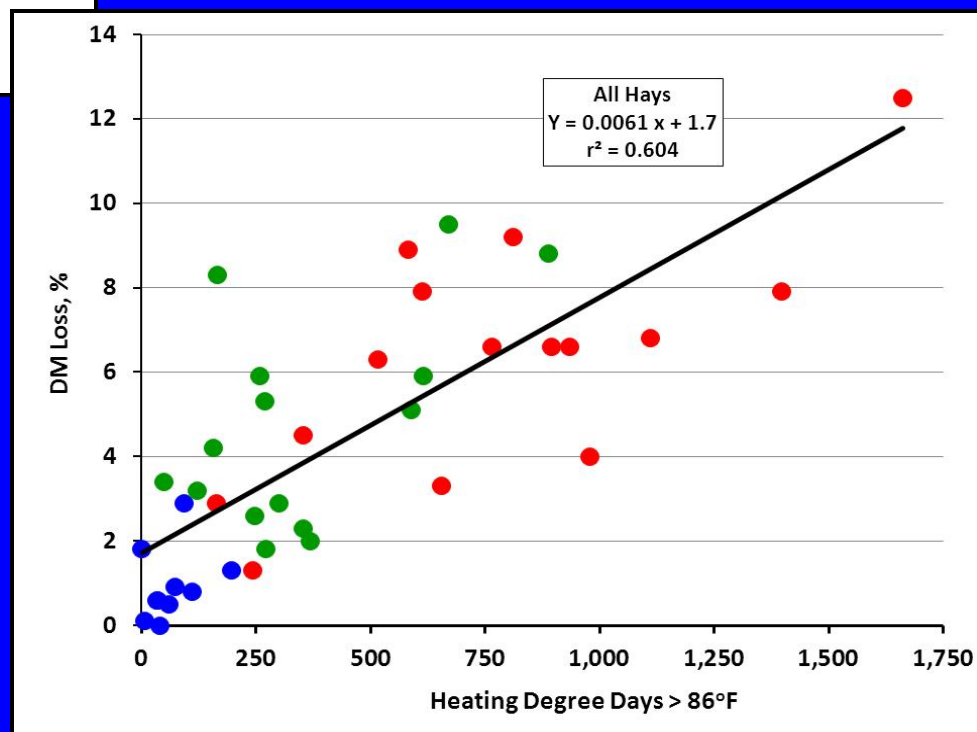
## Summary of 10 Experiments *Rotz et al. (1991)*

- each experiment contained:
  - positive (dry) hay control (10 to 20%)
  - treated hays (20 to 37%)
  - untreated hays (19 to 40%)
- application rates ranged from 1.0 to 2.3% of bale weight (50% dilution)
- some experiments contained more than one treated vs. untreated comparison



## Conclusions

- results were inconsistent across studies
- spontaneous heating was reduced, but not eliminated within treated hays
- regardless of treatment, HDD > 86°F were positively related to initial bale moisture
- losses of DM were positively related to HDD > 86°F accumulated during the first 30 to 45 days of storage



## Application of Propionic Acid Preservative<sup>1</sup> to Large Square Bales<sup>2</sup> of Alfalfa-Orchardgrass Hay (Coblentz et al., 2013)

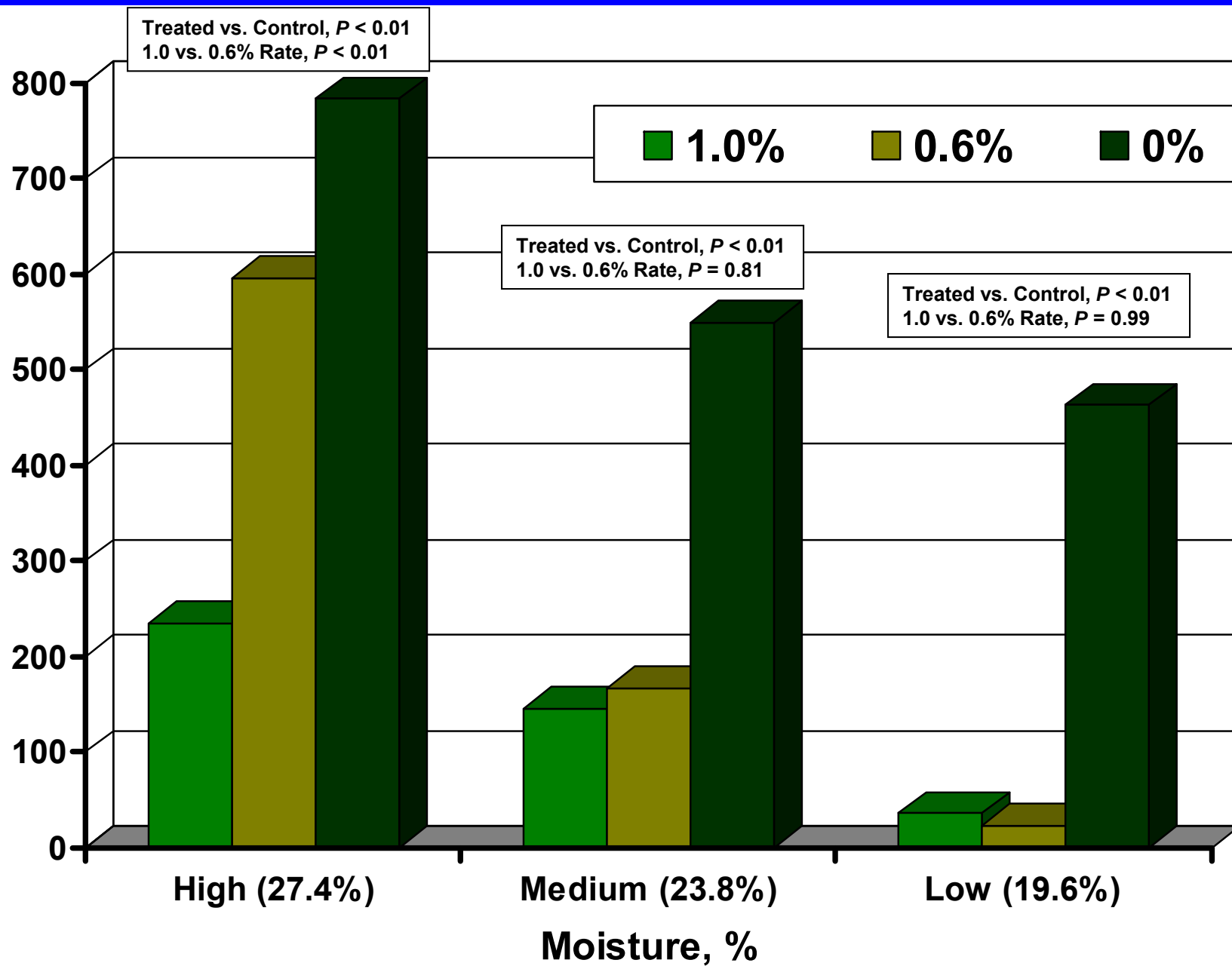
| Group  | Moisture | Volume          | Wet Weight | Dry Weight | DM Density             |
|--------|----------|-----------------|------------|------------|------------------------|
|        | %        | ft <sup>3</sup> | lbs        | lbs        | lbs DM/ft <sup>3</sup> |
| High   | 27.4     | 40.7            | 644        | 467        | 11.5                   |
| Medium | 23.8     | 40.7            | 626        | 476        | 11.8                   |
| Low    | 19.6     | 42.1            | 613        | 494        | 11.7                   |
| SEM    | 0.80     | 0.39            | 9.3        | 10.4       | 0.20                   |

<sup>1</sup> Rates: 0, 0.6, or 1.0% of fresh weight.

<sup>2</sup> Large square bales were 3 x 3 x 6 ft.

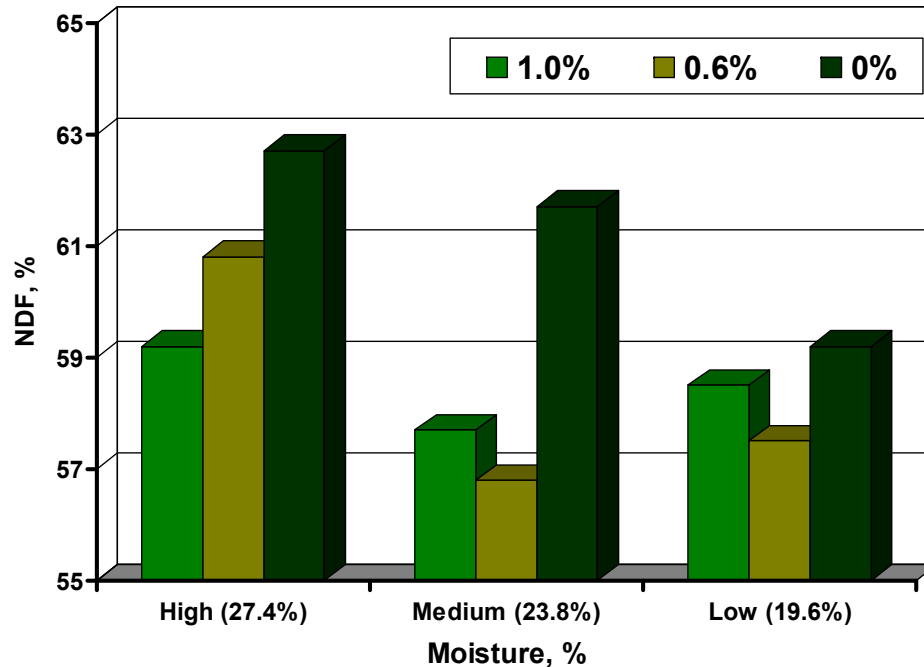


## Heating Degree Days > 86°F

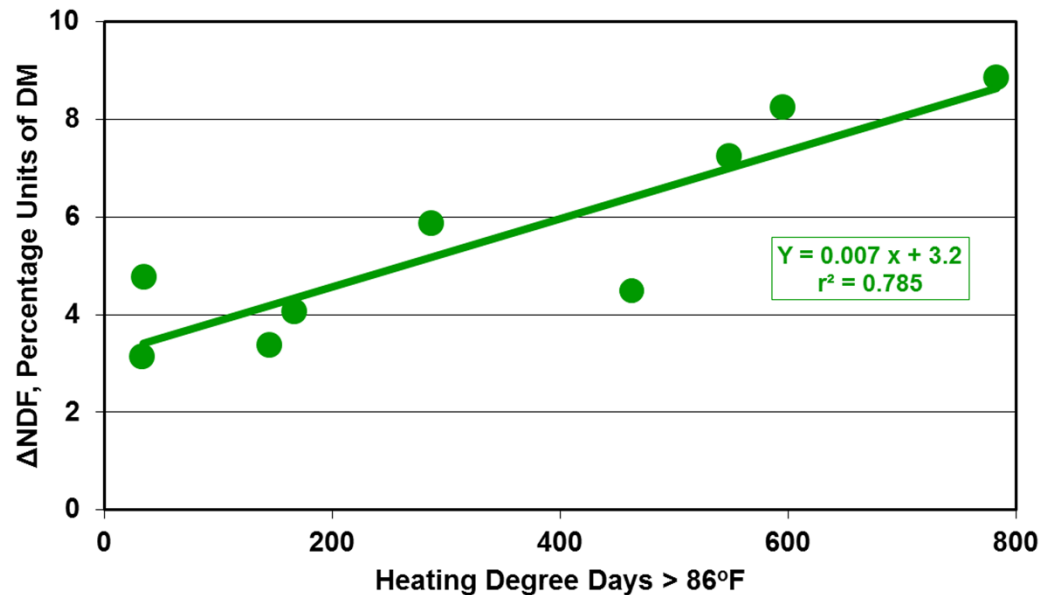




# NDF



| Contrasts                    | <i>P</i> > <i>F</i> |
|------------------------------|---------------------|
| HM: Acid-Treated vs. Control | < 0.01              |
| HM: 1.0 vs. 0.6% Rate        | 0.14                |
| MM: Acid-Treated vs. Control | < 0.01              |
| MM: 1.0 vs. 0.6% Rate        | 0.46                |
| LM: Acid-Treated vs. Control | 0.29                |
| LM: 1.0 vs. 0.6% Rate        | 0.50                |

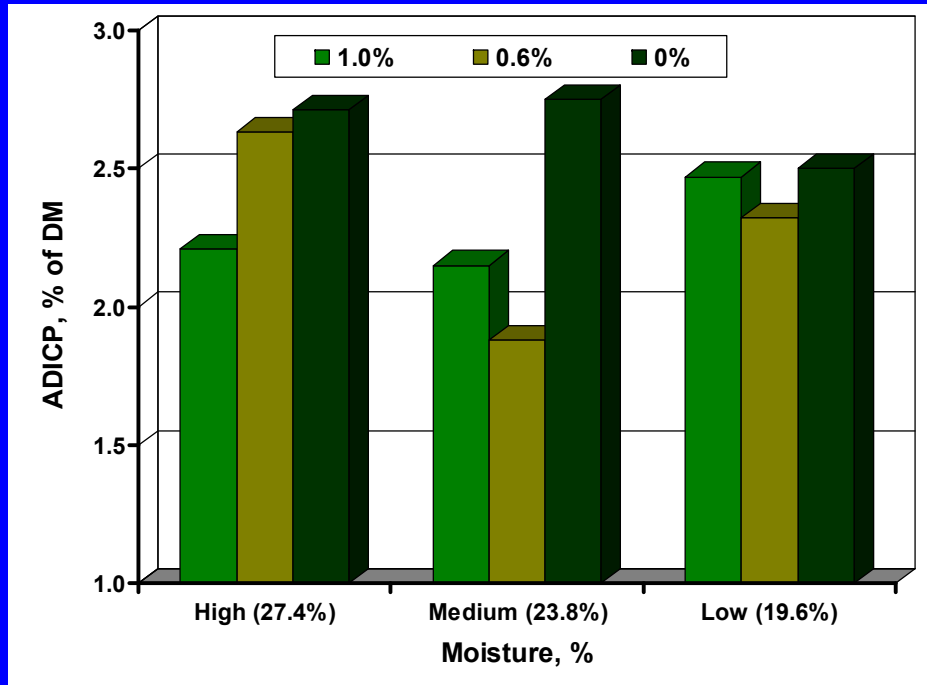


**N = 9 baling treatments**

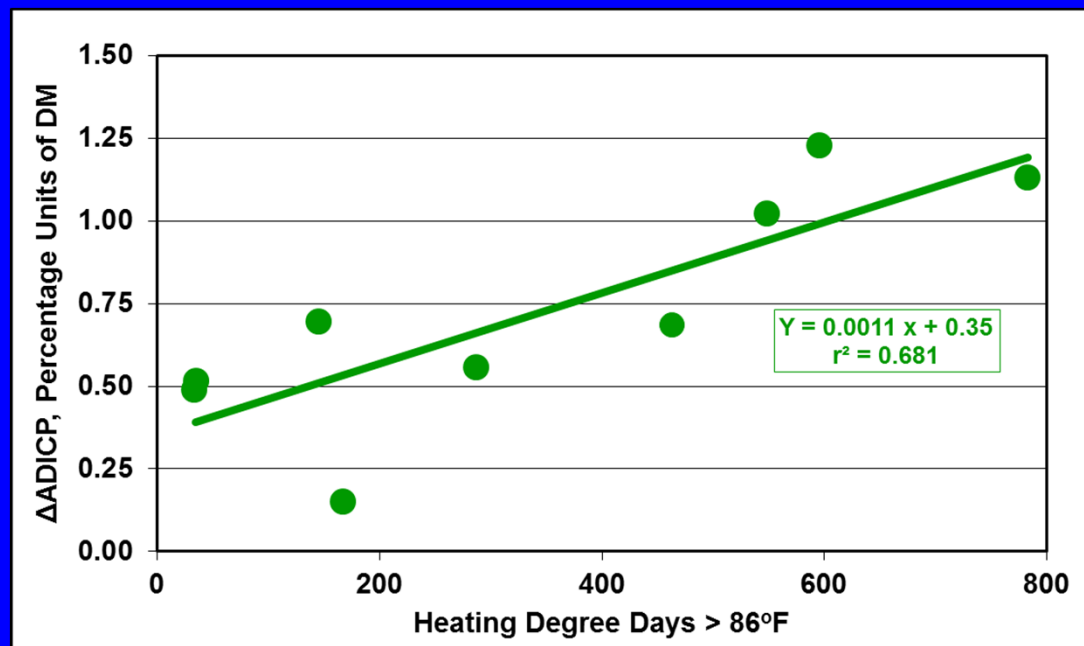
**Prestorage NDF = 53.7%, which corresponds generally to  $\Delta$ NDF = 0 on the y-axis**

*Coblentz et al. (2013)*

# ADICP



| Contrasts                    | <i>P &gt; F</i> |
|------------------------------|-----------------|
| HM: Acid-Treated vs. Control | 0.16            |
| HM: 1.0 vs. 0.6% Rate        | 0.13            |
| MM: Acid-Treated vs. Control | 0.01            |
| MM: 1.0 vs. 0.6% Rate        | 0.39            |
| LM: Acid-Treated vs. Control | 0.72            |
| LM: 1.0 vs. 0.6% Rate        | 0.70            |

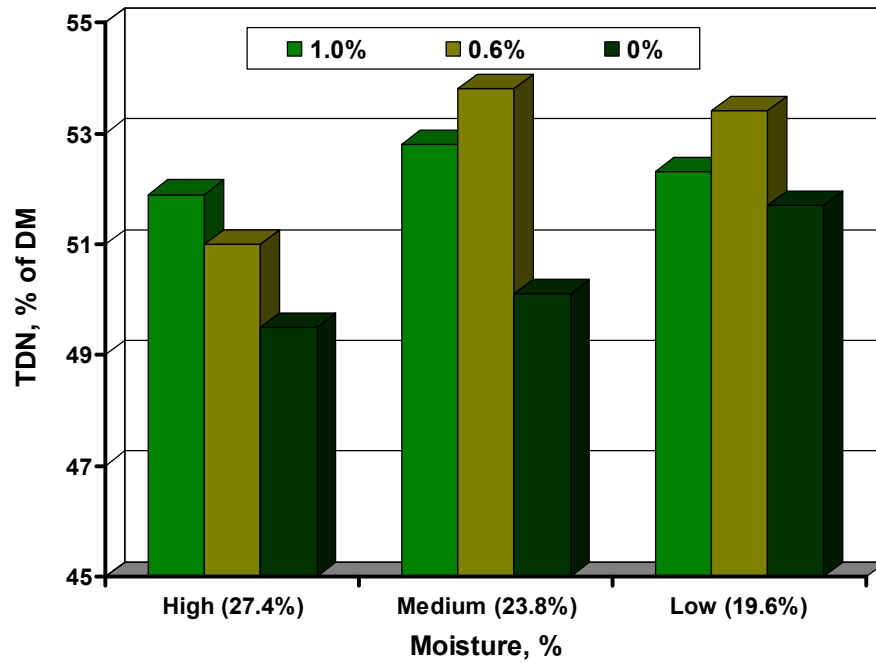


**N = 9 baling treatments**

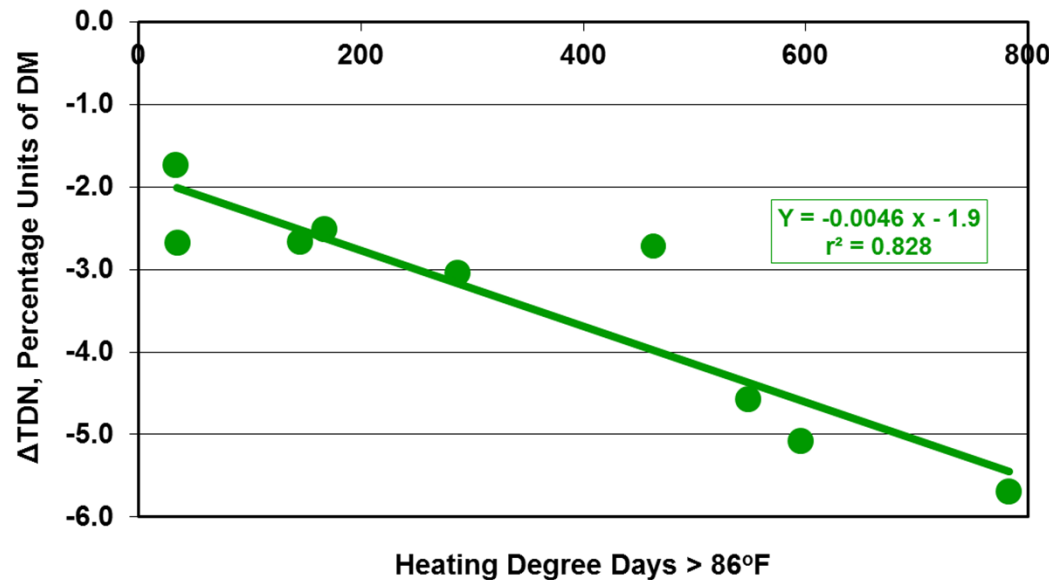
**Prestorage ADICP = 1.70%,  
which corresponds generally to  
 $\Delta$ ADICP = 0 on the y-axis**

*Coblentz et al. (2013)*

# Energy (TDN)



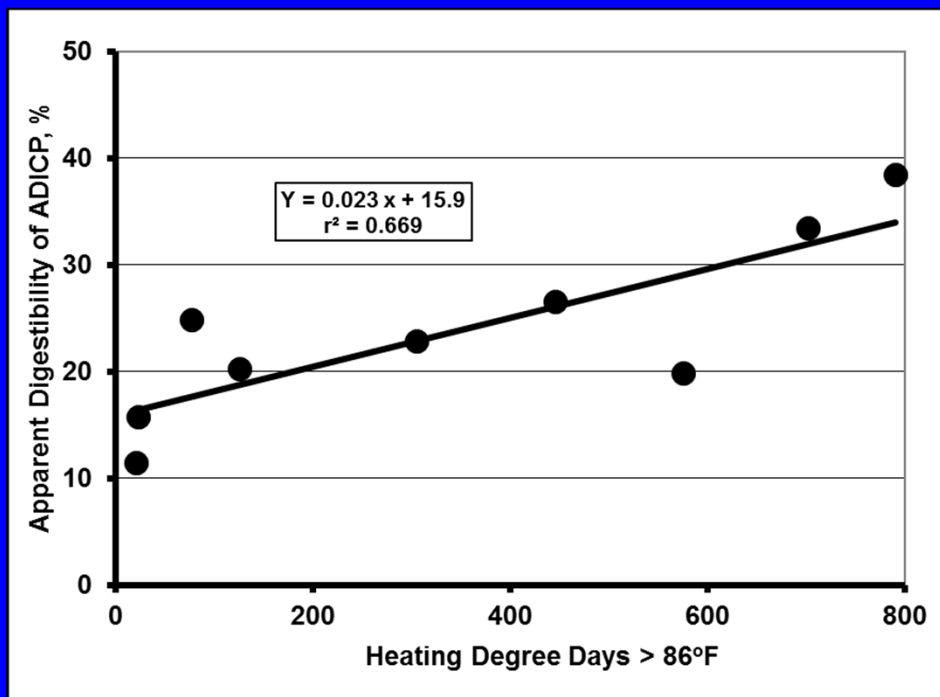
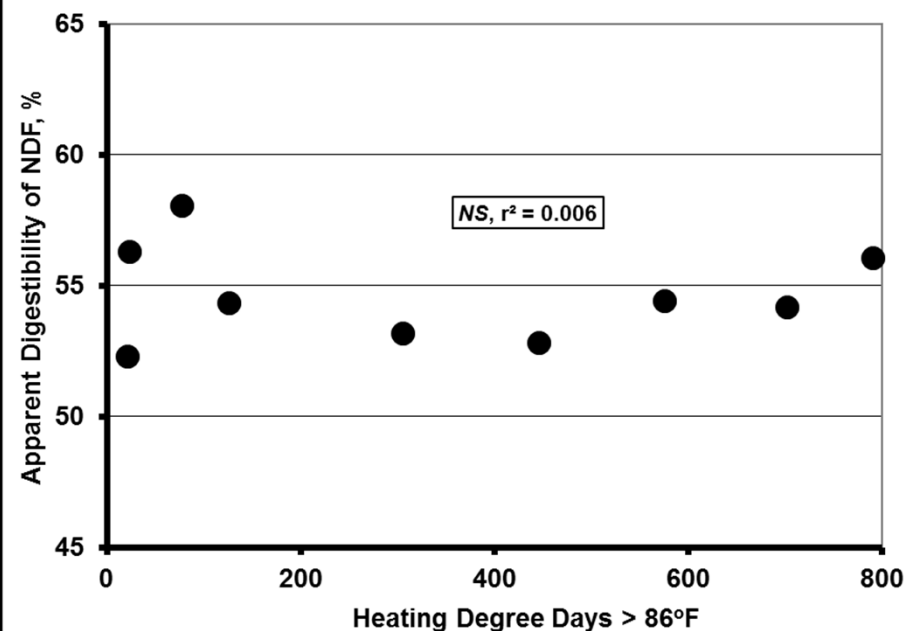
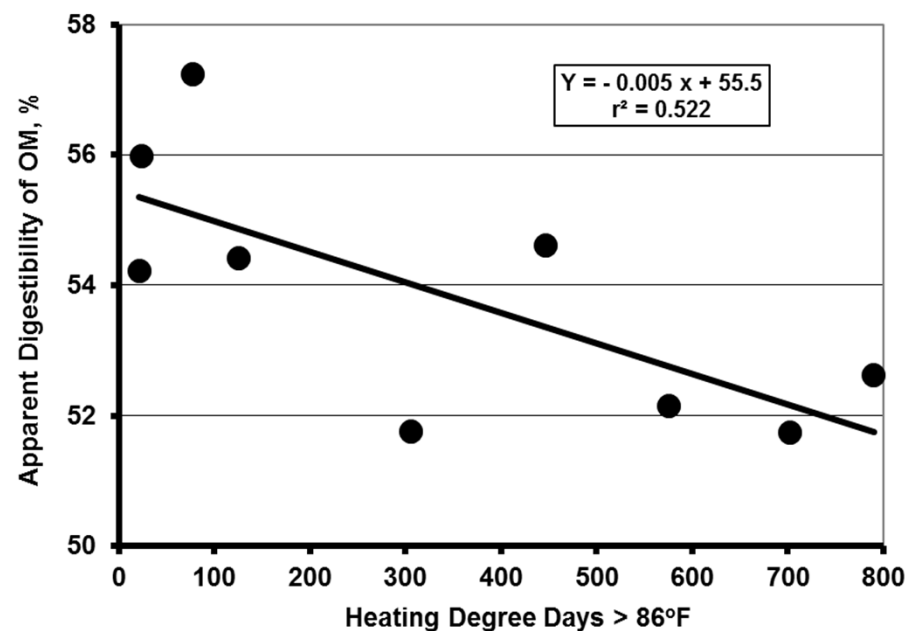
| Contrasts                    | <i>P &gt; F</i> |
|------------------------------|-----------------|
| HM: Acid-Treated vs. Control | 0.01            |
| HM: 1.0 vs. 0.6% Rate        | 0.37            |
| MM: Acid-Treated vs. Control | < 0.01          |
| MM: 1.0 vs. 0.6% Rate        | 0.35            |
| LM: Acid-Treated vs. Control | 0.27            |
| LM: 1.0 vs. 0.6% Rate        | 0.38            |



**N = 9 baling treatments**

**Prestorage TDN = 55.3%, which corresponds generally to  $\Delta$ TDN = 0 on the y-axis**

*Coblentz et al. (2013)*



## In Vivo Digestibility in Growing Lambs



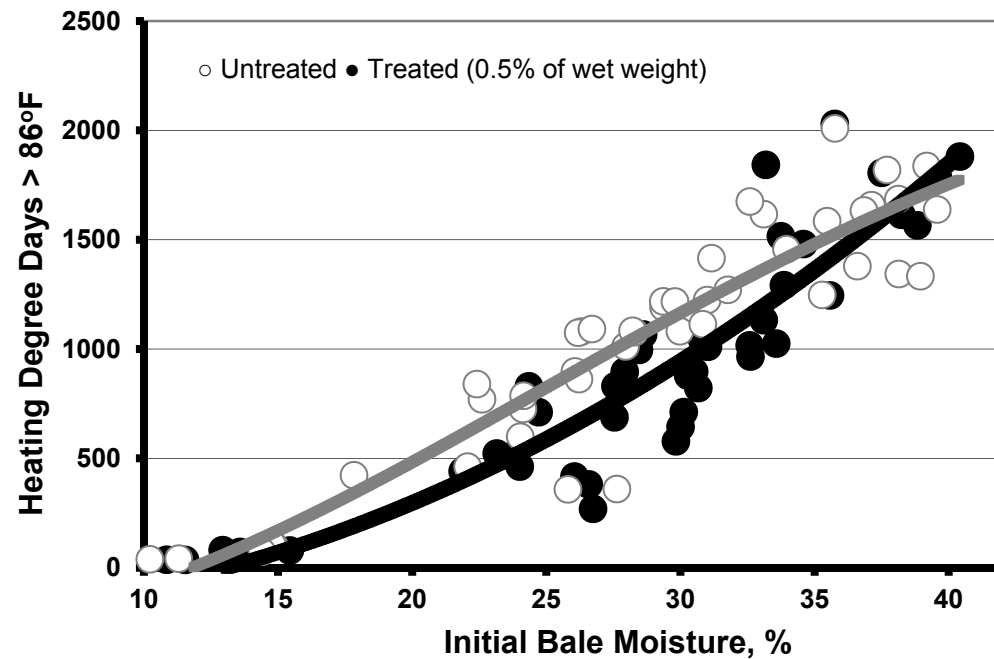
*Coblentz et al. (2013)*

# Propionic Acid Preservative on Round Bales of Alfalfa Hay

*Coblentz and Bertram (2012)*



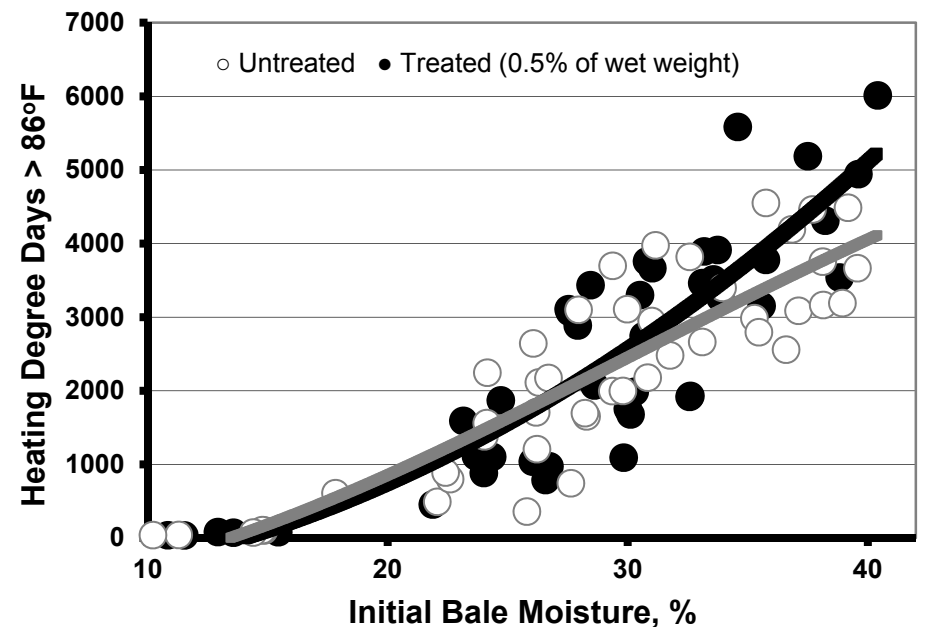




## Propionic Acid on Round Bales of Alfalfa Hay

Heating Degree Days > 86°F  
vs. Initial Bale Moisture

↑  
First 28 Days  
Entire Storage  
Period →



*Coblentz and Bertram (2012)*

## NDF

Control, N = 42 bales

Acid-treated, N = 38 bales

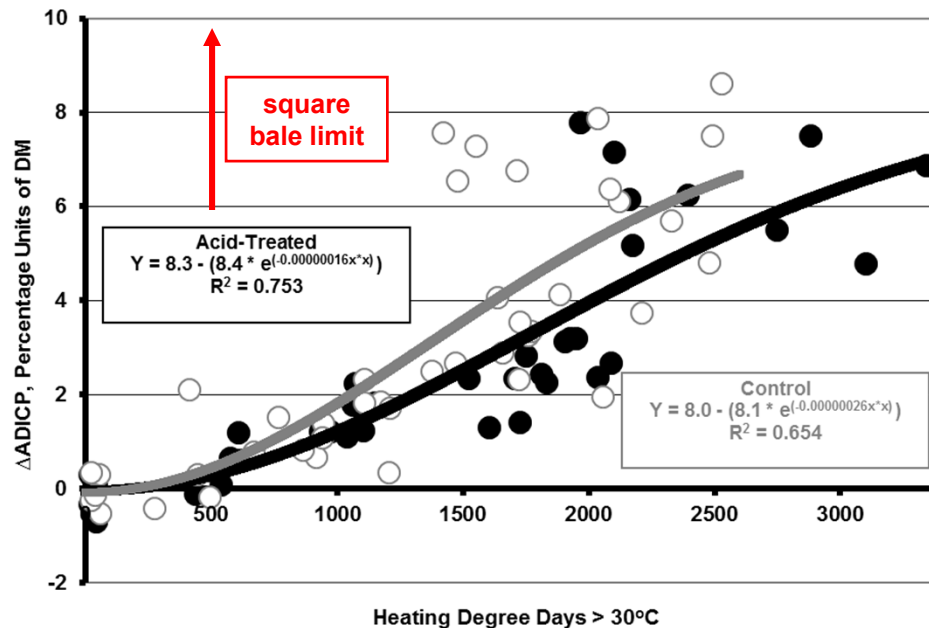
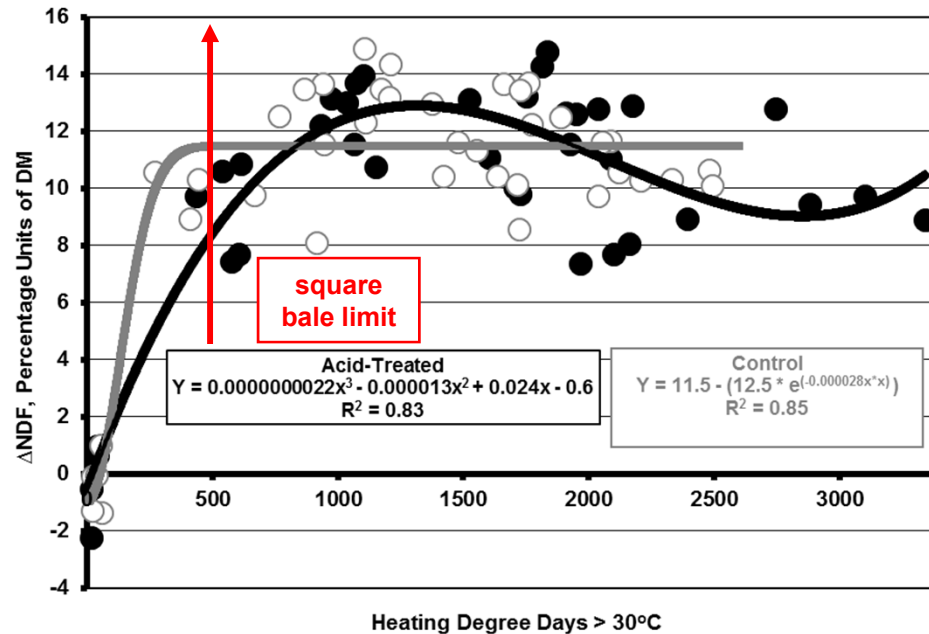
Prestorage NDF = 38.4%, which corresponds generally to  $\Delta\text{NDF} = 0$  on the y-axis

## ADICP

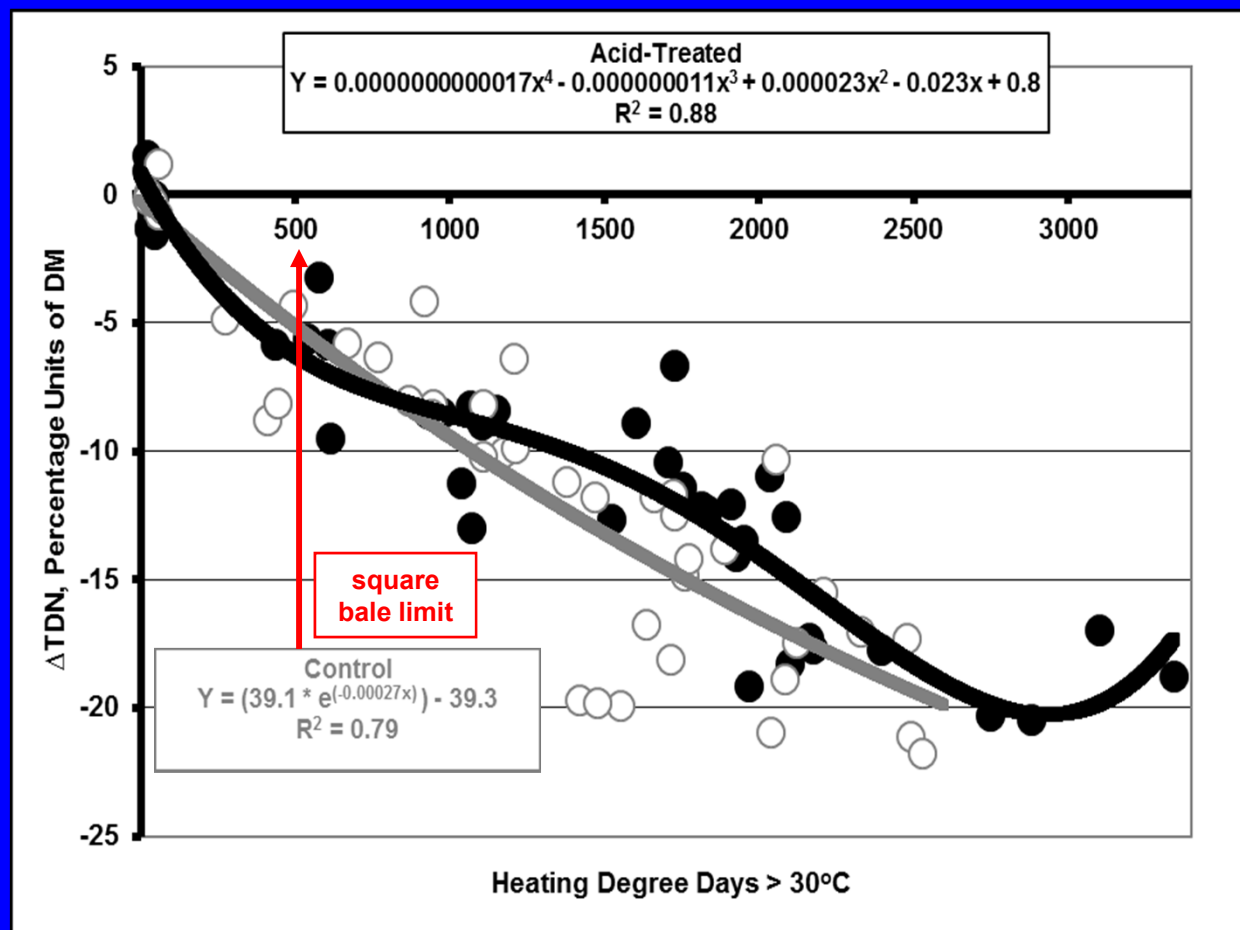
Control, N = 42 bales

Acid-treated, N = 38 bales

Prestorage ADICP = 1.57%, which corresponds generally to  $\Delta\text{ADICP} = 0$  on the y-axis



*Coblentz and Bertram (2012)*



**Control, N = 42 bales**

**Acid-treated, N = 38 bales**

**Prestorage TDN = 61.5%, which corresponds generally to  $\Delta$ TDN = 0 on the y-axis**

*Coblentz and Bertram (2012)*

# Summary

- Propionic acid-based preservatives will not eliminate spontaneous heating, and effectiveness will decline as bale moisture increases.
- Effectiveness will be greatest when moisture concentrations are  $< 25\%$ ; however, *it should not be assumed that these products will be as effective within large stacks of bales.*



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# Summary

- Based on our work, propionic acid-based preservatives are more likely to be effective within rectangular bales in which the preservative is applied in the bale chamber.

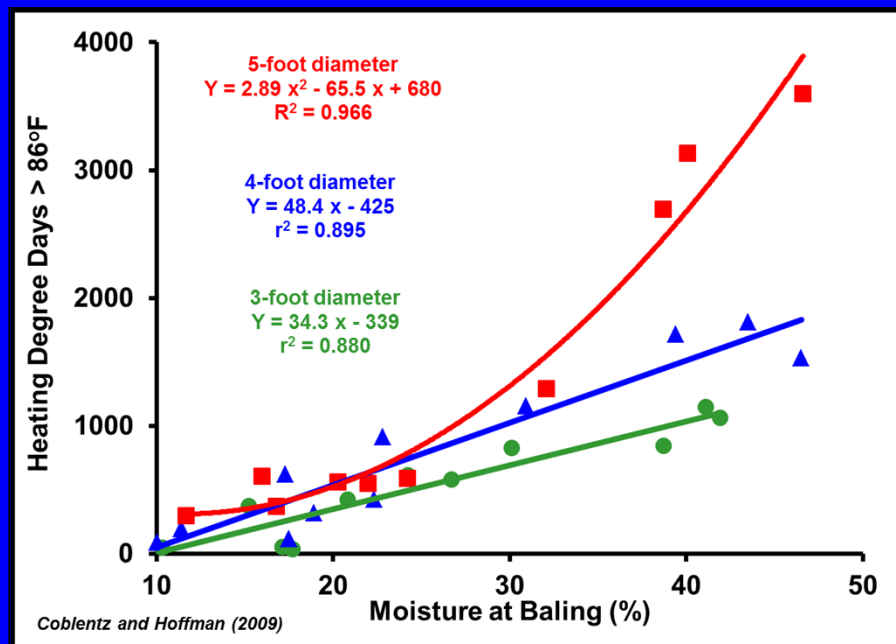


- Keep a written log of baling conditions, initial bale moisture, acid-application rates, and stacking/storage management in order to assess effectiveness of these products under routine production management.



# Summary

- Hays baled in large hay packages have a much increased likelihood of heating spontaneously, and catching fire.
  - *Be cautious!*



Questions ?



**United States  
Department of  
Agriculture**

