

Strategies for Preventing Hay Fires

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September 27, 2013

Loss in Yolo County hay fire estimated at \$5 million



A multi-million dollar hay fire that spread to barns and expensive agricultural equipment along Interstate 505 near Winters this morning is likely to burn for some time.

The fire was first reported at about 10:30 p.m. Thursday between Winters and Vacaville in [Yolo County](#). The hay belonged to a company called Haykingdom, whose business includes super-compressing hay and

OBJECTIVES

- Describe forage moisture
- Process of plant and microbial respiration
- Review how to sample and estimate forage moisture in the windrow, bale, and stack
- 11 Steps to prevent hay fires
- Reduce everyone's risk of hay fires

“No one wins in a hay fire!”

Hay Moisture

- **Stem moisture** remains in the plant stem during the curing process.
 - Windrowed hay, given ample time to field-dry, will eventually dissipate stem moisture.
- **Dew moisture** on the outer surface of the stem and leaf is caused by the relative humidity and condensation.
 - Dew moisture is rapidly removed by sunlight or a light breeze and usually only remains for a few hours each day.

Microbial Respiration

- Microbial growth uses the carbohydrates as a source of energy
- Converts carbohydrates and oxygen into carbon dioxide, water and heat

Large bales are susceptible to greater storage losses and risk of spontaneous heating than small bales formed at the same moisture.

Large bales

- Higher density
- More volume
- Less vapor routes

Small bales



Bale Characteristics

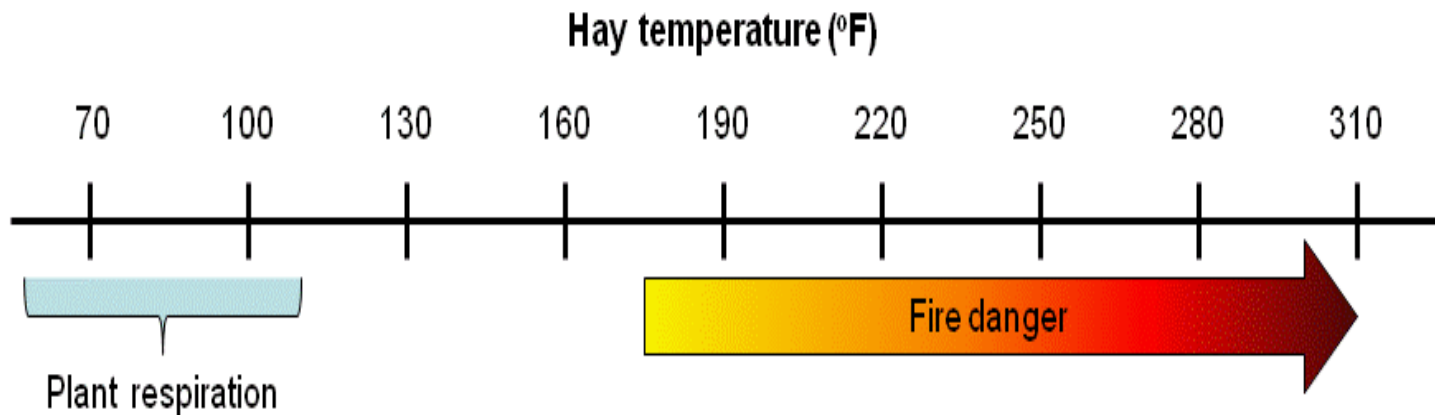
Characteristic	Small	3-string	Mid-size	Large	Round
End size (in)	14 x 18	15 x 22	32 x 32	48 x 48	72
Length (in)	38	44	96	96	60
Volume (ft ³)	5.5	8.4	56	112	141
Weight (lb)	60	130	900	1800	1900
Density (lb/ft ³)	8-11	15	14-16	14-16	10-13
Max moisture (%)	20	18	16	15	18

Heating

- All hay baled at moisture contents above 15 % will undergo some elevation in temperature in the first 1-3 weeks following baling.
- “Sweating”
- Due to plant respiration and microbial activity.
- Hay at 15 to 20 % moisture content will heat enough to cause measurable dry matter losses (4 to 5 %).

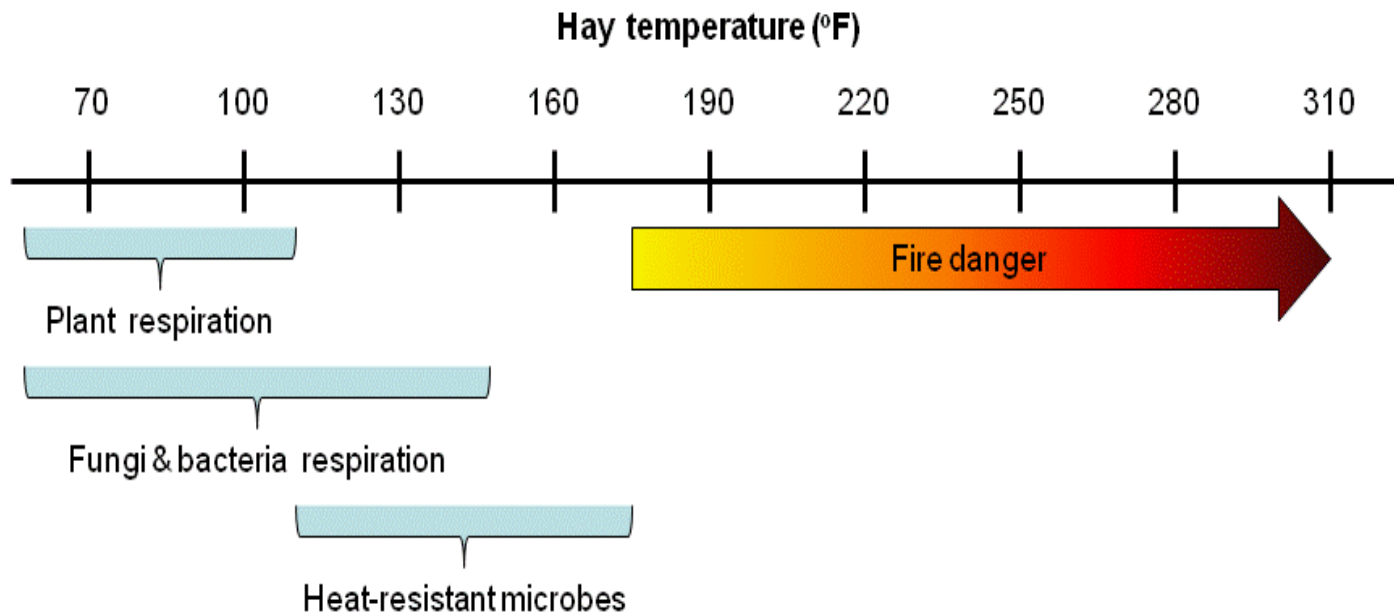
Normal Heating in Baled Hay

- Sugars are respired to yield carbon dioxide, water, and heat.
- Temperature may reach 100 degrees F or higher.



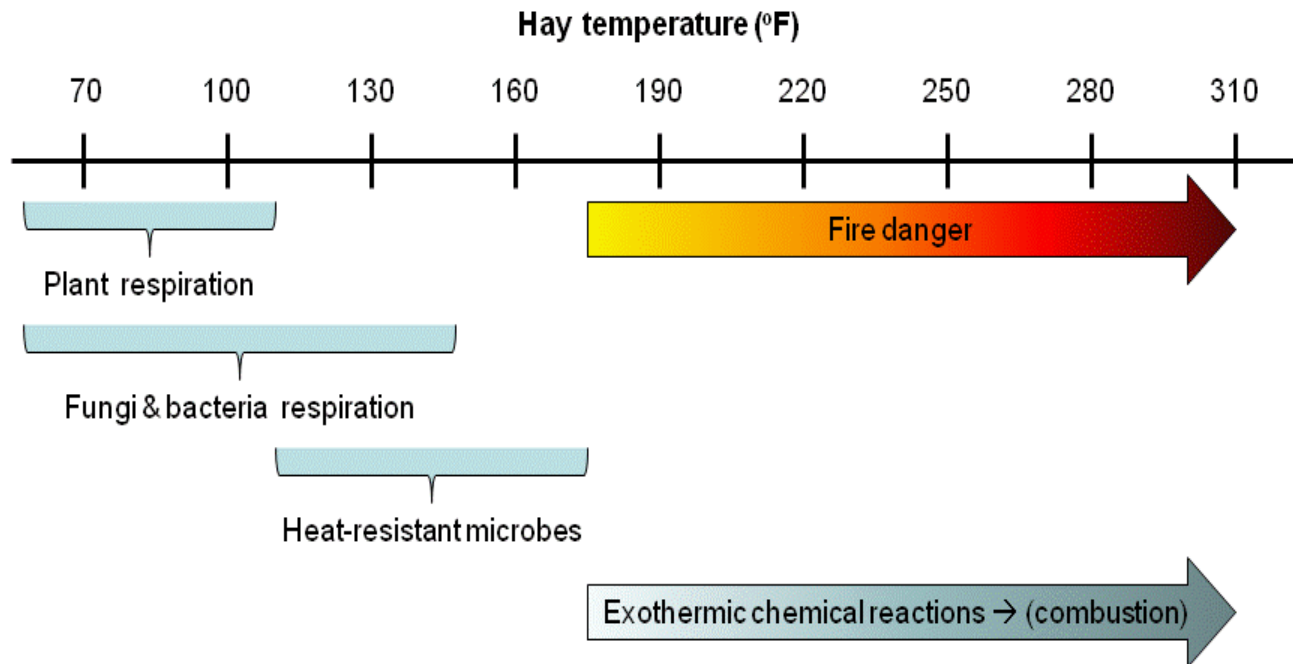
Secondary Storage Heating Hay

- Microorganisms continue to respire and heat accumulates faster than it dissipates.
- Temperature may reach 160-170 degrees F.



Exothermic Heating

- O₂ combines with highly oxidizable material produced during secondary heating.
- Temperature will rise to the kindling point if enough O₂ and moisture are present to generate heat faster than it escapes.
- Process starts at about 130°F and may reach 190°F when the situation becomes critical.



- Since heat movement in dry hay is slower than in moist hay, the movement of heat from the center to the outside of the bale slows down as the surface layers begin to dry.
- This causes the internal bale temperatures to increase rapidly after much of the surface moisture appears to have been removed.

Spontaneous Combustion

- Caused when respiration and microbial heating raise temperatures greater than 170° F.
- However, when spontaneous combustion occurs, it does not originate in the center of the bale, but nearer the outside, because oxygen levels in the middle of the bale are usually too low for combustion to occur.





28% ADF

46% ADF

Steps to Reduce Hay Fires I

1. Record day of cutting and drying conditions in a journal.
2. Monitor windrow hay moisture prior to raking, tedding, and baling
 - a) Use a tactile (feel) method to evaluate hay moisture
 - b) Use a windrow moisture device appropriate to simulate the bale density that electronic moisture probes are designed for

Measuring Moisture

- 12 samples may be adequate in forage with uniform dryness



Sampling the Moisture Content of Alfalfa in the Windrow: A New Tool Helps

Ron Thiemert and Glenn Shewmaker

Introduction

The production of high quality hay is vital for the dairy industry and provides revenue to the forage producer. The determination of forage moisture content in the windrow is often a neglected but critical step in the preservation of high quality hay.

Knowing the accurate moisture level of the forage windrow is the key to preserving a high quality product for marketing. This Publication:

- emphasizes the importance of windrow moisture,
- defines the relationship between bale

Dew moisture on the outer surface of the stem and leaf is caused by the relative humidity and condensation. Dew moisture is rapidly removed by sunlight or a light breeze and usually only remains for a few hours each day. It is important to recognize the moisture level in windrowed alfalfa at baling time because high moisture levels will cause molding in the stored product, and, in many instances, internal combustion and hay stack fires.

Relationship of bale size, moisture levels, and other quality factors

bale, which had been baled with moisture content higher than 20 percent. The green, leafy alfalfa hay in the outer edge of the bale retained its original supreme quality. (Supreme quality is defined as having less than 27 percent ADF and greater than 22 percent crude protein. It is important that ADF be less than 30 percent because higher values indicate a lower digestibility level than a lactating dairy cow requires.) The interior of the bale was dark-brown-to-black in color, a result of the browning reaction from heat caused initially by microbial respiration.

High moisture and high density of the bale promote microbial growth. The

Windrow compaction tool



The compaction tool simulates the density of a large bale



Method	Sample size	Testing time	Typical error
	(grams)		(%)
Microwave oven	50-200	5-15 minutes	-2 to +1
Electronic probe	Bale or windrow	1 minute	±5
Convection oven	10-1,000	5 hours – 3days	±1
NIRS	0-40	1 hour	±3

Steps to Reduce Hay Fires II

3. Record the day of raking, tedding, inversion, and baling and drying conditions.
4. Test first 3 bales from a field with a hand-held electronic moisture probe in 2 places on each side or end of bale (total 12 readings) and note the low, high, and average.
 - If the average moisture is below the maximum for the type of bale and forage, continue baling.

Steps to Reduce Hay Fires III

5. Observe the baler moisture meter if available, and/or the bale pressure indicator: when anything changes, get out and retest more bales as in #4
6. Record date, time, weather conditions, and moisture average and range in your journal

Steps to Reduce Hay Fires IV

7. **Mark** any bales with higher moisture than desired, and **notify** the person stacking the hay to place those bales **separate** from the dry bales with space between bales to facilitate air movement and drying. Try to feed these bales as soon as possible.
 - Do not store any bales with moisture over the recommended level for the type of bale in a large stack or hay shed!

Steps to Reduce Hay Fires V

8. Review and comply with your carrier's requirements for fire insurance coverage.



Photo from Kittitas Co Fire Marshall

Steps to Reduce Hay Fires VI

9. If moisture is marginal, stack the bales in a single column with no more than 500 tons per stack with at least 100 feet of separation to another stack.
 - Layout the stack so it can be quickly broken apart with a loader.
 - Avoid mixing different lots of hay
 - Monitor the moisture and temperature, if the moisture is marginal, in the stack at about 20 random or systematic locations.

Steps to Reduce Hay Fires VI

10. Obtain a bale core sample, double sack the core sample in 2 zip-lock plastic bags, and submit it to a NFTA certified lab for moisture and forage quality analysis.

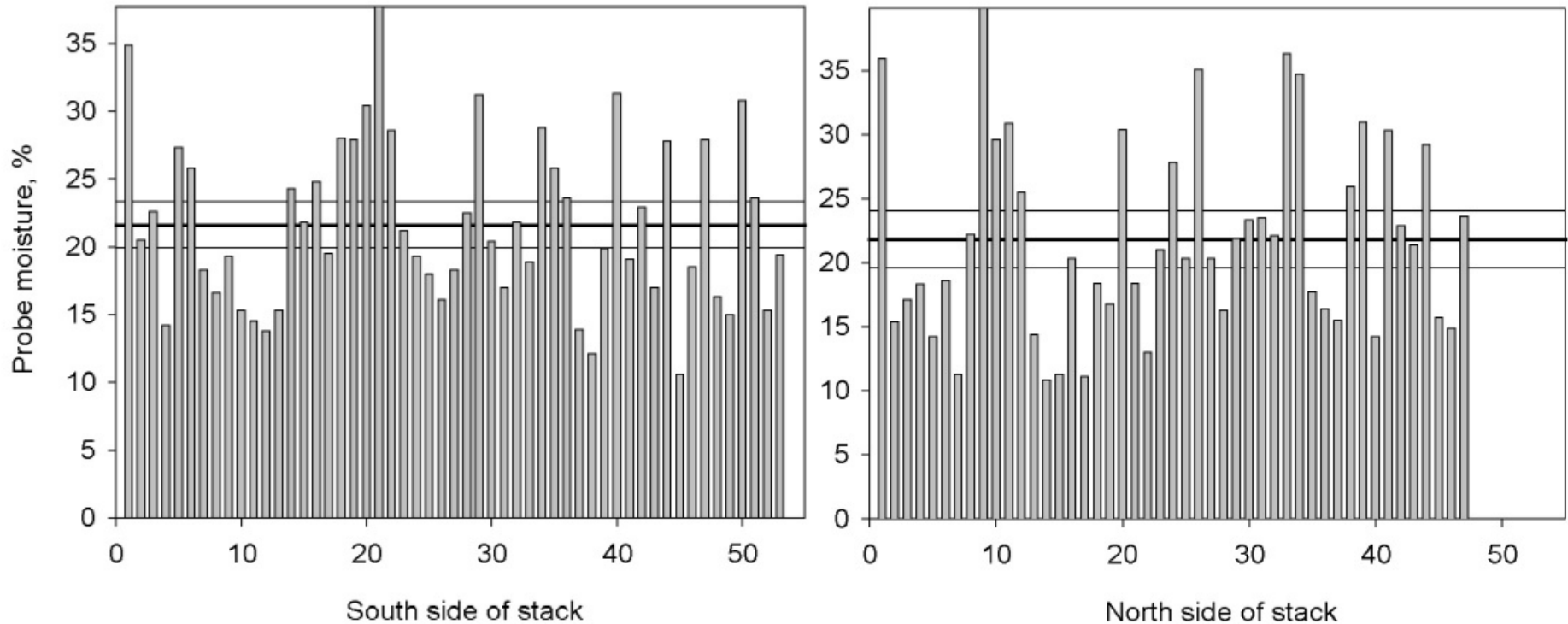


Steps to Reduce Hay Fires VII

11. Protect the stored hay from external weather and water flow by elevating the base and having adequate rain gutters to direct flow of water away from the stack.



Problem: Moisture Sampling in the Stack



	<u>South</u>	<u>North</u>
Mean	21.62	21.81
Std Dev	6.12	7.56
Std Err	0.84	1.10
95% Conf	1.69	2.22
99% Conf	2.25	2.96
Min	10.6	10.8
Max	37.7	39.9

Student's T test

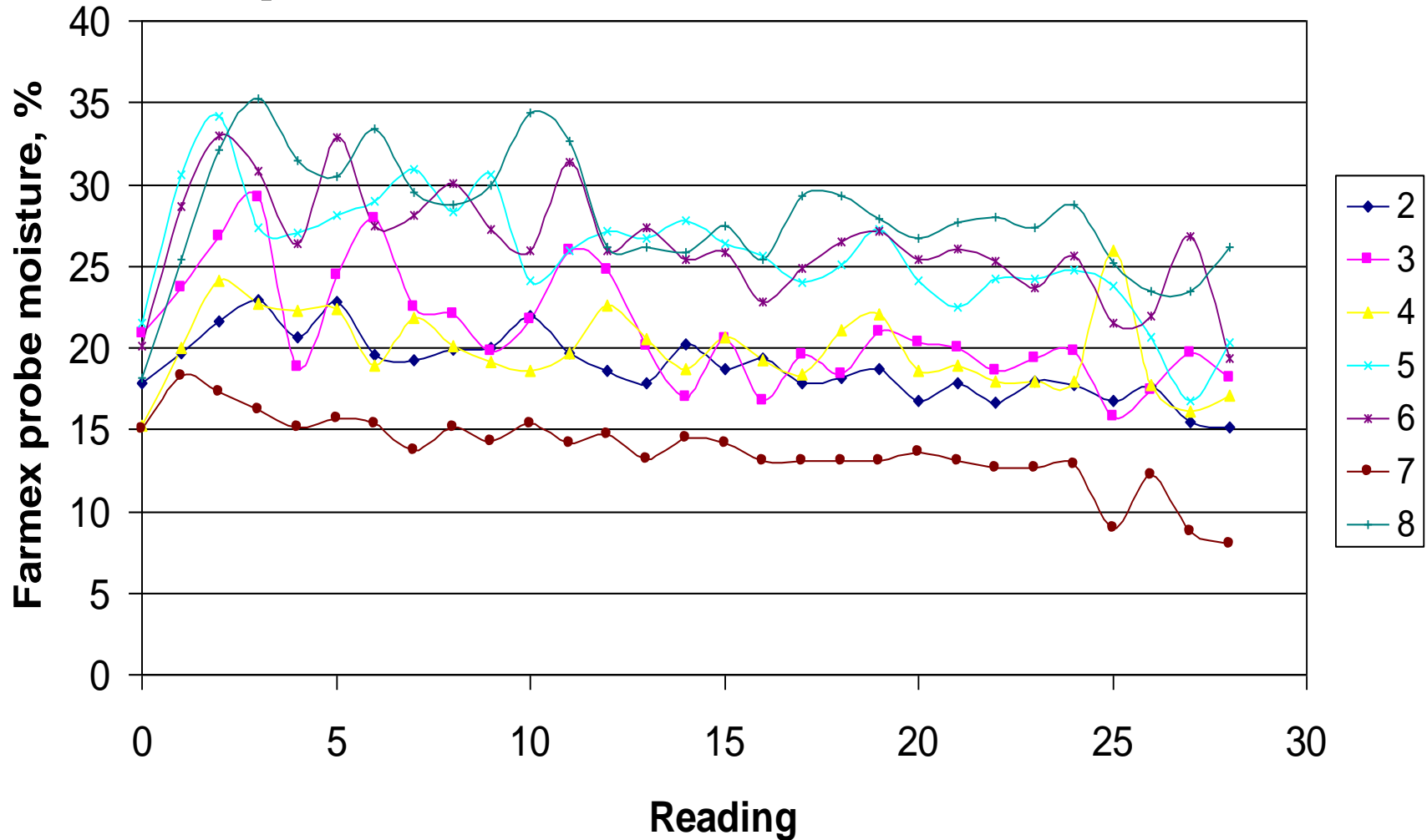
T value = 0.0029

P value = 0.997

Degrees of Freedom = 46

North vs South is not significant

Sequential Moisture in 1-ton Bales



CONCLUSIONS

- Monitor forage moisture in the windrow, bale, and stack or silo.
- Moisture is not usually uniform.
 - Mark high moisture bales and feed soon!
- Monitor bale temperature.
- Stack hay so moisture can escape, and you don't burn up the whole thing!

CONCLUSIONS

- Drying ovens and NIR instruments tend to be more accurate than electronic conductance moisture testers
- Results can be affected by many factors
- The electronic probe is not a "magic box", but a tool to estimate moisture.

CONCLUSIONS

- Take Numerous Random Samples (12-20)
- The electronic probe has the advantage of allowing for many samples done quickly.
- A basic protocol should be followed, but in the end, each farmer uses the moisture tester, based on his own experience, to produce quality hay with the management and equipment he uses.





