Harvest timing and moisture determination: Forage Drying Rates and Moisture Probe Accuracy

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Introduction

Scott County Kentucky currently has a beef cattle herd of 28,509 head (USDA, 2017). These cattle utilize forage as a large part of their diets. Baleage is bales of wilted, high moisture forage which have been wrapped in several layers of UV-resistant plastic and allowed to ensile like traditional chopped silage (Henning et al., 2021). Baleage has become another way for farmers to harvest and store forage to be used in cattle diets. It has some advantages over the traditional hay production in Kentucky. One advantage is it can be harvested, baled, and stored in a shorter period of time, which is ideal with Kentucky's weather conditions. Baleage keeps a higher level of forage quality over time, unlike hay when it is loses nutrients through the drying process. Producers are still learning about best practices in producing baleage for livestock. If done incorrectly it can cause issues with storage, forage quality, spoilage, and even cattle death.

When talking with farmers in Scott County about making baleage, the most common question I get is "When do I need to bale my forage for baleage?" This question is difficult to answer because there are many factors that go into drying down forages. Furthermore, when going through producer baleage data for a class project there was a wide range of moisture contents in which producers had baled their forage for baleage. With this in mind, I thought conducting a study forage drying rate would be practical in aiding farmers to produce good quality baleage. I wanted to get an idea as to how different forages dry down. Since I was already going to be out in the field collecting data on true moisture content of forages, I thought adding a test to check the accuracy of commercially available moisture testers would be beneficial.

My research question was, "How long does it take for different forage types to reach a moisture content of 60% after cutting and how accurately does a commercial moisture tester reflect this process." I picked 60% moisture content because it is the top end of the 40-60% moisture content range recommended for baling baleage (Henning et al., 2021).

Methodology

The study required that we collect quantitative data to help assess drying rates for different forages. Data that was collected included forage moisture content, weather conditions, and producer practices. The moisture tester in this study was an agraTronix windrow moisture tester (agriTronix^{TM} part number 07140, https://www.agratronix.com/product/windrow/) advertised to measure moisture content from 13 to 70% with +/- 2 to 4% accuracy. The probe was utilized according to manufacturer recommendations.

Data collection procedures:

a. Identify producers willing to allow data to be collected on their forage during cutting and baling.
b. Record producer details that include information on equipment used, cutting, baling, wrapping, and forage conditions.
c. Start sampling forage at cutting and then at two-hour intervals until forage is baled. If forage is not baled within the same day, stop sampling at 6:00pm and start back at 10:00am until the forage is baled. Conduct four replications across the field at each sampling time.
d. Record time at start of replication.
e. Collect weather data from the location using handheld weather station or by collecting from a nearby weather station if handheld device not available.
f. Collect forage from one windrow location and follow moisture tester protocol to get estimated moisture content of forage. Use a scale to ensure adequate down pressure during the test. Record data.
g. Place at least a third of the forage from the bucket into large paper bags and record fresh weight of bag plus forage. Record empty weight of bag separately.
h. Repeat steps d through g until four replications are completed.
i. Take samples to UK Spindletop Research Farm for drying in forced air ovens.
j. Record dry weight after four days or when samples are dry.
k. At baling, select five bales at random and estimate moisture content using bale moisture probe. Record data.
l. From same five bales, take two core samples from each bale and place in small paper bag and get a gross weight. Record empty weight of paper bag. Take sample to forced air dryer and record dry weight after four days.

Results

When putting pen to paper, it was interesting to see how the results came together. First, we will start with the drying times of the three forages sampled. Before we dive into the graphs, it would be best to go over what the graphs display. The X axis represents the time after cutting in hours, the Y axis indicates moisture content in percent. Each dot represents the average of four replications at each time period. The time starts at zero, or cutting, and continues until baling which will be the last dot on the graph. The red bars indicate the start of a new day. The dotted line is the drying curve for the forage.

Sorghum-sudangrass Drying Time (Figure 1): This sample started with a very high moisture of around 87%. This may have been because of dew on the ground the morning of cutting. As we go along, the drying rate was at a slow place. It took the forage around 50 hours to reach a moisture content of 60%.

Forage Soybeans Drying Time (Figure 2): The forage soybeans were able to achieve 60% moisture content around the 17-hour mark. There was a big variance in moisture at the four- and six-hour samples. It is believed that this could have been caused by taking too much sample from the top of a windrow (hour four) and then too much sample from the bottom of a windrow (hour six).

Alfalfa Drying Time (Figure 3): This graph may look a little different because this alfalfa was made into dry hay, thus the sampling continued up until baling. The alfalfa dried down relatively fast compared to other forages. It reached a moisture content of 60% at around hour five to six. This alfalfa could have been baled the same day it was cut if it was to be harvested as baleage. Another observation is that rewetting occurred overnight with alfalfa. This is indicated by the first sample of a following day being wetter than the last sample of the previous day.

We then move on to look at the comparison of true moisture content versus how the commercial moisture probe measured moisture. When looking at these graphs it is important to note which line represents the true moisture content, listed as "Average MC" on legend, and which line represents the commercial moisture probe, listed as "Tester Average" on legend.

Sorghum-sudangrass Moisture Probe Graph (Figure 4): When looking at this graph, there is a stark difference between the true moisture content (blue line) and moisture tester (orange line). Looking at the two data sets and lines, the moisture tester is consistently measuring moisture content around twenty to twenty five percentage points drier. When looking at individual samples, the tester was sensitive to changes over time. For instance, from hours 23 to 27 there was a decrease in moisture content only to be followed by an increase in moisture content sample at hour 29. The moisture content saw this same pattern when testing but was about 25 percentage points drier at each sample time.

Forage Soybeans Moisture Probe Graph (Figure 5): This graph showed the same tendencies as the sorghum-sudangrass graph. The moisture tester measure moisture consistently twenty to twenty five percentage points lower than the true moisture content. Also, the tester was sensitive to the moisture changes from sample to sample.

Alfalfa Moisture Probe Graph (Figure 6): Note that in this graph, the tester data is now the blue line (Tester Average in the legend), and the true moisture content is the orange line (Average Moisture Content in the legend). With alfalfa, the tester still did not show good accuracy on wet forage. On day one, we saw the moisture tester reading between five and twenty percentage points drier than measured moisture. Interestingly, the drier the forage, the more accurate the moisture tester results. Day 2, showed closer agreement between the tester and actual moisture, as all samples were within five percentage points of the true moisture content. On day 3, there was an outlier value for the tester on the first sample, but the next two samples were very close to actual moisture.

Conclusions

Utilizing the first half of the research question "How long does it take for different forage types to reach a moisture content of 60% after cutting…", it was determined that alfalfa was the quickest forage to dry down to a moisture content of 60%. It took the alfalfa around five to six hours to achieve that threshold. On the opposite end of the spectrum, sorghum-sudangrass was the slowest to dry down taking around fifty hours to reach a sixty percent moisture content.

When we look at the second half of the research question, "how accurately does a commercial moisture tester reflect this process" we saw some big variances. There were large differences of the moisture tester reading and the true moisture content. The biggest differences were in wet and thick stemmed forages, such as sorghum-sudangrass and forage soybeans. It did show more accuracy on the alfalfa and especially as the forage reached around fifty percent moisture content. The lack of accuracy of the tester on thick stemmed forages could be due to the inability to compress the forage enough to get a true reading on the moisture tester. Moisture tester instructions indicate to take a reading after tightly filling a bucket with forage and then inserting the tester, maintaining 40 pounds of down pressure. This protocol was followed with all measurements in this study. The finer stemmed alfalfa was much easier to compress and handle in the bucket. But even with alfalfa, the tester read significantly drier than actual moisture at the higher end of the range.

One last conclusion that came from the study was that there were large variances in moisture from the top to the bottom of a windrow. The top of the windrow was much drier compared to the bottom of the windrow. This was largely due to the fact that the forage was left in windrows and not tedded or re-spread during the drying process. Thus, the solar radiation was not able to penetrate the forage and dry the bottom of a windrow. In addition, the alfalfa windrows were much thinner than those of the sorghum sudan and the soybeans. Therefore, there would be less variation in moisture throughout when it was placed in the bucket to be measured. If the tester sample was pulled more from the top or bottom of the windrow, it could drastically change the moisture content of that replication.

For future studies, it would be beneficial to include other types of forages, as well as getting from earlier cuttings on cool season species such as small grains, orchardgrass and tall fescue, with and without clover. Another improvement for future work would be to better sample a windrow by collecting a whole portion of the windrow from top to bottom. This will alleviate the problem of grabbing too much from the top or bottom of a windrow that introduce error and variation in the moisture content reading.

Final thought: With these limited results, the baleage moisture tester used for this study was not accurate enough to assist producers in knowing when wilted forage was in the optimum moisture range for baleage. For all forages tested, the commercial tester returned moisture values that were much drier than actual.

References

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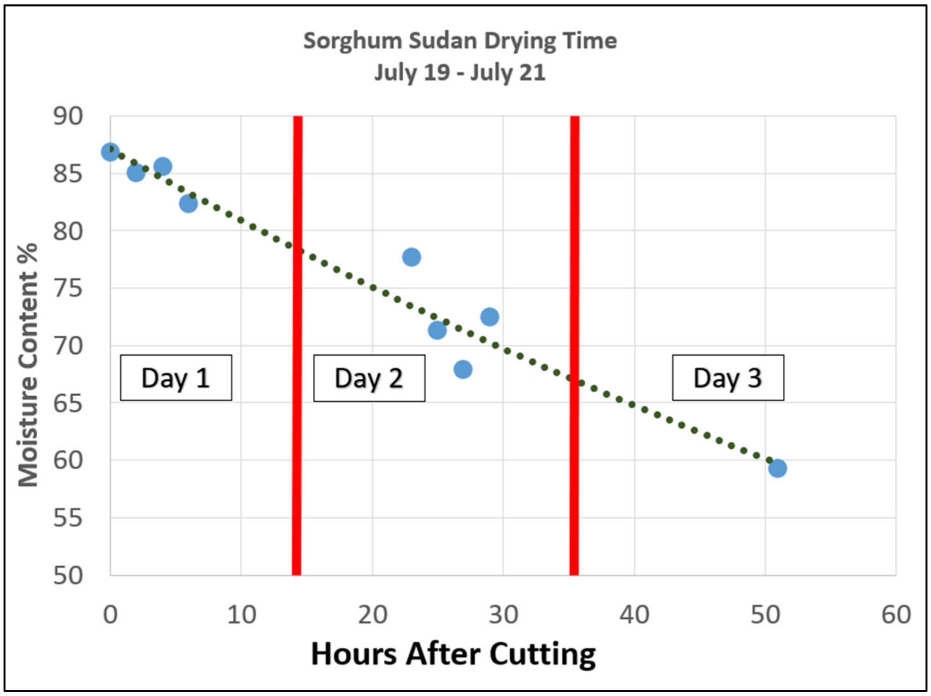

Figure 1. Sorghum sudan drying time. Red lines indicate the end of one drying day (midnight). Each data point is the average of four measurements. The last data point is from samples taken immediately after baling and represents a composite of 10 cores from five bales.

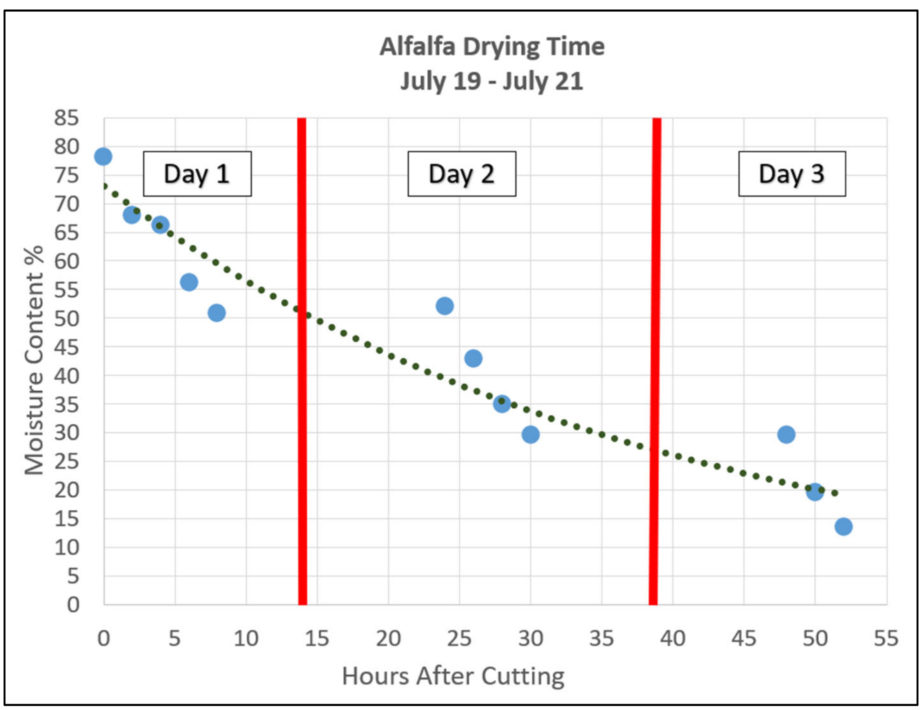

Figure 2. Alfalfa drying time. Red lines indicate the end of one drying day (midnight). Each data point is the average of four measurements.

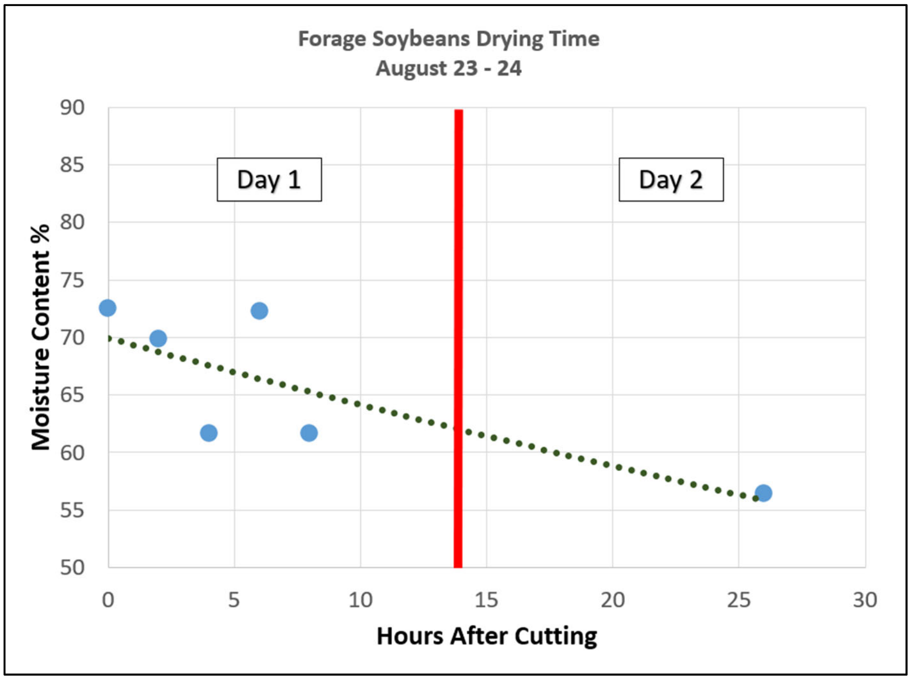

Figure 3.Forage soybeans drying time. Red lines indicate the end of one drying day (midnight). Each data point is the average of four measurements. The last data point is from samples taken immediately after baling and represents a composite of 10 cores from five bales).

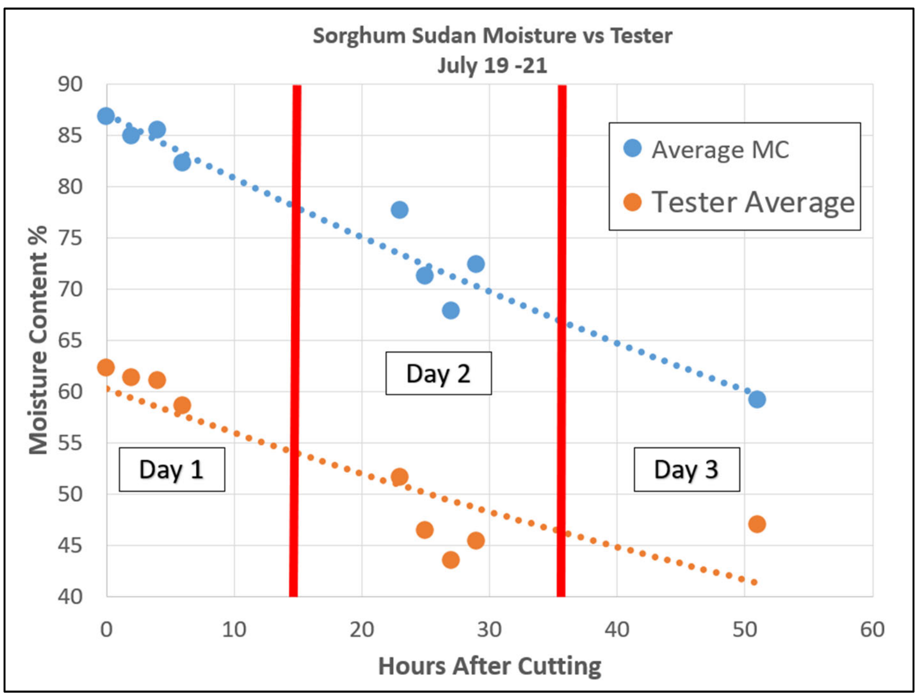

Figure 4. Sorghum sudan moisture measurement (blue circles) compared to moisture tester values (orange circles). All points are averages of four measurements. The last data point is from samples taken immediately after baling and represents a composite of 10 cores from five bales.

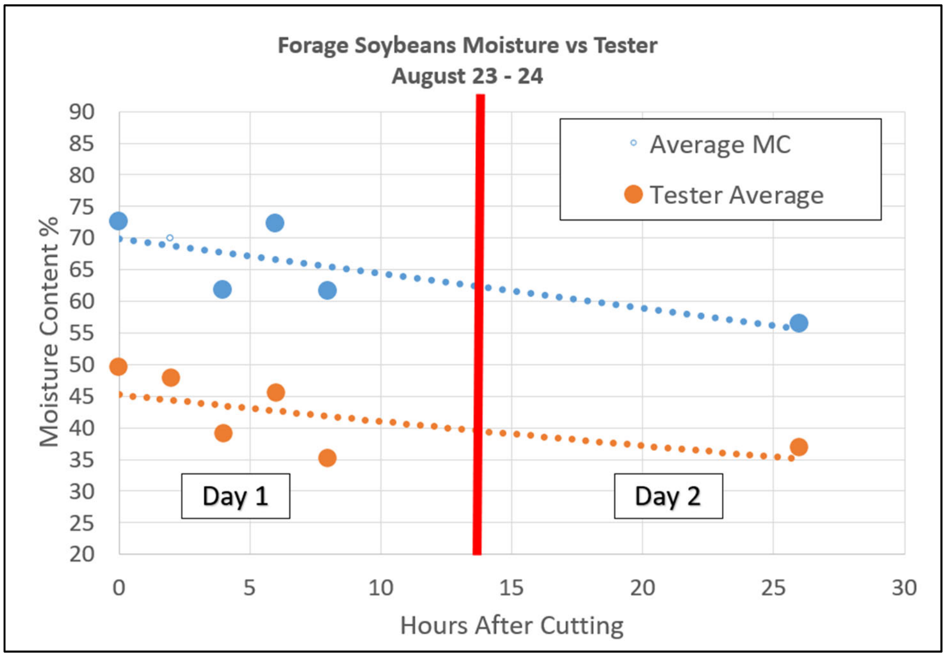

Figure 5. Forage soybeans moisture measurement (blue circles) compared to moisture tester values (orange circles). All points are averages of four measurements. The last data point is from samples taken immediately after baling and represents a composite of 10 cores from five bales.

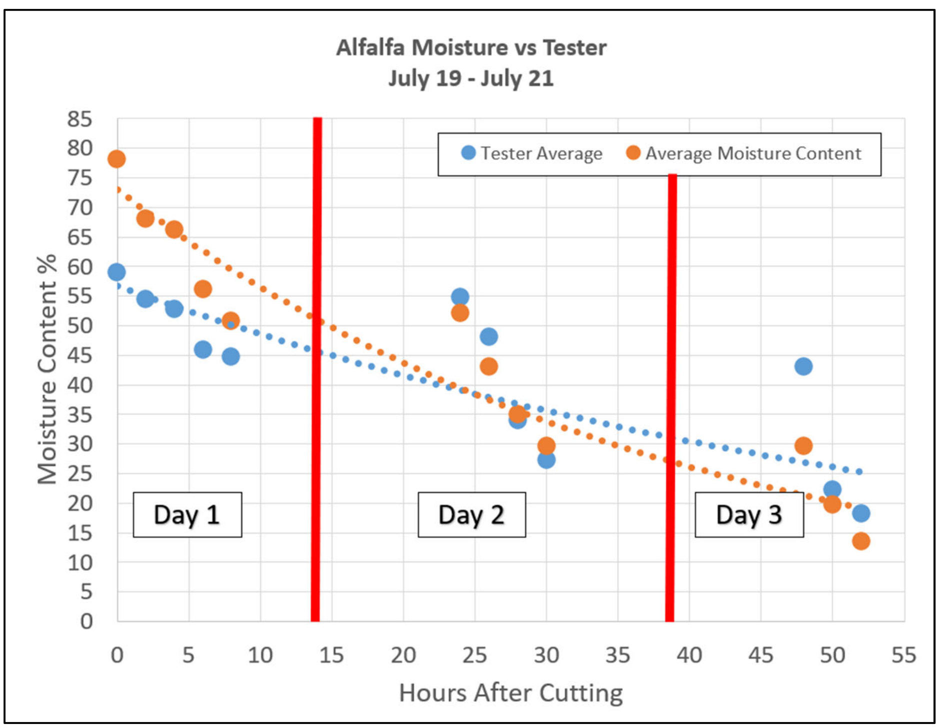

Figure 6. Alfalfa moisture measurement (orange circles) compared to moisture tester values (blue circles). All points are averages of four measurements.