Determining Forage Moisture Concentration

K·STATE
Research and Extension

Forages Series

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Producing high quality hay or silage requires forage to be harvested and stored at optimum moisture concentrations for each type of preservation. Forage used for hay should have a moisture concentration between 15 and 18 percent during baling. Forage used for silage should have a much higher moisture content – between 40 and 85 percent for proper ensiling.

When hay is baled at higher moisture levels it is subject to heat damage, dry-matter loss, mold spoilage, and fire. Hay baled at lower moisture levels is subject to increased baler, protein, and total digestible nutrient losses. Baling at the proper moisture level is especially critical to making high quality hay in large round and large square bales because moisture and heat dissipate more slowly than in smaller bales.

Recommended moisture ranges for ensiled forages are: 70-85 percent for direct-cut silage, 60-70 percent for wilted silage, and 40-60 percent for low-moisture silage. Higher than recommended moisture levels in silage increase the risk of butyric acid formation (foul odor) which reduces intake by livestock. Ensiling forage that is too high in moisture can increase dry matter loss, nutrient loss from seepage, and silo damage from silage effluent. When forage is ensiled at lower than recommended moisture levels the silage may undergo incomplete fermentation or be subject to heat damage and protein breakdown.

Accurately measuring forage moisture content requires the forage be oven-dried in controlled conditions. This is a time consuming process that is usually performed in the laboratory. However, a good estimate of forage moisture content can be made quickly and easily on the farm using one of three methods discussed in this publication – the hand method, measuring with a moisture tester, or drying in a microwave oven.

Hand Method

The hand method, also known as the grab or squeeze test, is a crude method for estimating forage moisture concentration. It also takes experience to perfect the technique and estimate the moisture content. To approximate the moisture content of hay, take a handful of forage, twist it tightly, and release. If the forage is brittle and falls apart (too dry), or stays wadded up and slowly untwists (too wet), the hay should not be baled. Hay that springs open and fluffs out upon release is at the right moisture content and is ready to be baled. If the hay is too dry, wait until either the early morning or the late afternoon to bale, when higher humidity and dew naturally increase moisture content. Baling forage with optimal moisture content will help reduce shattering losses.

The hand method can also be used to estimate the moisture content of forage to be ensiled. Take a handful of chopped forage, squeeze it into a ball, and release. Chopped forage is too wet to ensile if the ball stays together and too dry if it quickly falls apart. Forage that slowly falls apart is ready to be ensiled. Table 1 contains more detailed guidelines for estimating forage moisture concentration using the hand method.

Table 1. Hand method for estimating forage moisture concentration for silage.

Characteristic of forage for ensiling squeezed in hand	Moisture (%)	Condition
Water is easily squeezed out and material holds shape	> 80	Too wet
Water can just be squeezed out and material holds shape	75 – 80	Too wet
Little or no water can be squeezed out but material holds shape	70 – 75	Too wet
No water can be squeezed out and material falls apart slowly	60 – 70	Ready to ensile
No water can be squeezed out and material falls apart rapidly	< 60	Too dry

Moisture Testers

Two types of forage moisture testers are available commercially. One uses heat and the other uses electrical conductivity. Heat-type moisture testers consist of a heater/fan drying unit, a sample container with screen bottom, and a simple spring scale (Figure 1). You can determine moisture content by filling the sample container with a fixed amount of wet forage then drying the forage down to a constant dry matter percentage. The tester uses the weight difference between the wet forage and dry forage to determine the initial forage moisture concentration. Most heat-type moisture testers require 25 to 35 minutes per test to determine moisture content.

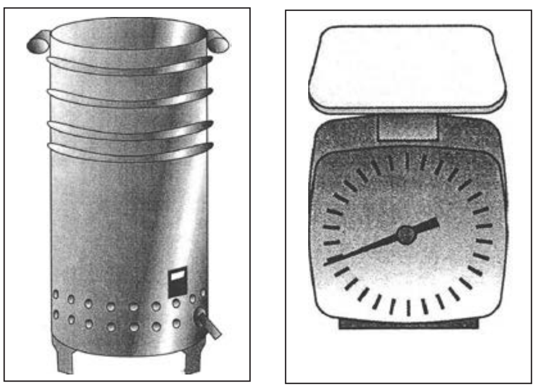

Figure 1. Heat-type forage moisture tester and scale.

Electronic conductance moisture testers provide an instant moisture content reading. Most electronic testers have a sensing probe and a hand-held display unit (Figure 2). The electrical resistance of the forage is measured between two metal contacts at the tip of the probe when inserted into the forage. Testers determine forage moisture concentration based on the relationship between moisture concentration and electrical conductivity.

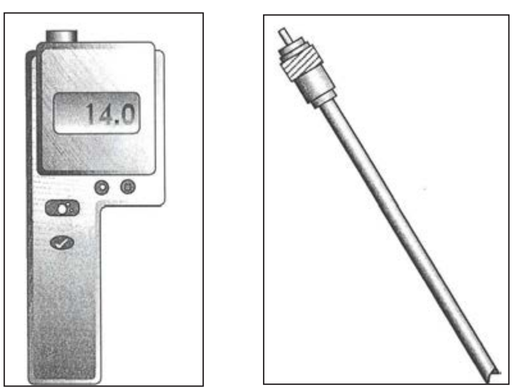

Figure 2. Electronic conductance moisture tester and probe.

Some electronic conductance moisture testers require several moisture readings per bale or windrow, then average the values to obtain a more consistent reading. Another type of electronic conductance moisture tester can be mounted on a baler to provide continuous moisture concentration readings during baling. Both electronic conductance and heat-type moisture testers work best for baled hay, and are not very accurate for determining moisture content of forages in a windrow.

Heat-type moisture testers tend to be more accurate than electronic conductance methods, but results can be affected by many factors, including the use of hay-drying agents and contact surface area between the probes and the hay. Either type of moisture meter can be purchased from agricultural suppliers for around $300.

Microwave Oven Method

The microwave oven method provides a reasonably accurate method to determine forage moisture in a relatively short time period (approximately 20 minutes). Although this requires more time than the electronic conductance meter, the moisture content measurement is much more accurate.

Before using the microwave oven method, assemble the following items:

- Microwave oven
- Scale (must weigh in grams)
- Microwave-safe plate
- 10- to 12-ounce cup of water (a coffee mug works best)
- Pencil and paper

Use the following procedure for best results:

1. Gather a representative forage sample (whole plant material).
2. Cut the sample into 1-inch pieces; keep leaves and stems uniformly mixed.
3. Place a paper towel on the plate.
4. Weigh the plate and record it as "plate weight".
5. Add approximately 100 grams of the forage sample to the plate; spread the sample as uniformly as possible.
6. Weigh the plate with the forage sample and record it as "initial weight".
7. Place the cup of water in the corner of the oven to capture unabsorbed microwaves as the plant tissue dries.
8. Place the sample on the plate in the center of the oven.
9. Set the oven on HIGH for 3 minutes* and "cook" the sample.
10. Remove the sample and plate, weigh, and record the weight.
11. Change the water in the cup to prevent the water from boiling over.
12. Set the oven on HIGH for 2 minutes* and "re-cook" the sample.
13. Remove the sample and plate, weigh, and record the weight.
14. Repeat steps 7 through 10 until the weight does not change more than 1 gram (this means the sample is dry); record as "final weight".
15. Use the following equation to determine the percent of moisture of the forage sample:

$$\text{Percent moisture (\%)} = \frac{(\text{Initial weight} - \text{Final weight}) \times 100}{\text{Initial weight} - \text{Plate weight}}$$

***Make sure to heat samples in short intervals to prevent the forage from igniting.**

Summary

Baling or ensiling forage at the proper moisture concentration can provide high quality feed and reduce both harvest and storage losses. Forage moisture concentration can be quickly estimated on the farm using one of three methods: the hand method, electronic moisture testers, or the microwave oven method. The hand method is fast, but provides only an approximation of forage moisture concentration. The heat-type moisture tester provides an adequate estimate of moisture concentration, but requires up to 35 minutes for operation. The electronic conductance-type moisture tester provides an instant reading, but is often less accurate than the heat-type tester. The microwave oven method requires approximately 30 minutes and provides relatively accurate results. Regardless of the method, use a good representative sample of the forage for the most accurate results.

Additional Information

Forage Moisture Concentration: *Forage Moisture Determination* – NRAES-59

Silage and Hay Preservation: *Silage and Hay Preservation* – NRAES-5

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