Practical and Economical Ways to Increase Alfalfa Hay Drying Rates

Michael Collins
Department of Agronomy
University of Kentucky

Introduction

Hay stores well for long periods and is better suited to cash sale and transportation than silage and remains the most popular method for harvesting the alfalfa crop. Rapid drying reduces field losses by reducing respiration and by reducing the incidence of rain damage during curing. Because of these factors, harvest losses are greatest for very dry forage and are low for very wet material like direct cut silage. However, the latter is subject to excessive storage losses due to seepage and to quality deterioration. Storage losses are generally minimized by harvesting at low moisture levels.

The Drying Process

When plants are growing, it is to their advantage to limit moisture losses. They do this in several ways. The outer surface of plants is covered with a waxy layer called the cuticle. The cuticle is very effective at limiting the loss of water. The great majority of water that plants use when they are intact and growing moves out through pores called stomates in the outer layer. Stomates can be opened or closed as necessary to control the movement of water and gasses from the plant. Stomates are found mostly on the leaves and although they are very numerous, cover only 1-2% of the total surface area. These well developed systems for restricting the loss of water in growing plants cause problems in obtaining fast hay curing. Due to all of these factors, moisture loss during hay curing has to distinct phases. The first and the most rapid phase covers the first 20% or so of the total drying time but accounts for up to 75% of the total water loss. During this phase, water is lost from leaf surfaces and through open stomates. British research indicates that after moisture concentration reaches about 60%, the stomates close and drying rate slows drastically. Moisture is also lost through the cut ends of the stems but this is not very effective. Mechanical conditioning is effective because it physically breaks this cuticle layer which allows additional water loss through this otherwise nearly waterproof layer.
Environment strongly affects hay drying. High levels of solar irradiance, low humidity levels and wind speeds of 10-15 mph are desirable. The data shown below illustrate the impact that differences in relative humidity can have on the time required for hay curing. The curing times shown are hours of daylight and do not include the dark period when no drying occurs. We can take advantage of all the sun that is available by making the swath as wide as possible, covering 75% or more of the surface area. If the soil is wet, it may be best to make a slightly narrower swath to let the bare area dry and then turn the hay after it dries on top.

Solar Radiation

About 20% of the incident solar radiation is reflected back into the atmosphere; the remainder is absorbed and aids in the evaporation of water. The sunshine intercepted by plants is dissipated mainly either by heating the forage material or evaporating water. However, the sun’s radiation does not really penetrate very far into the hay windrow or swath. It has been estimated that less than one-half of the radiation penetrates beyond 1 inch depth. This is a major reason for the emphasis placed on maintaining the maximum swath surface area during drying. This increases the proportion of the forage mass that is affected by the sun’s rays. Temperatures on the surface of a mowed swath may be as much as 40°F higher than that of the surrounding air on a sunny day.

The layer of air nearest the plant surface is called the boundary layer. The air nearest the surface of the alfalfa is more humid, and the air further away is less humid. Mixing this humid air with the surrounding, less humid air, improves drying because the moisture in the hay can move more readily into drier air. The presence of a roughness layer, such as plant hairs, increases the thickness of the boundary layer and reduces turbulence. We now believe that this may be one reason red clover hay dries more slowly than some other species, especially if it is not conditioned well.

A good way to visualize the impact of weather on hay drying is that weather sets upper limit for how quickly a crop can dry. Other factors, such as forage species, mechanical or chemical conditioning etc. determine how close we come to achieving that potential.

Mechanical Conditioning

Mechanical conditioning hastens drying by physically breaking the cuticle layer discussed previously. This helps to defeat the plant’s tendency to retain the water it contains. Mechanical conditioning is considered to be an effective way to improve the drying rate of all types of hay. In some cases, a good job of conditioning may actually halved the time required for hay curing.
Just after mowing, drying occurs primarily at surfaces exposed to the atmosphere and, thus, exposed to solar radiation. The humidity level within the swath is probably near 100% just after cutting, but as drying proceeds the humidity within the swath declines and eventually approaches levels in the outside atmosphere. Increasing surface area by making a wide swath helps to intercept more sunlight and hastens drying. Swath structure, and thus drying rate, may be adversely affected by severe crushing treatments due to increased difficulty in achieving and maintaining a low density swath. Tedding may aid in maintaining a loose structure and maximum surface area. Tedding should be done shortly after mowing or early enough in the day that some moisture remains in the leaf to prevent excessive losses.

Under high humidity, relatively cool conditions, hay does not dry as rapidly as under low humidity high temperature conditions. A good corollary is found in the way in which tobacco leaves become moist and pliable under high humidity conditions. Likewise, under high humidity conditions hay may not by able to reach the 20% moisture level recommended for baling dry hay regardless of the time spent in the field. At a relative humidity of 80% alfalfa would not dry below 25 to 27% moisture. It is because of this problem and in order to reduce the likelihood of rain damage that alfalfa hay is sometimes baled at moisture levels above 20%. Our data comparing alfalfa hay storage in round and rectangular bales indicates that for storage without heat damage, alfalfa in round bales should be slightly drier (18% moisture) than similar alfalfa in rectangular bales.

Chemical Desiccants

Potassium carbonate and sodium carbonate may be applied as a water solution to hasten hay drying. Legume hay benefits more from the application of these desiccants than grasses. Success with chemical desiccants is greatly affected by the achievement of good distribution of the material over the alfalfa stems. This requires 30 gal/acre or more of material per acre. The need for such a large volume of water for best application of these materials has been an important factor limiting their adoption. Research is under way with lower-volume alternatives for applying the chemical desiccants.

Potassium carbonate ($K_2CO_3$) has been widely studied in recent years as a chemical conditioning agent to hasten hay drying. This material as well as related compounds like sodium carbonate increase drying rate when applied in water solutions at the time of cutting. Apparently they act in some way to render the cuticle layer less restrictive to water movement. Field research with potassium carbonate in recent years indicates that the response is greatest on cuts other than the first and under conditions of lower rather than higher humidity. The latter situation is not surprising since we depend upon the air surrounding the hay swath
to remove hay moisture. If this air is already near its moisture holding capacity, moisture moves out of the hay less rapidly.

Tedders

Tedding hay after it has been cut mixes the crop to break up clumps of forage and distributes the crop over the entire surface area. Distribution over a greater surface area increases interception of sunshine, leading to more rapid drying. Research indicates that tedding can increase hay drying rates by 20-40%, possibly reducing the curing period by one day. The initial tedding can be done after a brief wilting period following cutting. Clumps of forage seem to break up more effectively after 2 to 4 hours of wilting than immediately after mowing. To avoid excessive leaf loss from legumes like alfalfa, tedding should not be done when the leaf component is brittle. Tedding causes the loss of some dry matter, between 3 and 10% or so, depending upon the moisture content of the leaf component. Tedding can also be done after the first day as long as it is done before the leaf dries out.