METHODS OF ACCELERATING THE HAY DRYING PROCESS

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Abstract: Proper alfalfa harvesting is essential, as significant yield and quality losses can occur from poor harvesting practices. Rapid uniform curing of alfalfa is highly desired. Curing is a two phase process, the initial rapid curing phase where water is lost through pores (or stomates) and cut stems, and the slow second phase where moisture is lost through the waxy cuticle on the surface of plants. Management practices are available which can accelerate both phases of the curing process while minimizing losses that can occur during curing. Such practices include mechanical and chemical conditioning, wider windrows, and raking at the proper moisture content.

Keywords: Alfalfa (Medicago sativa), Harvesting, Swathing, Windrow width, Raking, Curing.

INTRODUCTION

When compared with other crops, alfalfa is one of the most difficult and exacting crops to harvest. If alfalfa is not harvested properly, significant losses in both yield and quality can result. There is an increasing amount of interest in maximizing hay quality primarily through variety selection and cutting the alfalfa at more immature growth stages. However, efforts to maximize quality with these production practices can be nullified if the alfalfa is not harvested using proper harvesting techniques or when weather conditions are less than optimum.

Alfalfa harvesting involves cutting, moisture reduction, and consolidation for storing. In the case of baled alfalfa hay, this means swathing, curing, raking, baling, and roadsiding. The goal of alfalfa harvesting is to cut the alfalfa at the proper growth stage for the optimum combination of yield and quality and to maintain quality and minimize losses through rapid curing and timely raking and baling.

THE DRYING PROCESS

One of the most critical aspects of the harvesting process is the hay curing phase. Dry matter losses occur everyday the hay is left in the field curing and the likelihood of rain damage and bleaching increases proportionally. The moisture content of growing alfalfa is generally between 75 and 85 percent, but may be as high as 90%. In other words, to produce one ton of hay at 20% moisture requires the extraction of seven tons of water from eight tons of fresh forage. To evaporate this quantity of water requires 15,000,000 BTU’s of energy. The drying
rate of cut alfalfa is dependent upon several environmental variables. Such variables include solar radiation, temperature, relative humidity, soil moisture content, and wind velocity. Research in Michigan and California has indicated that solar radiation is by far the most significant environmental factor influencing drying rate.

The objective of the hay producer is to utilize management practices that accelerate the drying rate within the confines of uncontrollable environmental conditions. To determine which management practices would be most effective, it is helpful to understand the drying process. This process has been summarized in an article by Dougherty.

Drying of cut alfalfa is actually a complex subject and is determined by the resistance to water loss from the plant. The resistances of alfalfa to water loss can be defined as:

**Boundary layer resistance**: resistance related to the layer of still air close to the plant surface.

**Stomatal resistance**: resistance that is controlled by the pores on the surfaces of leaves and stems.

**Cuticular resistance**: the resistance of the plant surface to water movement.

Two distinct phases occur during the drying process of alfalfa. The first phase, or rapid drying phase, accounts for approximately 75% of the moisture loss that occurs in the curing process and requires only 20% of the total drying time. The stomates are wide open and moisture loss occurs from leaves through the stomata (or pores), and from water transfer from the stems through the leaves. Some water also departs through the cut ends of stems and through bruised tissue. The main limiting factor to the drying of the forage is the boundary layer, or layer of still air around the plant. Wind during this phase can accelerate drying by replacing the moist air in the boundary layer with drier surrounding air. The first phase is completed before the end of first day after cutting. The second phase, the slow drying phase, commences at about 60% moisture content, when the pores of the leaf and stem close. Stomatal resistance increases immensely and drying rate depends on cuticular resistance. Moisture loss is extremely slow in this phase of the drying process compared to the initial phase. In fact, the drying rate in this phase is 1/100 of the initial drying rate.

An understanding of the drying process allows us to develop management practices to hasten the drying process.

**Mechanical Conditioning**

Mechanical conditioning or crimping has become a widely accepted practice. Most conditioners lightly crush the forage between intermeshing rubber rolls located behind the header of the swather. Leaves dry considerably faster than do stems. The rationale for crimping is to crush and break the stems, facilitating water loss from the stem and bringing the
drying rate of stems more in line with that of leaves. Mechanical conditioning affects both phases of the drying process. It accelerates the rapid phase by cutting stems and it accelerates the slower phase by crushing the cuticle. Sometimes growers question the effectiveness of mechanical conditioning and wonder if the cutting operation could be simplified if the conditioning rollers were removed. However, data in the literature over many years have shown that mechanical conditioning does hasten the drying process. The amount of drying time saved with mechanical conditioning varies considerably depending on weather conditions and alfalfa yield.

**Chemical Conditioning**

Chemical conditioning involves the use of what is commonly referred to as a drying agent, usually potassium carbonate or a mixture of potassium and sodium carbonate. The chemical quickens the drying process by changing the water transmitting properties of the waxy cuticle on the surface of the plant, allowing moisture to exit the plant more freely. Thus, drying agents affect the slow second phase of the drying process. By in large, drying agents have not become popular in California, primarily because their cost and the relatively good curing conditions in most of California. Therefore, they are not believed to be cost effective under most situations in California.

**Swath Management**

It has been demonstrated in several California trials, and in numerous trials throughout the United States, that wider thinner windrows dry more rapidly than conventional narrow thick windrows. In the California studies, the advantage to wider windrows depended on the geographic area of the state, the time of year, and the yield. In general, wide windrows appeared to be most beneficial in the spring when yields were higher and day length was longer (more solar radiation). It is not uncommon for there to be at least a day difference in curing time between wide and narrow windrows. Wide windrows dry faster because the forage is spread out thinner and more of the alfalfa is exposed to radiant solar energy. Also, moisture movement is not as inhibited in a wide windrow as it is in narrow windrows. Wide windrows accelerate the first phase of drying by reducing boundary layer resistance. Not only do side windrows accelerate drying, they also improve the uniformity of drying. Timing of raking and baling is not limited as much by the average windrow content, but rather by the moisture content of the wettest portion of the windrow. Therefore, since the moisture content of wide windrows is more uniform, they could be raked or baled earlier.

There has been some reluctance to switching to wide windrows because of the fear that wider windrows will result in greater color loss from bleaching since more surface area is exposed to the elements. However, no significant color difference has been observed between wide and narrow windrows. Usually wide windrows are raked and baled sooner, so while more of the alfalfa is exposed, exposure time is reduced. Also, wide windrows are only left wide during the initial drying phase or until they have dried sufficiently to rake. Little sun bleaching occurs
during the initial phases of curing, as the waxy cuticle of the plant is largely intact. During the final curing phase, when most bleaching occurs, wide windrows would have been raked and combined and their width is essentially the same as raked conventional windrows.

Many growers have not switched to wider windrows because of equipment limitations, windrow width is confined by the width of conditioning rollers and windrow baffles. Some of the new swather designs have nearly full width conditioners and windrow width can be altered with a simple adjustment of a lever. Fortunately, windrow conditioner shields have been developed to spread windrow for other swathers. Figure 2 shows the plans for a windrow spreader to spread the windrow the width of the rear tires on a New Holland swather. The two side windrow baffles or shields are removed, the center baffle is lifted up, and the windrow spreaders are mounted on the conditioner housing. This design could be altered to accommodate other swather types. The angle of the baffles can be altered to form different windrow widths.

Raking

Most of the alfalfa hay in California is raked prior to baling. Raking expedites the drying process by inverting the alfalfa so that higher moisture content alfalfa on the bottom of the windrow is exposed to drying elements. Raking should be done at the proper moisture content or excessive yield and quality losses can occur. Many growers are raking the alfalfa when it is too dry. Figure 1 illustrates the losses that occur from raking at different moisture contents. The optimum moisture content for baling is approximately 50%. At this moisture content, a significant increase in drying rate is accomplished while severe leaf loss is avoided. Many fields are raked too dry. Twenty one percent of the leaves are lost when raking at 20% moisture content compared to only 5% when raking at 50% moisture. The greatest loss is in leaves which significantly reduces the quality of the hay since leaves are the most nutritious component of alfalfa. Research conducted by Meyers and Jones in the early 1960's showed that raking alfalfa hay too dry was most detrimental to hay quality (compared with baling too dry). It resulted in a 25 percent loss in yield and a reduction in TDN of 2 to 4 percentage units. In contrast, baling too dry resulted in a 5% loss. However, if the alfalfa was both raked and baled too dry, the loss increased to 16% over the raking losses alone.

An innovative technique has been developed by Robert Phelps of Lovelock Nevada in which an 8 inch diameter pipe is pulled along with the rake. The pipe serves as a mandrel when two windrows are combined with the rake. The pipe forms a tunnel in the windrow allowing improved air flow and less alfalfa is in contact with the soil, thus accelerating the drying rate of the alfalfa. This process has not been tested by the University but the approach seems logical and warrants consideration.
SUMMARY

Rapid uniform curing of alfalfa is highly desired. Rapid curing minimizes quality losses due to bleaching, respiration, leaf loss, and rain damage while improving yields by reducing the shading effect of windrows, lessening traffic damage to regrowth buds, and allowing more timely irrigation after cutting. This goal can be achieved through a combination of management practices. These include proper adjustment of conditioning rollers, wider thinner windrows, and raking the alfalfa at the proper moisture content so that a significant increase in drying rate can be attained while avoiding excessive leaf loss.

REFERENCES


Moisture Content During Raking Effects on Harvest Losses

% Loss

25

20

15

10

5

0

20%

30%

50%

90%

70%

Moisture Content

Fig

Moisture Content During Raking Effects on Harvest Losses

Source: Silage and Hay Preservation
Figure 2. Windrow conditioner shields for New Holland swather. Baffles spread hay to the width of rear tires.

Each baffle is made of sheet metal and is 30 inches long by 7 inches at the widest point with a 3 inch fold (90 degrees to the baffle). The design of each baffle is shown in Figure A. The 3 inch lip of the baffle is bolted to the conditioner housing behind the rollers in the configuration shown in figure A. A total of 4 baffles are needed.