Effectiveness of Equipment to Speed Hay Drying

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High quality forage is recognized as an important requirement for maintaining maximum production of cattle, particularly in dairy production. Adequate roughage is needed in diets to provide good rumen function, but as more roughage is fed, the energy density of the diet is reduced. High quality forage allows the animal to consume adequate forage while increasing energy intake to maximize production. The greatest obstacle to producing high quality hay is rapid field curing.

In our climate, good drying conditions are important and difficult to obtain. Adequate periods without rainfall are sporadic and hard to predict. Although processes are available to speed hay drying, they must be used along with good drying weather to be effective. New equipment and processes have been promoted to make better hay, but few have proven to be effective tools.

Although high quality hay production is a challenge in our region, there are practical steps that can help. Using the right process at the right time is important. Conditioning and tedding treatments can speed drying, but such processes also cause loss. Dry matter loss and nutritive changes occur each time a machine passes through the crop reducing the quality of the final product. Although some loss is inevitable, good management can reduce or compensate for these losses to provide the quality forage needed. The benefits received from these treatments or processes must be weighed against the added costs to determine the best procedures for hay making on your farm.

Hay Drying

The need for rapid wilting or drying of forage crops in the field is well recognized, but accomplishing this task remains a challenge. Many factors affect the field-drying rate of forage (Rotz, 1995). Drying is restricted by the structure of the plant, swath structure, and soil and weather conditions. The most restricting factor varies throughout the drying process and with crop management. When a high yield crop is laid in a narrow swath, the swath tends to be most limiting because the moisture cannot readily move out of the swath. When forage is spread in a thin swath, the movement of moisture out of the plant can become limiting. Under these circumstances, conditioning of the crop is most beneficial in allowing moisture to leave the plant more easily.

In temperate climates, weather is often the most restricting factor in drying. Of all weather influences, solar radiation level is the most important (Rotz, 1995). This energy from the sun is required to evaporate and move moisture out of the plant. The drying of hay requires the removal of about three tons of moisture for every ton of hay produced. This requires 7 billion joules of energy, which is the equivalent of 70 gallons of fuel oil. In haymaking, we are fortunate that free energy from the sun can be used to carry out this process. Be skeptical when you hear of new, miraculous and inexpensive processes that can dry hay without the sun. Warm air temperature and low humidity also aids drying, but the sun is the primary driving force. Wet soil under the swath also slows drying by allowing moisture to move up into the swath.

Dry matter losses and quality changes occur while the crop is wilting or drying in the field. These include plant respiration, rain, and machine induced losses. Plant respiration is a natural process that continues after the plant is cut. Respiration converts carbohydrates stored in the plant tissue to carbon dioxide, heat, and moisture that leave the plant causing a DM loss. Plant respiration ceases when the crop dries to a moisture level below 40%, so rapid drying early in the field curing process can reduce this loss (Rotz and Muck, 1994). Since this loss is primarily readily digestible carbohydrates, the loss increases the fiber content and reduces the energy content of the forage. With rapid drying, this loss is less than 5%, but it can be excessive when drying conditions are poor.

Rain damage, when it occurs, can have the greatest effect on loss and quality. Rain causes loss by knocking off leaves and leaching soluble nutrients from within the plant tissue. Since leaves are normally higher in nutrient concentrations than stem parts, the loss of leaves reduces the quality of the remaining forage. The greater loss though is the less visible loss from leaching. Soluble carbohydrates, proteins, and minerals are washed from the plant material leaving a higher fiber concentration and lower energy content. In general, the greater the amount of rain and the drier the crop at the time of the rain, the greater the loss of dry matter and nutrients. The goal is always to avoid rain damage, but when it occurs, it is better to have it early in the drying process rather than about the time the crop is ready to bale. This is somewhat beyond our control, but the producer can be less concerned about rain the day of mowing if better weather lies ahead.

Mowing Equipment

Producing high quality forage begins when the crop is mown. Forage crops should be mown at the right maturity to optimize yield and quality. Quality in most forage crops declines rather rapidly as the crop enters a reproductive stage of development and growth begins to slow. The optimum maturity varies among forage species, but normally this optimum occurs in the late vegetative to early reproductive stages. Mowing at this time provides a good yield, a relatively low fiber content and adequate energy and protein contents.

A challenge in hay production is to obtain this quality level at a time-period when weather conditions are suitable for drying the crop. When heavy rain and poor drying conditions are expected, it is normally best to delay. If the forecast is light rain or a brief thunder storm with adequate to good drying conditions ahead, it may be best to proceed with mowing. The loss in quality may be greater by delaying harvest then that caused by the rain.

There are several mower designs available for cutting forage crops with the primary types being cutterbar and rotary disk mowers. The type of mower used has little effect on drying, mowing losses and the resulting forage quality. Rotary mowers tend to have a higher power requirement and thus require a larger tractor and more fuel to operate. With a higher mowing capacity, though, less time is required offsetting some of the increased fuel use and reducing the labor required. Even though the purchase price of rotary mowers is a little higher for a given width of cut, the overall cost of mowing is similar between these major mower types.

Conditioning to Speed Drying

Mechanical conditioning treatments are often used to speed drying; these can be categorized as either roll or flail conditioners. Rolls smash and/or break the plant stems, and flails abrade the waxy surface of the plant and break stems. Both processes can improve drying, but for alfalfa, roll devices are more effective with less field loss (Rotz, 1995). Some roll designs are promoted for faster drying, but field and laboratory studies consistently show little or no difference in the drying of alfalfa or grass treated with commonly used crushing roll designs. Roll conditioning is most effective on a thick stemmed crop such as an early cutting of alfalfa. Flail type conditioners are better suited to grass crops, and they provide a greater throughput capacity when harvesting high yielding or entangled crops.

Adjustment of the conditioning mechanism can affect drying. Roll clearance and pressure often can be adjusted. A minimum clearance must be maintained. If the clearance becomes too close, excessive damage and loss of plant particles occurs. With too much clearance, plant material flows between the rolls with little crushing. Too little or too much pressure on the rolls has similar effects. On flail type conditioners, the clearance between the rotating flails and a stationary bar can be adjusted to control the amount of breaking and abrasion that occurs.

Dry matter losses and the associated nutrient changes caused or promoted by conditioning increase with crop maturity and the severity of conditioning. Although more severe conditioning can provide faster field curing, harvest losses are generally greater. Normally moderate conditioning is recommended to obtain adequate drying with relatively low loss (1-2% of yield). This relatively low loss has little effect on forage quality.

Considerable research and development has been devoted to “intensive conditioning” over the past 20 years. Several machine designs have been evaluated, which shred the plant material to allow more rapid field curing. Drying rate is increased by 25 to 150% with the fastest drying in thin wide swaths under good drying weather. Power requirement is at least twice that of a mower-conditioner, and field losses can be very high. To reduce losses, various methods have been used to press the shredded material into a mat. When rain occurs, losses can still be up to four times greater than regular conditioning. Due to a complex and expensive machine design, commercial application has not occurred.

A chemical treatment, referred to as a conditioner or drying agent, can be sprayed on alfalfa at mowing to help speed drying (Rotz, 1995). The chemical affects the waxy surface of the plant to allow easier moisture removal. The most effective treatment found, is a potassium and sodium carbonate based solution. This treatment has only been effective on legume forage crops, and it is most effective on cuttings harvested in the summer months. Chemical conditioning works well with mechanical conditioning because it is most effective on the crops where mechanical conditioning is least effective. The treatment can double the drying rate of the crop when used under good drying conditions with the crop dried in a relatively thin swath. On the average, this increase reduces field-curing time about half a day. Faster drying reduces respiration loss and occasionally avoids rain damage. The major deterrent to this process has been the need to handle large quantities of the liquid treatment (about 30 gallons of solution per acre).

Swath manipulation to speed drying

As forage dries in the field, the top of the swath dries more rapidly than the bottom. Manipulation of the swath can speed the drying process by moving the wetter material to the upper surface (Rotz, 1995). Swath manipulation can also improve drying by spreading the hay over more of the field surface, increasing exposure to the radiant solar energy and drying air. There are three operations used in haymaking to manipulate the swath: tedding, swath inversion, and raking.

Tedding can be used anytime during field curing, but it is best to do so before the crop is too dry (above 40% moisture content). The stirring or fluffing of forage typically reduces field-curing time up to half a day. Tedders are sometimes used to spread a narrow swath formed by the mower-conditioner over the entire field surface. When done soon after mowing, the average field curing time is reduced up to 2 days compared to drying in a narrow swath. In addition to speeding drying, tedding also tends to create more uniform drying, so wet spots in the swath are reduced.

Disadvantages of tedding include increased losses and increased fuel, labor, and machinery costs. When tedding is done on a relatively wet crop (above 50% moisture), the resulting loss is less than 3%; however, applied late in the drying process, the loss can be more than 10%. Tedding will also increase raking loss. When a light crop (less than 1 ton/acre) is spread over the field surface, raking loss can be more than double that when raking narrow swaths. Spreading the hay may promote bleaching of hay color. Bleaching does not necessarily affect the nutritive value of hay, but it often affects the market value. When the costs of performing the tedding operation are compared to the benefit received, routine use of tedding is difficult to justify, particularly for alfalfa. Occasional use under difficult drying conditions may bring greater economic benefit.

Swath inversion machines have been used that gently lift and invert the swath. Exposing the wetter bottom of the swath speeds drying, reducing the average field-curing time a few hours. Swath inversion is not as effective for improving drying as tedding, but shatter loss is very low. With less drying benefit, there is less potential for reducing rain and respiration losses. The added labor, fuel and machinery costs of the operation are generally greater than the benefit received.

Raking is another form of swath manipulation. Raking tends to roll the wetter hay from the bottom of the swath to the outer surface of the windrow, which improves drying. Following the initial improvement, the increase in swath density can reduce drying rate, so the crop moisture content at raking is important. Raking also causes loss, and the loss is related to crop moisture (2% when wet to 15% in very dry crop). The best moisture content to rake for low loss and good drying is between 30 and 40%. In dry weather periods, hay can be raked in the evening or early morning when leaves are moist and less prone to shatter. Raking at the proper time can reduce field-curing time a few hours to allow an earlier start at baling.

In haymaking, the best recommendation is to dry hay rapidly. Mechanical conditioning should be used, and high yielding crops should be spread in wide swaths. Tedding may be useful in drying grass crops, but it should be avoided with alfalfa, particularly after the crop has partially dried. In silage making, drying is a little less critical. Wilting in narrow swaths can reduce raking loss, particularly for low yielding harvests. Raking can be used to improve harvest capacity. A substantial economic benefit can often be obtained by rolling swaths together to allow large balers or forage harvesters to operate more efficiently.

Baling High Moisture Hay

Another option for shortening the field curing time is to bale hay before it is fully dry. Balers are available which produce bales of a wide variety of shapes and sizes and the safe moisture content for hay storage varies with size. Baling at the appropriate moisture content is important for minimizing harvest loss and maintaining quality following harvest. For low-density (small rectangular and most large round) bales, the recommended baling moisture content is about 18%. For high-density bales (large rectangular), drier hay in the range of 12 to 14% is recommended to improve preservation. Harvest loss increases when hay is baled at lower moisture contents.

Respiration of microorganisms (bacteria, fungi, and yeasts) on hay causes heating and further DM and nutrient loss during storage. Similar loss occurs in all sizes and types of bales stored in a shed (Rotz and Muck, 1994). Greater heating occurs as hay density increases, particularly in large bales. Dry matter loss during the first month of storage varies from 1 to 8% increasing with hay moisture content. For hay containing more than 25% moisture, excessive loss and even spontaneous combustion can occur. Although most loss occurs in the first month, a small loss of about 0.5% DM per month continues in hay stored in a shed. Unprotected hay stored outside experiences this same loss plus an additional loss from weathering on the exposed bale surface (outer 10 to 20 cm). Losses in large round bales stored outside vary widely, ranging from 3 to 40%. This loss is primarily affected by weather, length of storage, and storage method.

Field losses can be reduced by baling at a moisture content near 25%. Baling moist hay may reduce raking and baling losses providing an increase in harvested yield (about 7%) and harvested quality. However, moist hay deteriorates rapidly in storage, offsetting the benefit of reduced field losses unless treated to enhance preservation. Additives commonly used for the preservation of high-moisture hay include propionic acid, organic acid mixtures, buffered acid mixtures, and microbial inoculants.

Propionic acid (or an effective organic acid mixture) when applied at rates of 1 to 2% of hay weight, normally reduces mold growth and heating. To reduce corrosion of equipment, buffered acid products have largely replaced the straight acids. Acid treatment reduces storage loss during the first few months of storage, but the loss remains higher than that in dry hay. Acid-treated hay remains moister throughout storage maintaining a little higher level of microbial activity. Over a 6-month storage period, the loss in acid-treated hay catches up, providing little difference in dry matter and nutrient losses between treated and untreated high-moisture hays. When compared to dry hay, acid-treated damp hay is often higher in fiber content and less green in color. Treated hay will contain more moisture increasing bale weight and providing more supple hay.

Bacterial inoculants are sometimes applied to hay. Inoculation with a few strains of *Lactobacillus* have shown little effect on mold, color, heating, DM loss, and quality change in high-moisture hay. Products containing *Bacillus* bacteria are better suited to the aerobic hay environment, but there is still little scientific evidence that they can provide substantial improvement in preserving moist hay.

Based upon the scientific information available on chemical and biological treatments, my recommendation is to bale dry hay whenever possible. When moist hay is baled, organic acid treatments can provide a relatively safe method for insuring against excessive heating and browning of hay.

Feeding Considerations

For the commercial hay producer, high quality hay is important every time hay is made. When hay quality suffers for any of the above reasons, the economic value of the hay decreases and this affects farm profit. Thus, commercial hay production requires good management always, and techniques for assuring quality may be more cost effective than they would be for the livestock producer.

When hay is produced for on-farm use in feeding beef cattle and even dairy cattle, forage quality can be less important. This assumes though that good management is used to feed the highest quality forage to the animals that require that quality. For dairy animals in early lactation, the highest quality forage is needed to maximize their intake. Maximizing intake during this crucial stage will allow animals to peak their production at a high level. Thus, the value of forage quality cannot be overestimated for these animals. For other animals, including those in the last half of their lactation, early dry cows and yearling heifers, forage quality is less critical.

Thus, producers that are feeding animals must focus on producing or buying the best forage they can obtain for their critical groups while reserving lower quality forage for other animals. This means that only one-fourth to one-third of the total forage needed on dairy farms must be of this highest quality. In beef operations, the requirement for high quality forage is even less. For the dairy producer that keeps this in mind, producing high quality forage will be a less stressful process. Concentrate on making some of the best forage you can and feeding it appropriately, and do not worry about the times you fail. Some lower quality forage can also be used quite effectively on the farm.

Conclusions

Rapid field curing is important and a good mechanical conditioner can help. Spread hay in wide swaths to further speed drying, but avoid very thin swaths to reduce raking loss.

Tedding may be useful in drying grass crops, but it should be avoided with alfalfa, particularly after the crop has partially dried.

Bale hay at about 18% moisture in low-density bales, but use a lower moisture content for high-density large bales.

Avoid routine baling of high moisture hay. When damp hay is baled, use an organic acid based treatment to help preserve hay.

Remember that on the dairy farm, only about one third of the forage needs to be of the highest quality when that forage is segregated by quality and fed to animal groups accordingly.

References

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