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FORAGE PRODUCTION AND USE

CHEMICAL CONDITIONING OF FORAGES: Techniques and Economics

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A major problem in producing quality hay has always been the time required to get the crop dry and off the field before a rain. Research data show that even under good drying conditions, 20 percent of the crop dry matter is usually lost by the time the crop is placed in storage. A 30 to 40 percent loss occurs under adverse drying conditions, and a complete crop loss under very poor drying conditions. Nutrient losses are often of the same order or higher than dry matter loss. Generally, loss is directly related to the length of time the crop is in the field, so reducing field curing time can reduce losses and improve hay quality.

Chemicals can be used in two ways to reduce field curing time. First, they can be applied as the crop is mowed to increase the field drying rate of the cut crop. This process is referred to as chemical conditioning. The effect of the chemical is to allow moisture to leave the plant more easily. Second, chemicals can be applied at the time of baling to preserve hay baled at a higher than normal moisture content. This process of chemical preservation is discussed in Extension Bulletin E-1994, "Chemical Preservation of Forages: Techniques and Economics."

Different chemicals and processes are used for chemical conditioning and chemical preservation. The two chemical treatments can be used in one harvesting system. Benefits of each individual treatment will be additive when both treatments are used on the same hay crop.

Chemical conditioning originated in the raisin industry. In recent years, grapes have been dipped in a chemical solution to speed drying in commercial raisin production. This idea is not new—documents from nearly 2,000 years ago report the use of a dipping process to speed grape drying.

Using chemicals to speed hay drying is new. In the late 1970s, Jeff Tullberg, an Australian, determined that the process could be used in alfalfa hay production. The idea quickly spread to the United States, where research on the effectiveness of chemical conditioning was conducted primarily at Michigan State University. Scientists of the USDA and several universities extended this research and demonstrated the feasibility of the process. Chemicals that speed drying are being sold commercially for use by alfalfa growers. These chemicals are called chemical conditioners, desiccants or drying agents.

Equipment and Procedure

The chemical found to be most effective in speeding the drying process is potassium carbonate, an alkaline salt. Another alkaline salt that speeds drying is sodium carbonate. Sodium carbonate can be purchased for one-third to one-half the cost of potassium carbonate but is generally less effective.

Potassium and/or sodium carbonates can be purchased from industrial chemical suppliers as a white, fine, granular material. For chemical conditioning, a solution is prepared by mixing ¼ lb of the material per gal of water. Research has shown that a more concentrated solution does not work better.

Commercial products sold in the United States for hay drying often contain ingredients other than the alkaline salts. These include sodium silicate, methyl esters of fatty acids, vegetable oils, animal fat and various surfactants. Tests conducted at MSU have shown that the plain potassium carbonate in water solution works as well as any other solution to improve field drying over a wide range of environmental conditions. Some other combinations have given faster drying under laboratory conditions, but they have not been consistently more effective under the variable conditions in the field. An economical mixture is a combination of potassium and sodium carbonates (⅛ lb of each/gal of water). This mixture costs less than potassium carbonate alone and is equally effective.

Chemical conditioning treatments are most effective when applied while using the mower-conditioner. A spray boom mounted ahead of the reel along with a push bar (Fig. 1) is an effective method of application. The push bar pushes the crop over and opens up the leaf canopy to allow penetration of the spray onto stems. The spray boom can also be located after the reel and ahead of the

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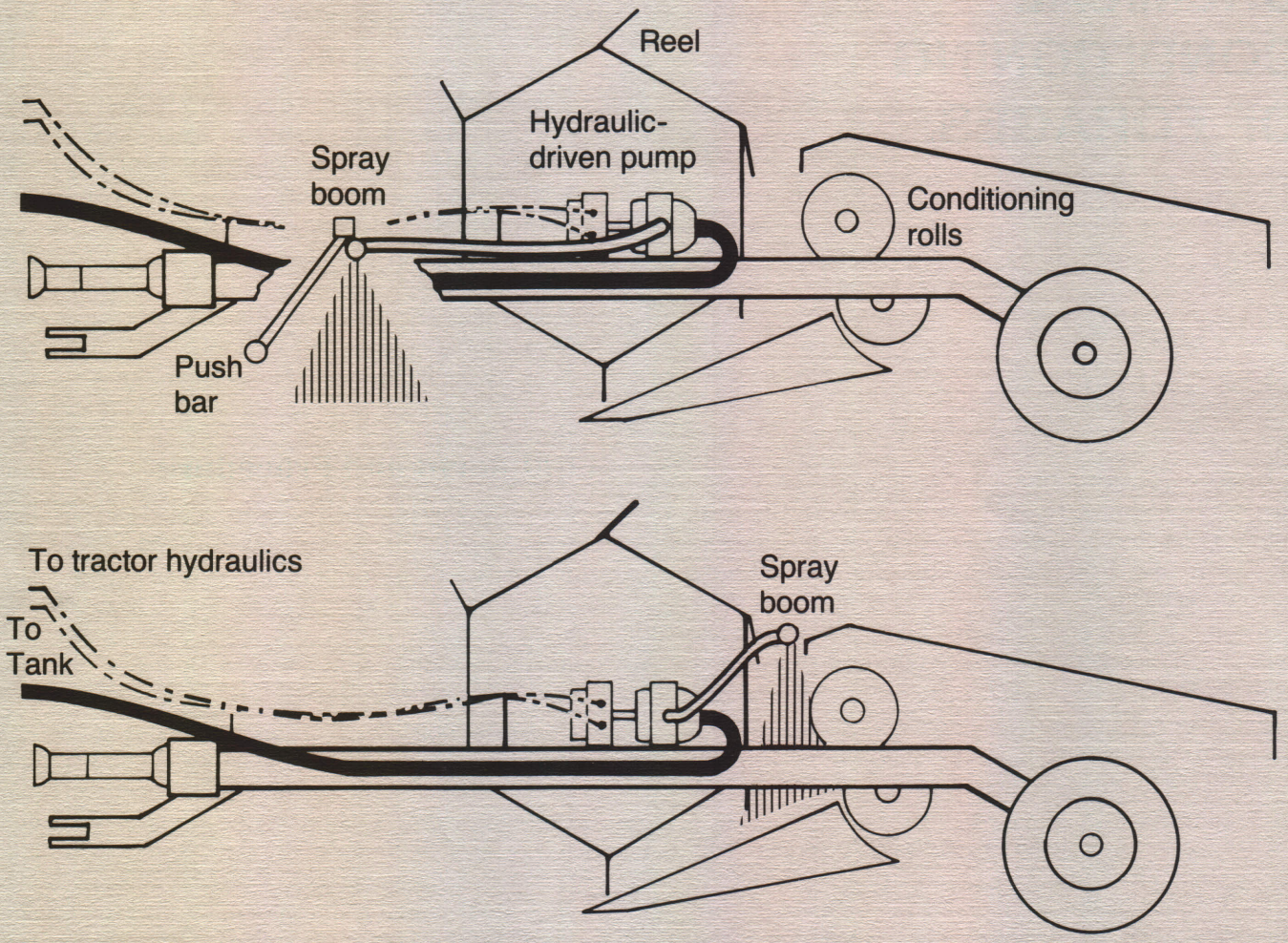
Figure 1.
Two methods for mounting equipment on a mower-conditioner for chemical conditioning of forages.



rolls on some mower-conditioners (Fig. 1). In this case, spray is applied uniformly on the ribbon or mat of mown hay just before it moves into the conditioning rolls. Either method will work, but the first method would be recommended for best results in fields with high crop yields, where better coverage may be obtained by spraying the standing crop. The tank and pump for the spray system can be mounted on the tractor or on a trailer drawn behind the mower.

With either method of application, a critical factor is the application rate. Large quantities of the solution have been required to get complete and uniform coverage of the plants. Tests conducted at MSU showed that drying speed increased as more solution was applied. Application rates as high as 100 gal/acre gave very rapid drying. Applying this much solution, however, required a large tank and the handling of unacceptably large quantities of spray solution. As a compromise, application rates of 15 to 30 gal/acre were used, with some decrease in performance. Increasing the concentration of potassium carbonate or other active ingredients in the water solution did not compensate for a decrease in application rate. High application rates have been required to obtain good coverage. Our current recommendation is a rate of 30 gal/acre in light crop yields (less than 1.5 tons/acre) and 50 gal/acre in heavier yields.

The type of nozzle used in the spray system is not critical as long as the nozzle maintains an adequate application rate. Tests have shown similar drying rates when hollow-cone, flat-fan or solid-cone nozzles are used. The operating pressure of the spray system also is not critical. A pressure of 20 to 25 pounds per square inch is satisfactory when used with nozzles designed and calibrated for that pressure.

Chemical conditioning may provide faster drying when used with some machines than with others. Tests have shown that the treatment provided faster drying when used with roll conditioners than with flail type conditioners. As the wet crop feeds into the rolls, the rolls become wet and help spread the solution over the surface of the plant for more complete and uniform coverage.

Chemical conditioning is most effective when the crop is dried in a thin mat. When possible, the shields on the mower-conditioner should be adjusted to lay the mown crop on the ground in a full-width swath. When the crop is dried in a heavier windrow, the drying rate is lower and the treatment is less effective. The chemical works by allowing moisture to leave the plant more easily. A heavy windrow inhibits moisture loss, slows the moisture removal from the plant and thus offsets the benefit of the chemical.

What to Expect from Chemical Conditioning

Chemical conditioning increases the drying rate of legumes, including alfalfa, bird's-foot trefoil and red clover. How it does this is not fully understood, but tests conducted in many areas have shown consistent increases in drying rate or reductions in drying time. The chemical is more effective on alfalfa and bird's-foot trefoil than on red clover and ineffective on brome grass and orchard grass. Grasses tend to dry faster than legumes, so a treated alfalfa and grass mixture may dry more uniformly, with both species drying at similar rates. Chemicals that speed the drying of grasses are being explored but are not available at this time.

The effectiveness of chemical conditioning of alfalfa varies among cuttings and climatic conditions. At times it provides very little benefit, but at other times conditioning may save a whole crop by avoiding a rainy period. When compared to mowing with a standard mower-conditioner alone, chemical conditioning can be expected to reduce field curing time of alfalfa in the northern United States by 0 to ½ day with first cutting alfalfa, ½ to 1 day with second cutting, ½ to 2 days with third cutting and 0 to 1 day with fourth cutting.

Several factors influence the differences across cuttings, but the primary factor is yield. Crop yield is greater with the first cutting, so less chemical is applied per unit of plant material. The heavier yields also produce heavier swaths, which inhibit drying. Limited laboratory drying data indicate that the chemical treatment is much more effective when used at warmer temperatures. Cooler temperatures during the harvest of first cutting, along with higher soil moisture content, may reduce the effectiveness of the treatment. First cutting alfalfa normally has a thicker stem, which may also impede the performance of the chemical.

The mechanism that allows moisture to leave the plant more readily also allows moisture to enter the plant more readily, so treated material tends to absorb more moisture from dew than untreated material. This additional moisture is lost rapidly from the treated material during the following morning, however.

When a rain occurs in the first day after the crop is mown, limited data indicate that the chemical tends to wash away and is not very effective. If rain occurs when the crop is nearly dry, however, treated material will redry faster than untreated material. Apparently, removing the chemical or reversing the change in the plant caused by the chemical is more difficult when the chemical remains on the plant until the plant is nearly dry. Thus, the treatment can be effective following a rain. The increase in drying rate following rain, however, is always less than that obtained in the absence of rain.

Potassium or sodium carbonate will not cause major harm to equipment. These chemicals are non-corrosive and will not promote rust. After several years of use, however, the paint on the mower-conditioner may become bleached or discolored.

When used at the recommended rates, potassium and/or sodium carbonates should not harm animals. No detrimental effects on animal health or performance have been found when hay treated with these chemicals was fed. Some research has noted slightly greater digestibility of chemically treated hay.

Economics of Chemical Conditioning

Chemical conditioning costs between $1.90 and $10/ton of hay produced, with the cost depending on the type of chemical used. Potassium carbonate costs about 45 cents/lb from industrial chemical suppliers. Properly mixed and applied at a rate of 50 gal/acre, the cost is $5.20/acre. When the hay yield is 2 tons/acre the cost is $2.60/ton. Using a mixture of potassium and sodium carbonates reduces the chemical cost to $3.80/acre or $1.90/ton. Chemical mixes developed for use on alfalfa are commercially available through some agricultural chemical suppliers at prices of 70 cents to $1.25/lb or $5 to $10/ton of hay.

The cost of additional equipment must also be considered. To equip a mower-conditioner or tractor with a tank and spray equipment costs approximately $1,000 for parts and materials. Additional labor may also be a factor. Mixing and handling the chemical may increase the time for mowing by 10 to 20 percent. An increase in mowing time increases not only labor but also the fuel requirement. Altogether, equipment, labor and fuel may cost the grower an additional 75 cents/ton of hay, for a total cost of at least $2.65/ton.

Proper evaluation of the benefit of chemical conditioning is difficult. Given long periods of good drying conditions, it gives little benefit, but under poor drying conditions it may save an entire crop. Computer simulation over 25 years of hay production has shown that chemical conditioning can reduce dry matter losses by 75 lb/acre and protein losses by 30 lb/acre in second or third cutting alfalfa. This gain in hay yield and quality can reduce a dairy farmer's use of feed supplements and cut feed costs by about $6/ton of hay fed. Comparing this savings to the treatment cost of $2.65/ton shows that the treatment provides a gain in crop value that exceeds the cost. This is not true in haylage production, however, where the modeling study showed little loss reduction and the gain in crop value was less than the cost of the treatment.

Summary

Chemicals can be used both to speed drying and to preserve hay during storage. Different chemical treatments are required for the two processes, but both treatments can be applied to the same alfalfa.

Application of a water solution of potassium carbonate to alfalfa as it is mowed will increase the drying rate of the crop. The rate of application of the chemical is important. Application rates of 30 to 50 gal/acre are required for good coverage of the plants and satisfactory drying results. The type of nozzle used to apply the chemical is not important as long as it maintains the proper application rate.

The treatment is not generally effective when used on first cutting alfalfa, but it provides good results on second and third cutting. In the later cuttings, treatment can save up to one or two days of field curing time. When rain occurs during field drying, the treatment is less effective following the rain.

The treatment costs between $2.65 and $10/ton of hay produced. The increased quality of treated hay justifies the cost in alfalfa hay production but not in haylage production.

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