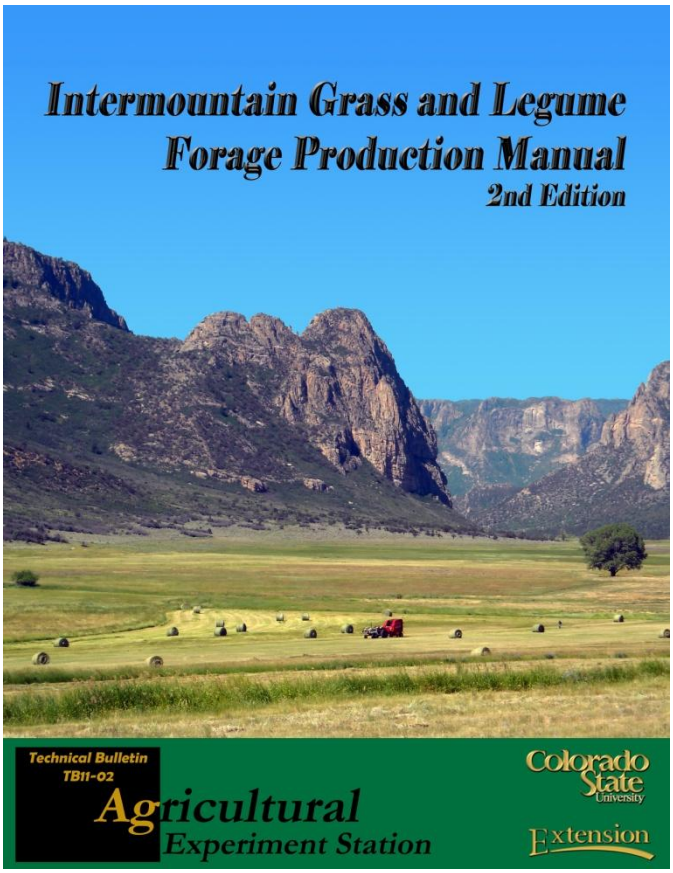

Compiled and Edited by

Calvin H. Pearson
Colorado State University
Western Colorado Research Center at Fruita
1910 L Road
Fruita, CO 81521

Joe E. Brummer
Colorado State University
Soil and Crop Sciences
Fort Collins, CO 80523

Bob Hammon
Melissa L. Franklin
Colorado State University
Tri River Area Extension
2775 Highway 50
Grand Junction, CO 81502

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Section I

Irrigated Pasture/Mountain Meadows

Chapter 9

Irrigated Hay Production

Joe Brummer, Mark Volt, and A. Wayne Cooley

The basic principles of growing and harvesting hay are the same regardless of elevation. The main difference between raising hay at lower compared to higher elevations is that most hay grown above 6,000 feet is typically only harvested once per growing season. The growing season is too short for a second cutting. Also, the selection of grasses and legumes that perform well at higher elevations is limited (see Chapter 2 on species selection). In this chapter, we will discuss the major factors that affect forage quality and how simple changes in harvest management can alter hay quality. Any considerations specific to elevation will be pointed out in the discussion.

Quantity Versus Quality

Hay producers must consider the balance or tradeoff between quantity and quality of the harvested forage. There is a yield level of hay required to meet animal needs or to have product to sell. Quality may also be an important consideration based on animal or customer's needs.

There is an inverse relationship between quantity and quality. As forage yield increases with maturity, quality of that forage with regards to factors such as protein content and digestibility decreases. Table 1 illustrates the relationship between percent total digestible nutrients (TDN) and crude protein (CP) as they relate to the growth stage of timothy at harvest.

The objective is to produce the maximum amount of hay per acre and still meet the nutritional requirements of the animals being fed. The decision of when to cut actually comes down to a compromise between obtaining the highest quality and the greatest quantity.

Table 1. Effect of stage of growth on forage quality of timothy.[1]

Stage of Growth	TDN (%)	CP (%)
Late Vegetative	62	14.0
Early Bloom	59	10.8
Mid Bloom	57	9.7
Full Bloom	56	8.1
Mature	47	6.0

[1]NRC. 1996. Nutrient requirements of beef cattle.

Stage of Maturity

There is a simple rule that applies to all forages. Protein content and digestible dry matter are greater in young, rapidly growing stems and leaves than in older plant tissues. Stems are usually considerably lower in quality than leaves. There are several reasons why these differences become more pronounced as plants mature. Both leaves and stems have structural tissue known as lignin. However, stems tend to have a greater proportion of such tissue because they support the leaves. The digestibility of the various chemical compounds responsible for the structural rigidity is low. Older stems have greater lignin content due to elongation of the main stem and the need to support an increasing number of leaves and associated smaller stems and seed heads. The result is

that older stems are lower in digestibility than younger ones. The protein content decreases as well with maturity due to dilution of nitrogen in the plant as biomass increases.

High quality hay is obtained when plants are harvested at immature or early growth stages

In high elevation mountain meadows, this is usually early- to mid-July when timothy, brome, and other grasses are just coming out of the boot stage (when the seedhead is just coming out of the sheath). Some quantity is sacrificed when cutting this early, but protein levels will be two to five percentage points higher. Good, early cut mountain grass hay will have 12-14% crude protein and an acid detergent fiber (ADF is a measure of lignin and cellulose) content in the low 30's. The higher the ADF content, the lower the digestibility of the forage.

Realistically, most mountain hay is cut a little later at growth stages that optimize the tradeoff between quality and quantity. Grasses are generally in full flower (seedhead stage) which usually occurs in late July through early August. Hay cut during full bloom will yield slightly more than early cut grasses, but quality will be lower (9-10% crude protein with an acid detergent fiber content in the mid 30's). Late cut hay harvested in mid September or later usually has completely cured on the stem. Crude protein will run less than 7% with ADF in the 40's. Each producer must decide which is more important to their operation, quantity or quality of the hay.

At lower elevations where multiple cuttings are possible, timing of harvest should focus on stage of growth (not the calendar), which will vary among the different forage species and from year-to-year due to variable environmental conditions. Grass harvested for hay should be cut at the boot to heading stage, but prior to bloom to maintain quality and obtain acceptable yields. This varies somewhat for each species of grass produced. For example, smooth brome, orchardgrass, and timothy should be cut when heads emerge. Reed canarygrass or tall fescue should be cut at flag-leaf to early heading. Most legumes should be cut at the bud to early flowering stage. Harvesting grasses or legumes at the earlier growth stages results in higher quality forage and allows more time for regrowth for additional cuttings or grazing. However, care must be taken not to harvest at early growth stages too often or plant vigor and stand longevity may be compromised.

Plant Species Effects On Hay Quality

As discussed above, forage quality is directly related to stage of maturity at time of harvest. Because each forage species matures at a different rate, forage quality can vary widely among species harvested at the same point in time. When establishing a new pasture or hay meadow, choose your forage species carefully. In addition to selecting species that are well suited to your climate, soils, and moisture conditions, it is important to select species that have similar maturities that will meet your quality as well as quantity objectives. Even within a species, there can be significant differences among varieties as far as maturity, leafiness, etc. which ultimately affect forage quality.

For example, timothy hay cut in the early bloom stage is quite leafy and has good quality (Table 1). However, if cut later at full heading, timothy will have more stem than leaf and have relatively poor quality. Comparatively, smooth brome hay cut early is nearly all leaf, and even when cut at full heading, still retains most of its leaves and therefore its quality. Garrison creeping meadow foxtail is leafy only for a short time during the growing season. It goes to seed early and thus is generally very stemmy when cut at the full heading stage. Blue-

grasses remain high in quality for much of the growing season because they stay leafy for long periods of time. However, due to their short growth habit, they do not yield well. Regrowth characteristics are good for bluegrasses. They can withstand vigorous grazing and still regrow rapidly, given favorable moisture and fertility conditions.

Any grass when mixed with a legume, such as alfalfa or red clover, will produce higher quality hay compared to pure grass hay. Typical brome/alfalfa hay contains 12-16% crude protein.

When making decisions on which forage species to plant, check with your local land grant university, such as Colorado State University, the University of Wyoming, or Utah State University, as well as NRCS Plant Material Centers, because they are continually evaluating the adaptability of new grass and legume varieties for different areas of the intermountain region.

In the cutting process, the whole plant is harvested, but the leaves are the most nutritious part

Quality Evaluation

Hay quality evaluation standards can be based on several factors. Typically, hay quality will be subjectively evaluated on the basis of type, maturity, color, smell, amount of foreign material, dust or mold, or any combination of these observable characteristics. More recently, objective analytical standards have been used to evaluate and determine hay quality. Chemical analysis reveals invisible characteristics such as crude protein, acid detergent fiber, and net energy. It is important when evaluating hay quality to use both visual and chemical analysis.

Top quality hay is high in crude protein as well as digestible dry matter and therefore, highly palatable and readily consumed by livestock. The ultimate indicator of forage quality is animal performance, whether it is milk production, average daily gain, or weaning weights.

Harvest Management

The purpose of putting up hay is to harvest plants in a high quality stage of growth and preserve that forage through drying for future use.

How hay is harvested makes a difference in quality of the end product, be it small bales, big round bales, loaves, or loose stacked hay. Hay is usually cut using a sickle bar mower, disc type mower, or swather. It is then generally fluffed or raked and finally baled, loafed, or loose stacked.

The important thing to remember is that you are trying to harvest the entire plant, and most importantly, the most nutritious part, the leaves. Any harvesting technique that looses leaves should be minimized.

Most cutting methods only cause minor losses in quality or quantity. Stubble height after cutting should average about four inches for most grass and legume species. Sickle bar and some disc mowers lay the hay flat while swathers concentrate the hay into a windrow.

There are advantages and disadvantages to both methods of cutting. Hay that is cut and laid flat tends to dry faster than hay that is swathed into a windrow. Flat mown hay must be raked into windrows before baling. Raking can result in significant leaf loss (>20% dry matter loss), especially if done at high speed or when the hay is overly dry. Swather-mown hay is often raked or turned so that the top of the windrow does not get overly dry while the bottom is still green and wet. It is important to rake, turn, or fluff the hay as little and as gently as possible. Over handling hay results in leaf and nutrient loss. The same is true for baling, loafing, or stacking loose hay. Rough handling of dry hay should be avoided. The system that han-

dles the hay the least and captures the most leaves harvests the most nutritious hay.

One management change that can lead to higher quality, more palatable forage is to harvest your hay in the afternoon versus the morning. Plants photosynthesize during the day and accumulate and store excess carbohydrates (simple sugars). Some of these carbohydrates are then utilized as plants respire during the night. Therefore, the carbohydrate content of growing plants is highest in mid to late afternoon and lowest at dawn the next day. Research has shown that animals ranging from rabbits to cows have a distinct preference for hay cut in the afternoon versus the morning. Since these carbohydrates are highly digestible, rate of passage of the forage through the animal is higher which leads to increased intake and animal performance.

Hay harvested in the afternoon is higher in quality and palatability

Although higher quality hay can be produced by cutting in the afternoon versus the morning, this approach is not for everyone. Producers with large amounts of hay to put up cannot afford to wait until afternoon to cut all of their hay. They must keep moving to take advantage of the time and labor available to them. It is more important for them to get the hay down, dried, and baled to avoid any weather related losses. The extra carbohydrates that are produced can easily be leached out of the hay with an untimely rain. However, for producers with smaller acreages, there may be advantages to cutting in the afternoon and selling or feeding the higher quality hay. When considering afternoon cutting, you need to be aware that little drying will occur that first day, so you need to keep a close watch on the extended weather forecast and time your harvest accordingly.

Climatic conditions also play an important role when harvesting and putting up hay. High humidity or rain after cutting can have detrimental effects on hay quality. Wet conditions from rainfall over several days can result in considerable mold, loss of soluble nutrients, and bleaching. Rain can leach the majority of soluble nutrients from drying hay and losses can be as high as 15% of total dry matter. Bleached hay results in loss of vitamin A and of course visual appeal. Some buyers are reluctant to purchase hay that is not green and such hay must often be sold at a discount.

Plant respiration continues for a period of time after cutting and can result in up to 3% dry matter loss per day. This is especially true when the moisture content of the forage remains above 25%. Conditions of light rain and high humidity add to this problem. Rainfall following hay cutting is always problematic. A fairly heavy rain for a short duration followed by sunshine and low humidity usually results in the least damage to cut hay as compared to lighter rainfall amounts periodically over several days.

Stems typically dry 2 to 3 times slower than leaves. To speed drying, most swathers are equipped with conditioners which crack the stems every few inches to enhance loss of plant moisture. Some cell contents can be lost during this stem cracking process, but the loss is usually minimal. Conditioning is important to speed drying, especially if the hay is cut with a swather and laid in a narrow windrow. These days, most alfalfa is cut with swathers that condition the hay. However, some grass hay is still cut with sickle bar or disc type mowers which lay the hay flat. In our arid western climate, drying time for grass hay that is laid flat can be as little as two days, so conditioning is not deemed as necessary to speed drying. In addition, grass hay is not as susceptible to leaf shatter during the raking process compared to alfal-

fa, so dry matter loss is minimal when raking the hay into windrows for baling.

Putting hay up at optimal moisture conditions is extremely important. Hay should be baled or packaged at no more than 20% moisture for small bales and 15 to 18% for large bales. If hay is put up at more than 20% moisture, it will generally heat and mold in the stack or bale. If it is put up at less than 12%, many leaves will shatter and be lost during the baling process. Generally, if you look back at your baler and there is a big cloud of dust, you are baling too dry and are losing leaves. This is especially important when harvesting alfalfa. The use of a hand held hay moisture meter is recommended to help growers accurately determine moisture in their hay prior to baling.

Mold develops if cut hay remains in the field too long, is exposed to wet conditions, or is baled too wet. Mold can cause a loss of dry matter that is given off as heat. If mold activity raises the temperature to 104°F or more, "browning" can occur which reduces digestibility of protein and carbohydrates. In a worst case scenario, if the temperature rises above 150°F, spontaneous combustion of the hay can occur.

Hay additives can be used during harvest that allow baling at greater than 20% moisture. The two basic types are acid preservatives and salt-based drying agents. These are not commonly used and are generally not needed when putting up hay that is predominantly grass.

If you must bale hay at higher moisture levels, an acid-based preservative would be your best choice for grass hay. The salt-based drying agents do not work well on grass hays. The acid preservatives do have limitations and are not intended to be used on hay wetter than 25% moisture. Hay that is put up at greater than 25% moisture will heat and mold in the bale. Protein will be damaged and lost as heat damaged protein. Mold in the hay can also make the forage unpalatable to livestock. Also, dust and molds in the hay may be toxic and cause respiratory problems in livestock.

In conclusion, follow the basics of hay harvest:

- Cut at early growth stages for highest quality.
- Handle the hay as gentle and as little as possible and use techniques to dry the hay as rapidly as possible.
- Bale as soon as possible at the optimal moisture for your baler or packaging system.
- Monitor weather forecasts and, if possible, factor weather conditions into your hay-making operations.