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UT Extension
SP437-A

High-quality Hay Production

Gary Bates, Professor, Plant Sciences

When pasture growth is limited, some type of stored feed must be provided to grazing animals. Hay is one of the most versatile stored feeds available because:

1. Accumulated forage from periods of excess growth can be cut for hay, which minimizes waste.
2. It can be stored for long periods of time with little loss in nutritional value if protected from weather.
3. It can be produced and fed in large or small amounts.
4. It can be produced and fed either mechanically or manually.
5. It can supply the nutrient requirements of most classes of livestock.
6. A large number of crops can be used to produce hay.

Since hay is such a widely used stored feed, it is important to understand the factors that influence hay quality and the criteria used to evaluate hay quality. This information can then be used to develop a feeding program that will be the most effective and efficient in meeting each producer's goals.

Importance of Hay Quality

Hay quality is usually measured by the amount and availability of nutrients contained in the hay. The estimation of protein, fiber and digestibility of a hay can all be used to determine quality. The ultimate test of hay quality, however, is animal performance. Quality can be considered satisfactory when animals consuming the hay perform as desired. Three factors which influence animal performance are:

1. **intake**—hay must be palatable if it is to be consumed in adequate quantities to produce the desired performance.
2. **digestibility and nutrient content**—once the hay is eaten, it must be digested and converted to animal products.
3. **toxic factors**—the hay must be free of components that are harmful to the animals.

Factors Affecting Hay Quality

There are many factors that will influence hay quality, some of which can be manipulated by the producer. These are:

A. Plant species
B. Stage of maturity
C. Curing and handling conditions
D. Soil fertility
E. Seed quality

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Plant species - The species of forage will have a large impact hay quality. Legumes are generally higher quality than grasses, and cool-season grasses such as tall fescue and orchardgrass are higher quality than warm-season grasses like bermudagrass (Table 1). Within each class there can be a wide range of quality, however. When properly cut, a mixture of a grass and legume usually produces high-quality hay. Perennials such as alfalfa, orchardgrass, timothy, fescue, bermudagrass, etc. are usually more economical as hay crops than annuals, although annuals such as sorghum-sudangrass hybrids, pearl millet, small grains and ryegrass can be used effectively.

Stage of maturity when harvested - As grasses and legumes advance from the vegetative to the reproductive (seed) stage, they become higher in fiber and lower in protein, digestibility and palatability. Forage quality deteriorates rapidly as the forage matures, even though yield continues to increase (Table 2). Within each forage species, the most important factor that affects hay quality and the one where the greatest improvements can be made is stage of maturity. The optimum stage of maturity for harvest of many hay crops is listed in Table 3.

Table 1. Yield, crude protein (CP), and total digestible nutrient (TDN) content of various hay crops[1].

Forage species	Yield (ton/acre)	CP (%)	TDN (%)
alfalfa	3-6	17-22	57-62
orchardgrass	2-5	12-15	55-60
tall fescue	2-4	10-15	55-60
rye	1-4	8-10	50-55
ryegrass	1-4	10-16	56-62
bermudagrass	5-8	10-14	52-58
johnsongrass	2-5	10-14	50-60
pearl millet	2-6	8-12	50-58

[1] dry matter basis
Adapted from: D.M. Ball and co-workers. 1991. Southern Forages.

Table 2. The effect of age of Tifton-44 bermudagrass hay on yield and quality[1].			
Cutting Interval	**Yield**	**Crude Protein**	**Digestibility**
	(lb DM/acre)	(%)	(%)
1 week	8539	19.8	61.8
2 weeks	8603	17.0	62.2
4 weeks	8197	14.1	61.3
8 weeks	13329	9.7	54.3

[1] dry matter basis
Source: W. Monson and G. Burton. 1982. Agronomy Journal. 74:371

Table 3. Recommended stage to harvest various forage crops.	
Forage Species	**Time of Harvest**
alfalfa	Bud stage for first cutting, 1/10 bloom for second and later cuttings. For new spring seedings, allow the first cutting to reach full bloom.
orchardgrass, timothy, tall fescue	Boot to early head stage for first cut, every 4-6 weeks thereafter.
red clover, crimson clover	Early bloom to 1/2 bloom.
wheat, rye, ryegrass, oats, barley	Boot to early head stage.
white clover	Cut at correct stage for companion grass.
sudangrass, sorghum hybrids, pearl millet and johnsongrass	40-inch height or early boot stage, whichever comes first.
bermudagrass	15- to 18-inch height for first cutting, every four weeks thereafter.

Table 4. Effect of stage of maturity at harvest of timothy on hay quality[1], animal intake[1] and milk yield.					
Stage at Harvest	**Crude Protein**	**Acid Detergent Fiber**	**Intake**	**Intake**	**Milk**
	(%)	(%)	(lb DM/day)	(% of body wt)	(lb/day)
late boot	11.3	35.9	33.3	2.84	37.5
late bloom	5.4	42.1	24.3	2.17	20.1

[1] dry matter basis
Source: Vinet and co-workers. 1980. Canadian Journal of Animal Science. 60:511

Table 5. Effect of stage of maturity at harvest on alfalfa hay quality[1].			
Stage at Harvest	**Crude Protein**	**Acid Detergent Fiber**	**Digestibility**
	(%)	(%)	(%)
pre-bloom	21.1	30.2	63.3
early bloom	18.9	33.0	62.4
mid-bloom	14.7	38.0	55.4
full bloom	16.3	45.9	53.2

[1] dry matter basis
Source: Kawas and co-workers. 1990. Journal of Animal Science. 68:4376.

As plant maturity advances, increased fiber levels and decreased crude protein and digestibility result in a drop in dry matter intake and milk production by cows consuming the hay (Tables 4 and 5). The nutrient needs of gestating cows can be met by feeding hay. As more mature hay is used, however, the reduced nutrient content and digestibility of the hay results in the need for an increased level of grain supplementation for cows to maintain their body condition and rebreed after calving.

Curing and handling conditions - After mowing, poor weather and handling conditions can lower hay quality. Rain can cause leaf loss and nutrient leaching from plants during curing (Table 6). Sunlight can reduce Vitamin A content through bleaching. Raking dry, brittle hay can cause excessive leaf loss.

Table 6. The effect of rain during curing on hay losses[1].						
	Alfalfa			Red Clover		
Loss	no rain	2" rain during curing	3" rain on dry hay	no rain	2" rain during curing	3" rain on dry hay
	(%)	(%)	(%)	(%)	(%)	(%)
leaf loss	8.8	16.4	14.7	10.5	16.8	20.4
leaching and respiration loss	1.3	27.7	39.1	0.5	32.5	34.7
total loss	10.0	44.0	53.8	11.0	49.2	55.1

[1] percent of initial dry matter
Source: M. Collins. 1983. Agronomy Journal. 75:523.

Crushing stems (conditioning) at the time of mowing will cause stems to dry at nearly the same rate as leaves. Conditioning has been shown to decrease the drying time of large-stemmed plants approximately one day and result in less leaf and nutrient loss. Plants with an 80 percent moisture content must lose approximately 6,000 pounds of water to produce a ton of hay at 20 percent moisture. Raking while hay is moist (40 percent moisture) and baling before hay is crisp (at 18 percent moisture) will help reduce leaf losses.

Soil fertility - Adequate amounts of lime, nitrogen, phosphate, potash and certain minor elements are needed to produce high yields of hay. Maintaining a high level of fertility will also help to maintain the stand of desirable plants and prevent weed encroachment. A soil test should be used as a guide in determining the amount of fertilizer and lime needed for economical hay production.

High yields of hay remove large amounts of nutrients. Since properly inoculated legume plants are capable of fixing atmospheric nitrogen, mixtures containing more than 30 percent legumes usually do not give economic responses to nitrogen fertilization. With pure grass stands, nitrogen must be added for high levels of production.

Seed quality - Plant certified seed of a recommended variety. This will ensure the use of quality seed of a variety adapted to local conditions. Fall seedings should be made early enough for establishment before cold weather stops or slows growth. Late winter and early spring seedings should be made early enough to provide a vigorous stand which can survive summer drought and weed competition.

Table 7. Score card for visual hay quality evaluation.			
Characteristic	**Description**	**Range**	**Score**
I. Stage of Harvest	1. Before blossom or heading 2. Early blossom or early heading 3. Mid-to-late bloom or head 4. Seed stage	26-30 21-25 16-20 11-15	
II. Leafiness	1. Very leafy 2. Leafy 3. Slightly stemmy 4. Stemmy	26-30 21-25 16-20 11-15	
III. Color	1. Natural green color of crop 2. Light green 3. Yellow to slightly brownish 4. Brown or black	13-15 10-12 7-9 0-6	
IV. Odor	1. Clean - “crop odor” 2. Dusty 3. Moldy - mousey or musty 4. Burnt	13-15 10-12 7-9 0-6	
V. Softness	1. Very soft and pliable 2. Soft 3. Slightly harsh 4. Harsh, brittle	9-10 7-8 5-6 0-4	
		subtotal	
VI. Penalties	1. Trash, weeds, dirt and other foreign material	subtract 0-35	
SCORING	> 90 Excellent hay 80 - 89 Good hay 65 - 79 Fair hay < 65 Poor hay	**TOTAL**	

Clean seed (seed free of weed contamination) is important, especially when planting perennial hay crops. Weeds generally reduce hay quality by adding material lower in palatability and digestibility, while some may be harmful or toxic. Certified seed insures quality.

Evaluating Hay Quality

Chemical evaluation - The most reliable way to determine hay quality is through chemical analysis. The Soil, Plant and Pest Center in Nashville, part of University of Tennessee Extension, can analyze a sample of hay for crude protein, fiber and total digestible nutrients. These results can be used to assess quality and to determine type and amount of supplementation needed for the desired level of animal production. Accuracy depends on obtaining a representative sample, which usually requires the use of a core sampler. Determining hay quality and matching the quality to different classes of livestock based on nutrient requirements can lead to a more efficient forage-livestock program. Contact your local Extension office for more information concerning forage testing.

Visual evaluation - Although not as reliable as forage testing, a visual estimate can be helpful in determining forage quality. A guide for visual evaluation is given in Table 7. Learning what to look for in high quality hay will help in determining when to cut hay, and will give a guide for the relative ranking of hays. High quality hay is early cut, green, soft, leafy, free of foreign material and has a pleasant odor.

Producing high-quality hay should be a goal of each cattle producer. Feeding high-quality hay during periods of reduced pasture growth can result in better weight gain in calves, and better milk production and rebreeding in cows. Feeding high-quality hay can also reduce the level of grain supplementation needed during winter. Cutting hay early, proper fertilization and cutting when the hay will not get wet will allow cattle producers to get higher-quality hay and more efficient use of pastures.

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Forage Testing Information

Sampling Information

Results and recommendations are no better than the sample submitted for testing. Please follow the sampling suggestions below for best results.

How much is needed? Approximately 1/2 gallon of sample (forage or grain) should be sent for an adequate test.

How to sample:

Hay – obtain samples from approximately 10 bales. Best samples are obtained with the use of a forage sampling probe. Check with your local Extension office about the availability of these samplers. For square bales, take one core from one end of each bale. For round bales, take a sample from each side of the bales. If grab samples are taken, be sure to obtain a representative sample.

Silage or haylage – if haylage is in round bales, follow the same procedures as for round baled hay. If haylage or silage is chopped, then obtain 2-3 gallons of material from 10-15 places in the silo. For upright silos, run unloader and collect one sample per minute for several minutes. In both situations, mix all of the collected material together, then fill sample bag with this mixture. Be sure to seal bag to ensure correct moisture determination.

Grain – obtain several small samples from different areas of the bin or storage area. Mix as listed above. Commercial feeds should not be submitted.

Mailing Information

1. Seal the plastic bag containing the sample to be tested.
2. Put name and sample number on bag. Sample number is important for identification during the laboratory process, especially when more than one sample is submitted.
3. Be sure the name, address and sample number on information sheet correspond to information on the bag.
4. For each sample to be tested, there is a $10 charge for the basic test. Make check payable to "The University of Tennessee." Place checks and forms in an envelope and mail separately.
5. Submission forms and other information can be found at *www.soilplantandpest.utk.edu*
6. Mail samples to:

Soil, Plant and Pest Center
5201 Marchant Dr.
Nashville, TN 37211-5850
(865) 832-5850

Visit the UT Extension Web site at
http://www.utextension.utk.edu/

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