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Harvesting Quality Hay

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FORAGE QUALITY - The characteristics of a forage which when fed to livestock will produce high yields of animal products. It is often referred to as nutritive value or feed value.

Quality hay is nutritious. It has a high nutrient content and is efficiently utilized by livestock for maintenance, growth and reproduction. The value of a roughage for feed is related to its nutritive or feed value and the rate of voluntary intake or animal consumption (Fig. 1).

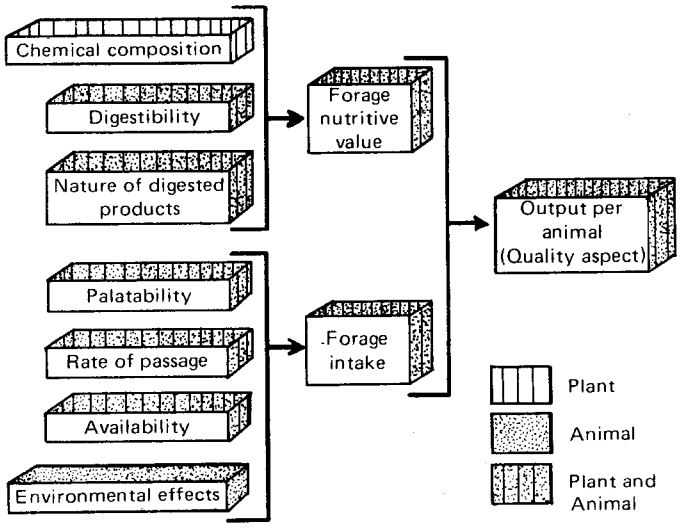

Fig. 1. - Plant and Animal Factors Influencing Forage Quality and/or Animal Output.

The nutritive value of a particular forage is influenced by its chemical composition, digestibility and how efficiently the animal utilizes the products of digestion for productive purposes. Chemical composition is related to the forage variety being grown and the environmental or growing conditions. The most commonly used measure of forage nutritive value is digestibility. Forage digestibility and the nature of the end products of digestion are related to both the inherent characteristics of the forage crop being grown and the efficiency with which the feed consumed and digested is utilized by the animal. Forage intake is a plant and animal related factor. It is related to the willingness of the animal to consume the forage available and the time required for the forage to pass through the digestive tract.

- **The more digestible a forage the greater the rate of intake or quantity consumed.**
- **Digestibility of a forage is closely related to the growth stage when harvested.**
- **Low forage digestibility reduces the rate of forage intake due to a greater amount of undigested material which must pass through the digestive tract.**
- **Utilization efficiency of digested forage decreases as digestibility declines.**

The class of livestock being raised will influence the quality of forage required. Dairy cows and calves, growing beef calves, feedlot animals, pregnant and lactating ewes and growing lambs require high quality forage. In addition, high quality hay can be used to supplement rations containing low quality hay and/or straw, providing a relatively low cost ration for wintering the beef cow herd.

Assuming forage varieties adapted to an area possess the chemical characteristics required for quality forage production, proper harvesting and storage are the keys to packaging a product that retains the essential quality components for the production of animal products. Quality forage should possess several observable characteristics following a successful harvest. These characteristics include leafiness, color and aroma, softness and pliability of stems, foreign material and condition. Value ratings for visually judging quality legume, grass-legume and grass hay in storage are listed in Table 1.

TABLE 1 - CHARACTERISTICS FOR JUDGING HAY QUALITY

Factor	HAY TYPE		
	Legumes	Grasses	Grass Legume Mixtures
	..... Point Score		
LEAFINESS - Legume hay should contain 40% or more leaves	25	....	15
COLOR & AROMA - hay should be green, bright, and have a pleasant smell	25	30	25
SOFTNESS AND PLIABILITY OF STEMS - indication of early harvest for high nutrient content, digestibility and palatability or acceptance by livestock	15	30	20
FOREIGN MATERIAL - low content insures greater intake and less waste	15	20	20
CONDITION - hay cut, cured and stored properly will be free from dust and moldiness	20	20	20
TOTALS	100	100	100

The major component of forage quality or nutritive value is digestibility. The stage of plant maturity at which first growth forage is harvested has a major influence on forage quality and is closely related to forage digestibility. In general, protein, vitamins and minerals decrease and fiber, the least digestible component, increases as forages advance in maturity. Studies conducted by the NDSU Agronomy and Animal Science Departments using alfalfa (Fig. 2) and smooth bromegrass (Fig. 3) show the relationship between digestibility, protein and fiber content of the plant with advancing maturity.

Leafiness of hay, especially legume and grass-legume hay, has a major influence on the nutritive value of forage. Studies conducted at Swift Current, Saskatchewan, Canada with smooth bromegrass (Fig. 4) and alfalfa (Fig. 5) growing under ideal moisture conditions show the value of leaves to the nutritive value of first cutting hay. The per cent protein of smooth bromegrass leaves decreased from 27 per cent during early growth to 14 per cent at maturity, stems from 23 to 4 per cent and the whole plant from 24 per cent during very early growth to 9 per cent at maturity. The proportion of leaves in the total dry matter yield of bromegrass hay increased until the mid-bloom stage.

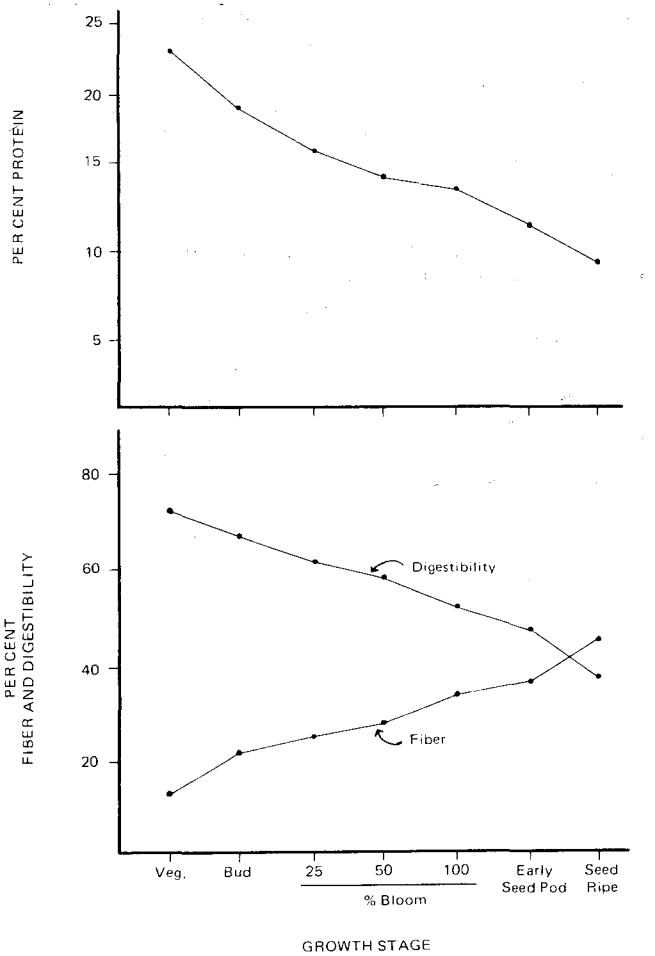

Fig. 2. - Influence of Alfalfa Growth Stage on the Average Per Cent Protein, Fiber Content and Apparent *In Vitro* Digestibility for Cattle.

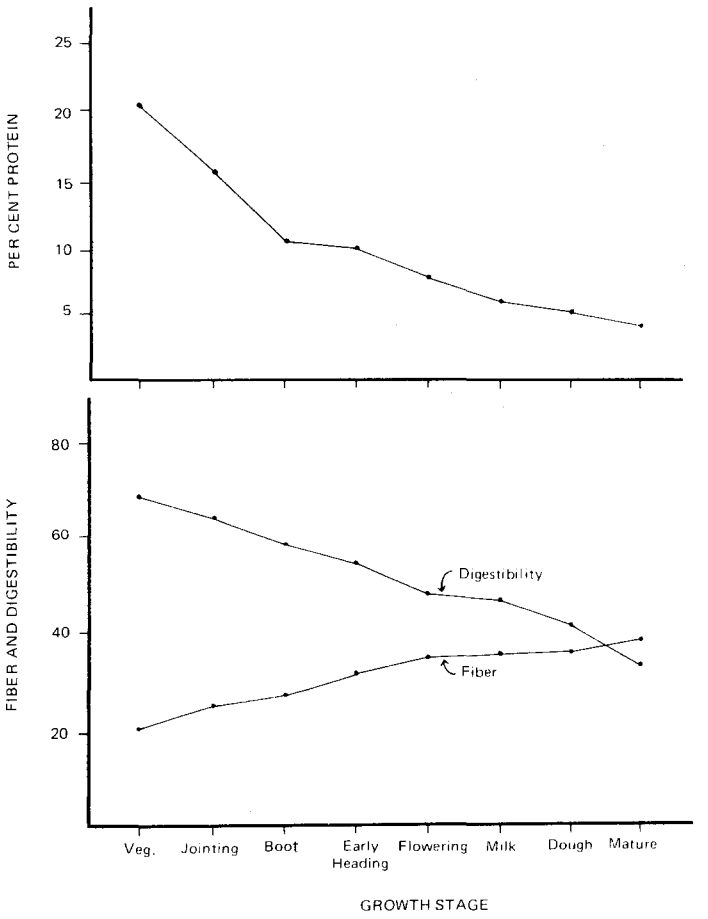

Fig. 3. - Influence of Smooth Bromegrass Growth Stage on the Average Per Cent Protein, Fiber Content and Apparent *In Vitro* Digestibility for Cattle.

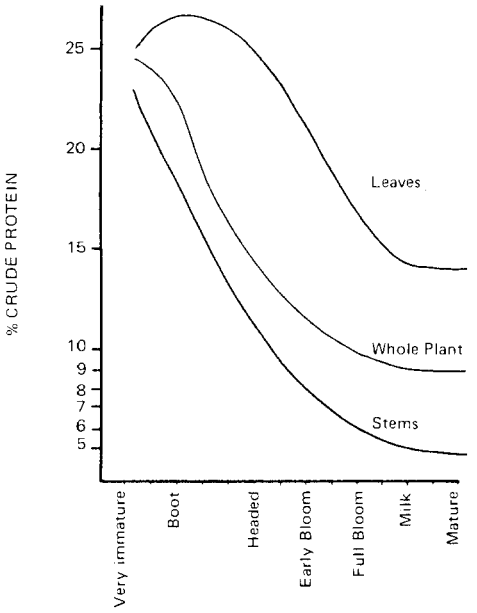

Fig. 4. - Protein Content of Stems, Leaves and Whole Plant of Carlton Bromegrass by Growth Stages.

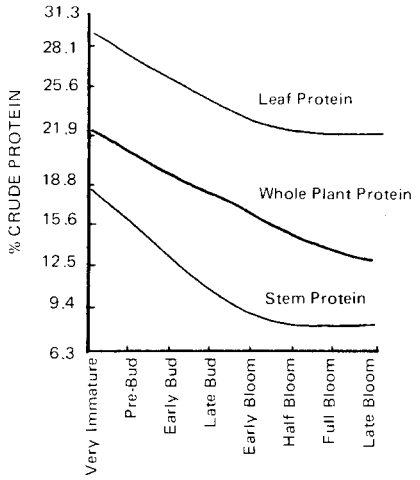

Fig. 5 - Per Cent Crude Protein in Alfalfa by Growth Stage.

The leaf protein content of alfalfa decreased from about 30 per cent during early growth to 23 per cent at maturity, stems declined from 18 per cent to less than 8 per cent and the whole plant from about 23 to 13 per cent at the late bloom growth stage. The proportion of leaves and stems in the total dry matter yield was approximately equal during the bud growth stage, whereas the forage contained 60 per cent stems and 40 per cent leaves at the late bloom growth stage.

Leaf loss, especially in legumes, can be very high in drouth-stressed forage and during harvest due to mechanical shattering when forage is turned and/or baled too dry. Shattering losses can be reduced by handling the forage during morning and evening hours when forage is "tough" or the relative humidity of the air is higher.

Forage intake or the amount of forage voluntarily consumed by the animal is a major determinant of forage quality, in addition to forage nutritive value. Studies have shown that forage nutritive value accounts for about one-third of the animal's performance potential and forage intake represents about two-thirds of the difference in animal performance.

The amount of forage voluntarily consumed by cattle is dependent upon several factors. They include the animal's age, size, sex and genetic production potential; passage rate of consumed forage through the digestive tract; moisture content of the forage; physical form of the forage fed (i.e., chopped vs long hay), and forage digestibility, which reflects the stage of maturity of the forage consumed. Major variations in forage intake have been shown to be due to animal size, which reflects rumen or stomach capacity, rate of passage of indigestible material through the digestive tract and forage digestibility. In general, studies have shown that plant digestibility and animal intake of first growth forage each decrease from 0.3 to 0.5 per cent per day from early flowering to near the mature growth stage regardless of the kind of forage being grown. Grass hay, when compared to alfalfa of similar digestibility, has a slower rate of digestion resulting in less forage voluntarily consumed by the animal.

Studies by the Ohio Agricultural Experiment Station, Dairy Science Department, show the effects of advancing maturity of alfalfa-brome forage on digestibility, dry matter intake and daily milk production per cow in the dairy herd (Table 2). Forage digestibility declined from about 67 per cent at the pre-bud growth stage to about 56 per cent at maturity. Dry matter intake decreased with advancing maturity of the forage from 34 pounds per 1,000 pounds of animal weight per day to about 26 pounds. The decline in forage intake reflects the slower rate of passage of the ingested material through the digestive tract and the animals capacity to voluntarily consume the forage available. This in turn has a major influence on the nutrients available for the production of milk. Milk production per 1,000 pounds of animal weight declined from 42.5 pounds daily to less than 20 pounds due to reduced forage intake and digestibility.

TABLE 2 - Effects of Stage of Maturity of Green-chopped Alfalfa - Brome Forage on Digestibility, Forage Intake and Milk Production When Offered Free Choice with 3-5 Pounds of Grain Concentrate.

Growth Stage of Alfalfa	% Forage Digestibility	lbs. Dry Matter Intake	lbs. Milk Per Day
Pre-bud	66.8	34.0	42.5
Bud	65.0	33.2	39.5
Early bloom	63.1	32.0	31.4
Mid bloom	61.3	30.6	31.4
Full bloom	59.4	29.2	26.5
Late bloom	57.5	27.8	23.4
Mature	55.8	26.3	19.5

As forage crops advance in maturity prior to harvesting for hay, the more difficult it is for livestock to digest and efficiently utilize the products of digestion for the production of animal products - meat, milk, wool, etc. Forage digestibility decreases, forage intake or the amount of forage consumed by the animal decreases; but, the total forage dry matter harvested increases with plant maturity. The Swift Current, Saskatchewan, Canada study shows that total dry matter yield of smooth bromegrass (Fig. 6) and alfalfa (Fig. 7) increases until approximately the full bloom growth stage.

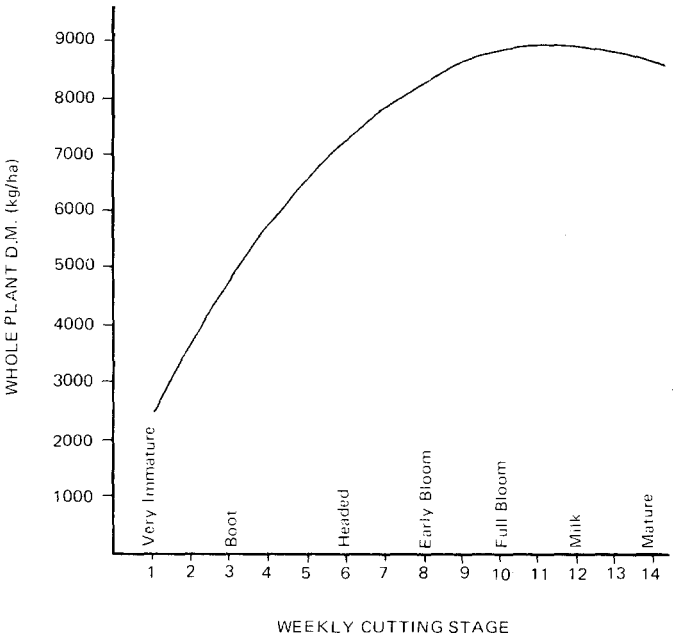

Fig. 6. - Dry Matter Yield of Carlton Bromegrass by Growth Stage.

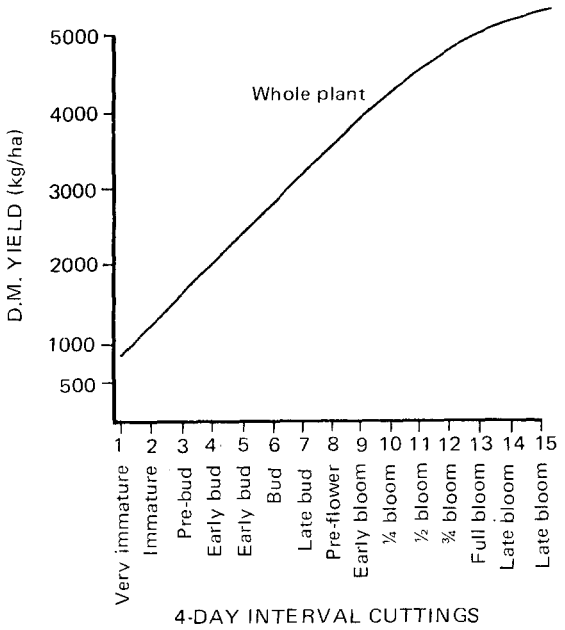

Fig. 7 - Dry Matter Yield of Alfalfa by Growth Stages.

Although dry matter yields increase with advancing maturity, the additional dry matter produced is small due to a slower growth rate. Delaying harvest past the mid-bloom growth stage increases the proportion of stems in the forage yield, reduces the potential for regrowth forage, increases the risk of leaf loss due to moisture stress, decreases nutrient content and decreases the forage palatability and/or acceptance by livestock due to an increase in plant fiber content.

Studies conducted by the NDSU Agronomy Department show that the yield of alfalfa under a 2 vs 3-cut harvest system produced equal total forage yield (Fig. 8). The 2-cut system produced higher yields of forage during the first and second harvest compared to the 3-cut system. Total protein production per acre was higher under the 3-cut system which was due to a higher per cent protein content of the forages - 20.0, 23.1 and 21.4 per cent for the 1st, 2nd and 3rd harvest respectively, compared to 17.7 per cent for each harvest under the 2-cut system when harvested at a 3-inch stubble height.

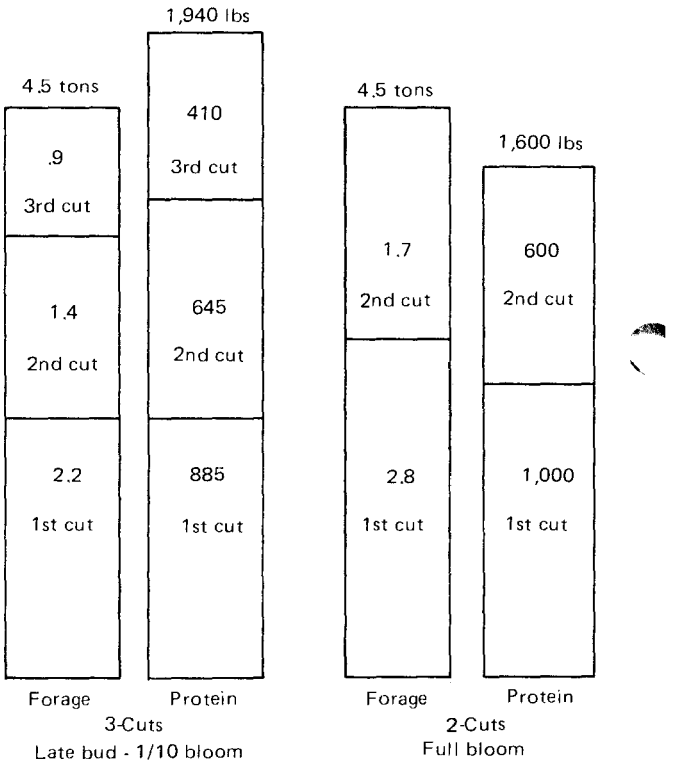

Fig. 8 - Alfalfa Protein and Dry Matter Yield Per Acre Under a 2-cut and 3-cut Harvest System when Harvested at a 3-inch Cutting Height. Fargo, N.D. 1966-71

The NDSU study shows that forage digestibility is increased by earlier and/or more frequent forage harvesting. **In vitro** dry matter digestibility, a test tube measurement of forage digestibility by animals, was 4.5 and 3.7 per cent higher when harvested at the late bud to 1/10 bloom growth stage (3 cuts) compared to the 2-cut system harvested at the full bloom growth stage. Although total forage yield was similar under the 2- vs 3-cut harvest systems, the tons of digestible dry matter harvested were higher, 3.2 tons per acre under the 3-cut system compared to 2.9 tons for the 2-cut management system. This is due to the higher digestibility of the harvested forage which averaged 67.7 per cent digestible compared to 63.5 per cent for the 2-cut or full bloom alfalfa.

Nutritional value of forage declines quite rapidly after the crop has reached heading to early flowering growth stages. Highest quality hay will be obtained if the different forage crops are harvested at a stage of growth when their nutrient content (protein, vitamins and minerals) and forage digestibility are at relatively high levels. The preferred stages of growth for harvesting several commonly grown forage crops to obtain high quality hay are shown in Table 3.

TABLE 3 - PREFERRED GROWTH STAGES FOR CUTTING DIFFERENT FORAGE CROPS FOR HAY

Crop	Remarks
Legumes	
Alfalfa	
1-cut	Cut when plants are 25 to 50 per cent bloom.
2-cuts	Harvest 1st cut at 10 per cent bloom, 2nd cut at 50 to 75 per cent bloom.
3-cuts	Harvest 1st cut at first flower to 10 per cent bloom, 2nd and 3rd cuts by 25 per cent bloom. The 3rd harvest should be removed by Sept. 1 to allow for 8 to 10 inches of regrowth before the first killing frost.
Sweetclover (2nd yrs. growth)	Cut in the bud to very early flower stage. If two crops are expected, leave a minimum of 5 to 6-inches of stubble. The later the 1st harvest the higher the stubble required for regrowth forage.
Alfalfa-Grass Mixtures	Cut when alfalfa plants are 10 to 25 per cent bloom. If grass makes up 75 per cent or more of mixture use the grass as the guide.
Grasses:	
Crested Wheatgrass	Cut when plants begin to head for best quality.
Smooth Bromegrass and other tame grasses	Cut just after heading and while still in flower.
Native Hay	Cut during heading and while still in bloom. If needlegrasses are present, harvest early before needles form or after needles have dropped from the plants.
Cereals - oats, barley, etc.	Cut in late milk to very early dough stage. The earlier growth stage is preferred depending on acreage to be harvested.
Millet (hay type)	Cut as soon as headed and not later than full bloom.
Sudangrass (including hybrids)	Cut from heading to early bloom stages. If two crops are expected cut first crop at the boot to very early heading stage of growth to allow adequate time for regrowth forage.

Harvesting grasses and/or legumes at the PROPER TIME or GROWTH STAGE is one of the first essentials to obtain quality hay. In addition, MOISTURE CONTROL in the harvested forage is essential if field losses during raking, baling or stacking and storage losses are to be kept to a minimum.

Field cured hay should contain a moisture content of between 20 and 25 per cent if storage losses are to be maintained at acceptable levels. Baled and chopped hay should contain less moisture than loose hay when stored due to a tighter, more dense package which delays the loss of moisture. If hay is drier than 20 per cent, excessive mechanical leaf losses will occur, especially when harvesting legume hay. A moisture content above 25 per cent will cause excessive storage losses to occur due to 'heating' caused by the activity of microorganisms.

Hay stored below 20 per cent moisture will lose 5 to 10 per cent of the original dry matter. Properly cured hay will go through a sweat or slight fermentation but it will not lose its green color. As the moisture content of undercured hay increases, the intensity of the fermentation process increases. Hay which is moderately undercured will lose its green color and molds will develop. Distinctly undercured hay will appear brownish or blackish in color due to the heat produced by microorganisms. The heat causes destructive chemical reactions which destroy carotene (Vitamin A), and other vitamins, and lowers protein digestibility. The damaged hay may be readily eaten by livestock, but it is of low digestibility. The amount of dry matter lost during storage varies depending on the amount of moisture above 20 per cent in the hay, amount of heat produced during storage, and the length of time the high temperature is maintained in the hay.

LOOSE, LONG HAY SHOULD NOT CONTAIN MORE THAN 25 PER CENT MOISTURE FOR SAFE STORAGE. Hay at this moisture will have stems which are slightly tough when twisted by hand.

BALED AND CHOPPED HAY SHOULD ORDINARILY CONTAIN NOT MORE THAN 22 PER CENT MOISTURE FOR SAFE STORAGE. The butt ends of stems at this moisture are slightly tough.

When using the 'twist' test to determine moisture content, use the following guidelines. If the twisted hay is tough and there is moisture where the stems are broken, the hay is not safe for storage. If the stems are slightly brittle when twisted and broken and there is no evidence of moisture when the stems are twisted, the hay can be stored safely. Another method is to scrape the outside of the stem with a fingernail. If the surface stem tissue can be peeled from the stem, the hay is too moist. If it does not peel off, the hay is usually dry enough for storage.

In summary, forage crops should be harvested for hay at their preferred growth stage if quality forage is the goal. Forage dry matter yield increases with advancing maturity but, only small increases in dry matter yield are obtained following the mid-bloom growth stage. The additional forage obtained due to delayed harvest is primarily undigestible fiber which is of little economic value. Forages cut at the proper time, and properly cured, packaged and stored will possess a higher nutritive value resulting in greater animal production potential when compared to mature weathered forage.

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