



FactSheet

Extension

Ohio State University Fact Sheet

Animal Sciences

2129 Fyffe Rd., Columbus, Ohio 43210

Forages for Dairy Cattle

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W.P. Weiss

M.L. Eastridge

J.F. Underwood

Ohio State University Extension

Introduction

The quality or nutritional value of a forage can be defined as its ability to support a certain level of animal performance. Dairy cows fed high-quality forage produce more milk with less supplemental concentrate than cows fed lower-quality forage. The nutrient or chemical composition of forage largely determines its quality. Chemical composition of a forage depends on plant characteristics and harvesting and storage methods. The objectives of this fact sheet are to discuss: 1) methods of determining forage quality; 2) factors affecting forage quality, including forage harvesting and storage procedures; and 3) the value of different forages in dairy feeding situations.

Forage Quality

Measures of forage quality. All forages should be analyzed for nutrient composition prior to feeding. An actual laboratory analysis is the only way to properly judge the quality or feeding value of a forage. Forages should at least be analyzed for dry matter (DM), crude protein (CP), fiber (acid detergent [ADF] or neutral detergent [NDF]), and available energy (TDN or NEL). Other nutrient information, such as mineral content, is needed to balance diets but it will not be discussed in this publication.

Generally, CP content is positively correlated with quality. In other words, high-protein forages generally are high-quality forages. Alfalfa, if harvested in the late bud stage of maturity, can contain 20 to 25% CP (DM basis). Grasses, if fertilized properly and harvested in the vegetative stage of maturity, can have more than 20% CP. An exception to this general relationship is corn silage, which is low in CP but is a high-quality forage because of its energy content.

Forages with high concentrations of CP are considered high quality for two reasons. First, if a high-protein forage is fed, less supplemental protein will be needed. This usually reduces feed costs since most protein supplements are purchased. Secondly, CP content is positively correlated to energy content of forages. High-protein forages generally are more digestible and provide more energy per pound than low-protein forages.



Alfalfa is one of Ohio's most prominent forages.

Fiber content of forages is inversely related to quality. Forages with high concentrations of fiber generally will support less milk production than will low-fiber forages. Fiber can be measured many ways, but the single best method for comparing different forages is to use NDF. Acid detergent fiber is determined frequently and is useful in comparing and estimating forage quality within forage species; however it should not be used to compare quality among different forage species. Plant fiber is composed largely of cellulose and hemicellulose. The amount of cellulose is relatively constant among forage species, but the amount of hemicellulose differs greatly between grasses and legumes. Cellulose is the primary constituent of ADF, but NDF contains both cellulose and hemicellulose. Therefore, grasses and legumes may have similar ADF values, but NDF values will almost always be substantially higher for grasses. High-quality alfalfa will contain 35 to 40% NDF (25 to 30% ADF), and high-quality grasses will contain 55 to 60% NDF (30 to 35% ADF). Low-quality grasses can contain 70 to 80% NDF.

Fiber content and energy content are closely related since almost all laboratories use fiber (either ADF or NDF) to estimate available energy. Concentration of fiber is negatively related to quality because forages with high concentrations of fiber contain less available energy and are consumed in lesser amounts by cows than are forages with low amounts of fiber. The most important factor controlling milk production by dairy cows is intake of available energy. Consumption of available energy is determined by multiplying feed intake by the concentration of energy in the feed. Both intake and concentration of energy are low for forages with high concentrations of fiber; therefore, energy intake from these types of forages can be extremely low.

In certain instances, acid detergent insoluble nitrogen (ADIN) can be important in determining forage quality. Heat-damaged forages have less nutritional value than do normal forages and ADIN can be used as an index of heat damage. This protein fraction is also called unavailable protein, heat-damaged protein, or fiber bound protein. Protein and energy digestibility decreases significantly as ADIN increases. A general rule is that if available protein is within 95% of the value of CP, the nutritive value of the forage does not need to be discounted. If available protein is less than 95% of the value of CP, available CP, not total CP, should be used for ration formulation. Many energy equations do not adjust for heat damage, and in those cases, available energy (TDN or NEL) will be overestimated. Users should check with their lab to determine what equation is used to estimate energy of feeds. Instances where ADIN may be important will be discussed later.

Table 1. Grades for Legumes and Legume Mixtures (Hay Marketing Task Force)*

Grade	Stage of Maturity	Definition	Physical Description	Typical Chemical Composition (%) ^b			
				CP	ADF	NDF	RFV ^c
1	Pre bloom	Bud to first flower; stage at which stems are beginning to elongate to just before blooming.	40 to 50% leaves; green; less than 5% foreign material; free of mold, musty odor, dust, etc.	>19	<31	<40	>140
2	Early	Early to mid bloom; stage between initiation of bloom and stage in which 1/2 of the plants are in bloom.	35 to 45% leaves, light green to green; less than 10% foreign material; free of mold, musty odor, dust, etc.	17-19	31-35	40-46	124-140
3	Mid bloom	Mid to full bloom; stage in which 1/2 or more of plants are in bloom.	25 to 40% leaves; yellow green to green; less than 15% foreign material; free of mold, musty odor, dust, etc.	13-16	36-41	47-51	101-123
4	Full	Full bloom and beyond.	Less than 30% leaves; brown to green; less than 20% foreign material; free of musty odor, etc.	<13	>41	>51	<100

*Source: Rohweder et al. 1978. Journal of Animal Science 47:747.

^bChemical analyses expressed on dry matter basis. CP = crude protein; ADF = acid detergent fiber; NDF = neutral detergent fiber.

^cRFV: relative feed value. $RFV = (65.5 + .975 ADF - .0277 ADF^2) \times (39.0 + 2.68 NDF - .041 NDF^2) \times .025$.

Factors affecting forage quality. Forage species, agronomic conditions, maturity at harvest, and storage procedures determine the quality of the forage when fed to the animal. The most important classification scheme to separate hay crop forage species is grasses versus legumes. Quality of different species within these classes is fairly similar; however, quality can differ greatly between the two classes. The major legume species used for forages in Ohio are alfalfa, clovers, and birdsfoot trefoil. The most important grasses are orchardgrass, ryegrass, fescue, and timothy. Grasses almost always have more NDF and less CP than do legumes. Therefore, in general, legumes are higher in feed value than are grasses. Intensively managed grasses, however, can be equal to or exceed legumes in feeding value. Grasses must be fertilized heavily with nitrogen (greater than 100 pounds N/ acre/year) and cut frequently (4 or 5 cuttings/year in Ohio) to have high feeding value. Corn silage and other high-energy forages, such as sorghum and small-grain silages, fit into a separate category. These forages are grasses, but due to the amount of grain harvested with the other plant parts, they do not act as other grasses.

The agronomic conditions the forage is grown under affect quality. Many of these factors such as rainfall, day length, and temperature are beyond the producer's control. Drought generally increases the feeding value of hay crop forages, but greatly reduces yield per acre. Drought stunts plant growth which limits the amount of fiber produced by the plant. Therefore, drought-stressed forages generally have lower concentrations of fiber and higher concentrations of energy than do normal forages. Concentration of CP in drought-stressed forages may also be somewhat higher than normal. Day length and temperature also influence the feeding value. In general, conditions that promote growth (long days and warm temperatures) reduce feeding value by promoting fiber synthesis by the plant.

Agronomic conditions that the producer can control include pest control and fertilization. Forage fields infested with weeds or insects generally yield less per acre, but quality may or may not be affected. Maintaining proper soil fertility (based on soil test) increases yield per acre. Nitrogen (N) is the plant nutrient that has a large influence on forage quality. Legumes do not need to be fertilized with N; however, grasses should receive N fertilizer to improve both quality and yield. Nitrogen fertilization increases CP content of grasses markedly, but slightly reduces the concentration of available energy.

Recommendations concerning fertilization regimens and pest control can be found in the Ohio Agronomy Guide.

Table 2. Grades for Grasses and Grass-Legume Mixtures (Hay Marketing Task Force)^a

Grade	Stage of Maturity	Definition	Physical Description	Typical chemical composition (%) ^b			
				CP	ADF	NDF	RFV ^c
1	Pre head	Late vegetative to early boot; state at which stems are beginning to elongate to just before heading; 2 to 3 weeks regrowth.	50% or more leaves; green; less than 5% foreign material; free of mold, musty odor, etc.	>18	<33	<55	124-140
2	Early head	Boot to early head; stage between late boot where inflorescence is just emerging until the stage in which 1/2 inflorescence are in anthesis; 4 to 6 weeks regrowth.	40% or more leaves; light green to green; less than 10% foreign material free of mold, musty odor, dust, etc.	13-18	33-38	55-60	101-123
3	Head	Head to milk; stage in which 1/2 or more of inflorescence are in anthesis and the stage in which seeds are well-formed but soft and immature; 7 to 9 weeks regrowth.	30% or more leaves; yellow green to green; less than 15% foreign material; free of mold, musty odor, dust, etc.	8-12	39-41	61-65	83-100
4	Post head	Dough to seed; stage in which seeds are of dough-like consistency until stage when plants are normally harvested for seed; more than 10 weeks regrowth.	20% or more leaves; brown to green; less than 20% foreign material; slightly musty odor, dust, etc.	<8	>41	>65	<83

^aSource: Rohweder et al. 1978. *Journal of Animal Science* 47:747.

^bChemical analyses expressed on dry matter basis. CP = crude protein; ADF = acid detergent fiber; NDF = neutral detergent fiber.

^cRFV: relative feed value. $RFV = (34.8 + 2.56 ADF - .0491 ADF^2) \times (54.8 + 1.22 NDF - .0176 NDF^2) \times .025$.

The stage of maturity when a plant is harvested is the most important factor influencing quality that the producer can control. As hay crop forages mature, feeding value decreases steadily. To maximize both stand life of forage and its feeding value to high-producing cows, grasses should be harvested in the vegetative stage of maturity and legumes in the late bud stage. Research has shown that for every day alfalfa is allowed to mature past late bud stage, the amount of concentrate needed in the diet must be increased one percentage unit to produce the same amount of milk as when cows are fed late bud alfalfa. Increasing the amount of concentrate in the diet will not completely overcome the detrimental effects of maturity on forage quality. Wisconsin research found that dairy cows fed a diet of 70% late bud alfalfa and 30% concentrate (dry matter basis) produced more milk than did cows fed a diet of 30% full bloom alfalfa and 70% concentrate. Since high concentrate diets often cause metabolic and digestive problems, there is a limit to the amount of concentrate that can be used to replace low quality forage. Concentrate cannot completely eliminate the adverse effects of forage quality on dairy cow performance, and maximum milk production cannot be achieved with mature forage. The effects of forage maturity are even more pronounced with grasses. Grass harvested in the vegetative stage will have approximately 30% more available energy than grass harvested in early anthesis (heads are emerging). In Ohio, the interval between the vegetative stage and early anthesis is about 7 days for some grasses.

Maturity affects quality of corn and similar silages but to a much smaller degree than for hay crop forages. Immature corn is generally 5 to 10% more digestible than mature corn; however, yields per acre are substantially less. For maximum yield of energy per acre, corn should be harvested between the one-half and two-thirds milk line stage of maturity (milk line is measured from the top of the kernel). If immature corn has to be harvested because of late planting or early frost, silage should be high quality if

ensiled at the proper moisture content. Sorghum silage is similar to corn. Small grain silage should be harvested in the boot stage of maturity. Available energy decreases significantly as small grains mature from the boot stage to soft dough stage.

Importance of Forage Quality to Cow Performance. As mentioned above, forage quality has a significant impact on cow performance. Forage quality affects feed intake and the amount of concentrate needed to balance the diet. Digestibility of a diet has a major influence on feed intake by cattle. Fiber is generally less digestible than non-fiber components; therefore, high-fiber feeds such as forages are less digestible than low-fiber feeds such as grains. High quality forages such as corn silage, late bud alfalfa, and vegetative grasses are usually digestible enough that feed intake is not restricted significantly. Mature forages generally restrict feed intake due to their digestibility. Late bud alfalfa is about 65% digestible, but full bloom alfalfa is only about 55% digestible. A summary of several experiments revealed the following relationship between alfalfa maturity and dairy cow performance. For cows producing more than 65 lb/day of fat-corrected milk, dry matter intake was reduced 0.3 lb/day and fat-corrected milk yield was reduced 0.35 lb/day for every 1 percentage unit increase above 40% NDF content of alfalfa. For example, a group of cows fed alfalfa with 45% NDF would consume, on average, 1.5 lb/day less dry matter and produce 1.75 lb/day less fat-corrected milk than cows fed alfalfa with 40% NDF.

High-quality forages not only support higher levels of milk production, but also lower feed costs. It costs essentially the same to produce late bud alfalfa as it does to produce full bloom alfalfa. However, one pound of late bud alfalfa contains about .08 pounds more CP and .09 Mcal more net energy than does full bloom alfalfa. This is equivalent to approximately .15 pounds of soybean meal. For an average cow fed a diet of 50% alfalfa, late bud alfalfa will provide about 1.8 pounds more CP and 1.9 Mcal more net energy than would full bloom alfalfa. This results in a savings of about four pounds of soybean meal. Using historical prices, this would result in a savings of 40 to 50 cents per head per day. The bottom line is that high-quality forages are essential to maximize production and keep feed cost low.

Comparing Forage Quality. Nutrient requirements differ among dairy cows based on production, age, and body condition. Therefore, all cows do not need the same quality of forage. Additionally, it is necessary to be able to compare the nutritive quality of different species (especially grasses vs. legumes). Relative feed value (RFV) is a way of comparing forage quality and can be an aid in matching forage quality with animal performance. The RFV of forages is determined by estimating the amount of digestible energy an animal would consume if fed a particular forage. The values are on a relative scale with full bloom alfalfa set at 100. Forages with an RFV greater than 100 are superior to full bloom alfalfa, and forages with an RFV less than 100 are nutritionally inferior to full bloom alfalfa. To calculate RFV, the ADF and NDF concentrations of a forage are needed. These numbers are used in equations to estimate energy content and potential intake (Tables I and 2). An alternative method of roughly estimating RFV is to simply use Tables 1 and 2. It is important to use the correct table for each forage. If the forage is predominantly alfalfa, use Table 1. If the forage is predominantly grass, use Table 2. In theory, a forage with an RFV of 140 is worth 1.4 times more than full bloom alfalfa. Early lactation and high producing cows should be fed forages with an RFV of at least 130. Medium producing cows can be fed forages with an RFV of 100-120. Late lactation cows can usually be fed forages with an RFV of around 100. Producers may have to adjust these recommendations to account for body condition and age of cows.

Harvesting and Storage of Forages

Forages can be fed as pasture, green chop, silage, or hay. Pasture is harvested by the animal, and if it is not managed correctly, harvest losses can be severe. Harvest losses of pasture are greatly reduced when

intensively managed grazing is practiced. If animals are allowed to graze a large land area at one time, much of the forage will be trampled, contaminated with manure, or otherwise wasted. Pasture is not stored so no storage losses occur. Green chop is very similar to intensive grazing except that a machine is used to harvest the crop. Harvest and storage losses are very low; however, equipment, energy, and labor costs are high. Harvest and storage losses are greatest for hay and silage, but if proper silage and hay making practices are followed, these losses can be minimized.

Harvest Losses. Major losses in both yield and quality can occur during harvest and storage of forages. Certain losses during these steps cannot be avoided, but following proper procedures can keep quality and yield losses low. The two most common causes of harvest losses are mechanical handling and rain. Losses due to mechanical handling are directly proportional to the dry matter content of the forage when handled. Yield losses due to mechanical damage are about 3 to 6% of total yield if the forage contains less than about 60% dry matter. Losses can increase to 10 to 15% of total yield if forages are handled when they contain more than 60% dry matter. Forage made into silage usually contains less than 60% dry matter so losses due to mechanical damage are usually low compared to hay. Forage that is harvested as hay should be handled at an absolute minimum. Hay should not be raked or tilled any more than necessary.

Losses due to rain damage can occur in forages harvested as silage or hay, but because of the necessary extended drying time the risk is greater when making hay. Losses caused by rain depend on when it rains relative to cutting and how much rain falls. If forages are rained on shortly after cutting (within a few hours) very little damage is done. As the length of time increases from cutting to when it rains, losses increase. Utah research found that alfalfa receiving one inch of rain three hours after cutting lost about 2% of CP yield and 3.7% of dry matter yield compared to alfalfa not receiving any rain. If the rain fell 12 hours after cutting, CP yield was reduced 3.5% and dry matter yield was reduced 5%. As the amount of rainfall increases, losses increase. Alfalfa that received 0.2 inches of rain yielded about 5% less dry matter and 4% less CP per acre than hay that received no rain. When the amount of rainfall increased to 0.8 inches, yield of dry matter and CP were reduced by 10%. Since weather is beyond control, farmers often have to decide whether to cut and risk rain damage or allow forage to continue to mature, which will definitely decrease quality. As a general rule, the loss in quality and yield due to a one-inch rain will exceed the losses in quality caused by allowing alfalfa to mature an additional week. This is not true for grasses since the decline in quality due to maturity is much more rapid than it is for alfalfa.

Storage Losses. Losses for forages that are stored properly are extremely low; however, if either hay or silage is stored incorrectly, the entire harvest can be lost. Hay is preserved because its low water content prevents excessive growth of microbes. If it is baled with too much moisture, microbial growth is not controlled. Hay should contain less than 20% moisture in small bales, and hay in large bales should contain less than 16% moisture to be preserved correctly. Slightly wetter hay can often be preserved if it is loosely stacked in a well-ventilated area after baling. Hay containing more than 25% moisture will almost always spoil. Two types of spoilage can occur. When extremely wet hay is baled (greater than about 35% water), molds and bacteria will simply cause the hay to rot. When it is baled with 20 to 30% moisture, heat damage usually occurs. Bacteria and molds present on damp hay convert nutrients in the hay into more microbial matter and heat. Heat causes a reaction to occur between proteins and carbohydrates which greatly reduces digestibility of both fractions. The loss of digestibility due to heat is dependent upon temperature of the hay and length of time the hay remains hot. Little damage will occur if bale temperature does not exceed about 85°F or if the temperature remains above 85°F for less than two or three days. If temperature exceeds 130°F damage occurs rapidly. Measuring ADIN can be useful to estimate the extent of heat damage.

Hay harvested at the correct moisture content can still undergo severe losses if stored improperly. To prevent excessive storage losses, hay should be stored under cover, protected from rain and snow. Under typical Midwest climatic conditions, hay in large round bales stored outside and uncovered can lose more than 20% of total dry matter and 30% of total CP during one winter. Storage losses in hay stored inside are essentially nil.

Forage stored as silage can also suffer extreme losses in quality and yield if ensiled incorrectly. To minimize storage losses in silage, chop the silage at the correct length (theoretical length of one-half to three-fourths inch), fill the silo rapidly, use a structurally sound silo, and cover silage between cuttings. As with hay, the most important factor affecting storage losses is DM content of the silage. Silage ensiled too wet (direct cut hay crop silage or immature corn silage) can undergo a poor fermentation and seepage from the silo can occur. Wet silage is more prone to clostridial fermentation, which increases dry matter and CP losses during ensiling and also results in less palatable silage. Seepage reduces the nutritive value of silage since many soluble nutrients such as protein and sugars are lost in the effluent. Seepage also causes pollution and odor problems. Forages that contain too little water (less than about 40% water or more than 60% DM) at ensiling undergo a very limited fermentation. These conditions facilitate mold growth and can result in heat damage. These silages are unstable and can spoil if exposed to air. A sound silo that prevents air infiltration is essential if this type of silage is stored. To prevent excessive storage losses in silage, the DM content should be between 35 and 55% (45 to 65% water).

Many different additives are available to use in hay and silage making. Information on hay preservatives, drying agents, and silage additives is available in Agronomy Fact Sheets.

Forage Crops

Many different crops are considered forages, but only crops used commonly in Ohio will be discussed. This publication is not intended to provide complete information regarding agronomic recommendations or feeding value for all forages. Rather, it is intended to provide specific advantages or disadvantages of the forage. Additional information regarding these forages can be found in the Ohio Agronomy Guide, Agronomy Fact Sheets, and tables of nutrient composition.

Alfalfa. A good well-managed stand of alfalfa generally will yield more CP per acre than any other forage. Yield of energy per acre is also high. It is probably the best overall forage available for dairy cows. Alfalfa must be cut at the proper stage of maturity to obtain maximum feeding value. The main disadvantages with alfalfa are the high cost of seed and specific soil drainage and fertility requirements. Alfalfa requires well-drained soils, high soil levels of phosphorus and potassium, and soil pH near neutral (pH 7).

Birdsfoot Trefoil. This legume is very similar in feeding value to alfalfa if managed properly. Birdsfoot trefoil will generally equal or out-yield alfalfa in poorly drained soils in northeastern Ohio, but stands generally will not persist throughout the rest of the state. In well-drained soils alfalfa generally produces about 20% more nutrients per acre than trefoil. Unlike alfalfa, trefoil does not induce bloat, making it useful in pasture situations.

Clovers. This category includes red, alsike, and white clover. Red clover can be used as silage, pasture, or hay. Because of the characteristics of the plant, curing time can be quite long. Nutritionally it is similar to alfalfa, but generally contains slightly more fiber and slightly less CP as compared to alfalfa at similar maturity. An advantage of red clover over alfalfa is that feeding value decreases slower with advancing maturity. Generally alfalfa will out-yield red clover in well-drained soil. Costs of establishing a stand of red clover are substantially less than for alfalfa; therefore, red clover may fit better when a

short stand life is desirable (e.g., a 3-year crop rotation). White clover can be used as a companion to grass in permanent pastures with alsike favored over white on poorer drained soils. Yields are low compared to alfalfa, but costs are also low. Nutritionally, white and alsike clovers are similar to alfalfa. Clovers can cause bloat.

Soybeans. Soybeans can be used as a forage in an emergency or if frost kills soybeans prior to maturity. The cost of planting soybeans is high and forage yield will not justify the cost under normal conditions. Because of the nature of the plant, soybean hay is extremely dusty (leaves shatter easily) and cures slowly. Leaf shatter also greatly reduces the feeding value of soybean hay. Soybean plants can be ensiled, but often, the silage is of very low quality because of the oil in the seed. A mixture of about half corn plants and half soybean plants can usually be ensiled satisfactorily. Soybeans should be harvested as forage when beans have formed in the pod and the leaves begin to turn yellow.

Orchardgrass. This is one of the most commonly grown grasses in Ohio and is especially noted for its excellent summer growth. Dry matter and nutrient yield per acre can be quite high if properly managed. Orchardgrass responds well to nitrogen fertilization, and CP concentration of more than 20% can be obtained if adequate nitrogen is provided to the plant. Orchardgrass cut in the early vegetative stage can be nearly equal to alfalfa in feeding value. It matures rapidly and feeding value decreases greatly with maturity. Orchardgrass that has headed is of very limited value to lactating dairy cows. Improved varieties with greater leafiness, finer stems, and with up to a 10-day later maturity than common orchardgrass can be selected for mixtures with alfalfa to improve the quality of alfalfa-orchardgrass forage.

Perennial Ryegrass. In northern Ohio, this is the highest quality grass available for hay and silage use. Harvested in the vegetative stage, concentration of NDF in perennial ryegrass is the lowest of all grasses. Nitrogen fertilization can increase the CP content to more than 20%. Yields per acre can be high if the stand is properly managed. New forage-type perennial ryegrass varieties have proven to be winter hardy and persistent for use in mixtures with alfalfa in northern Ohio, but persistence is poor in the southern part of the state. When grown in northern Ohio, perennial ryegrass may be lower yielding than orchardgrass, especially during periods of hot weather. It is also less competitive than orchardgrass in mixture with alfalfa.

Tall Fescue. Tall fescue can be easily established and is highly productive. Feeding value, however, often is poor and is associated with the presence of the endophyte fungus *Acremonium coenophialum*. When harvested in the vegetative stage of maturity, fiber concentration is usually slightly higher and energy slightly lower than for orchardgrass. As with orchardgrass, feeding value decreases rapidly with maturity. The major problem with older stands of tall fescue is that they often contain high levels of the endophyte fungus. Toxins produced by this fungus can cause severe decreases in milk production, reduced animal growth, reproductive problems, and elevated body temperatures when consumed as pasture, silage or hay by cattle. Auburn University recommends that dairy cattle not be fed tall fescue even if infection level is as low as 5%. Very satisfactory animal performance can result from feeding the newer improved endophyte-free varieties. Ohio growers can send plant samples to the Auburn University Fescue Diagnostic Laboratory to determine infection level. See Agronomy Facts AGF-008 for procedures.

Sudan Grass and Sorghum

Sudan Crosses. These crops produce large quantities of forage during late summer and are often used as an emergency source of forage. Feeding value is quite high if the grasses are harvested at an immature stage. Trampling losses can be severe in tall forages; therefore, the most efficient way of feeding these

forages is as greenchop or silage. These grasses make poor hay because the stems are difficult to dry. The main disadvantage in using these forages is the potential of prussic acid poisoning. If the crop is harvested when shorter than 24 inches, or immediately after a frost, the potential for toxicity is present. The safest way to feed these forages is as silage, since fermentation greatly reduces the prussic acid concentration. Greenchopping somewhat reduces the toxicity risk by eliminating the potential for animals to select specific plant parts.

Corn Silage. Corn harvested as silage has the highest yield of energy and dry matter per acre of all forage crops. However, yield of CP per acre is very low. Feeding value of corn silage is usually high, but corn silage diets must be supplemented extensively with CP and minerals. Drought-stressed corn is similar in feed value to normal corn even if ears do not develop fully. Frosted corn can make excellent silage regardless of stage of maturity if harvested at the proper moisture content. Corn containing less than about 30% dry matter should not be harvested for silage. Feeding value of immature corn is equal to or better than normal corn silage, but yield per acre is substantially less. Although dry matter yields are highest when silage corn is harvested at black layer, decreased digestibility of starch and fiber reduces milk yield per acre. Overall, highest milk yield per acre is obtained when silage corn is harvested between the one-half and two-thirds milk line stage of maturity.

Sorghum Silage. Sorghum silage has a feeding value of about 90% that of corn silage. In Ohio, yields of corn will almost always be greater than for sorghum, although it may be superior to corn under drier conditions. Sorghum can contain more water than corn at similar maturities; therefore, it is important to check dry matter content prior to ensiling. Frosted sorghum can also be ensiled if moisture content is not excessive. Ideal dry matter content for sorghum (35 to 40% DM) is similar to that for corn.

Small Grain Silage. This category includes barley, oats, spelt, forage triticale, and wheat when they are harvested for forage. Feeding value does not differ greatly among these crops. Harvest in the vegetative or milk stage to maximize forage quality and harvest in the milk stage to maximize yield of nutrients. If the crop is going to be ensiled, plants in the vegetative stage contain too much water to ferment properly so they must be wilted prior to chopping. Plants beyond the milk stage do not contain enough water to ferment properly.

These forages are very prone to heat damage when ensiled because the hollow stems prevent good consolidation of the silage mass and because these crops are often ensiled when too dry. The major problem with these crops is that DM changes rapidly with maturity so they are difficult to harvest at the correct moisture level. These crops contain about 90% as much energy as corn but usually contain three to four percentage units more CP than corn. Rye or triticale should be harvested in the boot stage (just prior to head emergence). Although there are fewer problems with triticale, palatability of these two forages decreases greatly with advancing stages of maturity.

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