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Agriculture and Natural Resources

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Forage Testing for Beef Cattle

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Clif Little

Forage quality changes with maturity and storage. A forage test can supply useful information about the nutritive value of hay or pasture. This information can be used to adjust the amount of supplement fed. If forage quality is high, the producer can feed less supplement, resulting in savings. Conversely, if the forage quality is low, diet supplementation can improve animal performance, and increase profits. This fact sheet discusses how to take a forage sample and how to interpret the laboratory results.

Taking a Forage Sample

Forage test forms can be obtained from your county Extension office. These forms contain complete instructions on how to collect forage samples. Proper collection and identification of a sample is very important. A tool is needed to collect hay samples. Your local Extension office may have a Penn State Forage Sampler. This device consists of a long tube with a cutting edge on one end and a shank on the other that can be fastened to an electric drill or hand brace.

1. To correctly sample a rectangular bale, the bit is driven into the end of 15 to 20 bales from a particular lot of hay. Drill to the full depth of the sample tube on loose bales and half depth in tight bales. Mix the cores thoroughly and send the entire sample to the lab in a sealed plastic bag.

2. Large round bales should be sampled on the rounded side of the bale. Collect a single sample from each of 10 to 12 bales from the same lot, combining the core samples into one sample for analysis. If the outer layer of the round bale is weathered, pull away 1 to 2 inches and sample below. Drill to the full depth of the tube.

Each hay type and cutting should be sampled and analyzed separately. Hay harvested on different dates within a cutting should also be sampled separately. Therefore, it is important that each cutting is stored separately and can be identified with its forage test. When sampling forages one cannot over stress the

importance of proper sampling technique. Samples should be representative and selected at random. In summary, sample each lot of forage separately, and make sure that the forage can be identified with its analysis when feeding.

Silage can also be analyzed. To sample silage, run the unloader and collect from the feed bunk in 5 to 6 places. Put four handfuls of silage into a plastic bag. Collect samples for two or three days, then mix thoroughly and subsample 1 to 2 pounds. Keep samples in the refrigerator during the collection period and store them in a plastic bag. Seal the bag, attach a completed tag and mail immediately or freeze and mail the frozen sample to the laboratory.

Bagged silage can be sampled by cutting slits along the side of the bag in 5 to 6 places. Collect handfuls and mix in a clean plastic bucket. Mix well and bag in plastic with a tag. Reseal the slit with heavy duty tape.

Silage can also be sampled while it is going into the silo. Collect representative samples from each wagon as it is unloaded and mail immediately or freeze the samples. Take the same number of samples from each wagon and keep them in a container. If the silage lot changes (i.e., a particular hybrid, field, area of the farm), start another container. When all samples have been collected, mix the sample within each container, and collect a random 1 to 2 pound subsample for analysis. Seal in a plastic bag and send to the lab immediately or freeze if they can't be mailed promptly. Fresh silage samples are a good way to plan your feeding program. However, it is a good idea to sample silages when they are being fed and have gone through the fermentation process.

Pastures can be sampled by collecting pasture grass at the height animals are grazing. Collect random grab samples of forage from several locations. Air dry the sample if possible, before sending to the laboratory. This can be done by hanging the forage inside a burlap bag for about a week. Fresh samples should be mailed immediately.

There are many reasons to forage test. If you are considering testing your forage, most forage testing labs can provide forage or feed analysis. Instructions for sampling and the input forms for the Ohio State University R.E.A.L. lab are available from county Extension offices.

Interpreting Lab Test Results

Let's say you have sampled four lots of different hay. Let's take a look at some typical lab results from The Ohio State University Research Extension Analytical Laboratory. Listed in Table 1 are samples taken from hay produced on a farm in Guernsey County. These samples were all harvested in mid-June to late June.

Now that we have our results, how do we use them and what do they mean? As a hay producer you probably have a similar scenario, several lots of hay, each with a different nutrient composition. Let's go through our report and look at the differences between each nutrient and finally determine how we might use these forages. As we consider the nutrient levels in our hay we should consider the animal's sex, weight, daily gain, stage of production, and environmental conditions. Below are recommendations of nutrients for beef cattle.

Table 1. Analytical Results on a 100 Percent Dry Matter Basis (Except as Noted)

Feed Code #	158 Alfalfa/Orchard	173 Alfalfa/Grass	225 Orchard	178 Alfalfa/Grass

	Grass		Grass	
Percent				
Dry Matter (DM)	83.3	88.1	88.6	88.6
Crude Protein (CP)	16.9	8.4	7.9	9.6
Crude Protein, As Fed	14.1	7.4	7.0	8.5
ADF	45.5	40.7	44.4	41.2
NEM	0.48	0.54	0.50	0.53
NEG	0.19	0.24	0.20	0.24
Phosphorus (P)	0.34	0.26	0.29	0.19
Potassium (K)	3.37	2.26	2.28	1.80
Calcium (Ca)	1.39	0.50	0.29	0.55
Magnesium (Mg)	0.33	0.22	0.23	0.22
Parts Per Million				
Manganese (Mn)	53	89	110	102
Iron (Fe)	68	39	31	32
Copper (Cu)	10	5	5	5
Zinc (Zn)	26	14	23	19
LH = Lowest/Highest Possible value Detected by Spectrograph				
K/Ca + Mg	1.96	3.1	4.4	2.34

Table 2. Nutrient Requirements of Beef Cattle

Body Weight (lb)	Daily Gain (lb)	Dry Matter Intake (lb)	Crude Protein		TDN		Ca (%)	P (%)
			lb/day	% of DM	lb/day	% of DM		
Heifer calves								
400	1.5	10.2	1.17	11.4	7.0	68.5	0.45	0.24
500	1.5	12.1	1.25	10.3	8.3	68.5	0.38	0.22
600	1.5	13.8	1.32	9.5	9.4	68.5	0.32	0.21
Pregnant yearling heifers-last third of pregnancy								
750	1.4	16.6	1.5	8.9	10.0	59.9	0.32	0.21
850	0.9	17.6	1.4	8.2	9.6	54.5	0.26	0.20
950	0.9	19.0	1.5	8.0	10.3	54.1	0.27	0.20
Dry pregnant mature cows-middle third of pregnancy								
1000	-	18.1	1.3	7.0	8.8	48.8	0.18	0.18
1100	-	19.5	1.4	7.0	9.5	48.8	0.19	0.19
1200	-	20.8	1.4	6.9	10.1	48.8	0.19	0.19
Dry pregnant mature cows-last third of pregnancy								

1000	0.9	19.6	1.6	7.9	10.5	53.6	0.26	0.21
1100	0.9	21.0	1.6	7.8	11.2	53.2	0.26	0.21
1200	0.9	22.3	1.7	7.8	11.8	52.9	0.26	0.21
Two-year-old heifers nursing calves-first 3 to 4 months postpartum; 10 lb milk per day								
800	0.5	17.6	1.9	10.8	11.2	63.8	0.34	0.24
900	0.5	19.2	2.0	10.4	12.0	62.7	0.32	0.23
1000	0.5	20.8	2.1	10.0	12.9	61.9	0.31	0.23
Cows nursing calves-first 3 to 4 months postpartum; average milking (10 lb/day)								
1000	-	20.2	2.0	9.6	11.0	56.6	0.28	0.22
1100	-	21.6	2.0	9.4	11.5	56.0	0.27	0.22
1200	-	23.0	2.1	9.3	12.1	55.5	0.27	0.22
Cows nursing calves-first 3 to 4 months postpartum; superior milking (20 lb/day)								
1000	-	20.6	2.5	12.3	13.8	67.0	0.39	0.27
1100	-	22.3	2.6	11.9	14.5	65.2	0.38	0.27
1200	-	23.8	2.7	11.5	15.2	63.7	0.36	0.26
Bulls-maintenance and slow rate of growth (regain condition)								
1400	2.0	27.7	2.2	8.0	17.8	64.0	0.25	0.20
1600	1.0	29.7	2.2	7.3	16.6	55.8	0.22	0.19
1800	0.5	30.9	2.2	7.0	16.1	52.0	0.20	0.20
Vitamin A requirement for (1) pregnant heifers and cows = 1270 IU per lb dry feed; (2) lactating cows and breeding bulls = 1770 IU per lb dry feed.								
Source: NRC. 1984. Nutrition Requirements of Beef Cattle (6th Ed). National Academy Press, Washington, D.C.								

Table 3. Mineral Requirements and Maximum Tolerable Concentrations

Mineral	Unit	Requirement			Maximum Tolerable Concentration
		Growing and Finishing Cattle	Cows		
			Gestating	Early Lactation	
Chromium	mg/kg, ppm	-	-	-	1,000.00
Cobalt	mg/kg, ppm	0.10	0.10	0.10	10.00
Copper	mg/kg, ppm	10.00	10.00	10.00	100.00
Iodine	mg/kg, ppm	0.50	0.50	0.50	50.00
Iron	mg/kg, ppm	50.00	50.00	50.00	1,000.00
Magnesium	%	0.10	0.12	0.20	0.40

Manganese	mg/kg, ppm	20.00	40.00	40.00	1,000.00
Molybdenum	mg/kg, ppm	-	-	-	5.00
Nickel	mg/kg, ppm	-	-	-	50.00
Potassium	%	0.60	0.60	0.70	3.00
Selenium	mg/kg, ppm	0.10	0.10	0.10	2.00
Sodium	%	0.06-0.08	0.06-0.08	0.10	-
Sulfur	%	0.15	0.15	0.15	0.40
Zinc	mg/kg, ppm	30.00	30.00	30.00	500.00
Calcium and phosphorus requirements are specific for class and performance of the animal.					
Source: NRC. 1996. Nutrition Requirements of Beef Cattle (7th Ed). National Academy Press, Washington, D.C.					

Dry Matter (DM)

Beef cows will consume 2 percent to 2.5 percent of their body weight in dry matter per day. This means that a 1000 pound cow would consume 1000 x 0.025 = 25 pounds of dry matter per day. This is approximately 30 pounds of hay sample 158 (25 — 0.833). The questions become: 'Is it possible for the cows to eat this much hay,' and 'Am I supplying enough feed to meet the dry matter needs?' In addition, proper dry matter content of hay and silage is essential for successful storage. OSU Agronomy Fact Sheet 004 suggests the proper DM content for storing forages.

Crude Protein (CP)

We have a range of protein percentages for these hay types. Recommended crude protein levels, as a percentage of DM, range from approximately 7.0 for mid-gestation mature dry cows to approximately 13 percent for cows nursing calves. Sample 158 of the Alfalfa/Orchardgrass hay would supply enough nutrients to support a dry cow and would meet most of the nutrient requirements of a lactating cow. Therefore, we could best utilize this hay on growing replacement heifers, and pregnant and lactating cows.

To meet the protein needs of our cows being fed the other analyzed hay sources, we would have to supplement. A popular non-protein nitrogen source is urea. Urea must be fed with care since it rapidly decomposes to ammonia in the rumen. Large quantities of urea can cause ammonia toxicity and is potentially fatal. When feeding urea, be sure to mix rations well. Furthermore, calves under 450 pounds will gain more efficiently on natural protein rather than a non-protein nitrogen source.

Typical Forage CP Values as a Percent of Dry Matter	
Grass Hay	Crude Protein Content
High Quality	10-13% +
Medium Quality	8% +

Low Quality	below 8%
Legume/Grass	
High Quality	19% +
Medium Quality	17-19%
Low (full bloom)	13-16%
Source: NRC, 1996, Nutrient Requirements of Beef Cattle (7th Ed.) National Academy Press, Washington, D.C.	

ADF (Acid Detergent Fiber)

ADF is a measure of cellulose and lignin. As the amount of ADF in the forage increases, digestibility decreases.

Typical Forage ADF Values as a Percent of Dry Matter

Grass Hay-ADF levels range from less than 33 to 39% or higher for late cut hay.

Legume/Grass-ADF levels range from less than 31 to 38%.

Source: OSU Dairy Ration Balance Program

As our samples illustrate, all of our hay sources have high acid detergent fiber values. Total dry matter intake decreases as acid detergent fiber levels go up.

NDF (Neutral Detergent Fiber)

NDF is determined from the amount of cellulose, lignin, and hemicellulose in the forage. This material for the most part makes up the cell wall of plants. As the NDF values increase, plant materials become indigestible and cows will consume less dry matter. Our samples were not analyzed for neutral detergent fiber.

Typical NDF Values as a Percent of Dry Matter

Range from 42 on early bloom legume hay to 72 on late cut grass hay.

Source: OSU Dairy Ration Balance Program

As a rule of thumb, the maximum NDF dry matter content of the daily ration should be from 1.2 to 1.5 percent of the cow's body weight. The higher the quality of the forage, the closer to the top end of the range can be consumed. For this reason, NDF values can be used to estimate forage intake. As NDF values increase, forage intake will decrease.

NEM & NEG

NEM is net energy required for maintenance, and NEG is net energy required for gain. Adjustments in requirements are made for various stages of production. Most of these analyzed forages will just meet a cow's energy needs. For example, the NEM requirement for a pregnant yearling heifer gaining 1.9 pounds per day and weighing 900 pounds is 0.68 megacalories/pound (Mcal/lb) on a dry matter basis.

NEM levels for mature cows range from 0.42 (Mcal/lb) for dry cows to 0.67 (Mcal/lb) for cows nursing calves and in peak production. Growing heifers require at least a minimum NEG of 0.32 (Mcal/lb) on a dry matter basis. Energy values can be used to compare forages. Cattle require higher energy levels during lactation, and growth. Adjustment in maintenance requirements are made for breed, sex, season, age, hide, temperature, and physical activity. Grazed cattle may have a 10 to 20 percent increase in maintenance energy requirements as compared to penned cattle. Research has indicated that net energy requirement for steers and heifers is similar when comparing animals of same body type and stress. Conversely, bulls may require twelve percent more energy for maintenance than heifers of the same body type and stress. Sample 173 contains the highest energy levels because it has the lowest ADF levels. As the percentage ADF and NDF decrease, the starch and sugar in the feed will increase. Producers wanting to improve body condition scores should consider increasing dietary energy levels.

Phosphorus (P)

Phosphorus levels are generally lower in forages and higher in grains. Samples 173 and 178 are low in phosphorus. Lactating cows and growing animals have higher P requirements. Levels approaching 0.25 percent P on a DM basis are at the critical level. In grazing animals, phosphorus deficiency is common. Phosphorus deficiencies will often manifest themselves as reproductive problems.

Potassium (K)

Potassium levels of 0.6 percent of the ration dry matter is considered adequate for beef cattle. Fresh forages are excellent sources of potassium. Diets containing a high level of concentrates may require potassium supplementation. The K levels of forages decrease as plants mature. Low concentrations of K have been occasionally found in tall fescue during the winter. Potassium may be supplemented to cattle diets as potassium chloride, potassium bicarbonate, potassium sulfate, or potassium carbonate. All forms are readily available.

Ohio forages often contain excessive levels of potassium. High K levels have been associated with reduced magnesium absorption. For this reason, K that has been added for winter feeding should be removed from the mixture when fescue starts growing in the spring. Three percent K on a DM basis is the maximum tolerable concentration for beef cattle. Sample 158 has a particularly high concentration of K. If grazing this field in the spring, we would expect reduced absorption of magnesium (see Magnesium below).

Source: NRC, 1984, Nutrition Requirements of Beef Cattle (6th Ed.) National Academy Press, Washington D.C.

Calcium (Ca)

Forages are typically high in calcium, particularly alfalfa hay, our samples illustrate this well. Calcium levels on a percent DM basis will reach the critical level at 0.18 percent for dry cows. Lactating cows and growing calves will have the highest requirements needing approximately 0.39 percent and 0.45 percent Ca as a percent DM respectively. Sample 225 is below the recommended level for calcium for some stages of beef cow production. Calcium serves in the development of bones, teeth, and is involved in other body functions such as blood clotting, muscle construction, and transmission of nerve impulses. The ideal Ca to P ratio is 2 to 1, but ratios of 7 to 1 are acceptable.

Source: NRC, 1984, Nutrition Requirements of Beef Cattle (6th Ed.) National Academy Press, Washington D.C.

Magnesium (Mg)

A common magnesium deficiency occurring in the spring is grass tetany. This problem is usually associated with lactating cows. The initial signs include: nervousness, and muscular twitching around the face and ears. Magnesium oxide and magnesium sulfate are two common sources of supplemental magnesium. However, magnesium in dolomitic limestone is poorly available. Magnesium levels below 0.10 percent are of particular concern for growing and lactating cows. Finishing cattle reach critical Mg levels at 0.2 percent, while gestating beef cows need 0.12 percent Mg (as a percentage of DM). High soil potassium levels have been associated with increased incidence of grass tetany. The ratio of potassium to calcium plus magnesium should be less than 2.2 to avoid problems with grass tetany, i.e., K — (Ca + Mg) < 2.2. sample 158 has a k — (ca + mg) ratio of 1.96, so grass tetany is a risk when feeding this forage without magnesium supplementation.

Manganese (Mn)

All samples contain acceptable levels of manganese. Corn silage is often low in Mn. Manganese is a major component of enzymes and serves as an activator of enzymes. Breeding animals require 40 mg/kg and diets containing less than 15.8 mg/kg result in reduced conception rates (delayed cycling). Deficiencies in young animals may be seen as twisted legs and enlarged joints.

Sulfur (S)

Sulfur is an essential component of amino acids, B vitamins, thiamin, and biotin. Microorganisms in the rumen are capable of synthesizing many sulfur containing compounds from the amino acid, methionine. The sulfur recommendation in beef cattle diets is 0.15 percent as a percentage of dry matter. The maximum tolerable concentration is 0.40 percent.

Source: NRC, 1984, Nutrition Requirements of Beef Cattle (6th Ed.) National Academy Press, Washington D.C.

Iron (Fe)

Samples 173, 225, and 178 are low in iron. The OSU Dairy ration evaluator program recommends between 50 and 1000 ppm iron for dairy cattle. The minimum recommended level of iron for beef cattle is 50 ppm. Iron is essential for the red blood cell to transport oxygen. Cereal grain and oil seed meals are common sources of iron.

Copper (Cu)

Three of our four samples are low in copper. The minimum recommended level of copper is 10 ppm of the ration dry matter. If the forage contains a high level of molybdenum (2 ppm) or sulfur at (0.25 percent), copper could be deficient.

Copper is a component of essential enzymes. Copper deficiency causes reduced growth, anemia, and change in hair coat. Copper can be very toxic to sheep.

Diets that contain excess protein will be high in sulfur and can cause a copper deficiency. Copper is less available in forage diets than in grain diets. Ideally the copper to molybdenum ratio should be 5 to 1 or greater.

Source: Munshower, F. F., and D. R. Neuman, 1979, Vegetation on Mine Spoils Low in Key Nutritional Elements. Animal and Range Research Highlights, Montana State University.

Zinc (Zn)

Zinc plays a role in the immune system and is involved in the metabolism of protein and carbohydrates. Zinc deficiencies have also been linked to impaired sperm production in bulls. All four forage samples are low in zinc. The OSU Dairy ration evaluator program recommends levels between 40 and 1000 ppm for dairy animals. Beef cows require 30 ppm Zn.

Source: NRC, 1996, Nutrient Requirements of Beef Cattle (7th Ed.) National Academy Press, Washington, D.C.

The levels of trace elements (Mn, Cu, Zn, Fe) may have extreme variations in analyzed levels taken from samples of the same lot.

Although our forage sample was not analyzed for vitamins, it is reasonable to assume we would need to supplement beef cows with vitamin A via an injection or as an addition to the mineral mixture. Vitamin E may also need to be supplemented. The analysis of these forages has indicated that only one sample (158) can meet most of the nutrient requirements for our cattle. The three other hay sources will need to be supplemented with a protein source and mineral supplement. Our good quality hay should be used for cows requiring an improvement in body condition, lactating or growing. Analyzing your ration will save you money and help to ensure the nutrient requirements of your cattle are being met. Almost all forages should be provided with access to trace mineralized salt. Hay quality is most greatly affected by maturity. Early harvest and pasture rotation before seed heads appear will greatly improve the quality of your forage. When determining the mineral source to buy, consider the bioavailability of the nutrients. Mineral supplements containing chelated or proteinated forms of minerals are generally more digestible while sulfates, carbonates, and oxides are less available to animals.
