Supplementation of Forages for Kentucky Beef Cattle

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Introduction

The ultimate objective for providing supplemental nutrients to grazing or hay-fed cattle is to improve performance. However, this may be desirable when forage supply and quality are high or low, and these scenarios require different approaches. The dominance of endophyte-infected tall fescue in Kentucky creates another potential use for supplementation as an aid in the management of cattle grazing such forage. Typically, supplementation has been used to dilute the endophytic toxins in the diet of the animal, although strategies may exist to provide therapeutic agents through a supplement, as well. There are additional management benefits that can be derived from supplementing cattle. Providing supplements gives producers the opportunity to closely observe their cattle, allowing them to identify “poor doers” more rapidly, and providing an opportunity to intervene with therapeutic treatment at an earlier stage, increasing the opportunities for a positive outcome. With growing calves destined for the feedlot, supplementation can provide some “bunk training”, thus minimizing the time required to get cattle started in the feedlot and decreasing health problems during this phase. An often overlooked potential advantage is that supplemented cattle may be easier to gather from pasture. Less stress on the cattle while gathering and hauling to the sale should translate into less shrink and a bigger check. Despite these many benefits, this paper focuses on the direct effects of providing supplemental protein and energy on animal performance.

The potential benefits of a given supplementation strategy need to be weighed against the costs of supplementation. Compared with the benefit side of the equation, the costs are relatively easy to calculate, once you have decided how much of which supplement to use, how often to feed, etc. Thus, the objective of this paper is to give some guidelines on determining what type of supplement to feed, how much of that supplement to feed, and estimating the benefits from a given strategy.

Effects of Supplements

The primary difficulty in determining how an animal will respond to supplementation is that supplements will alter the intake and utilization of the forage portion of the diet. In the absence of such ‘associative effects’, we could estimate the intake and digestibility of the forage and add the quantity of digestible nutrients from the supplement to arrive at an estimate of total digestible intake. However, depending on several factors, supplements can either increase or decrease the voluntary consumption and digestibility of the basal diet. In general, one of the primary objectives of supplementation should be to enhance the amount of nutrients derived from the forage. Insituations where this is not possible, we should strive to minimize any negative effects of supplements on forage utilization.

Positive Associative Effects. When supplementation results in an improvement in forage use, we call this a positive associative effect. Typically, positive associative effects will result when a specific nutrient deficiency in the forage is overcome. The most notable example of this situation is the alleviation of a protein deficiency. Although protein requirements vary with animal class and level of production, some generalizations can be made with respect to forage protein content and utilization. Firstly, if protein content is below around 7% (of forage dry matter), intake and digestion of the forage can be limited by the lack of protein. Use of supplemental protein sources in such a situation will generally result in increases in voluntary intake and digestibility. The second generalization relates to supplement composition. A concentration of approximately 20% crude protein is required in concentrate-type supplements to get a 'protein-type' of response. Thus, if a supplement contains at least 20% crude protein, we may classify it as a 'protein supplement', whereas supplements with less than 20% crude protein will generally be classified as 'energy supplements'. This relationship does not hold true for fiber-based supplements, however. Thus, a 15% crude protein hay can be effectively used to supply protein to a low-protein diet in some situations.

Negative Associative Effects. Conversely, addition of supplements under certain situations can decrease intake and/or digestion of the basal forage. This type of a response is known as a negative associative effect. The most notorious negative associative effect is the depression in forage digestibility with the addition of starch to the diet. Negative associative effects cause many difficulties in predicting performance of supplemented animals.

Predicting Responses to Supplementation

Although we are still working on developing an overall picture of the interactions between dietary nutrients that govern the response to supplementation, some researchers have developed equations to allow us to get an idea of the impact of supplementation on animal performance. Several pieces of information are required to allow us to estimate responses. In equations developed by John Moore at the University of Florida, criteria that were important in determining the influence of supplementation on intake and digestion included voluntary forage intake (without supplementation), amount of supplement fed, and the crude protein and energy (TDN) contents of both the supplement and the basal forage. Although the equations are somewhat complex (Table 1), several important relationships can be derived from them.

Table 1. Prediction equations for determining influence of supplementation on intake and energy utilization in forage diets supplemented with concentrates[a].

	Equation[b]
Forage OM intake with supplement	-1.9875 + 1.0101 * FOMI + .0587 * $FOMI^2$ - .0195 * FCP - .0408 * FTDN - .911 * STDNI + .0204 * SCP + .0699 * STDN - .000569 * $STDN^2$ + 5.87 * SCPI – 9.74 * $SCPI^2$ - .221 * FOMI * STDNI - .0143 * FOMI * SCP + .00509 * FTDN * STDN + .211 * FTYPE - .0638 * SCODE
Total mixed diet TDN	59.71 - .8948 * ETDN + .01399 * $ETDN^2$

[a]From Moore et al. (1998).

[b]FOMI = forage organic matter intake without supplement; FCP = forage crude protein concentration; FTDN = forage TDN concentration; STDNI = supplement TDN intake; SCP = supplement crude protein concentration; STDN = supplement TDN concentration; SCPI = supplement crude protein intake; FTYPE = code for forage type (1 = temperate or tropical forage; 2 = native mixed forage or straw); SCODE = code for supplement type (1 = protein only; 2 = molasses; 3 = grain or byproduct; 4 = forage). Intakes are expressed as percentage of body weight, concentrations are expressed as percentage of feedstuff organic matter.

Using these equations, predicted changes in forage intake (Figure 1) were established for various hypothetical forage and supplement combinations. Forage compositional data were derived from a database containing a wide variety of information on the composition of fescue hay. Supplement composition was determined from tabular values (NRC, 1992) and converted to the appropriate units for use in these equations. *One of the most important components is the use of intake (both forage and supplement) expressed as a percentage of body weight.* This allows us to make generalizations that are applicable across a wide variety of animal sizes. Figure 1 shows the predicted changes in forage intake as a consequence of increasing the amount of supplement fed with different forage and supplement types. Of importance is the greater opportunity for depression in forage intake as supplement amount increases. Although this general trend may seem intuitive, we must be able to quantitatively predict these responses in order to accurately formulate supplements for a specific situation. In most situations, adding supplements to the diet depresses intake. However, as discussed above, in the situation in which soybean meal is added to a low protein forage, we see that the equation predicts

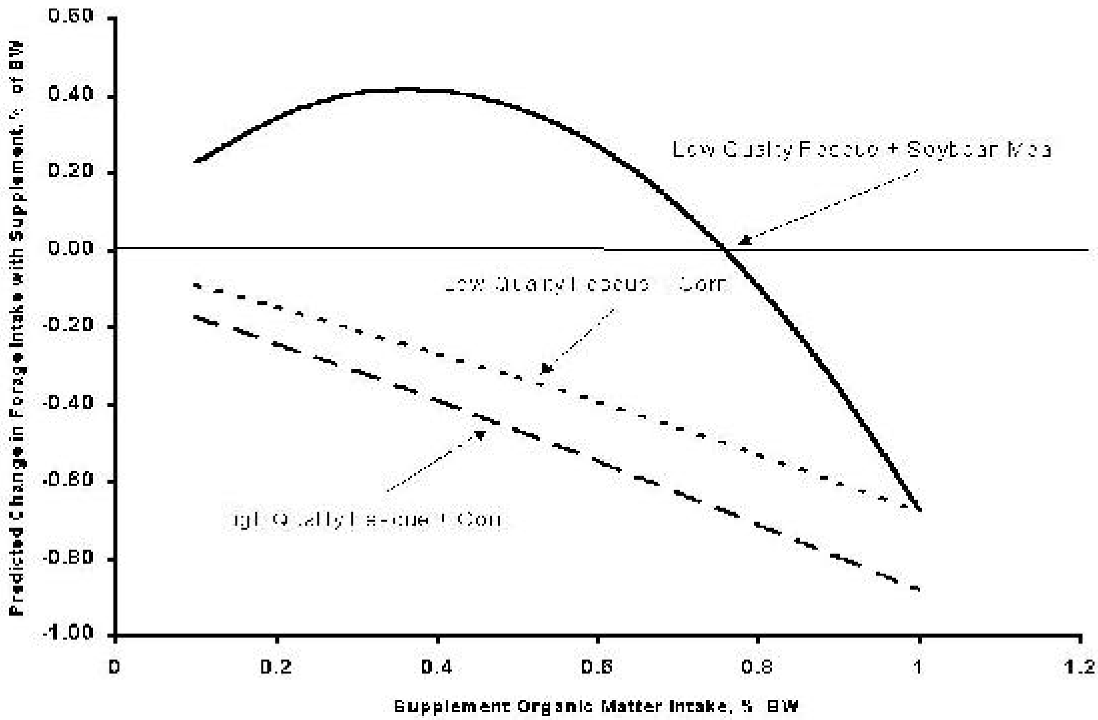

Figure 1. Predicted change in forage organic matter intake resulting from supplementation at various levels with various forage and supplement types. Adapted from equations published by Moore et al. (1997).

an increase in forage intake (predicted change in intake is greater than zero) with most levels of supplementation. Conversely, when an energy supplement (e. g. corn) is added to either a low- or high-quality forage, the model predicts a depression in intake that ranges from about 0.1% of body weight with 0.1% of body weight supplement fed to .9 % of body weight when supplement amounts reach 1% of body weight. Note that *the absolute amount of intake depression depends on the amount and type of supplement as well as the quality of the forage*. Similarly, the effect of supplementation on the energy available from the diet depends on these same factors. The second equation in Table 1 predicts effects of supplements on the realized energy concentration of the entire diet. In other words, if we add grain supplement (e. g. corn) to a low quality forage diet, the energy concentration of the resultant mixture will be less than the sum of the energy values of the forage and supplement determined independently. If initial forage quality is low enough, the model will predict increases in digestibility as a result of protein supplementation. Although few endophyte-infected forages were used in the development of these equations, limited research suggests that the effects of supplements will be similar in the presence of the fescue endophyte. However, endophytic toxins do depress intake and this should be accounted for when predicting animal performance on an endophyte-infected fescue diet. *Research data indicates that, in general, voluntary intakes on endophyte-infected fescue average about 0.2% BW lower than on non-infected fescue*. However, the degree of this depression is almost certainly dependent on the environmental conditions, with greater depressions expected with higher ambient temperatures.

Making Use of the Numbers

One of the most difficult aspects of predicting performance of forage-fed animals is obtaining a reasonable estimate of voluntary forage intake. At present, no generalized equations do an adequate job of predicting intake. However, the information in Table 2 can be used as a general guideline for animals consuming various qualities of fescue. Although the equations developed by Moore and coworkers are useful for giving us a general impression of the type of response to expect under various situations, they require more validation before widespread use under field conditions. Despite this, sufficient data exist to allow us to make some broad generalizations that should enable us to provide supplements in an economically viable manner.

Table 2. Estimated composition and intake values for fescue of various qualities.[a]

	Fescue quality			
	Poor	Low	Moderate	High
Crude protein, % of OM	6	11	17	22
TDN, % of OM	50	57	63	70
Forage Organic Matter Intake Estimate, % of Body Weight				
Growing steer or Dry/Pregnant Cow	1.3	1.7	2.1	2.5
Lactating Cow	1.8	2.1	2.4	2.7

‘If fescue is endophyte-free, add 0.2% VW to intake estimates’.

Low protein forages (< 7% crude protein) should be supplemented with protein to take advantage of positive associative effects. Within the range of 8 to 11% crude protein, the situation is less clear. Generally, in such situations, protein supplements will be converted to gain at a partial efficiency of around 5 or 6 pounds of supplement per pound of additional gain (above non-supplemented controls). Thus, beef prices should exceed the cost of supplement (including processing, labor, fuel and equipment costs associated with feeding the supplement) by more than 5 or 6 times for this to be economically feasible. Often, the most logical approach to the protein supplementation issue is to avoid it by managing the forage to ensure adequate protein levels.

Typically, with grain supplementation for growing animals on moderate- to high-quality forages, partial conversion efficiencies of around 10 pounds of supplement per pound of additional gain are likely, provided grain supplementation does not exceed 0.4 to 0.5% of the animals' body weight. Thus, for a 600 pound steer grazing summer fescue, feeding approximately 3 pounds of corn per day would be expected to yield in the neighborhood of 0.3 pounds of ADG. If the value of the added gain exceeds the expense of the supplement and the labor, fuel, and equipment costs associated with its delivery by more than ten-fold, we would consider the supplementation to be an economically sound practice. Research with growing cattle grazing endophyte-infected pastures appears to be consistent with these generalizations.

Importance of Supplement Composition

Within the broad categories of protein and energy supplements, several options are available relative to the ingredient composition of the supplements. Besides the nutrient composition, per se, the most important distinction among protein supplements is the relative proportion of non-protein nitrogen versus true protein in the supplement. Traditionally, nutritionists have recommended that non-protein nitrogen (e. g. urea) not be fed with forage diets. However, recent research suggests that a portion of the supplemental protein can come from urea in certain situations without negative effects. Technically, the urea can replace only the ruminally degradable portion of the dietary protein and thus, it is most appropriate to think in terms of the amount of degradable protein that can be provided by non-protein nitrogen. Using this guideline, research suggests that approximately 20 to 30% of the degradable protein in the supplement can come from non-protein nitrogen without negative effects in forage-fed cattle. Most of us think in terms of crude protein, however. For typical cattle diets that have protein degradabilities of around 70%, this translates into about 15 to 20% of the supplement crude protein equivalents that can come from non-protein nitrogen. It is essential that *careful mixing and bunk management* be practiced when using non-protein nitrogen because of the toxicity potential when non-protein nitrogen is accidentally overconsumed. Also, research data suggests that non-protein nitrogen feeding may lead to *significant reproductive problems if used during the breeding season*. Thus, non-protein nitrogen should not be fed during this time.

Although we are actively researching the importance of protein degradability in forages and supplements, insufficient information exists at present to allow us to incorporate this information into general supplementation guidelines for Kentucky forages. Thus, to compare the economic values of various protein supplements, the crude protein concentration and percentage of the crude protein derived from non-protein nitrogen sources should be used.

For energy supplements, the composition of the carbohydrate fraction may be important. Typically, negative effects on forage use have been associated with energy supplements that contain large proportions of starch. Thus, researchers have begun to focus on various supplements that provide energy in a non-starch form. However, limited research is available from fescue-based systems, and the data that is available is quite variable. In some cases, fibrous supplements have not improved forage digestibility relative to starch-based supplements and in several cases substitution effects have been greater for fiber- than for starch-based supplements. However, preliminary data from the University of Kentucky indicates that under some situations (e. g. stockpiled fescue) highly digestible fiber sources such as soybean hulls may result in enhanced animal performance relative to starch-based supplements (e. g. corn). Additional research is ongoing to help us accurately predict responses with various energy sources. At present, the primary utility of high-fiber byproduct feeds is their cost per unit of energy. If a rapidly digested fiber source can be purchased at a reasonable price relative to corn, it may be practical to use in your supplementation program. Assuming effects on forage use are similar, supplement costs can be compared on an equal-TDN basis. Nutrient content of several feedstuffs are shown in Table 3. To calculate prices on an equal TDN basis, divide the price (on an as-is basis) by the dry matter percentage of the feedstuff, and then divide this quantity by the TDN concentration of the feedstuff dry matter. For example, assuming corn cost is $115/Ton (including processing and delivery), one ton of TDN from corn would cost $115/T As-fed * 1 T As-fed/.88 T DM * 1 T DM/.90 T TDN = $145. Thus, if I can purchase an alternate feedstuff for less than $145 per ton of TDN, it will likely be economically advantageous to do this. Similarly, protein supplements can be compared with soybean meal on a dollar per ton of crude protein basis by dividing the cost per ton of as-fed material by the dry matter percentage and the crude protein percentage of the feedstuff. A slightly more complex approach can be taken to account for both the energy and the protein simultaneously. In this situation, a corn/soybean meal mix is formulated to contain a similar CP:TDN ratio as the feedstuff of interest. Then, the quantity of TDN supplied by a ton of dry matter from the supplement of interest is determined (2000 lb * TDN content) and this quantity is divided by the TDN concentration of the corn/SBM mixed supplement to determine the equivalent quantity of our mixed supplement. This quantity is multiplied by the price of the mixed supplement (on a dry matter basis) and this value is converted to an as-fed basis for our feedstuff of interest by multiplying by the dry matter percentage of that feedstuff. In Table 3, equivalent values for the TDN and CP contained in various feedstuffs are shown for the situation in which corn costs $115/ton and soybean meal costs $200/ton. Although this approach can give us a relative idea of the value of the nutrients contained within feedstuffs, we must also take into account the total amount of feedstuff needed to provide the required amount of a nutrient, and the subsequent effect on forage use. For example, even if I could get oat mill byproduct for free, I could not use it as a protein supplement because the concentration of CP is too low to effectively get it into the animals.

It is important to note that the composition values in Table 3 are ‘ballpark estimates’ and that values can vary around these averages considerably, especially with the byproduct feeds. Thus, it is critical to know the composition of a given batch of product before making comparisons.

Table 3. Nutrient contents and economic values of various feedstuffs[a]

Feedstuff	DM	% of DM TDN	CP	Value[b] TDN basis	CP basis	TDN and CP basis
Ground shelled corn	88.0%	90.0%	10.0%	$ 115.00	$ 39.63	$ 115.00
Soybean meal	89.0%	84.0%	49.9%	$ 108.55	$ 200.00	$ 200.00
Corn Distillers Dried Grains	90.0%	90.0%	30.4%	$ 117.61	$ 123.21	$ 162.44
Corn Gluten Feed	90.0%	80.0%	23.8%	$ 104.54	$ 96.46	$ 137.12
Corn Gluten Meal	88.2%	89.0%	66.3%	$ 113.98	$ 263.34	N/A
Cottonseed Hulls	91.0%	45.0%	4.1%	$ 59.46	$ 16.80	N/A
Cottonseed - Whole	92.0%	96.0%	23.0%	$ 128.24	$ 95.29	$ 155.57
Cottonseed - Whole, Delinted	90.0%	96.0%	25.0%	$ 125.45	$ 101.33	$ 156.61
Ground Ear Corn	87.0%	83.0%	9.0%	$ 104.85	$ 35.26	N/A
Ground Wheat	90.2%	88.0%	14.2%	$ 115.25	$ 57.68	$ 124.77
High-quality Hay	89.0%	67.0%	15.0%	$ 86.58	$ 60.12	$ 102.75
Medium quality Hay	89.0%	55.0%	11.0%	$ 71.08	$ 44.09	$ 81.50
Hominy feed	90.0%	87.0%	11.5%	$ 113.69	$ 46.61	$ 117.63
Oat mill byproduct	92.0%	31.0%	6.1%	$ 41.41	$ 25.27	N/A
Peanut skins	94.0%	65.0%	17.4%	$ 88.72	$ 73.66	$ 111.85
Soybean Hulls	90.3%	77.0%	12.2%	$ 100.96	$ 49.61	$ 108.81
Wheat Bran	89.0%	70.0%	17.4%	$ 90.46	$ 69.74	$ 111.11
Wheat Middlings	89.3%	69.0%	18.7%	$ 89.47	$ 75.20	$ 113.30

[a]Composition values from NRC, 1996 and Feedstuffs, 1997.

[b]Value of the TDN contained in 1 T of feed (as-fed basis) based on corn price of $115.00 per ton; value of CP in 1 T of feed (as-fed basis) based on soybean meal price of $200 per ton; value of CP and TDN based on providing an equivalent amount of protein and energy from an appropriate corn/soybean meal mix at the same prices as above

Summary

The major points to be drawn from the above discussion are:

1. The type of supplement to feed (e. g. protein versus energy) is dictated primarily by the protein and energy content of the forage.

2. Providing protein supplementation with low protein forages enhances the intake and digestion of the forages.

3. Whenever possible, it is more economically sound to manage forages for high protein than to provide protein via a supplement.

4. CP equivalents) of non-protein nitrogen can be used, provided adequate care is taken and such supplements are not used during the breeding season.

5. Although some differences in utilization of various energy supplements may exist, current data is only sufficient to allow us to accurately price energy supplements based on their overall energy values.

6. Make supplement purchasing decisions based on calculations of dollars required to purchase the nutrients you need (e. g. TDN, protein, macrominerals, etc.) while keeping in mind the importance of nutrient concentrations, per se.