Texas AgriLife Research and Extension Center at Overton

Proceedings: Adjusting to High Fuel and Fertilizer Prices
April 2008

Research Center
Technical Report
No. 2008-01

Texas AgriLife Research
The Texas A&M System

PROCEEDINGS

Adjusting to High Fuel and Fertilizer Prices

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Center at Overton

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TEXAS AGRILIFE RESEARCH AND EXTENSION CENTER AT OVERTON

Programs at the Texas Agrilife Research and Extension Center at Overton are focused on the unique problems and potentials of East Texas. The development of new technology to serve both agricultural producers and consumers is the purpose for the programs of Texas AgriLife Research. Texas AgriLife Research scientists at the Center function in a multi-discipline approach to research in horticulture, soil and crop science, animal science and related disciplines. Information in many subject areas is provided to producers and consumers through the coordinated efforts of resident subject-matter specialists of Texas AgriLife Extension Service in conjunction with County Extension Programs. Extension is charged with area educational programs to provide producers and consumers with the best information available to meet the rapid changes occurring in East Texas.

Recent cash receipt estimates for primary areas of agricultural production in Northeast, East and Deep East Texas (62 counties in Extension Districts 4, 5 and 9) are shown below:

	$ Million	%
Livestock and Meat	1,331	26
Nursery	1,166	22
Poultry	827	16
Timber	675	13
Feed Crops including Hay	492	10
Recreation and Ag Related	316	6
Miscellaneous Crops/Livestock	225	4
Dairy	141	3
Total	5,172	100
Texas Total	17,832	
East Texas proportion of state total		29

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LIME AND FERTILIZER STRAGTEGIES FOR FORAGE PRODUCTION

Vincent Haby

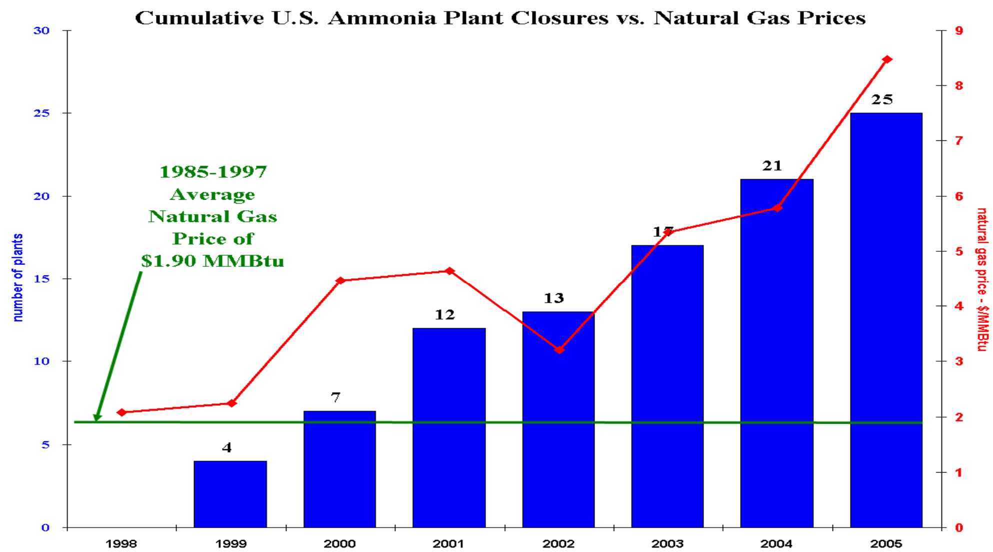
A sustainable cattle industry depends on economical production of forage grasses and legumes. However, recent trends involving higher fuel prices that affect equipment operation, transportation, production inputs, haying, and marketing are causing increasing concern about the economies of forage and livestock production. The forage and livestock production gamble is increasing. Although producers may not directly use natural gas to power their equipment, their bottom line is affected by the increasing cost of this fuel for producing nitrogen (N) fertilizer.

Natural gas is used to make anhydrous ammonia (NH_3) N. In the synthesis of NH_3, air that contains 78% N is reacted with natural gas (methane, CH_4) under high temperature and steam pressure with a catalyst to produce NH_3 and carbon dioxide (CO_2). Ammonia is the starting material for manufacture of most other N fertilizers.

Since 1999, the increasing price of natural gas caused permanent shut down of 25 US ammonia plants and idled several more because economical ammonia production could not be sustained. As ammonia plants shut down, fertilizer imports have increased to more than 50% of usage in the US.

$$N_2 + 3H_2 \xrightarrow[H_2O,\ Heat]{Catalyst} 2NH_3$$

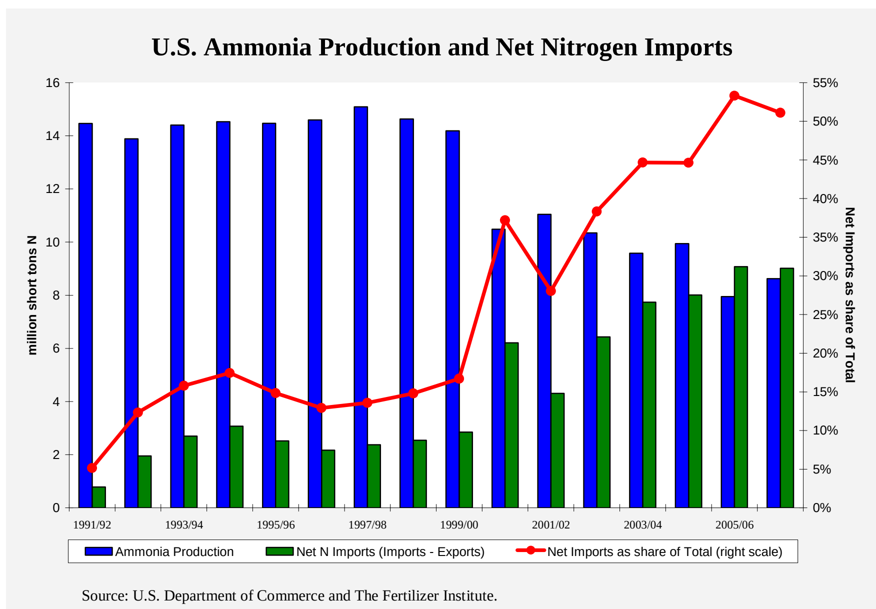
N from air (N_2O) and H from methane (CH_4) are reacted under high pressure & temperature with a catalyst to produce ammonia (NH_3)

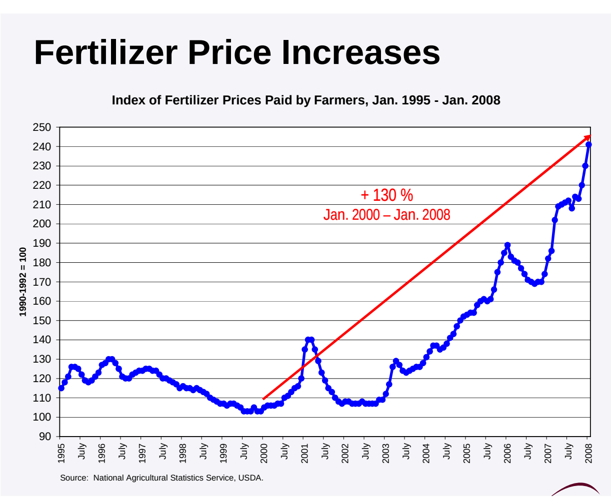


Source: Blue, Johnson and Associates, Natural Gas Week and The Fertilizer Institute.

Fertilizer prices

Because of the increasing costs of fuel for transportation, natural gas for manufacturing, and greater international demand, the cost of commercial fertilizers has more than doubled since the year 2000. Recent data indicate rapid escalation of fertilizer prices. Most N fertilizers are up more than 130% over the past several years. Diammonium phosphate (18-46-0), the phosphorus source used in fertilizer blends, currently retails for at least $1,000/ton; potash (0-0-60) fertilizer costs $600/ton, or $0.50/lb of K_2O and is predicted to increase even more by 2009; sulfur (S) recently increased by $250 to sell for $625/ton and it is expected to increase another $125/ton in the third quarter of 2008.





With the rapidly increasing prices of fertilizers, it has become even more important for farmers and ranchers to know the cost of inputs for forage crops and other crops production. Pricing fertilizer by the pound of plant nutrient contained in a ton allows one to know the cost of the plant nutrients applied.

The chart below shows the value per pound of N contained in a ton of selected N sources and potash available for application on forage grasses as of April 7, 2008. The percentage N in each material is shown with the cost per ton and the cost per pound of N in each ton. The price of the N fertilizers ranges from $340 to $500/ton. The price per ton is higher for the more concentrated N sources, but on a price per pound of N basis, the cost range is not as great. By knowing the price per pound, it becomes easier for producers to determine the lowest priced N material. So, how do we determine the price per pound of nutrient?

Fertilizer prices including cost of spreading at 70 lb of Nitrogen per acre (Prices as of week of April 7, 2008)

Source (% N)	Lb N/ ton	Retail/ ton	Spread/ ton†	Cost/lb of Nitrogen spread
	--------------------	---------$---------	--------------------	
Urea (46)	920	500	65.71	0.61
Ammonium Nitrate (34)	680	440	38.86	0.70
Ammonium Sulfate (21)	420	340	30.00	0.88 + sulfur
with 20 lb S/ac @		625		0.79‡
Urea-Ammonium Sulf. (33.5)	670	420	47.86	0.70 + sulfur
with 20 lb S/ac @		625		0.61‡
Urea- Ammonium Nitr. (32)	640	385	45.71	0.67
Diamm phosphate (18- 46- 0)	360	1,050 w/	920 lb P_2O_5/ ton	1.00 /lb of P_2O_5
Muriate of Potash (0 - 0- 60)		600 w/ 1,200 lb K_2O / ton		0.50 /lb of K_2O

† Lb of N/ton ÷ 70 lb of N/acre x $5.00/ac; Spreading cost is $5.00/acre for all but ammonium nitrate @ $4.00/acre.

‡ Includes value of 20 lb sulfur (S) applied with 70 lb N/ac- 99.9% S @ $625/ton, or $0.31/lb

Calculating the cost/lb of N

By knowing the cost per ton and the N percentage in an N fertilizer material, such as urea, the cost per pound of N can be calculated. First, convert the percentage N to a decimal fraction by dividing by 100. Multiply the decimal fraction by 2000 lb/ton. The amount of N in a ton of urea is 920 lb. Divide the cost/ton by the amount of N in each ton to find the cost/lb of N. If it is not already included in the price per ton, fertilizer venders charge for spreading. In the example above, the spreading fee is $5.00/ac for driving the spreader truck over the field. In this example the N rate is 70 lb/ac. Dividing the per-acre spreading fee by the N rate being applied

Calculating the cost of plant nutrients per pound

- **Urea nitrogen fertilizer costs $500.00/ton at the field**
- **One ton of urea contains 46% nitrogen**
- **(46% N ÷ by 100%) x 2000 lb/ton = 920 lb N/ton**
- **Divide the cost/ton by the lb N/ton**
  - **$500.00 divided by 920 = $0.543/lb of N**
- **Add spreading cost @ $5.00/acre @ rate of 70 lb N/ac**
  - **$5.00/acre divided by 70 lb N/ac = $0.071/lb of N**
- **Cost of N/lb + spreading cost = total**
  - **$0.543 + $0.071 = $0.614/lb of N spread**

70 lb N/ac x $0.614/lb N = $42.98/acre

determines that spreading adds 7 cents/lb to the N. So the cost of N applied to the field is $0.614/lb. The amount of N applied multiplied by the cost of N/lb determines the total cost of N. In this example it is $42.98/ac. Similar calculations can be done for other N fertilizers. For ammonium nitrate selling at $440/ton with a spreading fee of $4.00/ac, 70 lb of N costs $49.28/ac.

The same approach can be used to determine the cost/lb of potash (K_2O) applied/ac. Potash is 60% K_2O, or 0-0-60 for the red colored material. Convert the 60% to the decimal fraction and multiply that fraction by 2000 lb/ton to determine that a ton of potash contains 1200 lb K_2O. Divide the $600 cost/ton of potash by the pounds of K_2O/ton to determine that each pound of K_2O costs $0.50/lb before adding the spreading cost. Rarely is potash applied by itself; it usually is applied in a blend with other plant nutrients, so the cost of spreading is more difficult to determine for individual nutrients in a blend.

At low to moderate N rates, urea is not as effective as is ammonium nitrate or ammonium sulfate for grass production. In N-rate studies conducted by AgriLife Research scientists at Overton, urea and urea-ammonium nitrate produced 14 and 20%, respectively, lower Coastal bermudagrass yields compared to ammonium nitrate at the 40 lb N/ac rate/cutting for 3 to 5 cuttings. Ammonium sulfate produced equal yields compared to ammonium nitrate at the 40 lb/ac N rate. Yield differences between N sources generally decline as the N rate is increased.

Coastal bermudagrass yield response to nitrogen sources and rates on Gallime fine sandy loam soil (3-yr average)

Nitrogen source	Nitrogen rate, lb/ac†				
	0	40	Diff.	80	Diff.
	t/ac	t/ac	%	t/ac	%
UAN	2.66	5.62	-20	7.29	-9
Urea	2.66	6.04	-14	7.51	-6
Amm. Nitrate	2.66	7.01		7.97	
Amm. Sulfate	2.66	6.82	- 3	8.22	+3
LSD (0.05) = 0.67, CV = 6.9%					

†Nitrogen rates applied for each regrowth of bermudagrass (3 applications in year 1, four applications in year 2, and five applications in year 3.

Agrotain, Nutrisphere, SCU, Polymer coated urea

The pounds of forage produced per pound of N applied decreases as the N rate is increased. However, in haying situations, crude protein in forage receiving the lower N rates on N-deficient soil will be low and additional N is needed if higher nutritive value forage is desired.

The increasing cost of energy and natural gas to manufacture N fertilizers is directing some companies toward use of lower production energy requiring fertilizers such as urea. However, urea and urea-containing N fertilizers lose N as ammonia gas by a process called volatilization when these materials are applied and left on the soil surface. Companies are working to develop materials that delay conversion of urea to ammonia and prevent volatilization losses. These products include coatings and inhibitors that delay the activity of urease, an enzyme responsible for converting urea to the ammonia gas, or by delaying conversion of the ammonium form of N to the nitrate form. Texas AgriLife Research scientists are evaluating some of these materials in cooperation with manufacturers. Agrotain, Nutrisphere (NSN), Environmentally Smart N (ESN), calcium thiosulfate, and sulfur coated urea are some of the materials being evaluated and may be available at ag chemical companies or urea or urea-ammonium nitrate fertilizer distributors.

Production strategies

The forage and livestock production gamble is changing and the old rules are becoming even more important. Soil testing is critically important to determine the residual fertility levels of soil in order to prevent unneeded fertilizer application. The need to maintain an adequate pH by liming acid soils for forage production cannot be over-emphasized, and the limestone should be incorporated when possible. The fertility strategy must be re-evaluated- will it pay to apply limestone and fertilizer? How much can be applied and still be economical? If the fertilizer and limestone input is reduced, be prepared to lower the stocking rate because of lower forage production. Use alternative nutrient sources such as broiler litter and other manures if these are available and if they are economical to apply. Make certain that any alternative nutrient source being considered actually is a reliable source of plant nutrients, and not some fly-by-night, watered down material supported only by testimonials i.e., "For only $25/gallon and applied at the rate of 1.0 gal/ac, company X's material will produce the same forage yield as will the fertilizer recommended by soil test." Don't even try these types of materials claimed as all-purpose miracle fertilizers.

Forages take up definite amounts of the 16 essential plant nutrients. Average season-long nutrient uptake by Tifton 85 bermudagrass under hay production conditions includes 368 lb of nitrogen, 33 lb of phosphorus, 325 lb of potassium, 53 lb of calcium, 19 lb of magnesium, 60 lb of sulfur/ac, and smaller amounts of the

Bowie County — Sample Received on 3/20/2006

Laboratory Number 267851; Customer Sample ID: Field #2 — Printed on 3/31/2006

Crop Grown: IMPROVED AND HYBRID BERMUDAGRASS, GRAZING — AREA REPRESENTED: 10 ACRES

Analysis	**Results**	**CL[1]**	**Units**	**V Low / Low / Mod / High / V High / Excess**	**Fertilizer Recommended**
pH	4.9	(5.8)		strongly acid	
Conductivity	49	(-)	umho/cm	none	
Nitrate-N	11	(-)	ppm		35 lbs N/acre
Phosphorus	7	(50)	ppm		60 lbs P205/acre
Potassium	83	(125)	ppm		40 lbs K2O/acre
Calcium	247	(180)	ppm		0 lbs Ca/acre
Magnesium	46	(50)	ppm		5 lbs Mg/acre
Sulfur	14	(13)	ppm		0 lbs S/acre
Sodium	186	(*)	ppm		
Iron	36.21	(4.25)	ppm		
Zinc	0.38	(0.27)	ppm		0 lbs Zn/acre
Manganese	3.38	(1.00)	ppm		0 lbs Mn/acre
Copper	0.15	(0.16)	ppm		0.5 lbs Cu/acre
Boron					
Limestone Requirement (Soil texture & pH)					1.5 t ECCE 100%/ac
Limestone Requirement (Chemical Test)					1.5 t ECCE 100%/ac

[1]CL =Critical level is the point at which no additional nutrients and/or limestone are recommended.

Limestone recommendations are based on ECCE 100% limestone. Limestone applications >3 tons/acre should be made >4 months prior to crop establishment to lessen micro-nutrient availability issues.

Nitrogen: Apply an additional 70 lb of nitrogen/acre for each subsequent heavy graze down.

micronutrients including zinc, copper, iron, manganese, boron, molybdenum, and chloride. If these are not available in soil, they must be applied as fertilizer, limestone, or in the case of N, by legumes, or the desired amount of grass will not be produced. No soil activator or foliar-applied material sprayed at a gallon/ac is going to provide these amounts of nutrients to grass.

The image of a soil test report on the previous page is shown to indicate that soil testing is very important and that the recommendation for needed limestone is made based on application of 100% effective limestone, described as Effective Calcium Carbonate Equivalence and abbreviated as ECCE.

Limestone quality and economics

Quality of limestone begins at the quarry where it is crushed and screened. Pure limestone has a calcium carbonate equivalence (CCE), or neutralizing value, of 100%. The ECCE is determined by passing the crushed limestone through a series of sieves.

Efficiency factors are assigned to limestone fractions on each sieve. Material passing a 60-mesh sieve is considered 100% efficient for totally reacting in three years. The greater the ECCE % of the limestone, the more rapidly it will react, and less limestone will be needed to change soil pH.

The increased efficiency of ECCE 100% limestone is shown in the chart below. Limestone with ECCE 62, 81, and 100% was applied to Darco soil and left on the surface at rates of 0, 1, 2, and 3 tons/ac. Crimson clover yields were measured on these plots two and one-half years later,. Three tons ECCE 62% limestone was required to optimize clover dry matter compared to two tons/ac for ECCE 81%, and only one ton of ECCE 100% was needed to produce the same yield. Additionally, the ECCE 100% limestone maintains a higher pH over a longer time because the finer limestone more fully reacts to neutralize soil acidity and raise pH to a higher level than does the coarser limestone. In a long-term study, soil pH

What about limestone quality

Limestone quality & effectiveness

Quality begins at the quarry-

- Calcium carbonate equivalence (neutralizing value), CCE, %
- Effective calcium carbonate equivalence, ECCE, %
- Effective liming material, ELM, lb/ton

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Effect of particle size on limestone reaction

Size mesh†	Efficiency Factor	% reacting in 3 years
> 8	0	0
8 to 20	0.2	20
20 to 60	0.6	60
< 60	1.0	100

†Mesh refers to the number of holes per linear inch in a sieve or screen

Why is it important to apply high-quality limestone?

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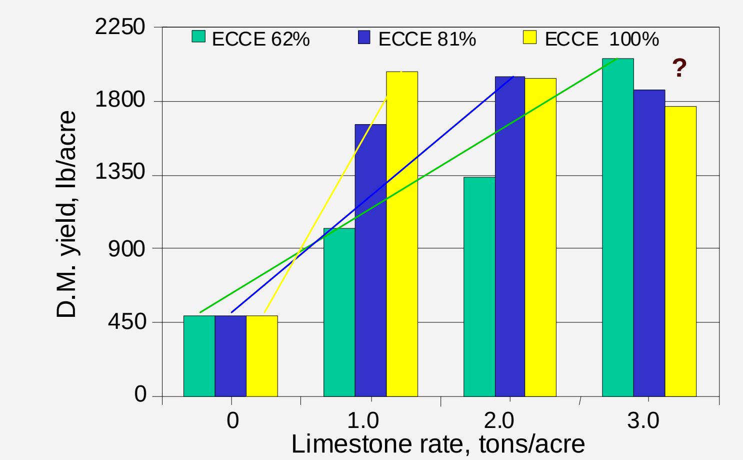
remained 0.3 units higher from ECCE 100% limestone compared to ECCE 62% when both materials were applied seven years earlier at 0, 3, and 6 ton/ac.



Crimson clover response to limestone rate and ECCE on Darco loamy fine sand 2.5 yr. after surface treatment of field plots.

Application of the more efficient, high ECCE % limestone is more economical than applying the coarser, lower ECCE % materials. The argument for this is presented in the adjacent chart. If the soil test recommends application of 1.0 ton of ECCE 100% limestone/ac, that one ton will contain 2000 lb of effective liming material (ELM). If the choices of limestone to apply are ECCE 62% at a cost of $42/ton, and ECCE 100% at a cost of $45/ton, application of one ton of ECCE 100% limestone/ac will cost $45.

However, if the ECCE 100% is not available, or your local limestone vendor doesn't handle it, the recommended rate using a lower quality limestone such as ECCE 62% must be adjusted. This is done by dividing 100% by 62%, as shown, and applying that adjustment factor to determine the rate of ECCE 62% limestone/ac. Using ECCE 62% limestone increases the cost/ac from $45 for the ECCE 100% limestone to $67.74 when using the ECCE 62% material. Applying 62% limestone increases the liming cost by $22.74/ac. This is a significant cost increase that can be avoided by locating a limestone supplier who is willing to spread the ECCE 100% material.

Two Texas quarries are listed in the chart to the right. These companies each have an ECCE 99% limestone that contains about 4% magnesium (Mg). One company also makes an ECCE 63% limestone that sometimes is referred to as ag-grade limestone. Several companies in Oklahoma also sell limestone into northeast Texas. Each of

Economics of limestone quality and efficiency

Limestone recommendation: 1 ton of ECCE 100%/ac

Limestone costs $42/ton for ECCE 62%, and
$45/ton for ECCE 100%

Applying of 1 ton of ECCE 100% limestone/acre = $45

To substitute ECCE 62%:

100% ÷ 62% = 1.61 tons ECCE 62%/acre

1.61 x $42.00/ton = $67.74/acre to apply correct rate of ECCE using the 62% limestone

Using the coarse lime cost an extra $22.74/acre

Limestone readily available to East Texas

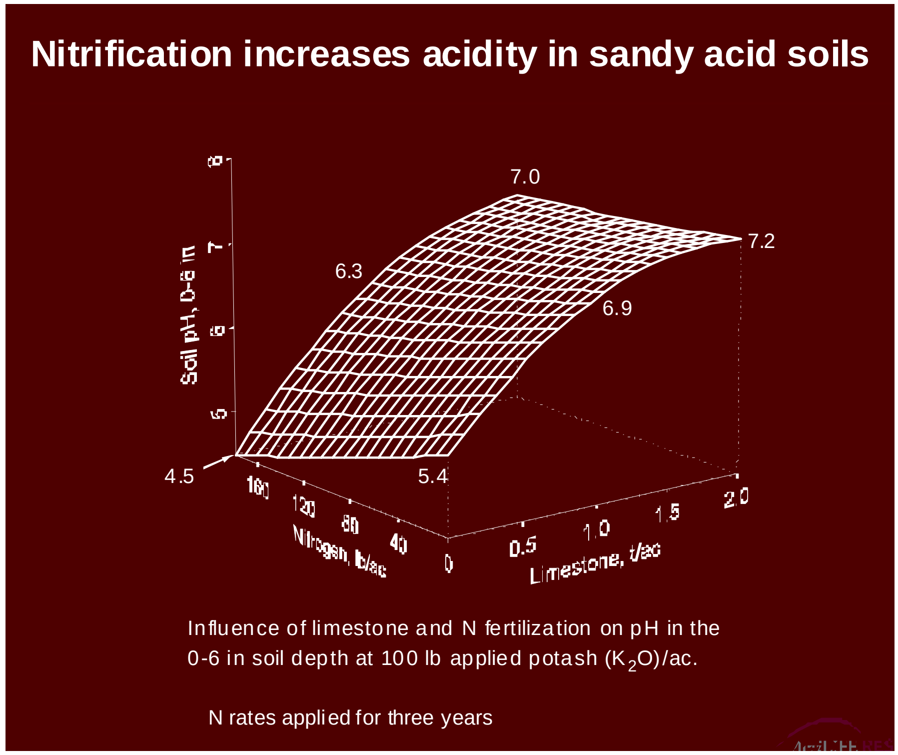
Company	Location	ECCE	Mg
		------%------	
Texas Crushed Stone,	Georgetown	63	4
		99	4
Franklin Ind. Minerals,	Nolanville	99	4

Other limestone suppliers in Oklahoma:

Hugo and Idabell- Coarse limestone
Mill Creek- Coarse and Fine; also fine dolomitic

these Oklahoma companies has coarse limestone, but the one at Mill Creek, OK also makes high ECCE calcitic and dolomitic limestones. Pure dolomitic limestone contains about 13.1% Mg, and at equal particle size is slower reacting than is calcitic limestone. Acid soils that need limestone in Texas are usually low in Mg and benefit from application of Mg in limestone.

Nitrogen in the ammonium form applied to the low-buffer capacity, acid soils causes increased acidity. This occurs when the ammonium is converted to nitrate. The slide below shows a decline in pH at the lower left from 5.4 to 4.5 after three years of N application at rates 200 lb/ac/year when no limestone was applied. As the rate of limestone was increased from zero to 2.0 ton/ac on the lower right axis, the acidifying effect of the applied N becomes less. The pH change at the high rate of limestone and three years of applying 200 lb of N/ac each year is only 0.2 pH units lower compared to pH at the high rate of limestone with no N applied.



Conversion of ammonium in anhydrous ammonia, urea, ammonium nitrate, and urea-ammonium nitrate to nitrate in the soil increases acidity that requires 1.8 lb of additional limestone to neutralize the acidity for each pound of N applied. The acidity generated by nitrification of ammonium in ammonium sulfate and diammonium phosphate is even greater. When fertilizing with nitrogen, it is important to take soil samples at least every two years to monitor soil acidity levels and maintain pH in the range favorable for forages on acid soils.

Nitrogen fertilizer increases soil acidity

Nitrogen fertilizer	Nitrogen content % N - P_2O_5 - K_2O	Limestone required/lb of N applied lb	Limestone required/100 lb of N applied lb
Anhydrous ammonia	82 - 0 - 0	1.8	180
Urea	46 - 0 - 0	1.8	180
Ammonium nitrate	34 - 0 - 0	1.8	180
Urea ammonium nitrate	32 - 0 - 0	1.8	180
Ammonium sulfate	21 - 0 - 0	5.4	540
Diammonium phosphate	18- 46- 0	3.6	360

The chart at right expands one shown earlier and shows the eventual cost/lb for five N sources applied at a rate of 100 lb of N/ac. The cost of limestone to neutralize the acidity has been added to the cost/lb of N and spreading costs. For forage production on low-buffer capacity, acid sandy soils, the cost of 100 lb of N ranges from $71 to $100 based on April 2008 prices.

Estimated cost of applied N fertilizer with additional limestone and spreading costs included- Apr. 2008.

N Source	% N	$/ton	$/100 lb N†	Limestone $/100 lb N‡	$/100 lb N/acre†
Urea	46	500	61.49	4.05	65.54
Amm. Nit.	34	440	70.04	4.05	74.09
Amm. Sul.	21	340	88.10	12.15	100.25+S
			78.72§	12.15	90.87§
Urea AS	33.5	420	69.83	8.10	77.93
Urea AN	32.0	385	67.30	4.05	71.35

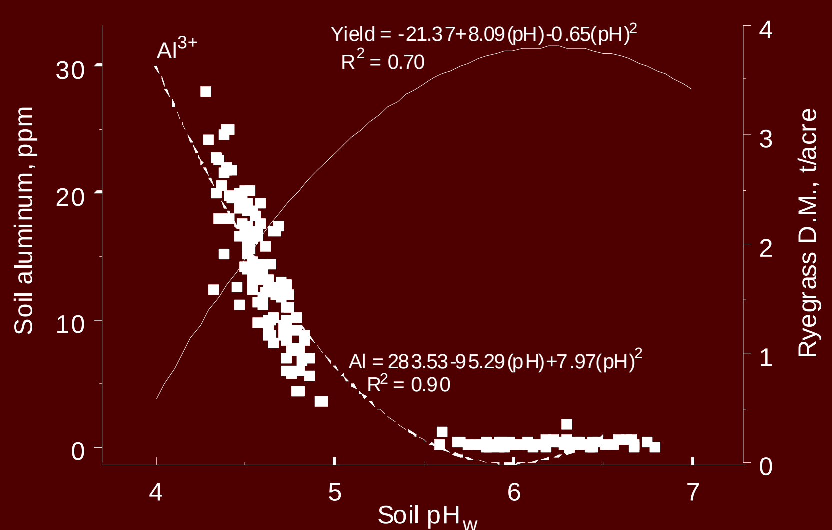
†Includes spreading cost

‡Based on 1.8 lb of limestone/lb of N in UAN, Urea, and Ammonium nitrate, 5.4 lb of limestone/lb of N in Ammonium sulfate, and $45/ton of applied limestone.

§Includes value of 30 lb sulfur (S) applied with 100 lb N/ac- S valued at $625/ton, or $0.31/lb

Annual ryegrass, like many grasses and legumes, is sensitive to soil acidity. As soils become increasingly acidic at pH 5.5 and lower, aluminum rapidly increases in solubility (see graph below). Aluminum in sufficient concentrations is toxic to acid-sensitive plant roots and prevents these roots from growing and exploring the soil mass for water and nutrients. The consequence is acidity-induced yield reduction. The solution is to lime acid soils to maintain pH above 5.5 for forage production. The favorable pH can vary by crop, but is considered to be about 6.0 to 6.2 for most forages. Alfalfa and Tifton 85 bermudagrass are two exceptions that continue to increase yield at soil pH levels near 7.0.

Effects of acidity on soil aluminum and ryegrass production



Effect of soil pH in the 0-6 in. depth on 1.0 M KCl extractable Al^{3+} and on the yield of annual ryegrass on a Lilbert fine sandy loam

Apache arrowleaf clover responses to limestone and boron treatments

The image at the left shows arrowleaf clover response to limestone and boron applied to field research plots. Clovers need limed soils in order for the Rhizobia on the roots to thrive and fix adequate amounts of N for the plants.

The image below graphically shows Tifton 85 response to soil pH on the lower right and to poultry litter rates on the lower left. Yield is indicated on the left vertical line. Data from Tifton 85 response to increasing pH was interpreted and put into the table (on next page) to show the projected yield increase at increasing pH and the value of that increased yield beginning at different pH levels. For example, at soil pH 4.5 in the left column, bermudagrass hay yield was 10,071 lb/ac. When the soil was limed to pH 5.0, hay yield increased 783 lb and its gross value increased $39.15/ac when hay was valued at $100/ton. When pH was increased to 6.5, yield was raised by 3,133 lb/ac and gross value of that higher yield was $156.65/ac. Yield and gross hay value increases due to liming also are shown for beginning soil pH values of 5.0 and 5.5. Annual ryegrass response to limestone is shown in the adjacent image. The darker colored taller growth was the result of liming Lilbert loamy fine sand to pH 6.2 using 1.7 tons of ECCE 62% limestone/ac disked into the soil. Initial soil pH of the unlimed area with the much shorter grass was 4.5.

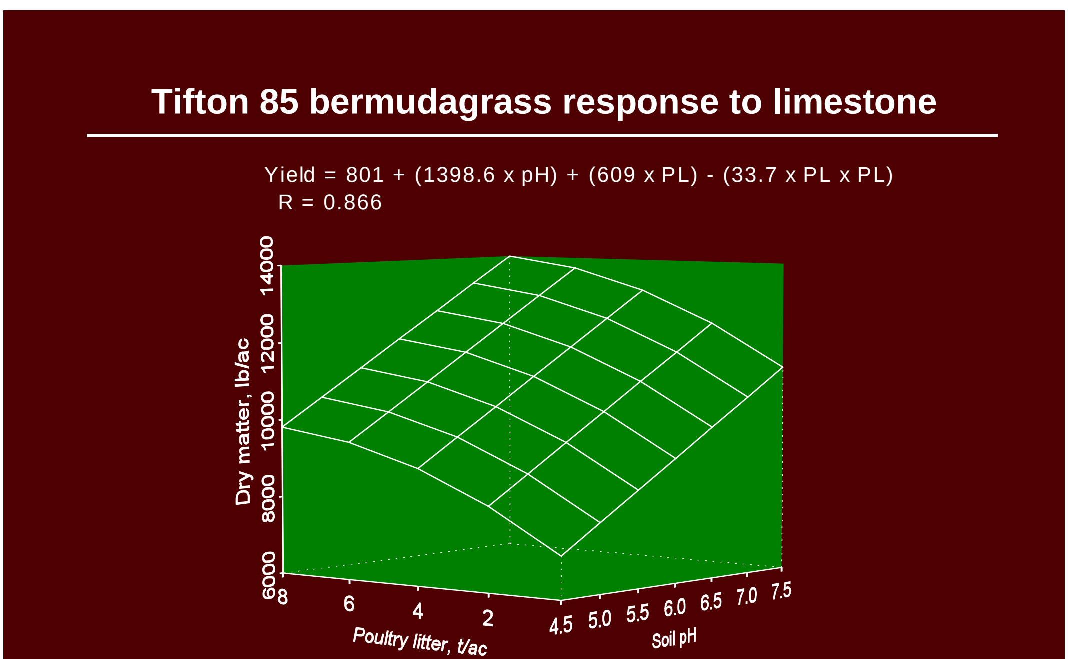


Fig 1. Tifton 85 bermudagrass response to soil pH and poultry litter rate on Darco soil in 2004.

Tifton 85 bermudagrass hay yield and $ value affected by soil pH at constant rates of N, K, and 4 tons of poultry litter/acre.† (12% moisture, $50/1,000 lb roll)

Soil pH	Yield	Difference from pH 4.5		Difference from pH 5.0		Difference from pH 5.5	
	lb/ac	lb/ac	$/ac	lb/ac	$/ac	lb/ac	$/ac
4.5	**10,071**						
5.0	**10,854**	**783**	**39.15**				
5.5	**11,637**	**1,566**	**78.30**	**783**	**39.15**		
6.0	**12,420**	**2,349**	**117.45**	**1,566**	**78.30**	**783**	**39.15**
6.5	**13,204**	**3,133**	**156.65**	**2,349**	**117.45**	**1,566**	**78.30**
7.0	**13,987**	**3,916**	**195.80**	**3,133**	**156.63**	**2,349**	**117.45**

N (540 lb/ac) and K_2O (200 lb/ac) applied to all plots during the season

Yield and soil pH change data from this limestone-rate ryegrass study were collected for three growing seasons. Dry matter yield (right) increased 1.30, 1.99, and 2.39 tons/ac in the three seasons, or a total of 5.68 tons in the limestone treated plots compared to the unlimed, pH 4.5 soil at equal N, phosphorus, and potassium rates. The ECCE 62% limestone, even when it was disked into the soil, needed two years to maximize pH to its highest level of 6.2. With limestone applied at the rate of 0.3 tons/ac, there was little change in soil pH, from 4.5 to 4.7 the second season. By the third season, soils treated with the 0.3 ton/ac rate declined to pH 5.5, similar to the unlimed plots.

The value of liming acid soils for ryegrass production?

Effect of limestone on soil pH and ryegrass dry matter yield on Lilbert loamy fine sand†

Lime rate	pH, year 1	DM, year 1	pH, year 2	DM, year 3	pH, year 4	DM, year 4
T/acre		T/acre		T/acre		T/acre
0	4.7	1.39	4.5	1.72	4.5	0.32
0.3	4.8	2.26	4.7	2.29	4.5	0.49
1.7	5.7	2.69	6.2	3.71	4.6	2.71

†Data from Dr. Jeff Hillard's dissertation, Texas Agricultural Experiment Station, 1988.

5.68 t/ac dry matter increase in 3 seasons

The chart, right, uses the ryegrass yield increase from the limed plots and projects weight gain and value of that additional forage if it were grazed by stocker steers. The increased value of the weight gain is then related to the cost of the limestone applied on a per acre basis. The net value of the weight gain after subtracting limestone costs is $214.87/ac per season, or a three-season total of $716/ac. This shows the value of limestone applied at 1.7 tons per acre at a cost of $71.40. If ECCE 100% limestone had been used, net income would have been even greater as less of the higher quality limestone would have been applied to achieve the same pH.

Limestone value- stocker steers on ryegrass:

Applied limestone to change pH from 4.5 to 6.2

- Limestone cost = $71.40
- Heavy weight stocker steers consume 15 lbs of ryegrass dry matter (DM) to gain 2.25 lb/head/day
- 5.68 ton = 11,360 lb/ac DM increase over 3 seasons

Adjust to 70% grazing efficiency = 7,952 lb ryegrass

Additional 1,193 lbs of gain/ac valued at $0.60/lb

- Increase in value = $716 per acre over 3 seasons
- $716 beef gain - $71.40 limestone cost = $644.60

= **$214.87/ac/season** above limestone cost

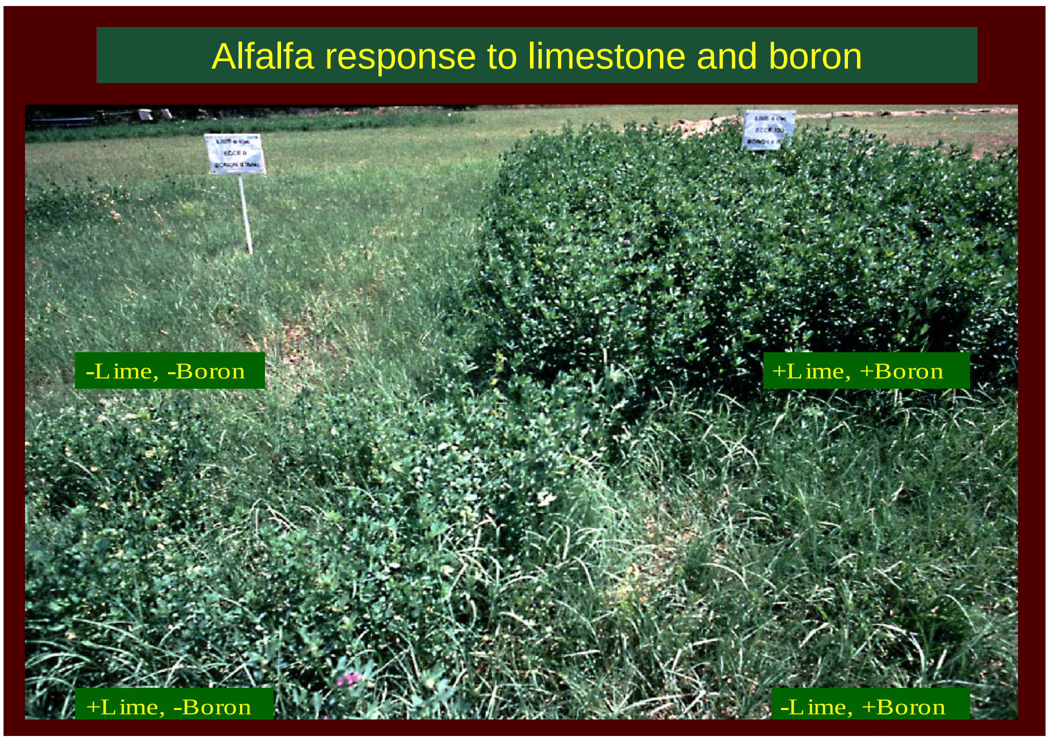
The value of the protein in the increased ryegrass yield is calculated in the chart below by comparing it to 38% protein cubes at a cost of $330/ton. Ryegrass was assumed to contain 15% crude protein, but the actual value would be higher. The value of ryegrass compared to 38% protein cubes is calculated to be $450/ac for the three ryegrass production seasons, or $150/ac per year. The previous slide regarding stocker steers grazing ryegrass and this slide comparing ryegrass protein to 38% protein cubes show the increased value of ryegrass produced on an acid soil that was adequately limed compared to not liming the soil. These calculations show that liming acid soils generates a good return on the investment.

Limestone value- Ryegrass protein content:

At $330/ton, 38% crude protein (CP) cubes = $0.4342/lb of CP

- **At 15% CP/ton of dry matter (DM), one ton of ryegrass = $130.26**
- **Limestone cost = $71.40 spread**
- **Value of 1.0 ton ryegrass DM above lime cost = $58.86/ac**
- **Ryegrass yield over three seasons = 5.68 tons/acre > zero lime. At 70% graze efficiency, DM yield is 4 tons/acre.**
- **(4 tons ryegrass x $130.26/ton) - $71.40 limestone = $450/acre for three ryegrass production seasons, or $450.00 ÷ 3 = $150/acre per season**
- **A 6.3 fold increase above the cost of limestone**

Similar values as shown for limestone and ryegrass production could be projected for increased crimson clover yield from limestone applied to a strongly acid Darco soil as shown in the middle slide.



The slide at left shows the response of alfalfa to limestone and boron on Darco soil. Where limestone and boron were not applied, there was no alfalfa, and where limestone was applied to increase soil pH to above 7.0 and boron was applied at 4 lb/ac, there was an excellent stand and increased alfalfa yield.

The chart at right shows the increased alfalfa yield and the value of this increased yield. Increasing soil pH from 6.0 to 6.5 increased hay yield 1.08 tons/ac valued at $146 with hay priced at $135/ton. When soil pH was increased to 7.0, the 1.94 ton/ac increased hay yield was valued at $262. Only 1.5 tons of limestone/ac would adjust pH from 6.0 to 7.0 on Darco soil. At a cost of $45/ton of ECCE 100% limestone, 1.5 tons would cost

Alfalfa hay yield increase with increasing pH and value of hay in $/acre. (12% moisture hay at $135/ton)

pH	Yield	Difference from pH 6.0	
	tons/ac	tons/ac	$/ac†
6.0	3.18		
6.5	4.26	1.08	146
7.0	5.12	1.94	262

†One production season

$67.50/ac while the alfalfa yield increase for only one season was valued at $262, or a net increase in income from liming to pH 7.0 of $194/ac. Soil pH declines more slowly under alfalfa production than when N fertilizer is applied because Rhizobia fix atmospheric N and put it directly into the roots without the N needing to be converted to nitrate and acidifying the soil in the conversion process.

Results showing the increased yield and value of forages due to liming acid soils indicate the importance and economic value of this practice. When fertilizer prices are high and producers are hesitant to apply these plant nutrients, liming acid soils to improve plant nutrient efficiency and response of acid sensitive forage crops increases the value of this acid-neutralizing primary input. Fertilizers applied to strongly acidic soils are less efficient than when applied to adequately limed soils. This has been proven many times and several examples of this improved efficiency have been presented in this manuscript.

Nitrogen fertilization for grass forages

Nitrogen in forage grasses is the most highly concentrated plant nutrient. Numerous studies of fertilizer N and grass production have been conducted. Three studies on hybrid bermudagrasses are reported here to show the yield response and net dollar return from increasing fertilizer rates.

In the chart below, increasing the rate of applied N from zero to 45 and 90 lb/ac for each regrowth increased Tifton 85 bermudagrass hay yield from 3,748 lb to 12,591 and 16,253 lb/ac, respectively. If this hay was valued at $100/ton (even with no added N), the zero N treated grass value was $187/ac compared to $442 and $625/ac gross value for hay fertilized with 180 and 360 lb of N/ac in four split applications, respectively, or a gross increase for the fertilized hay of $255 and $438/ac. When the cost of the applied N was deducted from the gross value of the hay, the net increases in hay value due to fertilizing with N were $122 and $188/ac, respectively. At the 180 lb/ac rate, each pound of applied N produced 50 lb of hay/ac. When the N rate was doubled, hay yield per dollar invested in N declined to 35 pounds.

Economics of Tifton 85 bermudagrass response to rates of N @ pH 6.5.

N rate lb/ac† (total)	Total yield lb/ac‡	Yield increase lb/ac	$/ac	$/ac increase	Net $/ac increase§
0	3,748 c		187		
45 (180)	12,591 b	8,843	442	255	122
90 (360)	16,253 a	12,505	625	438	188

† 45 and 90 lb N applied for each regrowth/harvest- 180 and 360 lb N/ac for the season.
‡12% moisture hay valued at $50/ half ton round bale.
§ Increase above cost of N at $0.65/lb with a $4.00/acre fee/each of 4 applications; does not include cost of making hay @ $25/1,000 lb roll- $94, $315, and $406, respectively

A similar study was conducted on Coastal bermudagrass using zero, 40, 80, and 120 lb of N/ac per hay cutting. Hay yield with no applied N was about 3.5 tons/ac, and at $90/ton, was valued at $310/ac. As the total N rate was increased to 200, 400, and 600 lb/ac for the season, total hay yield increased to 12,309, 15,134, and 15,844 lb/ac, respectively. The increased gross value of this hay compared to the zero N hay yield was $244, $371, and $403/ac. When the cost of N applied at $0.65/lb plus a $4.00/ac spreading fee was subtracted from the gross value of the produced hay, applications of 40 and 80 lb of N/ac per regrowth produced similar net income. Applying 120 lb of N/ac per cutting lost money because this highest N rate produced only a small amount of increased hay compared to the 80 lb N/ac rate. These N-rate comparisons on Tifton 85 and Coastal bermudagrass do not include haying costs or applied P, K.

Economics of Coastal bermudagrass response to rates of N

N rate lb/ac†	(total)	Total yield lb/ac‡	Yield increase lb/ac	$/ac	$/ac increase	Net $/ac increase§
0		6,891 c		310		
40	(200)	12,309 b	5,418	554	244	93
80	(400)	15,134 a	8,243	681	371	91
120	(600)	15,844 a	8,953	713	403	-7

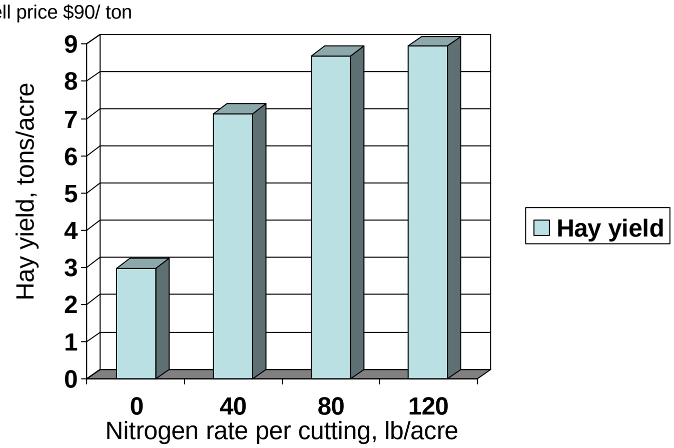
†N rate applied for each regrowth/harvest- 200, 400, and 600 lb N/ac for the season..
‡12% moisture hay valued at $45/1,000 lb round bale.
§Increase above cost of N at $0.65/lb with a $4.00/ac fee/each of 5 applications; does not include cost of making hay @ $25/1000 lb roll- $172, $308, $378, and $396, respectively

The cost of haying is added in the chart at right. In this study, yield with no applied N was only 3 tons/ac. The first 180 lb of N/ac increased hay yield to 7.1 tons/ac. The 360 lb/ac N rate raised yield another 1.6 tons/ac, but the yield increase/lb of N declined. Even with the cost of haying included with the cost of N, yields appear to be economical, especially up to the 80 lb N/ac rate applied for four cuttings to yield 8.7 tons of hay/ac.

Since many Coastal Plain soils are deficient in P or K, the cost of these nutrients must be added along with the N. The cost of a typical N, P_2O_5, and K_2O blend applied at 40 or 80 lb N/ac/cutting for four harvests is shown at right. Assuming that the hay yield was the same as in the previous chart when the phosphorus and potassium were added, that chart is repeated here with new fertilizer plus haying costs indicated. With the costs of N, P, K and haying included, the economic rate of return on hay is not much above the 190 lb/ac application of 21-8-17/cutting. At double this rate, the cost of production exceeds the value of the hay sold at $90/ton. Based on these data, the days of fertilizing hybrid bermudagrasses for maximum hay yield may be past; at least as long as fertilizer prices remain high and continue to increase and hay prices remain the same.

N plus haying†	$150	$467	$659	$786
Gross hay value‡	$270	$639	$783	$810

†N @ $0.70/ lb; haying $25/1,000 lb bale; P and K not included
‡ Sell price $90/ ton



Coastal bermudagrass response to N + P and K as 21-8-17 applied for each of four cuttings, 12% moisture hay.

Cost of a typical N, P_2O_5, K_2O blend for application

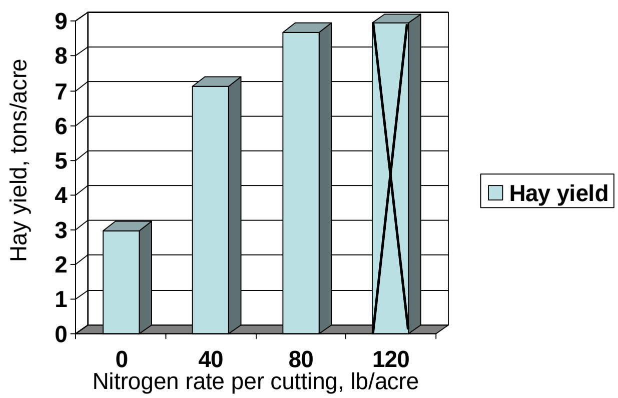
Soil test recommendation suggests 190 lb 21-8-17/ac

- **Blend made from 34-0-0, 18-46-0, & 0-0-60**
  - **34- 0- 0 @ $0.70/lb of N**
  - **18-46-0 @ $0.35/lb of N and $1.00/lb P_2O_5**
  - **0- 0- 60 @ $0.50/lb of K_2O**
  - **Spreading cost @ $4.50/acre**
  - – **40 lb N, 15 lb P_2O_5, and 34 lb K_2O + spreading cost = $57.15/acre**
  - – **If applied four times, fertilizer cost is $229 + $355 haying cost or a total of $584/acre to produce 7.1 tons of hay = $82.25/ton† for low nutritive value hay.**
  - – **Double the fertilizer to 80-30-68 lb/ac/cutting for four cuttings to increase hay yield to 8.7 tons/ac- Fertilizer cost = $457; Haying cost = $435 for cost of production = $892/ac.**

†Limestone and hay hauling costs not included in this price

N plus haying†	$150	$584	$892	~~$786~~
Gross hay value‡	$270	$639	$783	~~$810~~

†N @ $0.70/ lb; haying $25/1,000 lb bale; no lime or hay moving
‡Sell price $90/ ton



Coastal bermudagrass response to N + P and K as 21-8-17 applied for each of four cuttings, 12% moisture hay.

Poultry litter and other manures provide N, P, K, other plant nutrients, & organic matter. Manures at high rates are excellent nutrient sources.

Legitimate alternative plant nutrient sources

With the high cost of commercial fertilizers, forage producers need to evaluate alternative sources of plant nutrients such as in animal manures and lime-treated, stabilized sewage sludge (biosolids). National and international studies have shown the value of biosolids for increasing soil phosphorus content and raising pH and forage yield.

Animal manures probably were the first plant nutrient sources used for crop production. Poultry manures are routinely applied for forage production in eastern and east central Texas. Dairy manures are available in northeast Texas and parts of central Texas, but mainly are applied on-farm because of transportation costs. The average N, P_2O_5, and K_2O contents of dairy, beef, hogs, and chickens is shown in the top chart.

Broiler litter is available in much of the eastern and central Texas region and is a good source of plant nutrients for forages. However, as commercial fertilizer prices continue to increase and more forage growers turn to broiler litter as a plant nutrient source, longer wait times are being experienced before this material can be delivered.

In broiler litter, phosphorus is nearly as high as is the N content. If broiler litter is applied at rates sufficient to satisfy the N needs of grass forages, the soil phosphorus level will increase. When fertilizing with broiler litter, it is best to apply rates that will satisfy the phosphorus needs of the forage, and then supplement the grass with N and potassium to obtain the recommended levels of these nutrients for plant uptake. Data from Tifton 85 bermudagrass production studies at Overton indicate yield increases of more than 4,000 lb of dry matter when broiler litter was applied as a nutrient source. Even with increasing yields, average N, P, K, and copper concentrations were increased in the forage.

Average nutrient content of dry manures

Animal	Nitrogen	Phosphorus†	Potassium‡
	---Lbs/ton---		
Dairy	11	5	11
Beef	14	9	11
Hogs	10	7	8
Chickens	20	16	8

†Phosphorus as P_2O_5
‡Potassium as K_2O

Nutrient Content of Broiler Litter

Nutrient	Average	Range
	---Lbs/ton---	
Nitrogen (N)	62	34-96
Phosphate (P_2O_5)	59	22-142
Potash (K_2O)	40	13-99
Calcium (Ca)	35	13-98
Magnesium (Mg)	8	3-34
Sulfur (S)	6	0.2-13

Advantages and disadvantages of using broiler litter as a plant nutrient source for forages production are shown in the adjacent chart. One of the greatest benefits of broiler litter is that it contains some of all the nutrients needed for plant growth, even though these may not be sufficient to supply all the needs of the plants.

Broiler Litter

Advantages:

- Contains nutrients other than N, P, and K
- Slow release of nitrogen
- Contains calcium compounds that maintain soil pH
- Organic matter increases water and nutrient holding capacity of soil

Disadvantages:

- Variable nutrient content
- P level exceeds forage needs
- Odor (temporarily makes unpleasant neighbors)
- Not always available when needed

Summary

In summary, fertilizer costs are continuing to increase with little hope for a significant decline in the immediate future. It has become more important than ever to be attentive to the best management practices in an effort to maintain profitability in forage and livestock production. Specific attention must be given to:

- Maintaining adequate soil pH using the best quality limestone available
- Control weeds at an early growth stage- weeds use water and nutrients.
- Maintain a fertilizer program.
    - Carefully consider the economics of not fertilizing.
    - Fertilize according to soil test recommendations.
    - Fertilize for grazing- cut excess for hay; buy hay.
    - Fertilize in late summer to stock-pile reserve forage for fall and winter grazing.
    - When reducing fertilizer application rates, reduce livestock numbers.
    - Research least-cost fertilizer options including broiler litter and other manure nutrients.
    - Consider renting buggies to apply fertilizer if economical and time and equipment permit.
- Plant and graze cool-season clovers to provide part of the following warm-season grass N needs.
- Consider growing alfalfa for hay if soils are suitable- alfalfa uses Rhizobia-fixed N from the air and adds N to the soil.
- Seed best soils to small grains and ryegrass in fall.
    - Plant reduced acres and maintain an adequate fertilizer and liming program on these acres.
    - Limit graze cow/calf pairs a couple of hours per day- feed high nutritive value hay.

FORAGE LEGUMES FOR TEXAS

G. R. Smith, G. W. Evers, W. R. Ocumpaugh, and F. M. Rouquette, Jr.

Forage legume species are divided into annuals, perennials and biennials, and each of these categories is further divided into cool- and warm-season forages. Annuals germinate, grow, and mature in one growing season and therefore must be established from seed each year. Perennials have the ability to live more than one year under appropriate climatic conditions. They usually go dormant sometime during the year and then initiate new growth from roots, crowns, rhizomes, or stolons. Biennials require two growing seasons to complete their life cycle with the first season devoted to vegetative growth and flowering occurring in the second season. Warm-season annual forages begin growth in the spring and often die in the autumn with the first killing frost. Cool-season annual forages generally begin growth in autumn and develop mature seed in late spring or early summer. A general description of each forage class; description of selected species adapted to Texas and a list of recommended varieties follow.

Cool-Season Annual Legumes

Cool-season annual legumes are the most extensively used legumes in the southeastern United States. They are usually overseeded on warm-season perennial grasses, often in combination with annual ryegrass. In addition to providing forage with high nutritive value during the spring they can add nitrogen to the pasture system through N_2-fixation in association with *Rhizobium* bacteria. Other benefits are spring weed control, nitrogen sources for organic farming systems, and wildlife food plots. They are more soil specific than grasses and generally require a minimum soil pH of 6.0. They must establish from seed each autumn but some of the species have a high percentage of hard seed that permits volunteer reseeding if managed properly.

Annual Medics

The annual medics are a group of species belonging to the *Medicago* genus that are native to the Mediterranean region. They are annual relatives of alfalfa. Most species are best adapted to soils with a pH of 7 and higher and persist in lower rainfall areas than most clover species if rainfall occurs in late autumn and winter. Annual medics are more active winter growers than most annual clovers but most annual medic species also lack cold tolerance which limits their northern adaptation. They produce small yellow flowers that mature into spiny or smooth pods.

Annual medics are dependable reseeders because they produce a high level of hard seed and have excellent seedling vigor. This excellent seedling vigor makes them one of the easiest winter annual legumes to establish. Annual medics can easily establish with a light disking, broadcast seeding, and then dragging the pasture to cover the seed. Annual medics do have a high bloat potential. However, this can be overcome by proper management of livestock and providing other forage to the grazing animals such as frosted mature grass, hay, or planting ryegrass with the medic. Annual medics are best adapted in Texas to the Blackland Prairie ecoregion. (see Fig. 1; http://overton.tamu.edu/clover/forageres.htm for Texas ecoregion information)

Burr medic, or burr clover, (*M. polymorpha*) was introduced sometime in the nineteenth century and has become naturalized in South Texas and the West Coast. Armadillo burr medic, was selected from a naturalized ecotype in South Texas, and was released by the Texas Agricultural Experiment Station at Beeville in 1998. Armadillo is adapted south of Waco in Central and South Texas. Recommended seeding rates are 5 to 10 lbs per acre. Armadillo does well when grown with bermudagrass and kleingrass providing the perennial grasses are managed to be grazed short in the autumn to allow the seedlings to establish.

Button medic (*M. orbicularis*) has a large flat smooth pod and is best adapted to north central Texas. Estes button medic is currently being marketed for North Central Texas. A problem that is unique to this species is that the pod is very large and fleshy, and it is highly palatable to deer. Nearly complete removal of all pods has been observed when using this legume in deer food plots.

Little burr medic (*M. minima*) has become naturalized in the Texas Hill Country and has smaller leaves and smaller seed than most medics. The pods have long spines and the plant is very pubescent. Devine little burr medic was released in 2005 by Texas Agricultural Experiment Station at Beeville. Devine originated from a kleingrass pasture near Devine, TX, and is best adapted in the I-35 corridor from south of San Antonio to nearly the Oklahoma boarder. Recommended seeding rates are 3 to 5 lbs per acre. Devine grows well with most perennial grasses provided the grasses are managed to be grazed short in the autumn to allow the seedlings to establish.

Other annual medics include Barrel medic (*M. truncatula*), Spotted burr medic (*M. arabica*), and Black medic (*M. lupulina*).

Arrowleaf clover *(Trifolium vesiculosum Savi)*

This is one of the major annual clover species grown in the southeastern U.S. Arrowleaf clover has large white flowers that turn slightly pink as they mature and can grow over 4 ft tall if not grazed or cut. This clover is best adapted to well drained loam and sandy soils but is more sensitive to soil pH than other legumes with a preference of 6.5 to 7 pH. Iron chlorosis can be a problem on soils with a pH above 7. Arrowleaf clover is late flowering, and usually the highest yielding annual clover with growth continuing into June if moisture is adequate. Seedling growth is slow with seedlings staying in a rosette stage until late February. This results in very little forage production until early March. Arrowleaf clover has excellent reseeding potential with up to 90% hard seed. Only scarified seed should be planted at 10 lb/acre. Apache arrowleaf, developed at Overton and released in 2001 by the Texas A&M University System, has tolerance to bean yellow mosaic virus disease and is the recommended variety. Arrrowleaf clover is best adapted in Texas to the Piney Woods and Post Oak Savanah ecoregions.

Ball clover *(Trifolium nigrescens Viv.)*

If not cut or grazed, ball clover stems can grow up to 3 feet and are prostrate to partially erect, often forming a thick mat. This prevents using ball clover for hay and makes harvesting seed difficult unless it is grazed before flowering. Ball clover has small ovate leaflets and small white to yellowish-white flowers. Seed are very small (approximately 1,000,000 per lb) with a recommended seeding rate of only 2 to 3 lb/acre. Ball clover does best on loam and clay soils but has done well on relatively level sandy soils near creek or river bottoms that maintain good soil moisture. It does not have good drought tolerance and growth will be reduced in a hot, dry spring. It prefers a soil pH of 6 or higher. Ball clover can tolerate wet soils but not as well as white clover. It is medium maturity, flowering about a month later than crimson with yields usually slightly less than crimson.

Ball clover has excellent reseeding. Hard seed content is about 60% and it will produce some flowers even under close grazing. Ball clover does have a high bloat potential and should be managed accordingly. Since there are no commercial varieties at this time only common ball clover seed is available. Ball clover is best adapted in Texas to the Piney Woods and Post Oak Savanah ecoregions.

Crimson clover *(Trifolium incarnatum L.)*

This native of Europe is the most widely adapted annual clover species grown in the southeastern United States. Crimson clover has scarlet or deep red flowers and is used extensively as a forage crop and for roadside stabilization and beautification throughout the southeastern United States. This clover grows on soils ranging from sands to well-drained clay soils with a pH of 6 to 7. Iron chlorosis has been a problem on calcareous soils at a pH of 7.3 or higher. Recommended seeding rate is 16 to 20 lb/acre. Crimson clover is one of the larger seeded annual clovers with 150,000 seed/lb and has excellent seedling vigor. If planted early, it can produce some forage in the autumn and has earlier forage production in the spring than the other clover species.

Crimson clover is also one of the earliest maturing annual clovers. The combination of good seedling vigor and early maturity makes it ideal for overseeding warm-season perennial grasses. Present crimson clover varieties are considered poor reseeders because hard seed levels are only about 10%. Most soft seed germinate with the first rain after seed matures in May. Range in maturity of present varieties is about 12 days. Flame and AU Robin are early varieties and Tibbee and Dixie are late varieties. Crimson clover is best adapted in Texas to the Piney Woods and Post Oak Savanah ecoregions.

Rose clover *(Trifolium hirtum All.)*

This hardy clover species is native to the Mediterranean region and Asia Minor and is one of the few clovers that is adapted to lower rainfall areas. Most of the rose clover acreage is on the California rangelands that receive at least 10 in. of rain during the winter growing season. Overton R18 was selected for climatic and soil conditions in the southeastern US at the Texas AgriLife Research and Extension Center at Overton. It matures 4 weeks later with twice the production compared to the early varieties grown in California and Australia. Rose clover is adapted to all soil types with a pH of 5.5 or higher but does not tolerate poorly drained soils. Some iron chlorosis problems have been reported on calcareous soils with soil pH near 8.0. Optimum pH for seedling growth is 5.5 to 7.0. Recommended seeding rates are 12 to 16 lb/acre. Rose clover has a medium size seed with 164,000 seed/lb. Slow seedling growth is a limitation of rose clover that results in later spring growth than the other legume species.

Its greatest success has been in North Central Texas and Central Oklahoma where the annual rainfall is 25 to 30 in., which limits the growth of most other clovers. The good drought tolerance of rose clover is due to a deep rooting depth. Rose clover is an excellent reseeder because of a hard seed percentage of 90%. California data have shown that if volunteer clover stands are lost to drought or insects several years in a row, there would still be sufficient hard seed remaining to reestablish the rose clover stand. Rose clover is best adapted in Texas to the Piney Woods, Post Oak Savanah and Blackland Prairie ecoregions.

Annual Sweetclover *(Melilotuis alba Medik.)*

At one time, sweetclover was the most widely grown forage legume in the United States. It is one of the most drought-tolerant legumes and was grown for forage and soil improvement, particularly in the Great Plains and the Corn Belt. Sweetclover will grow almost anywhere there is a minimum of about 17 in. of rainfall and soil pH is 7.0 or higher. The three general cultivated types of sweetclover are biennial yellow flower, biennial white flower, and annual white flower. Hubam and Floranna were annual white flower types that were grown in the southern USA. In the late 1940's and early 1950's, over 9 million pounds of sweetclover seed were produced in Texas annually. The advent of cheap nitrogen fertilizer after World War II and the spread of the sweetclover weevil (*Sitona cylindricollis*) eliminated most of the sweetclover acreage in the United States. However, it is still grown in Canada. Both white and yellow flower types are found growing along roadsides throughout the United States.

Sweetclover can be planted in the southern states in October at 12 to 16 lb seed/acre. Successful stands have been obtained in Central Texas when seeded in late January and February. It has a medium seed size with approximately 260,000 seed/lb. Sweetclover plants are 3 to 7 feet tall at maturity depending on variety. Annual sweetclovers are late maturing, flowering from May through June in the southern United States. Sweetclovers contain coumarin that causes a bitter taste to which animals become accustomed. If sweetclover is baled at too high a moisture level, the coumarin changes to dicoumarol, a blood anticoagulant. Cows eating the moldy hay can die of internal bleeding. Genes for low coumarin have been found in a wild sweetclover type but none of the annual sweetclover varieties contain the low coumarin gene. A breeding program has been initiated at Texas AgriLife Research and Extension Center at Overton to transfer the low coumarin gene to annuals. At this time, only seed of Hubam sweetclover is available. Annual sweetclover is best adapted in Texas to the Blackland Prairie ecoregion.

Vetch *(Vicia)*

There are many different species of vetch including 15 that are native to the US. Cold-hardy vetch species such as hairy vetch are adapted over a wide area of the US. Common vetch is less cold-hardy and is limited to areas with mild winters such as the Gulf Coast area. Vetch is adapted to a wider range of soil types and pH's than most other forage legumes. It grows on sand, loam, and clay soils from pH 5 to 8. It also has excellent seedling vigor because of its large seed. There are approximately 16,000 seed/lb for hairy vetch with a recommended seeding rate of 20 to 25 lb/acre. Optimum planting depth is 1 to 2 inches because of the large seed. Stems bear leaves with pinnate leaflets and terminate in tendrils that attach themselves to stems of other plants. White or purple flowers, depending on the species, are borne in a cluster or raceme. Hairy vetch flowers during April and May. Seed and pod characteristics vary with species.

The main use for vetch is for a green manure crop because it maintains a high nitrogen concentration through plant maturity. A mature crop of hairy vetch will contain about 150 lb nitrogen/acre. Vetch does not tolerate close grazing and should not be grazed shorter than 6 in. Insects are the main disadvantage of vetch. Pea aphids, corn earworm, fall armyworm and spider mites can be problems. The vetch bruchid or weevil destroys the interior of the seed reducing seed yields, which is the main reason for poor reseeding. Hairy vetch is best adapted in Texas to the Piney Woods, Post Oak Savanah and Blackland Prairie ecoregions.

Cool-Season Perennial Legumes

A few cool-season perennial legume species are grown in the southern United States. Their acreage in the southern United States is limited by preference for loam and clay loam soils. Perennial clovers often act like annuals because of poor summer persistence.

Alfalfa *(Medicago sativa L.)*

The "Queen of Forages" is the best-known forage legume in the United States. Alfalfa is the only forage known to have been cultivated before the era of recorded history. Although classified as a cool-season legume, it grows throughout the summer if moisture is available. Because of this long growing season it has the capacity to produce large yields of high quality forage. Alfalfa is best adapted and grown most extensively in the mid-west US. However, varieties have been developed that are adapted to most climates throughout the United States.

Alfalfa does best on deep, well-drained loam to clay loam soils with a pH of 7.0 or higher. In the eastern half of Texas, the optimum sites are well-drained river bottoms of the

Brazos, Colorado, and Red Rivers. Alfalfa can be grown on any soil with good internal drainage and a subsoil pH of 5.5 or higher. Lime can be added to raise the surface soil pH to near 7 and nutrients limiting for optimum growth can be applied. When sandy acid soils are limed to pH 7, boron is critical for alfalfa if soil boron is less than 1.0 ppm. Autumn planting dates are preferred over spring because of fewer weed problems. Recommended seeding rates are 16 to 20 lb/acre planted at ¼ in. depth in clay soils to ½ in. depth in sandy soils in a clean, firm seedbed.

Alfalfa can be a very profitable forage crop, but it requires a high level of management. Chemical weed control is required to obtain good clean stands. Most disease problems have been solved by selecting for resistance. Alfalfa weevil and three-cornered alfalfa hopper are the main insect problems but all can be controlled with insecticides. Its primary use is hay for dairy cows and horses. With the development of grazing tolerant varieties, more alfalfa is being used for grazing.

For more information regarding alfalfa in east Texas see the following web site (http://overton2.tamu.edu/soils/alfalfa.htm).

White clover *(Trifolium repens L.)*

While perennial in nature, white clover in the southeastern US generally persists as a re-seeding annual. There are small, medium, and large (ladino) white clover types. Although a smaller plant, small and medium types are better seed producers than large types, which is important for reseeding in the south. Recommended varieties are Louisiana S-1 and Durana. White clover requires good soil moisture, is usually found on clay loam, bottomland soils, and is not productive under droughty, upland conditions.

White clover is often planted at 3-4 lbs/acre into existing tall fescue or bermudagrass stands. Best production will be obtained on fertile, well-drained soils if rainfall is favorable. White clover will tolerate wet soil conditions better than most legume species. Because it is often found on wetter sites, white clover may survive a drought during the summer months better than other forage legumes.

White clover does not exhibit the same erect growth habit as red clover and mixed grass-clover stands should be grazed at a 4 to 6 inch height to prevent competition for sunlight from becoming a limiting factor in white clover production. When cattle graze pure stands of white clover, bloat potential may be reduced using Bloat Guard blocks, feeding grass hay or grown in grass mixtures. White clover is best adapted in Texas to bottomland sites in the Piney Woods, Post Oak Savanah, Blackland Prairie and Gulf Prairies ecoregions.

Warm-Season Annual Legumes

Both annual and perennial warm-season legumes are used more for wildlife than livestock. It is difficult to grow warm-season legumes in association with warm-season perennial grasses because the warm-season grasses are so well adapted and competitive.

Cowpea *(Vigna unguiculata)*

This species is an annual viney plant with large leaves; and fairly tolerant of drought, heat, low fertility, and moderate soil acidity. Cowpeas, however, do require adequate levels of P and K to be productive. Forage nutritive value is generally high and plants are easily established from May through June. Many times cowpeas are used as a warm-season food plot for white-tailed deer to offset the negative effects of summer stress. Cowpeas do not cause bloat in ruminants, but are not found immediately palatable by cattle. Iron & Clay is an old forage-type cowpea cultivar (technically a variety mix) that remains vegetative during most of the summer and flowers in early September. Iron & Clay is the recommended cowpea cultivar for East Texas. Current cultivars of forage cowpeas are best adapted in Texas to the Piney Woods and Post Oak Savanah ecoregions.

Lablab *(Lablab purpureus)*

This tropical legume is tolerant of drought, heat and a variety of soil conditions, but not including wet, poorly drained soils or heavy clay soils. Forage nutritive value is high, similar to cowpea, with leaf protein ranging from 24 to 28%. Lablab is more tolerant of defoliation than cowpea or soybean. Generally, lablab is more palatable to cattle compared to cowpeas. Rio Verde lablab was developed through selection for tolerance to defoliation, forage production potential and Texas seed production. This new lablab cultivar was developed at Overton, Texas and released by the Texas Agricultural Experiment Station (TAES) in 2006. Rio Verde is the first lablab cultivar developed in the US and also has the value-added trait of Texas seed production.

Rio Verde lablab is adapted to sandy, sandy loam, clay loam and clay upland soils of the US southern region, including the following regions of Texas: Pineywoods; Gulf Prairies and Marshes; Post Oak Savannah; Blackland Prairies; Cross Timbers and Prairies and South Texas Plains. In the lower rainfall areas of the Cross Timbers and the South Texas Plains, irrigation may be required for establishment. In northeast Texas the primary growing season for Rio Verde lablab is June through October.

Soybean *(Glycine max)*

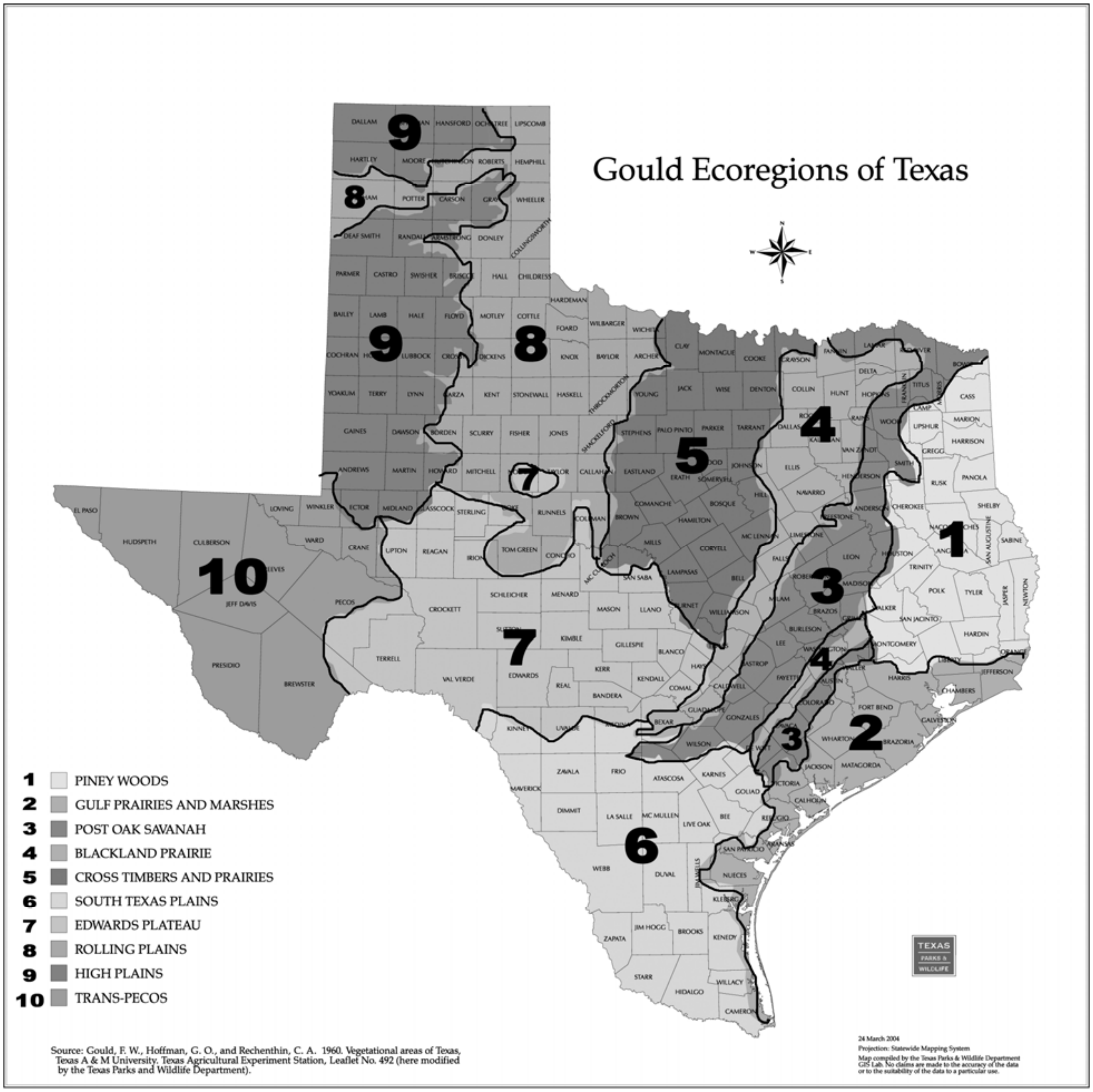
This temperate grain legume can be used as a grazing and hay crop. Soybean is not as tolerant of heat and drought as cowpea and lablab and does not regrow well after defoliation. Soybean is better adapted to heavy clay soils and wet soils relative to cowpea and lablab. Late maturing types are best suited for grazing or hay crops.

Warm-Season Perennial Legumes

Bundleflower (*Desmanthus*)

There are several species of bundleflower that are native to Texas and surrounding states. Two species have been commercialized for use in Texas. Sabine Illinois bundleflower *(Desmanthus illinoesis*) is adapted to North and Central Texas from about Austin northward. BeeWild bundleflower (*D. bicornutus*) was developed by the Texas Agricultural Research Station at Beeville and released by the Texas Agricultural Experiment Station in 2003. BeeWild consists of four (4) different cultivars that are produced as monocultures for seed production purposes, and then blended to produce BeeWild. The four different cultivars have a 100% range in seed size, and a broad range in flowering and seed maturation time. BeeWild is best adapted south of Waco, TX . All bundleflowers are poorly adapted to acid sandy soils, so their use is restricted to soils that are sandy clay loams and heavier with a pH near neutral and above. All bundleflowers contain tannin which reduces palatability and essentially eliminates the potential for bloat. Recommended seeding rates for bundleflower is 3 to 5 lbs per acre. Seeding into prepared seedbed is the preferred method of establishment, but successful seedings can be made following glyphosate treatment of the associated grass. Bundleflower is very sensitive to seeding depth, and should be seeded no more than ¼ inch deep. On prepared seedbed, broadcast seeding followed with dragging or cultipacking has been very successful. Bundleflower likes warm temperatures so April and May seedings are preferred.

Figure 1. Gould Texas Ecoregions.



PASTURE-BEEF CATTLE MANAGEMENT OPTIONS WITH INCREASED COSTS OF FERTILIZER, FEED GRAINS, AND FUEL: STOCKING STRATEGIES AND NUTRIENT CYCLING

Monte Rouquette, Jr.

The "energy crisis" we thought we had encountered a few years ago was just an appetizer compared to the "servings" we're now experiencing in forage-animal production. Regardless of current oil and gas production, captive supplies, import quotas, future inventories, fuel substitutes, or greed, the costs of living and doing business in the US has experienced dramatic price increases. With increased and seemingly ever-increasing energy prices, the costs of "doing business" have caused many to re-think their operating strategies. For the agricultural producer, not only have they experienced increased prices in fuel, fertilizers, and feed ingredients, but they also have to deal with appraisal districts and increased taxes. Management strategies and implementation options for pastures and beef production have been drastically altered by the more than doubling of nitrogen (N) fertilizer prices from 2003 to 2008. With the current world-wide energy demands, escalating prices of feed grains, and captive supplies of oil and gas, beef producers have been forced into major reassessments of management input and cash-flow alternatives. The economic dilemma for producers is that there is no transition period to adapt to the new pasture-beef production cost paradigm. With no likely price reductions in fuel, fertilizer, and feed grains in either the short-term or long-term future, every cash input must be evaluated and scrutinized for potential returns.

Grass production is nitrogen dependent. The basic forage for pastures in Texas, as well as in most of the grazing lands of the world, are warm-season perennial grasses. This category of forages includes bermudagrass, bahiagrass, dallisgrass, and numerous other introduced and native species. In many areas of Texas, nitrogen-containing fertilizers have been a regular part of hay and pasture production for livestock. The immediate and perhaps long-term extended changes in fertilization of forage for pasture and/or hay will be dependent upon numerous factors including: 1) price of cattle; 2) forage requirements for soil nitrogen-phosphorous-potassium (N-P-K) and lime to meet pasture and/or hay needs; 3) economic stocking rate that is sustainable with moderate, minimum, or no fertilization; and 4) alternative land-use without livestock. Thus, some of the management questions may include…"How many cattle can my pastures accommodate with reduced…or eliminated fertilizer input?" "How sustainable are my perennial grass pastures without nitrogen fertilizer?" "How long can I "mine" these pastures?" "Should I produce or purchase hay?" "Can I afford to use winter annual or perennial forages?" "If I make only one application of nitrogen when is the best time of the year to fertilizer?" "Should I consider stocker cattle in my operation?" "Should I lease more land…or lease my own land to someone else?" The primary management concerns remain focused on how to offset cow costs associated with fertilizer, hay, supplemental feed, fuel, etc. with projected percent calf crop weaned, sale weight of calves, and cull animals.

Pasture-Beef Cattle Management Options

Cow-calf and/or stocker operations on pastures require on-going management decisions to adjust for seasonal and total forage production-availability, animal performance expectations, wintering costs, and other operating expenses. In general, rainfall and temperature fluctuations and soil nutrient status control forage production. And, stocking rate adjustments dictate requirements for fertilizer, hay, and/or supplemental feed to meet animal performance expectations. For cow-calf producers, wintering costs associated with hay and supplement to maintain cow condition for calving and rebreeding are responsible for a substantial part of the 12-month cow costs. Thus, fertilizer management during the summer months, hay production or purchase, and inclusion of winter annual pastures requires primary consideration during times of escalating input prices. In response to increased fertilizer prices, management may choose an array of options; however, these strategies will likely include one of the following: 1) eliminate all fertilizer; 2) reduce fertilizer to minimum applications; 3) continue with moderate fertilization applications. With any strategy, there is an action followed by reaction or adjustment due to those decisions. Some of the action-reaction scenarios for fertilizer management may include some of the checklist scenarios that follow:

<u>Eliminate All Fertilizer</u>

1. Obtain a soil test analyses. If soil status of pH, P, etc are acceptable, then clovers may be overseeded for late winter-early spring grazing. These grazed clovers provide a source of nitrogen fixation via excreta and these nutrients are available for use by bermudagrass or other warm-season forage. This recycling of nutrients stimulates forage production and reduces the "soil mining" effects.
2. Reduce stocking rate and/or lease additional pastureland to account for reduced forage production.
3. Hay requirements may be met by purchasing hay based on nutritive value and weight. However, if clovers are components of the pasture system, then allowing them to set seed

with hay harvest after seed maturation will provide some of the hay requirements. In addition, these clover seed-abundant hay bales can act as a method of reseeding pasture areas, and this process is enhanced by “unrolling” the round bales onto new seeding areas during the autumn.

4. Supplementation may be required during the wintering period depending upon nutritive value of hay and/or deferred pasture for “standing hay”.
5. Time of calving may have to be adjusted to fit the seasonal availability of forage nutrient and dry matter from pasture and/or hay. In general, if winter annual forages are not components of this system, then a late spring calving may best fit pasture conditions without prolonged supplementation of the cow herd.
6. Herbicide applications and/or mowing of pastures will be required to control annual weeds and perennial woody species that will invade pastures.
7. Bahiagrass and ecotypes of common bermudagrass will initially invade and eventually dominate these pastures with an extended absence of N-fertilizer. Subsequent invasion by other annual and perennial weeds may become more predominant with time.

Reduce Fertilizer to a Minimum Amount

1. Obtain a soil test analyses
2. Fertilizer strategies based on soil analyses may include non-Nitrogen fertilizer plus overseeded clovers with required lime and/or Phosphorus fertilizer.
3. Other fertilizer strategies may include overseeding with annual ryegrass with one or two winter N application (50 lbs N/ac) to stimulate ryegrass and/or one or two spring-summer N application (50 lbs N/ac) to stimulate bermudagrass, bahiagrass, etc.
4. Strategic, timely application of N is imperative to match climatic conditions and best utilize the optimum effectiveness of N rate and forage production.
5. Hay requirements may be met with harvest of clover and/or ryegrass at seed maturation, or to purchase hay based on nutritive value and weight.
6. Evaluate forage conditions for proper stocking rate and incorporate a regimented cow culling procedure based on performance.
7. Herbicide applications and/or mowing may be required to control annual weeds and perennial woody species.
8. Some forage species composition changes will likely occur on non N-fertilized pastures with increases in bahiagrass and assorted ecotypes of common bermudagrass.

Continue With Moderate Fertilization

1. Obtain a soil test analyses for use with overseeded winter annual clovers, ryegrass, and/or small grains.
2. Apply lime (ECCE-100) as appropriate primarily for cool-season annual forages.
3. Consider rates of 50 to 60 lb N/ac for each application with the potential of 3± applications on small grain + ryegrass, 2± applications on ryegrass, and/or 2 to 3 applications during the exclusive bermudagrass phase.
4. Increase forage production-utilization efficiencies by harvesting hay and/or utilization of stocker calves (retained and/or purchased).
5. Consider selling excess hay.
6. Adjust calving and weaned dates for increased weaning percent and weaning weight.
7. Apply herbicides to eliminate competition for nutrients, water, and space.

There are no archived pasture-animal databases to answer all management concerns, there are some specific, long-term fertilizer regimen x stocking rate experimental data for both common and Coastal bermudagrass from Texas AgriLife Research at Overton. The text that follows will provide forage-animal experimentation information with discussions on general fertilizer x stocking rate management options and projected pasture production and forage persistence for cow-calf and stocker operations.

Recycled Nutrients and Cow-Calf Stocking Rates

Background. (Taken from Rouquette et al RCTR 2006-1) During the spring of 1968, common and Coastal bermudagrass pastures were established at the Texas AgriLife Research and Extension Center at Overton. Initial pH ranged from 5.7 to 6.4 on these upland, sandy loam Coastal Plain soils. During the year of establishment, all pastures received 2 tons/ac lime (ECCE 65), and split-applications of fertilizer at a rate of 120-65-65 lbs/ac N-P_2O_5-K_2O (Table 1). Grazing was first initiated during the spring of 1969 with three stocking rates based on forage availability. Beginning in 1969, all pastures received a total fertilization rate during the growing period of 200-100-100 lbs/ac N-P_2O_5-K_2O. Nitrogen was split applied at 50-65 lbs/ac at each fertilization; whereas, P_2O_5 and K_2O were applied once at the initial spring fertilization. During the 1969 and 1970 grazing season (April to October) of 180-days, pastures consisted of bermudagrass only and were not overseeded. Common bermudagrass pastures were overseeded in the fall of 1970 with a mixture of 'Gulf' ryegrass and 'Dixie' crimson clover. Coastal bermudagrass pastures were evaluated as pure stands until overseeding with Gulf ryegrass and 'Yuchi' arrowleaf clover in the fall of 1974. From the initiation of grazing overseeded common bermudagrass in 1971 and overseeded Coastal bermudagrass pastures in 1975, all pastures have been overseeded with ryegrass and/or clover through 2008. The original fertilization strategy was to apply N-P_2O_5-K_2O at an approximate ratio of 2:1:1. Although fertilizer rates were reduced by half during 1974 and 1975, the average annual fertilizer applications approximated 200-100-100 lbs/ac N-P_2O_5-K_2 from 1969 through 1984 (Table 1).

Table 1. Annual fertilization rates for all bermudagrass pastures.[1]

Year	**Lime** tons/ac	**N**	**P_2O_5**	**K_2O**
		------------------	**lbs/ac**	------------------------
1968	2 (all pastures)	120	65	65
1969 thru 1973		200	100	100
1974 and 1975		110	50	50
1976		175	50	50
1977		220	100	100
1978		200	70	70
1979		175	100	100
1980	2 (all pastures)	225	100	100
1981	1 (all pastures)	225	100	100
1982		195	100	100
1983		250	100	100
1984	1 (all pastures)	200	100	100

[1] Rouquette et al. Research Center Tech. Report 2006-1.

In the fall of 1984, a nutrient recycling experiment was initiated and all stocking rate pastures for both common and Coastal bermudagrass were sub-divided equally into two fertility x winter annual forage treatments: 1) N + ryegrass, and 2) no N + K_2O + clover. Phosphorus fertilizer was not included as a component of either N vs no N-fertility treatments because soil P concentrations were assessed to be adequate for grass or clover production. In addition, we wanted to eliminate long-term residual soil P buildup under stocking conditions. Fertilizer applications of either N-0-0 vs. 0-0-K_2O were initiated in 1985 through 1997 (Table 2). The N rates varied from an average of 408 lbs/ac from 1985-1989, 238 lbs/ac from 1990-1994, 290 lbs/ac for 1995-1996, and 221 lbs/ac for 1997. The annual K_2O rates averaged about 112 lbs/ac. During this 13 year period, 1985-1997, no fertilizer P was applied. Beginning with the 1998 grazing season and continuing through 2005, all pastures received phosphorus, potassium, sulfur, magnesium, and boron; however, only the N + ryegrass pastures received nitrogen fertilizer (Table 2). The annual application rates of N have ranged from 213 lbs/ac to 360 lbs/ac, and P_2O_5 and K_2O rates ranged from 100 to 135 lbs/ac from 1998 through 2004 and were reduced to about 50 lbs/ac each in 2005. Fertility ratios were altered in 2007 to reduce applications of S, Mg, and B.

Stocking rates have varied by bermudagrass and fertility regimens. Long term averages for stocking from mid-February to late September have approximated 0.75, 1.3, and 2.0 cow-calf pair (1500 lbs BW/acre) for common bermudagrass and about 1.0, 1.7, and 3.0 cow-calf pair/ac for Coastal bermudagrass.

Table 2. Annual fertilization rates for bermudagrass pastures receiving Nitrogen plus ryegrass and no-Nitrogen plus clover.[1]

Year	**Lime tons/ac**	**N +Ryegrass**	**no –N +Clover**
		N-P_2O_5-K_2O-B	**(lbs/ac)**
1985	2 (all pastures)	408-0-0	0-0-114
1986		400-0-0	0-0-100
1987	1 (all pastures)	400-0-0	0-0-100 +2
1988		450-0-0	0-0-150 +1.5
1989		400-0-0	0-0-120 +1.5
1990		250-0-0	0-0-112 +1.5
1991	2.25 (N only)	250-0-0	0-0-100 +1.5
1992 thru 1993		250-0-0	0-0-125 +1.5
1994	1 (N-only)	190-0-0	0-0-114 +2
1995 and 1996		290-0-0	0-0-108
1997	0.5 (N only)	221-0-0	0-0-120
		N-P_2O_5-K_2O-S-Mg-B	**(lbs/ac)**
1998		255-100-100-44-22-1	0-100-100-44-22-1
1999		360-114-114-50-27-1.2	0-114-114-50-27-1.2
2000		255-135-133-60-32-1.4	0-135-135-60-32-1.4
2001		306-100-100-44-24-1.1	0-100-0100-44-24-1.1
2002	1 (all pastures)	365-120-120-53-29-1.2	0-120-120-53-29-1.2
2003		365-120-120-53-29-1.2	0-120-120-53-29-1.2
2004		213-116-116-52-27-1.2	0-116-116-52-27-1.2
2005		306-48-48-42-22-1	0-48-48-42-22-1
2006		203-41-41-86-19-1	0-41-41-36-19-1
2007		272-50-50	0-50-50

[1] Rouquette et al. Research Center Tech. Report 2006-1.

Soil P Concentrations (Taken from Silveira et al RCTR 2006-1) Initial soil P concentrations in 1969 were very low (< 3 ppm). This was consistent with non-fertilized, P-deficient sandy Coastal Plain soils. Soil P concentrations in the 0-6 inch depth significantly increased (up to 10-fold) from 1975 to 1985 as result of P fertilizer application (~100 lbs P_2O_5/ac year) (Fig 1). Sixteen years (1969-1985) of P application (total P load of 1,500 lbs P_2O_5/ac) shifted soil P status from very low (0-5 pm) to high (21-40 ppm). This increased soil P level enhanced forage growth, especially ryegrass and clover. During 1985 to 1997, bermudagrass pastures received no inorganic P fertilizer; thus, the major P contributions to the soil occurred via nutrient recycling as animal excreta. Average soil P concentrations in 1985 were approximately 33 ppm for common and 27 ppm for Coastal bermudagrass. In 1996, soil P concentrations were comparable to those in 1985 (31 ppm for common and 24 for Coastal), suggesting that P was not depleted during 11 years of continuous stocking with no P-fertilizer applied. Nutrient cycling through animal residues and prior history of P application sustained relatively constant P concentrations in the 0-6 inch depth of soils.

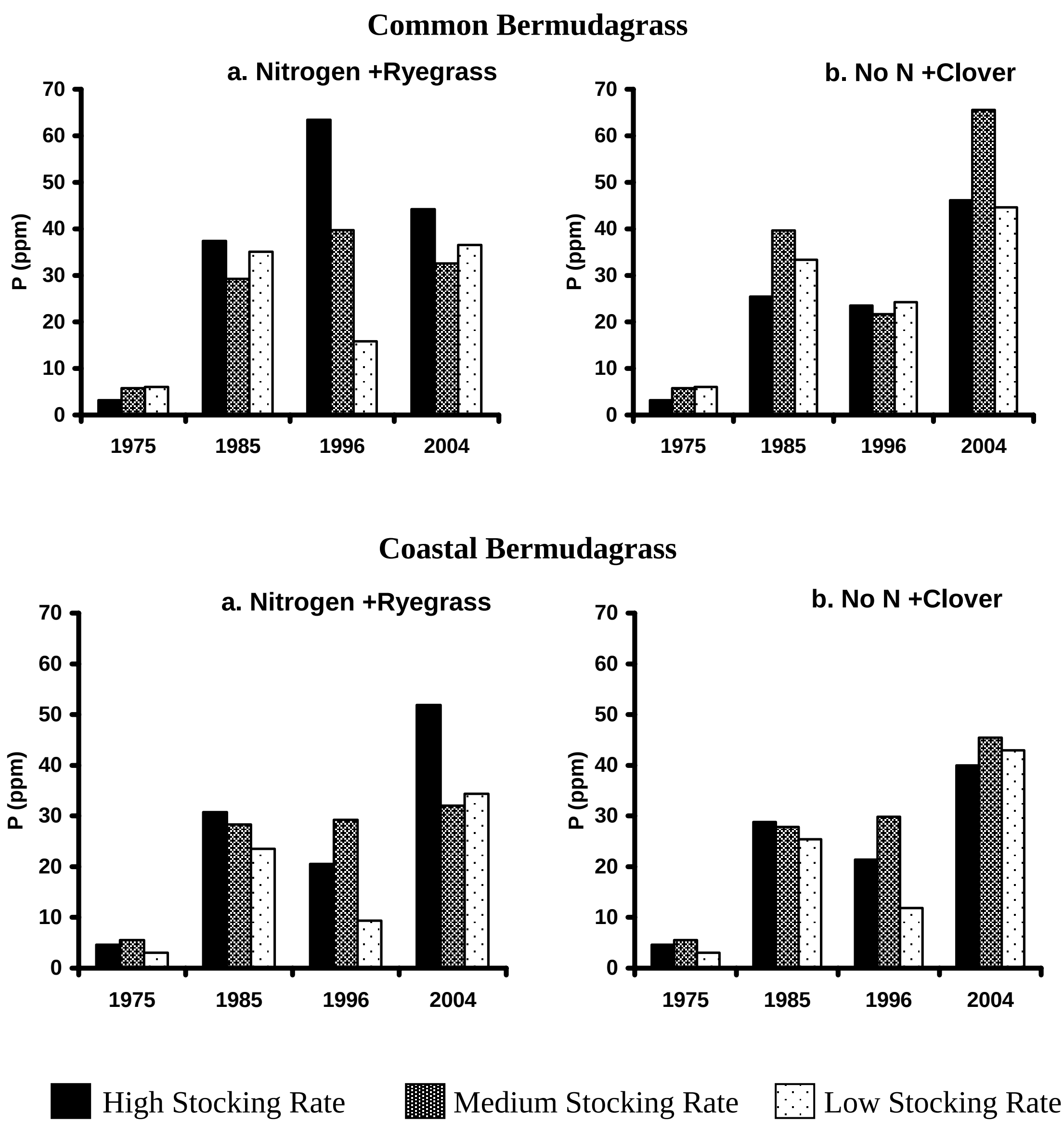


Figure 1. Changes in soil P concentrations (0-6” soil depth) in common and Coastal bermudagrass pastures after 29 years of continuous grazing at different stocking rates and fertility regimens. (Silveira et al Research Center Tech. Report 2006-1).

In general, soil P concentrations were similar in common and Coastal bermudagrass pastures with different fertility regimens (Fig 1). From 1985 to 1996 there was a slight decrease in soil P concentrations at low stocking rates (1 pair/ac) for both common and Coastal bermudagrass pastures. This suggested that animal excreta was playing an important role in P recycling. Relatively small increases in soil P concentrations were observed in common bermudagrass fertilized with N under high stocking rates (2 to 3 cow-calf pair/ac) from 1985 to 1996; however, this difference was not statistically significant. From 1999 to 2004, P fertilizer was applied at 100 lbs/ac P_2O_5. Soil P concentrations in the 0-6" depth increased across all treatments, except for common bermudagrass pastures under high and medium stocking rates. Increases in soil P due to fertilization during this 5-year period were more evident in pastures under low and medium stocking rates.

With continuous stocking of Coastal bermudagrass, soil P concentrations were nearly two times greater at high stocking rates (2-3 cow-calf/ac) than at the low stocking rates (1 cow-calf/ac) (Fig 2). Differences in soil P concentrations due to stocking rates were mainly observed in the top 48-in soil depth. In contrast, deeper soil depths showed no evidence of stocking rates affecting P concentrations. Across all treatments, P concentrations decreased significantly with soil depth. This trend was expected, since P has slow mobility in the soil profile and tends to preferentially accumulate in the surface horizons in grazed pastures due to above ground contributions from fertilizer, animal wastes, and nutrient recycling.

Nutrient cycling through animal excreta can sustain adequate soil P concentrations for optimum bermudagrass production. Overseeded ryegrass and clover growth are especially favored by adequate soil P levels. Coastal plain soils previously fertilized with P sustained relatively constant soil P concentrations during 11 years of no-P fertilizer. Phosphorus fertilization, however, can considerably affect soil P concentrations, and, thus, adequate fertilization rates and intervals of application should be carefully managed to minimize potential environmental concerns associated with accumulation of P in soils and subsequent edge-of-field P losses. Coastal bermudagrass pastures with prior history of P fertilization can maintain adequate soil P concentrations for several years under continuous stocking. Under low stocking rates, soil P will deplete faster than at high stocking rates. Animal manure can recycle substantial amounts of P and sustain adequate bermudagrass growth in Coastal Plain soils. During more than 35 years of grazing, there was no evidence that P was accumulating in soils at levels that may potentially become an environmental hazard.

Soil Nitrate-Nitrogen Concentrations (Taken from Silveira et al RCTR 2006-1) Soil NO_3-N concentrations significantly increased from 1985 to 1989 in bermudagrass pastures overseeded with ryegrass and fertilized with about 408 lbs N/ac annually (Fig 3). Excess N (not used for plant uptake) was contributing to NO_3 accumulation in the 0-6" soil depth. However, compared to the annual N load, increases in soil NO_3-N were negligible after four years of relatively high N application rates. During this 5-year period, bermudagrass pastures overseeded with ryegrass received approximately 2,000 lbs N/ac, while soil NO_3-N status increased less than 10 ppm (~ 20 lbs N/ac). This suggested that plant uptake was recovering a significant fraction of the applied and recycled N Coastal bermudagrass produces more total dry matter than common bermudagrass. Thus, soil N was likely more efficiently used for plant uptake by Coastal bermudagrass.

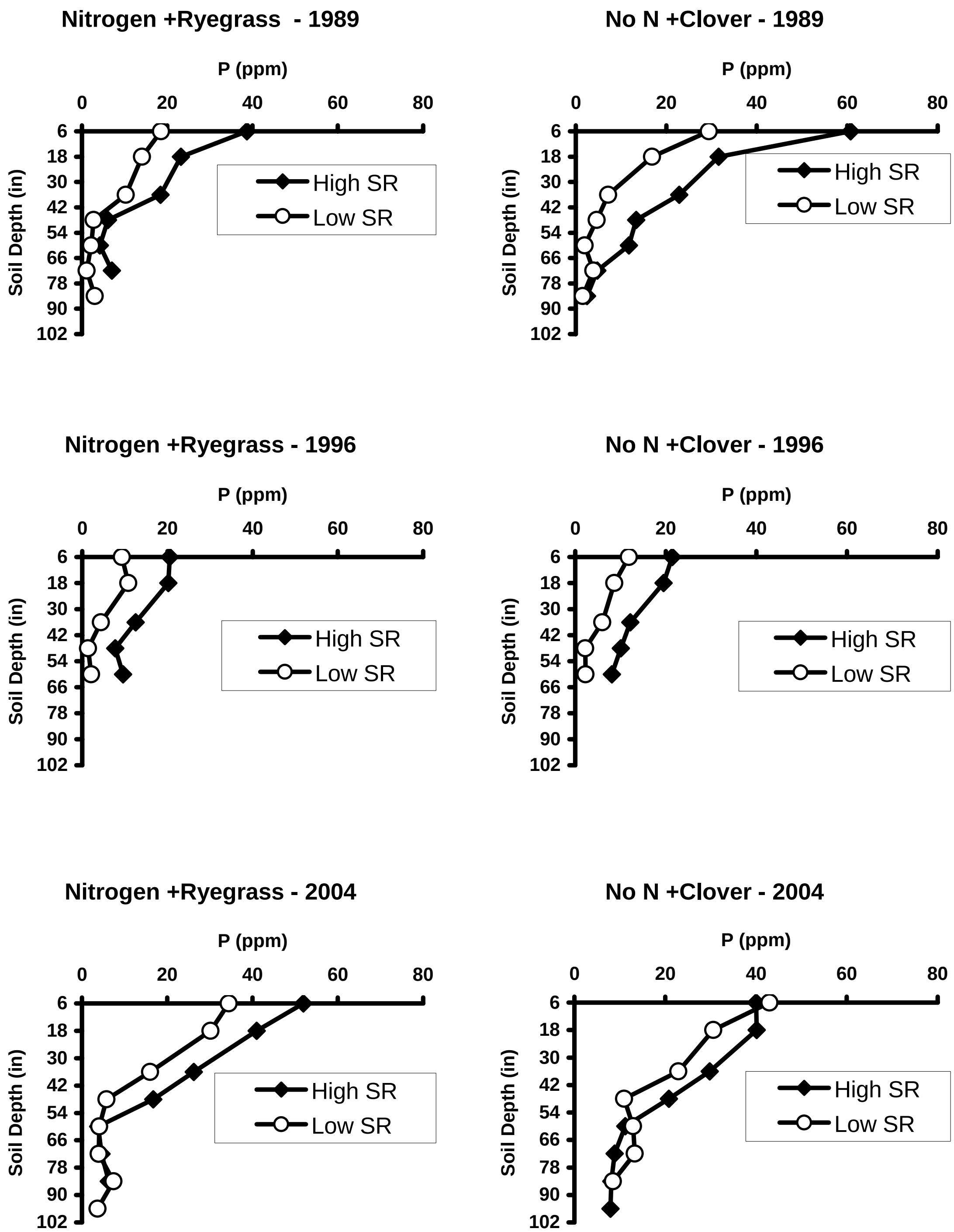


Figure 2. Phosphorus distribution in the Coastal bermudagrass soil profile as a function of different stocking rates (SR) and nitrogen fertilization. (Silveira et al Research Center Tech. Report 2006-1).

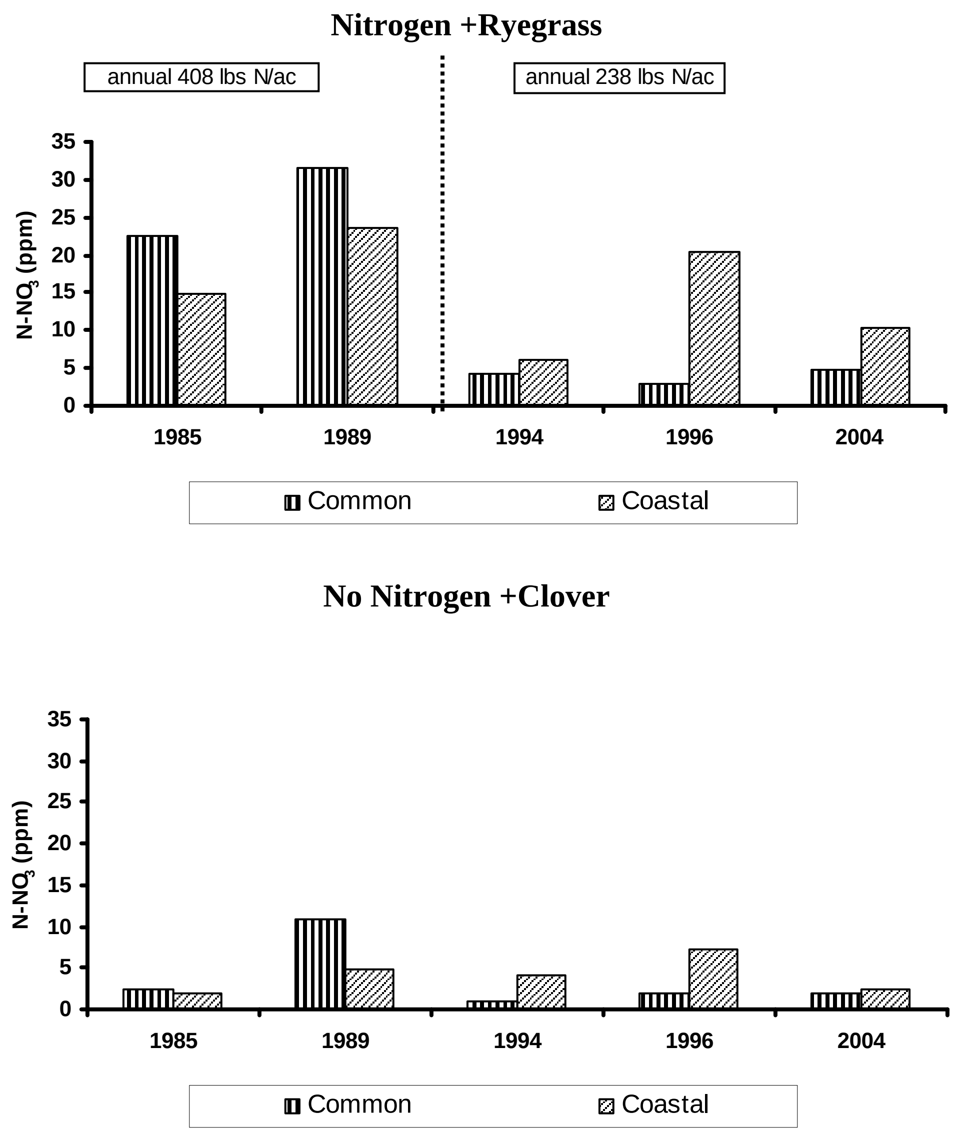


Figure 3. Changes in soil NO_3-N concentrations in the 0-6" soil depth of bermudagrass pastures with different fertility regimens. (Silveira et al Research Center Tech. Report 2006-1).

From 1989 to 2004, annual N fertilization rates were reduced to ~ 200 lbs N/ac, and there was a dramatic decrease in soil NO_3-N concentrations, especially in common bermudagrass pastures. Pastures overseeded with clover and not fertilized with N had much lower soil NO_3-N levels than N-fertilized ryegrass pastures. Although no N had been applied to the clover pastures since 1984, soil NO_3-N concentrations were relatively constant over 35-years of continuous stocking. Fixation of atmospheric N_2 by clovers and subsequent recycling via animal excreta maintained adequate levels of available N for modest forage production. Stocking rates varying from 1 to 2-3 cow-calf pair/ac showed no effect on soil NO_3-N concentrations. From 1994 to 2004, soil NO_3-N concentrations were greater for Coastal bermudagrass (average = 8.5 ppm) compared to common bermudagrass (average= 2.8 ppm). Both common and Coastal pastures at the high stocking rates had substantial changes in forage species composition. On Coastal bermudagrass pastures, there was a dramatic shift to multiple ecotypes of common bermudagrass to the extent that only about 30% of this pasture was Coastal and about 70% was mixed common types in 2008. On the non-N fertilized, high stocked common bermudagrass pastures, bahiagrass occupied about 45% of the area in 2008.

Soil NO_3-N concentrations on Coastal Plain, sandy soils, are strongly related to the fertilizer management. Large N application rates (greater than plant uptake) may result in NO_3 accumulation in soils and rapidly increase soil acidity. Environmental risks associated with N losses may occur. Excessive soil drainage associated with the warm and humid climate of east Texas may favor N losses via leaching and denitrification in heavily N fertilized sandy soils. Bermudagrass pastures overseeded with clover, with no N-fertilization for the previous 20-years, sustained moderate production of bermudagrass with significant species changes at the high stocking rate. Despite the inherent seasonal and spatial variability associated with NO_3 in soils, relatively constant NO_3 concentrations with time is an indication that N has been efficiently recycled via animal excreta in bermudagrass pastures overseeded with clover. Clover is an environmental and economic alternative to N fertilization, and can be integrated into fertility strategies for forage production for pastures and hay.

Soil Potassium Concentration (Taken from Silveira et al RCTR 2006-1) Extractable soil K concentrations in the 0-6" soil depth were consistently low, and ranged from ~ 7 to 150 ppm (Fig 4). On average, soil K concentrations were rated as either very low (0-90 ppm) or low (91-130 ppm). The only exception occurred in 1994, when extractable soil K increased on high stocking rate common bermudagrass pastures overseeded with clover + K_2O and no applied N. Potassium is utilized by forages in relatively large quantities, usually as great as N; therefore, soil levels can be considerably depleted due to plant uptake. Because K is mobile in soils, residual K (not used by plants) can be leached to deeper soil depths. Although larger K concentrations were usually observed in pastures that received no N, overseeded with clover and average annual application rates of ~100 lbs K_2O/ac for 35 years (Tables 1 and 2), K concentrations in the top 0-6-in soil depth were variable but not significantly greater than that in the bermudagrass pastures receiving only N and overseeded with ryegrass (Fig 4). Pastures fertilized with N and overseeded with ryegrass received no K for 13 years (1985-1997), and soil concentrations were relatively constant with time. From 1998-2004, all pastures received about 100lbs/ac K_2O (Table 2). Plant and animal wastes recycled K to maintain low soil levels. There was no clear effect of different stocking rates on soil K concentrations. The surface horizon (0-6") of Coastal Plain soils may not

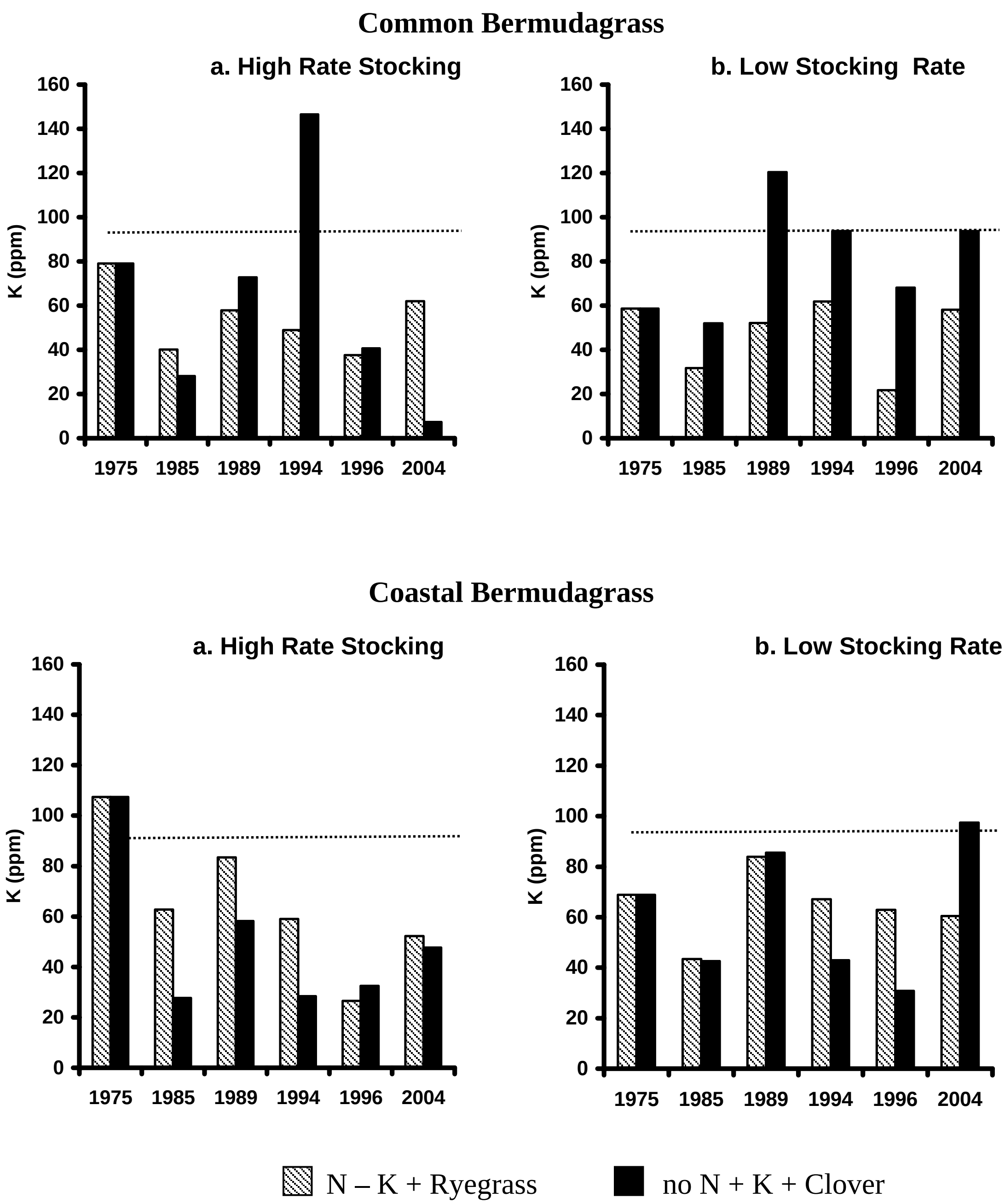


Figure 4. Changes in soil K concentrations (0-6”) in bermudagrass pastures under different stocking rates and fertility regimens. Dashed lines represent limit between very low and low K concentrations in soils. (Silveira et al Research Center Tech. Report 2006-1).

supply adequate amounts of K for optimal forage growth. The large K requirements of forages rapidly depletes soil K concentrations in the surface soil depths. Because of the coarse texture and poor sorbing capacity of these soils, residual K eventually leaches to deeper soil depths. Nutrient recycling via plant and animal wastes in grazed pastures contribute to maintain low levels of K in soils, but K fertilization must be included in soil fertility management strategies in order to maintain sustainable bermudagrass production on Coastal Plain soils. Relatively low K fertilizer inputs may be feasible for bermudagrass under grazing conditions. However bermudagrass used exclusively for hay production removes significant amounts of K exported with forage; thus, larger K fertilization rates are required to maintain adequate forage growth and sustained stands on hay meadows compared to grazed areas.

As previously discussed, both common and Coastal bermudagrass pastures at Texas AgriLife Research - Overton were initially stocked in 1968 with an average of 200-100-100 lbs/ac N-P_2O_5-K_2O through 1984 (Table 1). The currently active, long-term fertility regimen x stocking rate, nutrient cycling experimentation was initiated in 1985. For the next five years (1985-1989), N rates averaged 408 lbs/ac applied in 8 applications at 50 lbs N/ac, and with about half of the N applied during the ryegrass growing period and half of the N applied during the exclusive bermudagrass growth phase. The K_2O (0-0-100) was applied in a single application in the fall at or near clover planting. The five-year average suckling calf performance at three stocking rates on common bermudagrass (Table 3) and on Coastal bermudagrass (Table 4) are presented for both the N + ryegrass vs no N + K_2O + clover pastures. It is important to recall that this nutrient cycling experimentation was initiated after more than 15 years of fertilization and continuous stocking from February through September of each year.

Table 3. Five-year comparison of calf performance on common bermudagrass pastures overseeded with either arrowleaf clover or ryegrass and stocked at each of three levels (1985-1989).[4]

			Calf		
Fertilizer + Annual Forage	**STK Rate[1]**	**Grazing Days**	**ADG**	**Gain/animal**	**Gain/acre**
	(au/ac)		(lb/d)	(lb)	(lb/ac)
No N + K_2O + CLV[2]	1.92	174	.84	147	279
N + RYG[3]	2.15	199	1.48	294	624
No N + K_2O + CLV	1.40	178	2.27	405	568
N + RYG	1.45	200	2.29	460	664
No N + K_2O + CLV	0.83	178	2.52	450	371
N + RYG	0.88	202	2.69	544	482

[1] One Au = 1,500-lb body weight.
[2] CLV = arrowleaf; 0-0-100 applied in one application during fall planting.
[3] RYG = ryegrass; Annual N rate of 408 lbs/ac applied in 8 applications of 50 lbs N/ac each.
[4] Rouquette et al. 1992. Forage Research in Texas. CPR-5039.

Table 4. Five-year comparison of calf performance on Coastal bermudagrass pastures overseeded with either arrowleaf clover or ryegrass and stocked at each of three levels (1985-1989).[4]

Fertilizer + Annual Forage	STK Rate[1]	Grazing Days	Calf ADG	Calf Gain/Animal	Calf Gain/Acre
	(au/ac)		(lb/d)	(lb)	(lb/ac)
No N + K_2O + CLV[2]	2.82	184	1.32	269	709
N + RYG[3]	3.21	206	1.66	344	1011
No N + K_2O + CLV	1.50	178	2.46	438	653
N + RYG	1.98	204	2.31	472	897
No N + K_2O + CLV	0.92	181	2.70	523	446
N + RYG	1.19	203	2.67	544	631

[1] One Au = 1,500-lb body weight.
[2] CLV = arrowleaf; 0-0-100 applied in one application during fall planting.
[3] RYG = ryegrass; Annual N rate of 408 lbs/ac applied in 8 applications of 50 lbs N/ac each.
[4] Rouquette et al. 1992. Forage Research in Texas. CPR-5040.

Nutrient Cycling on Pastures Plant food nutrients, primarily N, P, and K may be absorbed from the soil and then returned to the soil for use once again. This return-process has been labeled as nutrient cycling. In general, plant nutrients are recycled from root decay, leaf-stem loss and accumulated as litter, and excreta deposition by the grazing animal. Recycling of plant food nutrients is most effectively accomplished via excreta of dung and urine, and the excreta nutrient-base is primarily a function of diet (forage). In general, fecal excretion of N has been reported to be relatively constant per unit dry matter intake; whereas N in the urine fluctuates with N content of the diet. Phosphorus is recycled in both dung and urine with both organic and inorganic P excreted in the urine. However, K is primarily recycled in the urine with only 10% to 30% excreted in the feces. With respect to the extent of nutrients returned to the pasture (recycling) vs the amount of nutrients removed from the pasture, grazing animals remove only a small part of the forage N, P, and K. Estimates of removal will vary according to an array of factors; however, the percent composition of N, P, and K in the animals body has been estimated at about 2.6% N, 1% P, and less than 0.5% K per pound of weight gain (Rouquette et al 1973). The greatest losses of plant food nutrients from pastures occurs via runoff, leaching through the soil profile, volatilization, etc. with forage, soil type, and climatic conditions governing the extent of nutrient loss. And, the effectiveness of these plant nutrients recycled via excreta is stocking rate and stocking method dependent. In general, with lower stocking rates, excreta is not well-distributed on the entire pasture area and tends to accumulate in resting-loafing areas as well as in near proximity to water, mineral and/or supplementation areas. Rotational stocking tends to enhance distribution effectiveness compared to continuous stocking; however, the overall effectiveness is based on stocking rate, duration of stocking, and extent of forage utilization in specific pasture areas.

During the first five years of fertility regimen x stocking rate, nutrient cycling (1985-1989), higher stocking rates and hence calf gain per acre were greater from N + ryegrass compared to no N + K_2O + clover. In addition, Coastal bermudagrass pastures had more production of calf gain compared to common bermudagrass (Tables 3 and 4). Following this initial 5-year period of stocking, a 7-year period followed in which the annual N fertilization rate was reduced to about 250 lbs/ac N. These N fertilizations of about 50 lbs/ac N per application were all applied during the ryegrass growing period with the exception of one application made on exclusive bermudagrass. Thus, the nitrogen cycling from fertilization of ryegrass was intended to provide N for the subsequent bermudagrass pastures (Tables 5 and 6). The 7-year average pasture-animal production (1990-1996) indicated some reductions in stocking rate and calf gain per acre primarily from the Coastal bermudagrass pastures. Thus, with continued reduction of N application, forage production from common bermudagrass and Coastal become more similar. Perhaps the most noteworthy response were those from non N-fertilized pastures during this 12-year period in that calf gain per acre were at 300 to 400 lbs/ac. In addition, moderate to low risk stocking rates ranged from about 1.3 acres to 1 acre per cow-calf pair during the active grazing period of February through September. Note that these stocking rates are not for the 12-month period; hence other pastures and/or hay must be provided to estimate year long stocking rate requirements and cow costs.

Table 5. Seven-year cow-calf performance from common bermudagrass pastures stocked at three levels and receiving Nitrogen fertilizer + ryegrass or no Nitrogen + K_2O + clover (1990-1996).[4]

Grazing Pressure	Fertilizer + Annual Forage	STK Rate[1]	Calf ADG	Calf Gain/Ac
		(au/ac)	(lb/d)	(lb/ac)
High	No N + K_2O + CLV[2]	1.97	0.71	229
High	N + RYG[3]	2.18	1.41	563
Medium	No N + K_2O + CLV	1.23	2.04	446
Medium	N + RYG	1.32	2.25	564
Low	No N + K_2O + CLV	0.70	2.53	304
Low	N + RYG	0.80	2.56	390

[1] One-Au = 1500-lb body weight.
[2] CLV = included crimson, arrowleaf, Subterranean, and ball clover.
[3] RYG = ryegrass; Approximately 250 lbs N/ac applied at 50 lbs N/ac per application with only one application on exclusive bermudagrass (late May).
[4] Rouquette et al. Research Center Tech. Report -1998-1.

Table 6. Seven-year cow-calf performance from Coastal bermudagrass pastures stocked at three levels and receiving Nitrogen fertilizer + ryegrass or no N + K_2O + clover (1990-1996).[4]

Grazing Pressure	Fertilizer + Annual Forage	STK Rate[1]	Calf	
			ADG	**Gain/ac**
		(ac/ac)	(lb/d)	(lb/ac)
High	No N + K_2O + CLV[2]	2.35	1.31	514
High	N + RYG[3]	2.76	1.36	645
Medium	No N + K_2O + CLV	1.23	2.21	490
Medium	N + RYG	1.61	2.39	716
Low	No N + K_2O + CLV	0.79	2.74	390
Low	N + RYG	0.98	2.73	494

[1] One-Au = 1500-lb body weight.
[2] CLV = included crimson, arrowleaf, Subterranean, and ball clover.
[3] RYG = ryegrass; Approximately 250 lbs N/ac applied at 50 lbs N/ac per application with only one application on exclusive bermudagrass (late May.
[4] Rouquette et al. Research Center Tech. Report 1998-1.

Pasture Costs Table 7 presents pasture costs for the first 5-year and follow-up 7-year experiments. Costs used were based on early April 2008 and these are subject to change. Assessing costs only seed and fertilizer, the N-fertilized + ryegrass pastures would cost $332/ac for 408 lbs/ac N and $222/ac at the 253 lb/ac N rates. In contrast the K_2O + clover pastures plus lime would cost $145/ac and $118/ac, respectively. Differences in cost were for lime additions during the first 5 years; however no lime was required on the no N fertilized pasture during the following 7-year period due primarily to an absence of N fertilization. Using these cost assessments for each fertility regimen, estimated pasture costs per pound of calf gain are shown in Table 8. Certainly, there are numerous other expenditures in estimating a year-long cow budget; however, these seed and fertilizer expenditures represent the major pasture costs. Other costs associated with wintering, land costs, labor, interest, etc. have to be included for accurate yearlong expenses. Evaluating these costs, it becomes readily apparent that the moderate stocked pastures may offer opportunities for least costs per pound of calf gain. However, from the perspective of reducing risk plus the opportunity to harvest hay off the pastures, a lower stocking rate of about 1.25 to 1.5 acres per cow-calf unit during the February to October period may be a best management strategy. Before one decides to eliminate ALL N from the pasture system, the pasture costs per pound of calf gain from N fertilization are greater than no N-fertilization; however, these N + ryegrass pasture costs remain within practical consideration for forage production.

Table 7. Annual seed and fertilizer costs for bermudagrass pastures overseeded with either clover + K or Ryegrass + N based on April 2008 costs.[1]

Item	Appl. Rate (lbs/ac)	Nutrient	Cost/Unit ($)	1984-89 $/ac	1990-96 $/ac
Ryegrass	25		.48/lb	12	12
34-0-0		408	.71/lb N	290	
34-0-0		253	.71/lb N		180
Lime	1300		45/ton	30	30
Total Ryegrass + N				**332**	**222**
Clover	20		100/cwt	20	20
0-0-60	190	114	.50/lb K_2O	95	
0-0-60	195	117	.50/lb K_2O		98
Lime	1300		45/ton	30	0
Total Clover + K				**145**	**118**

[1] Rouquette et al. Research Center Tech. Report 1998-1.

Stocker Calves and Winter Pastures As production costs rise, numerous pasture assessments of forage utilization, hay, overseeding, fertilization, etc. must be made. However, concurrent, critical decisions must also be made for the class of beef cattle used, their efficiency of production, and returns based on occupancy weight of the animal(s). Replacement Angus x Brahman (F-1) heifers were grazed on these same fertility regimen, nutrient cycling pastures during a 2-year period (Table 9). Stocking pastures with 535-lb heifers in early February resulted in heifer weights of more than 800 pounds by mid-June from low and moderate stocked pastures. And, although there were slight ADG advantages on N + ryegrass pastures, heifers made final weight expectations on both fertility regimens. With the low stocking rates of 1.5 535-lb heifers per acre at grazing initiation, the ADG approached 3 lbs/da. The same fertility regimens and fertilizer-seed costs (based on April 2008) as those in Table 7 for the 1990-1996 period of N + ryegrass at $222/ac and K_2O + clover at $118/ac were in place for this heifer study. Thus, these pasture costs per pound of calf gain on N + ryegrass ranged from $0.44/lb gain at 500 lbs/ac gain to $0.28/lb gain at 800 lbs/ac gain. Pasture costs for the K_2O + clover pasture costs ranged from $0.24/lb gain at 500 lbs/ac gain to $0.16/lb gain at the 750 lbs/ac gain. Thus, with adapted animal genotypes and adequate nutritious forage available, either N + ryegrass or K_2O + clover systems may be acceptable for developing replacement heifers or stockers steers.

Table 8. Bermudagrass (BG) pasture (PAS) costs/lb gain for suckling calves when grazed by cow-calf pair at three stocking rates (SR) based on April 2008 costs.[1]

Item	LOW SR		MED SR		HIGH SR	
1984 through 1989						
CLV + K_2O Costs/Ac = $145; RYG + N = $332						
Common BG	CLV+K	RYG+N	CLV+K	RYG+N	CLV+K	RYG+N
SR (1500 lbs)	0.83	0.88	1.40	1.45	1.92	2.15
Calf gain/ac (lbs)	371	482	568	664	279	624
PAS Cost/lb gain ($)	0.39	0.68	0.26	0.50	0.52	0.53
Coastal BG	CLV+K	RYG+N	CLV+K	RYG+N	CLV+K	RYG+N
SR (1500 lbs)	0.92	1.19	1.50	1.98	2.82	3.21
Calf gain/ac (lbs)	446	631	653	897	709	1011
PAS Cost/lb gain ($)	0.33	0.52	0.22	0.37	0.20	0.33
1990 through 1996						
CLV + K Costs/Ac = $118; RYG + N = $222						
Common BG	CLV+K	RYG+N	CLV+K	RYG+N	CLV+K	RYG+N
SR (1500 lbs)	0.70	0.80	1.23	1.32	1.97	2.18
Calf gain/ac (lbs)	304	390	446	564	229	563
PAS Cost/lb gain ($)	0.38	0.56	0.26	0.39	0.50	0.39
Coastal BG	CLV+K	RYG+N	CLV+K	RYG+N	CLV+K	RYG+N
SR (1500 lbs)	0.79	0.98	1.23	1.61	2.35	2.76
Calf gain/ac (lbs)	390	494	490	716	514	645
PAS Cost/lb gain ($)	0.29	0.45	0.23	0.31	0.22	0.34

[1] Rouquette et al 2000 RCTR.

Research on small grain (Maton rye) plus ryegrass sod-seeded on bermudagrass pastures were pioneered at the Texas AgriLife Research-Overton location during the late 1960's-early 1970's. In addition to ADG that may exceed 2.5 lbs/da, there are opportunities to exceed ADG of 3 lbs/da with supplementation. The ADG for a rye + ryegrass pasture experiment with 3 stocking rates and 3 levels of supplementation are shown in Tables 10 and 11. Using only the moderate stocking rate of 2.1 hd/ac (550 lbs at initiation), a budget assessment is presented in Table 12 that includes all cash expenses plus interest, but does not include charges for land, labor, and planting. Pasture expenses included 450 lbs/ac 34-0-0 split applied; Maton rye at $38/wt; and TAM 90 ryegrass at $48/wt. All animal expenditures for implant, de-wormer, vaccinations, mineral, etc. were included. Interest charges at 10% were made on all expenditures. Using these assumptions, N costs at $0.71/lb and corn at $240/ton ($6.70/bu) showed returns of more than $180 per acre for all supplement levels. This $180 per acre return must be used for land, labor, planting, etc. expenses before any net return may be realized. However, given the magnitude of these returns, a net profit should be expected from this management strategy along with budget estimates that include 148 days grazing with high performance animals on high nutritive value forage.

Table 9. Two-year performance from F-1) (Angus x Brahman) heifers stocked at 3 levels on common or Coastal bermudagrass and overseeded with TAM 90 annual ryegrass + Nitrogen vs Tibbe crimson clover + K_2O and without N fertilizer.[4]

Grazing Pressure	**Fertilizer + Forage[2, 3]**	**STK Rate[1]**	**ADG**	**Final Live Wt**	**Gain/Ac**
		(hd/ac)	(lb/d)	(lbs)	(lb/ac)
High	CM-CL	3.8	1.30	685	589
High	CM-RG	4.1	1.40	713	671
Medium	CM-CL	2.6	2.28	812	685
Medium	CM-RG	2.6	2.46	835	739
Low	CM-CL	1.5	2.94	882	519
Low	CM-RG	1.5	2.60	844	459
High	CS-CL	3.8	1.56	724	699
High	CS-RG	4.2	1.77	736	864
Medium	CS-CL	2.6	2.51	840	754
Medium	CS-RG	2.6	2.75	864	828
Low	CS-CL	1.5	2.93	889	518
Low	CS-RG	1.5	2.93	886	518

[1] Stocking rate based on 535 lbs per heifer; pastures stocked from early February to mid-June.
[2] CM = common bermudagrass; CS = coastal bermudagrass; CL = Tibbe crimson clover; RG = TAM 90 annual ryegrass.
[3] Fertilizer for CL = 0-100-100-22-44-1 (N-P_2O_5-K_2O-Mg-S-B) and for RG = 175 lbs N/ac split applied.
[4] Rouquette et al. Research Center Tech. Report 2000-1.

Table 10. Effect of stocking rate on average daily gain (ADG) on rye-ryegrass pastures.[3]

Stocking Rate[1] hd/ac	**Supplementation (% BW)**		
	0	**0.4%**	**0.8%**
	ADG (lbs/da)[2]		
1.5	2.80 a[2]	3.13 a	3.24 a
2.1	2.21 b	2.86 a	3.11 a
3.0	1.13 c	1.94 b	2.10 b

[1] Stocking rates based on 550 lbs = one stocker at initiation of grazing on 12-20-04.
[2] ADG followed by a different letter within a **supplement** column, differ at P<.05.
[3] Rouquette et al. Research Center Tech Report 2006-1.

Table 11. Effect of supplement level on average daily gain (ADG) on rye-ryegrass pastures.[3]

Supplement	Stocking Rates[1] (hd/ac)		
	1.50	2.1	3.0
		ADG (lbs/da)[2]	
Pasture Only	2.80 a[2]	2.21 b	1.13 b
0.4% BW	3.13 a	2.86 ab	1.94 a
0.8% BW	3.24 a	3.11 a	2.10 a

[1] Stocking rates on 550lbs = one stocker at initiation of grazing on 12-20-04.
[2] ADG followed by a different letter in a **stocking rate** column, differ at $P<.05$.
[3] Rouquette et al. Research Center Tech Report 2006-1.

Stocker ventures have always been associated with moderate to high levels of uncertainty related to climatic conditions and the margin of purchase price – selling price of the animals. In many cases the careful attention to details of pastures and animal management can be radically offset by the extent of negative margin between purchase-sales prices. Using the budget presented in Table 12 for non-supplemented cattle, the average purchase price for steers and heifers was about $1.07/lb and the average sales price was about $0.92/lb. This approximate $15/cwt negative margin showed estimated returns/ac at about $183. Various purchase-sales margin scenarios are shown in Table 13 for these previously used databases for stocking rate and ADG information. As has been shown by several others in previous assessments, as the absolute price of stockers declines, (i.e. say from $1.10/lb to $0.80/lb), there is less negative margin that can be absorbed and continue to return net income to the operation. In contrast, this performance data illustration shows that stockers purchased at $1.10/lb and sold for a $0.20/lb negative margin of $0.90/lb continues to have profit potential. Although positive margins are often rarely experienced in the stocker business, the old adage of....“if you can’t make money with stockers with a positive margin, you don’t need to be in the cattle business is probably correct.”

From 2003 to 2008, the price per lb of N has doubled to costs of about $0.70/lb N for ammonium nitrate (early April 2008). The primary management concerns with any pasture system, but particularly with the relatively expensive small grain plus ryegrass pastures, are how the continued cost per pound of N effects returns. Table 14 uses stocking rate data from Table 10 and budget estimates used for Table 12 to make assumptions on returns/ac for two stocking rate pastures with increasing prices of N ranging from $0.71 to $1.00 per pound. Although increased fertilizer N costs reduce net returns, there are potential “significant” returns/ac from either the low stocked pastures at 1.5 hd/ac or the moderate stocked rye + ryegrass at 2.1 hd/ac. In contrast, however, are those costs associated with increased supplementation of stockers grazing small grain + ryegrass pastures. Using the previous performance data and economic return estimates from pastures stocked at 2.1 hd/ac and receiving either 0, 0.4%, or 0.8% BW corn supplement, there is an abrupt, negative return with both increased price of supplement and with increased level of supplement (Table 15). Thus, assessing management strategies using these accelerating input costs, one can more easily contend with increased cost of N rather than increased costs associated with supplementation. Budget templates for use with estimating cost-returns for cow-calf or stockers may be found on the web site of Extension Economist, Dr. Greg Clary, at http://ruralbusiness.tamu.edu/.

Table 12. Performance, costs, and returns from stocker steers and heifers grazing rye + ryegrass at three levels of supplement and stocked at 2.1 hd per acre.[4]

SR (hd/ac)	**2.1**	**2.1**	**2.1**
SUP (% BW)	**0**	**0.4**	**0.8**
Days on Pasture	148	148	148
Avg. Initial Wt (lbs/hd)	565	587	582
Avg. Final Wt (lbs/hd)	893	1009	1042
ADG	2.21	2.85	3.11
Daily SUP (lb/hd/da)	0	2.8	5.9
Daily Hay (lb/hd/da)	4	3	3
Revenue per Hd ($)	829	912	944
Revenue per Acre ($)	1740	1914	2078
Value of Gain ($/lb)	0.67	0.67	0.69
Costs/Hd[1]	741	807	860
Costs/Ac	1557	1694	1892
Cost/lb Gain	**0.41**	**0.42**	**0.51**
Return/Hd[2]	87	105	85
Return/Ac[2]	**183**	**220**	**186**
Break-even ADG (lb/da)	1.6	2.1	2.48
Break-even Wt (lb/hd)	800	890	949
Break-even Price ($/lb)	**0.83**	**0.80**	**0.83**

[1] N @ $.71/lb N; SUP (corn @ $240/ton ($6.70/bu); Hay valued at $80/ton.
[2] Returns to off set cash expenses and intent. Not included are land, labor, and planting costs.
[3] Purchase price of $1.10/lb for steers and $1.05/lb for heifers with $0.15 negative margin sides for each.
[4] Rouquette et al. Research Center Tech. Report 2006-1.

Table 13. Returns per acre for stockers on rye-ryegrass pasture with varying margins of purchase prices vs sale prices.

Sale Price ($/lb)	Purchase Price ($/lb) 0.80	0.85	0.90	0.95	1.00	1.05	1.10
	Returns/ac ($/ac)						
0.60	-90	-151	-213	-275	-336	-398	-460
0.65	4	-57	-119	-181	-242	-304	-366
0.70	98	37	-25	-87	-149	-210	-272
0.75	192	130	69	7	-55	-116	-178
0.80	286	224	163	101	39	-23	-84
0.85	380	318	256	195	133	71	10
0.90	474	412	350	289	227	165	103
0.95	568	506	444	382	321	259	197
1.00	661	600	538	476	415	353	291

[1] Animal weights for non-supplemental stockers at 2.1 hd/ac, budget, and expense items included in Table 12.

Table 14. Projected returns per acre for steers and heifers stocked on rye + ryegrass pasture at two stocking rates with variable ammonium nitrate costs.

Ammonium Nitrate Costs		Stocking Rate[1] 1.5 hd/ac	2.1 hd/ac
Cost/ton	Cost/lb N	Returns/ac ($/ac)	
480	0.71	192	183
510	0.75	183	174
544	0.80	173	165
612	0.90	159	151
680	1.00	145	137

[1] Stocking rates and ADG from Table 10 and expense items from Table 12 format.

Stocker Calves and Bermudagrass Stockers grazing on bermudagrass pastures have wide arrays of average daily gain (ADG) responses based on breedtype, weight, age, sex, condition, and stocking rate. Thus, reported stocker ADG on summer-long stocking may range from less than 0.5 lb/da to more than 2 lbs/da. Grazing data from Texas AgriLife Research-Overton and other locations in Texas and the southeastern US have shown stocker gains of about 1 lb/da on Coastal bermudagrass. And, more recently, stocker gains on Tifton 85 bermudagrass have been about 1.5 lbs/da without supplementation. Table 16 provides a spreadsheet scenario for stocking rate x ADG and was intended to most closely relate to performance from bermudagrass pastures. Stocker-grazing experimentation at Overton has shown average stocking rates on Coastal bermudagrass at about 3 to 3.5 550-lb calves per acre, and about 3.5 to 4.5 550-lb calves per acre for Tifton 85 bermudagrass. Thus, using the previous database for estimate purposes, one may expect about 400 lbs/ac gain from Coastal bermudagrass and about 725 lbs/ac from Tifton 85 bermudagrass. Using those stocking rate x ADG scenarios and fertilizer costs of $130/ac per year, fertilizer costs per pound of gain may be estimated. Thus, from Table 17 fertilizer costs per lb gain may range from less than $0.20/lb gain for Tifton 85 to nearly $0.35/lb gain for Coastal bermudagrass. Both of these examples provide support for consideration of some form of stocker operation on bermudagrass. These examples have used only 150 lbs/ac N and 50 lbs/ac K_2O; however, additional forage may be possible with higher rates of N fertilizer. However, once the decision is made to harvest hay rather than exclusive grazing, then alternative fertility strategies involving P, K, and lime may be appropriate.

Table 15. Projected returns per acre for steers and heifers stocked on rye + ryegrass at 2.1 hd per acre and receiving three levels of daily supplement corn ration.

Supplement Cost		**Daily Supplement (lb/hd/da)[1]**		
Cost/ton ($)	**Cost/lb ($)**	**0**	**2.8**	**5.9**
		Returns/ac ($/ac)[2]		
240	0.12	183	220	186
300	0.15	183	193	126
360	0.18	183	166	65
400	0.20	183	148	25
460	0.23	183	121	-36
500	0.25	183	102	-
600	0.30	183	57	-
700	0.36	183	3	-

[1] Stocking rate and ADG from Table 11 for the 2.1 hd/ac performance.
[2] Budget and expense items taken from Table 12.

Table 16. Gain per acre assuming various stocking rates and ADG on bermudagrass.

Stocking Rate[1]	**ADG (lb/da)**				
	0.75	**1.0**	**1.25**	**1.50**	**1.75**
	Gain/acre (lbs/ac)[2]				
1.5	135	180	275	270	315
2.0	180	240	300	360	420
2.5	275	300	375	450	575
3.0	270	360	450	540	630
3.5	315	420	575	630	735
4.0	360	480	600	720	840
4.5	405	540	675	810	945
5.0	450	600	750	900	1050

[1] Stocking rate based on 550-lb = one steer at initiation of grazing.
[2] 120 day grazing (May 15 – Sept 15).

Table 17. Fertilizer cost per pound of gain on bermudagrass pastures.[2]

Stocking Rate[1]	**ADG (lbs/da)**				
	0.75	**1.00**	**1.25**	**1.50**	**1.75**
	Fertilizer Cost/lb Gain ($/lb)				
1.5	0.97	0.72	0.58	0.48	0.41
2.0	0.72	0.54	0.43	0.36	0.31
2.5	0.58	0.43	0.35	0.29	0.25
3.0	0.48	0.36	0.29	0.24	0.21
3.5	0.41	0.31	0.25	0.21	0.18
4.0	0.36	0.27	0.22	0.18	0.15
4.5	0.32	0.24	0.19	0.16	0.14
5.0	0.29	0.22	0.17	0.14	0.12

[1] Stocking rate based on 550-lb = one steer at initiation of grazing.
[2] Fertilization of 150 lbs/ac N applied at 50 lbs N/ac 3each time with N cost at $0.70/lb N; K_2O applied at 0-0-50 in single application cost of $0.50/lb K_2O. Total estimated fertilization cost of $130/ac per year.

Stocking Strategies and Nutrient Cycling

Stocking strategies and nutrient cycling have inseparable relationships, and in the course of stable or diminishing cattle prices and unstable and increasing costs of fertilizer, fuel, and feed grains, there is an increased dependency on recycled nutrients for forage production. Management strategies are personal and “zip code specific.” Using the long-term; fertility regimen x stocking rate, nutrient cycling database from Texas AgriLife Research-Overton as a model for management strategies, the following alternatives should be scrutinized for specific site economic benefits:

1. Pastures at Overton had a 15-year history of N-P-K applications, and once compromises were implemented, soil P was deemed to be at moderate to high levels. The soil nutrient “base” determines the fate of reduced fertilization of pastures. A soil test analysis provides this information.
2. By eliminating all N fertilizer, but continuing with annual applications of K_2O plus overseeding bermudagrass with an adapted clover, pastures continue to be stocked from about March 1 through September. And, at low stocking rates of 1.5 to 2.0 acres per cow-calf pair, forage will likely be sufficiently abundant to minimize risks due to climatic conditions. However, at high stocking rates, bahiagrass and various bermudagrass ecotypes are likely to invade the pastures. Perhaps more importantly is that the absence of N fertilization on bermudagrass pastures allows for increased opportunities for weed invasion, which in turn, requires herbicide applications or mowing.
3. When applying only N fertilizer and eliminating P_2O_5 and K_2O, overseeded ryegrass on bermudagrass has provided a more reliable winter-spring forage supply to initiate grazing by mid- to late- February. Ryegrass is more tolerant of dry conditions and frequent

defoliation compared to clovers. With the N + ryegrass strategy, nutrient cycling is active and suggested N fertilization may include one to two applications of 50 lbs/ac N for ryegrass period and one to two applications of 50 lbs/ac N for the bermudagrass growing phase.

4. Small grain + ryegrass overseeded on pastures with N fertilization of 150 lbs/ac N continues to be a viable option for winter-spring grazing as well as an excellent source of recycled nutrients. Due to the input costs for forage production, grazing may be limited to stocker cattle, including replacement heifers, and/or restricted-access grazing by cows and calves. This restricted grazing may consist of 2 to 3 hours grazing per day with one acre allocated to 2 to 3 pair to supply protein requirements but reduce costs per animal. During the other 20 to 22 hours, cows and calves are relegated to standing forage and/or hay.

As forage-cattlemen move into the next paradigm of input costs, the "secrets for success" are closely tied to "using forages that produce and animals that perform." This mandates that every aspect for the forage-cattle operation must be critically evaluated. For many operators who choose to eliminate most if not all fertilizers, the long-term experimentation at Texas AgriLife Research-Overton suggests nutrient cycling is a valuable asset for forage production. And, some species composition changes will occur once N fertilizer is removed for prolonged durations. Some of the checklist management strategies that may be implemented to counter increased fertilizer, fuel, and feed prices include the following:

1. Create a pasture management plan of action that is firm but flexible.
2. Implement a fertilization strategy via soils test and reason(s) of need.
3. In many situations, the most cost-effective fertilizer strategy is to apply one or two applications of only Nitrogen at 50 to 60 lbs N/ac per application.
4. Add legumes to the pasture system.
5. Use broiler litter as a nutrient source.
6. Increase efficiency of forage utilization.
7. Make hay from pastures and at any time practical, and eliminate exclusive hay meadows.
8. Purchase hay based on nutrient analyses and weight of package.
9. Make strategic, timely herbicide applications.
10. Maintain accurate, up-to-date cattle records for culling options.
11. Reduce stocking rate.
12. Enhance weaning percent, weaning weight and/or eight at time of sales.
13. Alter weaning schedule; retain ownership options.

14. Critically assess supplementation strategies, product cost, and supplement:extra gain conversion.
15. Market cattle proactively.

The “rules” for management have changed with increasing fertilizer and fuel costs for operating pastures-livestock systems. Although the “game” does not “look like” the more familiar one of a few years ago, the “game plan” remains the same. And, that is, to set production targets, manage to manipulate forage utilization systems to enhance economic returns, and sustain the soil – plant resources.

FORAGE SYSTEMS TO REDUCE THE WINTER FEEDING PERIOD

Gerald W. Evers

Livestock require some form of feed every day. Growing or stored forages (grasses, legumes, forbs, and browse) are used to support livestock throughout the year. Ruminants (four stomach animals) such as cattle, sheep, and goats can utilize lower quality or more fibrous forages than single stomach animals such as pigs. Forage systems are year round programs to provide sufficient nutrients to meet as much of the animal's requirements as possible to produce meat, milk, or fiber. Discussion of forage systems will be limited to beef cattle since that is the focus of this program.

Managing a pasture for grazing livestock is more difficult than growing a grain or fiber crop like corn or cotton. When growing a grain or fiber crop, the producer is concerned with the welfare of only one organism, the plant. In a grazing situation, the producer is concerned with two organisms, the plant and the animal, and therefore must understand the growth and development of both. Both must be managed to provide efficient and economic animal performance. There are times during the year that the producer must emphasize the plant and other times the animal. This plant-animal interface is a dynamic (always changing) system. The nutritive level in forage will vary with the class of forages, plant maturity, and season. The amount of forage varies with management level, season, and unpredictable climatic conditions. To further complicate matters, the nutritive requirements of livestock vary with age and physiological stage (young growing animal, cow nursing a calf, dry cow).

Forage Distribution

Unfortunately, production of warm-season and cool-season forages is not uniform during the growing season in a normal year, much less in an abnormal year. About half of the annual yield of warm-season perennial grasses, such as bermudagrass, normally occurs in a two month period from early May through early July. Growth is poor from mid-July through mid-September because of high temperatures and usually lower rainfall. Cool-season annual grasses such as ryegrass, rye, wheat, and oats produce some forage in late fall, very little from late December through mid-February, and a large production peak in spring. From 75 to 90% of annual clover production, depending on species, occurs in March, April, and May. Part of the problem with grazing pastures is not total annual forage yield but uneven forage distribution during the year. Excess forage production from warm-season perennial grasses in May through early July can be harvested as hay. Because of poor hay drying conditions in March and April, the peak forage production of cool-season annual pastures is best utilized by adding extra animals or harvesting part of the excess forage as silage or haylage.

Although lower in nutritive value than other forage classes (Figure 1), warm-season perennial grasses are the predominant forages grown in the southern US. They are well adapted to the mild winter and hot summer temperatures and will survive summer droughts. The grazing season is usually from sometime in April until first frost. The challenge to the forage producer is to maintain the highest nutritive value possible by keeping these grasses in a young growing stage with a high percentage of leaf. A fertilization program based on an annual soil test is the most efficient and economical way to maintain vigorous grass growth.

Cool-season forages are higher quality than warm-season forages and can meet the nutrition requirements of all classes of livestock (Figure 1). Over a million acres of annual ryegrass are grown in Texas each year because it is easy to establish, tolerates close grazing, and is adapted to a wide range of soil types. However, it is less productive during the fall and winter than rye, wheat, barley, or oat. If grown in an annual rainfall of less than 30 inches, irrigation will be necessary to obtain good annual ryegrass yields. The other cool-season annual grasses (rye, wheat, barley, or oat) should not be grazed shorter than 3 inches to maintain forage growth. Cool-season winter pastures are best utilized for growing animals with high nutrient needs such as stocker calves and replacement heifers.

Nutritive Value of Plants

The nutritive value of forages is based on the level of energy, protein, etc. and its availability to the digestive system of the animal. Based on digestibility, forages can be divided into the following five categories: 1) warm-season perennial grasses; 2) warm-season annual grasses; 3) cool-season perennial grasses; 4) cool-season annual grasses; and 5) cool- and warm-season legumes (Figure 1). As percent digestible dry matter increases, animal performance in terms of weight gain, milk production, weaning weight, and conception rate increases. In general, cool-season grasses are higher than warm-season grasses, annuals are higher than perennials, and legumes are higher than grasses.

Within each forage class, plant maturity is the major influence on nutritive value. Nutritive value is highest in new growth and decreases with plant age. One reason is that leaves are more digestible than stems and the percent leaves in the available forage decreases as plants mature and become stemmier. The second reason is that the digestibility of both leaves and stems decreases with maturity. Cell contents are 98% digestible and include carbohydrates, protein, triglycerides, and glycolipids. Cell walls are mainly composed of cellulose, hemicellulose, and lignin but are only from 45 to 75% digestible. About 70% of young plant cells are the highly digestible cell contents and 30% partially digestible cell wall. As the plant matures, the cell wall thickens with age by adding more fiber and lignin, to where the cell wall accounts for 80% of the cell and therefore is less digestible.

As forage plants mature, yield increases but protein and digestibility (nutritive value) decrease (Figure 3a, 3b). A compromise between yield and nutritive value is to cut bermudagrass between 3 to 4 weeks for horses and dairy cattle and from 5 to 6 weeks for beef cattle. There is also a seasonal influence on digestibility of warm-season perennial grasses. Nutritive value is the highest in the spring and then decreases as temperature increases, reaching a low point in late July and August (Figure 4). Digestibility improves with cooler autumn temperatures.

The challenge to the livestock producer is to maintain the pasture sward in a young growth stage that contains a high percentage of leaves, but has sufficient leaf area to intercept a high percentage of sunlight. A sward height of 5 to 8 inches is appropriate for most sod-type grasses such as bermudagrass, bahiagrass, and dallisgrass. The producer must have an understanding of the animal requirements and nutritive value of forages to manage pastures properly.

Animal Requirements

The general types of beef operations include cow-calf, raising replacement heifers, and stockering/backgrounding operations. One, two or all three of these operations may occur on pasture on the same farm or ranch. The segment of the beef cattle enterprise with the largest amount of variation in nutritional needs required during the year is cow-calf production. During the 12 month cycle of production, a beef cow goes from low nutritional demands when not producing milk, to high nutritional demands after calving, and to several stages of moderate nutritional requirements (Figure 5).

Energy (TDN-Total Digestible Nutrients) and protein priorities of a cow after calving are: cow survival, maintenance and producing milk for the calf, and rebreeding. Knowing these priorities, our management should be to make high quality forages available to cows early in lactation if we are to maximize milk production and rebreeding. Approximately 2 months after calving, a cow will reach her peak lactation, or maximum level of milk production. Non-lactating, mature beef cows require low levels of nutrition to maintain body condition. Excess energy is converted to fat which can be used later when nutritive value of the forage diet is less than the cow requires. Fall-calving cows will have calves weaned in May-June, allowing the cows most of the summer to regain the body condition lost during lactation. Optimum weaning time for late winter and spring born calves is no later than September to allow the cows to regain some body weight before winter.

Stocker programs place weaned calves on pasture to gain an additional 200 to 300 pounds before going to the feedlot. The smaller the calf, the higher the nutrient value of the diet must be. Only cool-season pastures of small grains, ryegrass, and clover have sufficient nutritive value for 350 to 500 lb calves to produce average daily gains of up to 2 to 3 lb/day for a 5 to 6 month grazing season. Tifton 85 bermudagrass can produce average daily gains of about 1.5 lb on fall born calves during the summer.

Over 90% of the nitrogen, phosphorus, potash, and most other nutrients that are in the forage consumed by livestock passes through the animal and enters to the soil in the urine and feces. This recycling of nutrients from the forage, through the animal, and to the soil where they can be taken up by the plant roots to enhance forage growth must be maximized to reduce fertilizer needs. Livestock must be grazing on pasture as much of the year as possible.

Legumes, like clovers, vetch, and alfalfa, have the ability to use nitrogen from the air if the legume plant roots are infected by the appropriate *Rhizobium* bacteria. This “free nitrogen” comes at a cost of adding lime and other nutrients to grow the legume. However, if the legumes are only grazed so that the nutrients are recycled, maintenance fertilization after the establishment year should be low.

Matching Animal Requirements To Forage Production and Nutritive Value

The nutrient requirements of several physiological stages of beef cattle are shown across ranges of dry matter digestibility of forage classes in Figure 2. We will begin with a cow-calf operation using only warm-season perennial grasses. It can be bermudagrass, bahiagrass, or some other warm-season perennial grass. Peak forage production normally occurs in May and June with the best nutritive value in spring (Figure 6). Because the beef cow's highest nutrient needs occur after calving when she is at maximum lactation and needing to rebreed, preferred calving time is February-March (about 2 months before peak nutritive value). Weaning calves in early fall will allow the cow to gain some weight before first frost and match her period of low nutritional needs with the winter feeding period.

A minimum of two pastures is required with the designated hay pasture being from 25% to 50% of the total pasture acreage. In March-April, cows and their calves have access to both pastures. About May 1, the hay meadow should be fertilized according to soil test and all the cows placed on the other pasture. From late April to early July, one to two hay cuttings are taken from the hay meadow with normal rainfall. It is important to harvest hay by early July when the nutritive value of the grass is still high (Figure 4). Another advantage is that a pound of nitrogen applied in late April will produce more pounds of forage than if applied during the summer when temperatures are higher and rainfall is lower. Cows and calves can graze both pastures after the last hay harvest until mid-September when forage growth rate is low. About mid-September the calves could be weaned and the hay meadow fertilized with 60 to 70 lb nitrogen per acre to produce a fall hay cutting that is to be stockpiled and grazed in late fall when hay feeding is normally initiated. Sufficient hay should have been made from the one to two hay cuttings to carry the dry cows through the winter. A general guideline for northeast Texas is to have 3 large round bales (5 x 6 ft) per cow. The main disadvantage of this system is that calves are weaned and sold in early fall when calf prices are usually at their lowest. However, the cost per pound of calf gain should be low because cow wintering costs are low since she is not nursing a calf during most of the winter feeding period.

A more advanced forage system is where part of the warm-season perennial grass acreage is overseeded with annual ryegrass-clover mixture (Figure 7). This system requires a minimum of three pastures. A hay meadow (about 40% of open pasture), a pasture to be overseeded with ryegrass-clover (about 40% of open pasture), and a third pasture used for feeding hay, and calving (about 20% of open pasture). The hay meadow should never be overseeded with annual ryegrass since ryegrass grows through May and delays growth of the warm-season perennial grass. This results in the loss of the early hay cutting when warm-season grass growth and nutritive value are the highest. With about 40% of the pasture land used as a hay meadow, one hay cutting about June 1 with a yield of 2½ large round bales per acre should be sufficient. If drought eliminates or reduces the first hay cutting, a second hay cutting can be taken in early July.

Ryegrass-clover grazing can usually begin sometime in February in East Texas. Cool-season forages have higher nutritive value than warm-season forages so the most digestible forage for the year in this system occurs from February through April. Cows should calve in December–January so their peak nutrient needs (after calving) match that of the ryegrass-clover growing period in March and April. These calves can be weaned in July or August before calf prices reach their normal low and allow the dry cow a longer grazing period before the first frost to gain weight and improve body condition score. An additional benefit of this system is a shorter winter feeding period which reduces the amount of hay needed. Calving in winter during harsh weather may increase calf death losses. Another disadvantage of this system is the dependence on fall rainfall to grow a standing hay crop and establish the ryegrass-clover.

Cows calve during the winter on the calving pasture. When ryegrass-clover reaches a height of about 6 to 8 inches, cows with calves can be moved from the calving pasture to the ryegrass-clover pasture. If winter pasture is limited, cow-calf pairs can limit graze the ryegrass and clover 2 hr/day or 4 hr every other day. Cows should be able to graze the ryegrass-clover full time beginning in mid-March during the peak ryegrass-clover growing period. When the ryegrass-clover matures in May, it may take some time for the warm-season perennial grass to come back, especially if rainfall is limited in April and May and the stocking rate is reduced for good seed production for volunteer reseeding of the ryegrass and clover. Cows can be moved back to the calving pasture which accumulated grass while the cows were on ryegrass-clover pasture. Following the last hay harvest, cattle can also have access to the hay meadow.

The success of this system is dependent on fall rainfall to grow a fall standing hay crop and get ryegrass and clover established. It is important to have a hay barn of some type to store excess hay in case of dry falls. If kept dry, hay will last over 8 to 10 years. Having hay stored under roof will reduce the risk of a dry fall on this pasture system. Rotational grazing can still be practiced by subdividing the hay meadow and ryegrass-clover pastures.

Summary

Two pasture systems have been presented as models for your beef cattle operation. No two beef cattle operations are exactly alike. They vary in soil, climate, size, producer goals, and amount of time available to manage the operation. Each producer must develop a pasture system that best fits their situation. Important factors in developing a good forage system are desire, knowledge of livestock nutrients requirements and forage management, and patience.

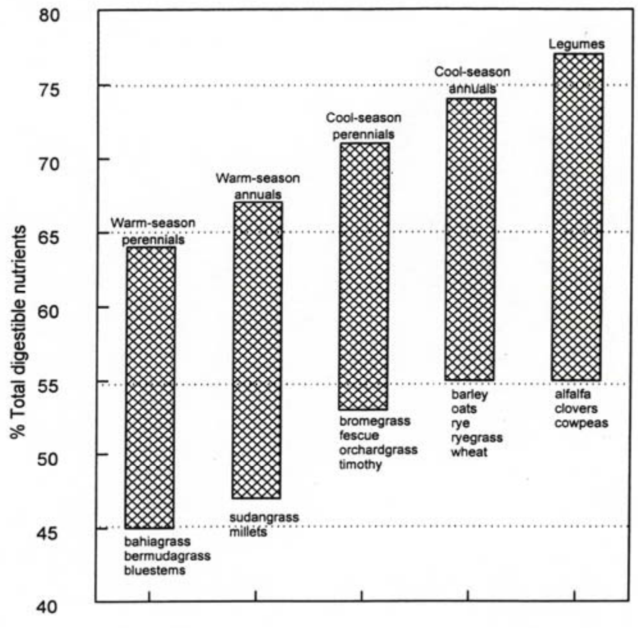


Figure 1. Digestibility percent ranges for several forage classes (H. Lippke and M. E. Riewe, Angleton, Texas).

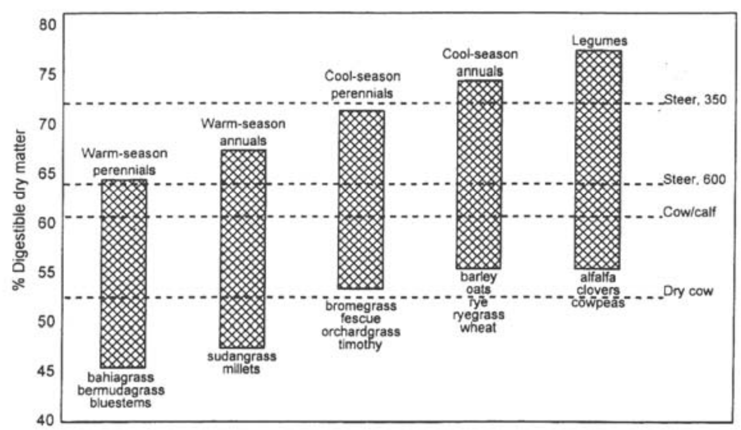


Figure 2. Digestibility percent ranges for several forage groups and requirements of different classes of livestock (H. Lippke, M. E. Riewe, Angleton, Texas).

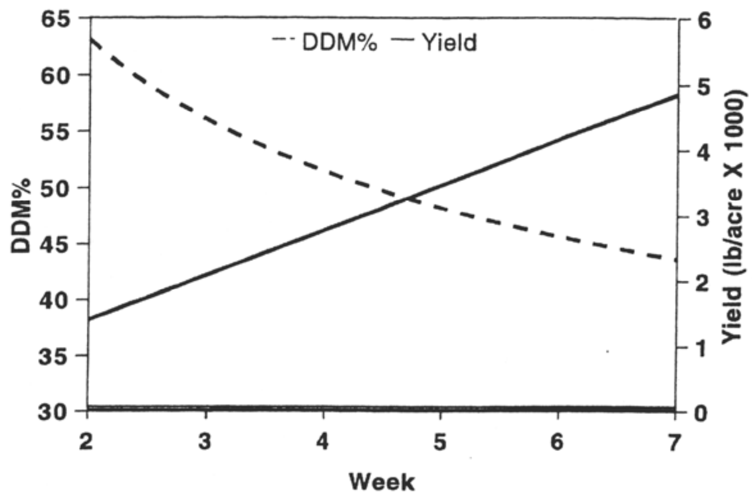


Figure 3A. Effect of maturity on dry matter digestibility and yield of bermudagrass (W. G. Monson, Tifton, GA).

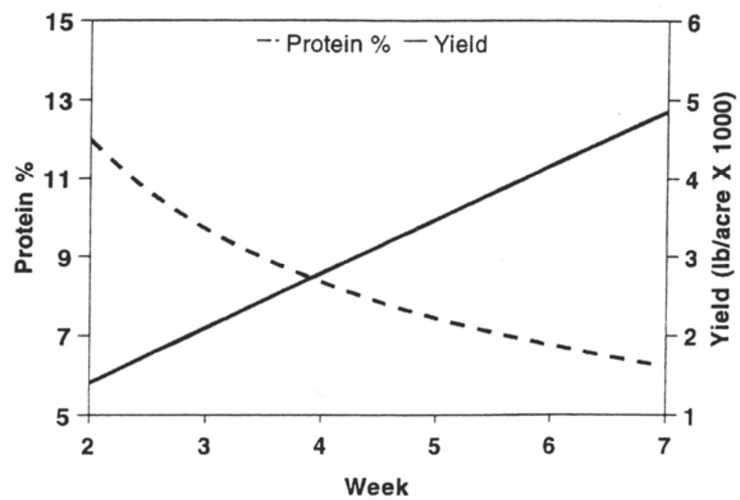


Figure 3B. Effect of maturity on protein percentage and yield of bermudagrass (W. G. Monson, Tifton, GA).

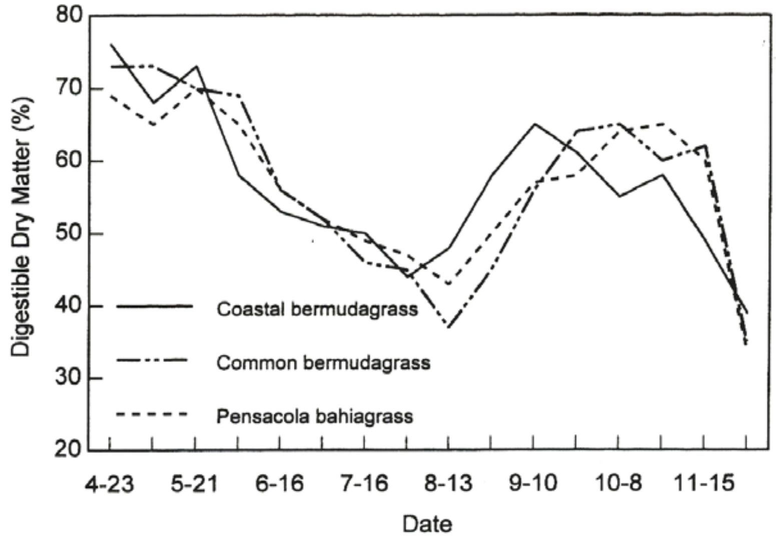


Figure 4. Influence of season on digestibility of continuously grazed sod grass at Overton, Texas, sampled at 2-week intervals (Duble, 1970).

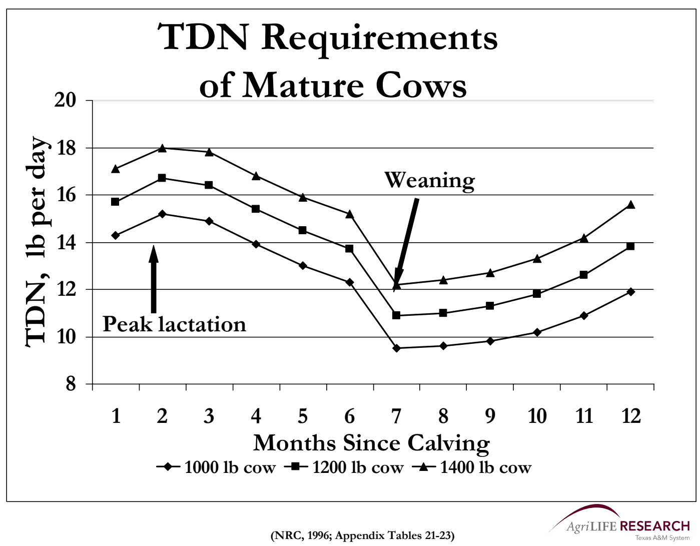


Figure 5. Total Digestible Nutrients (TDN) of three cow sizes for the year.

Utilizing Warm-Season Perennial Grasses (bermudagrass, bahiagrass, etc.)

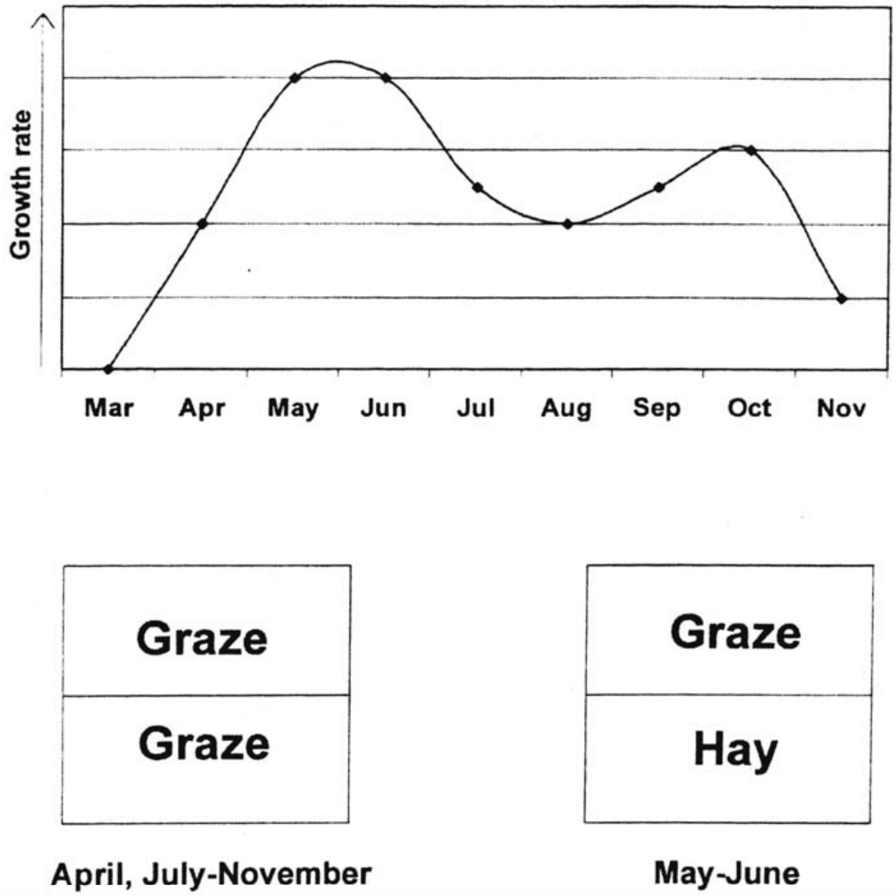


Figure 6. Utilizing a warm-season perennial grass (bermudagrass, bahiagrass, etc.) with a two-pasture system.

Overseeding Warm-Season Perennial Grasses with Annual Ryegrass and Clover Utilization by Winter Calving Cows (2-3 acre/cow)

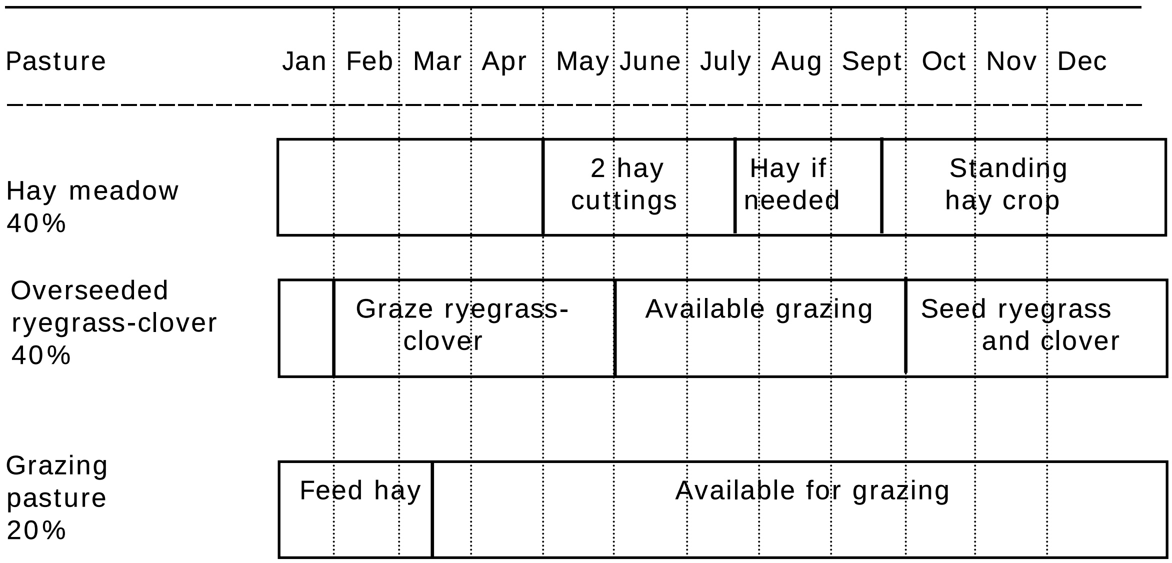


Figure 7. A three pasture forage system consisting of a hay meadow, pasture for overseeding with ryegrass and clover, and a winter feeding – calving pasture.

REDUCING SUPPLEMENTATION COSTS FOR BEEF CATTLE IN TODAY'S INDUSTRY

Jason Banta

Cost effective supplementation has always been an important factor in determining the economic bottom line of cow/calf and stocker producers. In today's industry of increasing feed, fertilizer, and other input costs it is increasingly important that producers develop cost effective supplementation programs. Supplementation programs should be evaluated based on 1) the type of supplementation needed (i.e. protein supplementation, energy supplementation, both protein and energy supplementation, etc.), 2) the cost per unit of protein, energy, or some other nutrient, 3) feeding frequency, 4) delivery and storage cost and requirements, 5) digestive implications, 6) intake variation, and 7) safety, just to name a few. The goal of this paper will not be to provide a comprehensive discussion on supplementation programs, but rather to highlight a few ways to reduce the cost of supplementation programs in today's industry of rapidly increasingly input costs. For more detailed reviews on supplementation several excellent Extension publications are available including:

Supplementation Strategies for Beef Cattle
http://beef.tamu.edu/academics/beef/pub/nutrition/b6067-supplementationstrategies.pdf

Beef Cow Nutrition Guide
http://www.oznet.ksu.edu/library/lvstk2/c735.pdf

One of the first steps in developing a supplementation program is to determine whether or not supplementation is needed. If cattle are grazing pasture or consuming hay that exceeds the level of nutrients needed for the desired level of performance then supplementation is not warranted from a performance standpoint. In this situation some producers choose to occasionally provide some supplement not to improve performance, but to facilitate cattle management and handling.

If it is determined that supplementation is required because available pasture or hay is lacking in nutritive value to support the desired level of performance, then the decision has to be made on which type of supplementation is most appropriate for the given situation. If a diet is low in protein, then a small amount of a high protein supplement such as cottonseed meal, soybean meal, or 40% crude protein cubes would be logical choices. If a diet is low in energy, then a supplement with a higher concentration of energy and a lower concentration of protein such as corn, soybean hulls, corn gluten feed, or 20% crude protein cubes would be logical choices.

After determining which type of supplement is most appropriate for the given situation, then supplements should be priced based on their cost per unit of protein, energy or other needed nutrient. This is accomplished by multiplying the nutrient concentration of the feedstuff by the quantity of feed purchased. For example, there are 20 lbs of crude protein in a 50 lb sack of 40% crude protein cubes (50 lbs x 40% = 20 lbs of crude protein). Once the pounds of protein per sack are determined then the price per pound of protein can be calculated by dividing the purchase price by the pounds of protein. If the 40% crude protein cubes cost $9.50/sack then each pound of protein would cost $0.475 ($9.50 ÷ 20 lbs of crude protein = $0.475 per pound of protein); where as the price per pound of protein for 20% crude protein cubes that cost $8.00 per sack would be $0.80 per pound of protein. This same calculation can be done when pricing energy supplements or any other nutrient. Total digestible nutrients or TDN is an energy measurement commonly used when comparing feeds per unit of energy. The example below shows how to calculate the price per pound of TDN for corn with a price of $200 per ton and a TDN concentration of 88%.

determine energy content per ton:
2000 lb x 88% TDN = 1760 lb of TDN per ton

determine price per pound of TDN:
$200 per ton ÷ 1760 lb of TDN = $0.114 per lb of TDN

Another factor to consider when choosing supplements is the frequency at which the supplement needs to be fed. Energy supplements typically need to be fed everyday. In contrast high protein supplements, such as cottonseed meal or 40% crude protein cubes can generally be fed everyday, every other day, or even twice a week. When protein supplementation is needed, feeding high protein supplements like the two mentioned above twice a week instead of daily can reduce labor and fuel costs, thus lowering the overall cost of the supplementation program.

Some producers choose to purchase “convenience” supplements which are available to the cattle at all times during the supplementation period and will last for several days or even several weeks. Examples of convenience feeds include blocks, tubs, liquid feeds, and mixed feeds with added limiters. When comparing these feeds to each other and traditional hand fed supplements it is important to calculate the cost per pound of utilizable protein or energy. Because of their potential convenience, blocks, tubs, liquid feeds, and mixed feeds with added limiters are generally more expensive per pound of protein or energy than hand fed supplements. On some occasions when a producer has several operations separated by long distances, the potential fuel savings provided by having to offer these supplements less frequently than traditional hand fed supplements may provide some economic benefit.

Producers may also be able to reduce supplement costs by adjusting the time of year when supplements are purchased. As a general rule, feed prices are lowest during the summer and increase through the fall and winter. Purchasing or contracting feed during the summer or early fall will typically reduce supplement costs. It should be noted that long term storage of many feeds can be difficult during the summer. Additionally, because of the rapid increase in feed costs many companies have reduced the length of time of contracts. Purchasing feed in bulk can also reduce cost compared with purchasing sacked feed. Producers who are unable to purchase in bulk may be able to enjoy cost savings by contracting with their feed dealer during late summer of early fall. Some feed dealers allow producers to contract smaller quantities of sacked feed and then pick that feed up as it is needed throughout the winter.

As the cost of traditional feed ingredients increase many cattlemen are considering the purchase of non-traditional feed ingredients. While these feeds may offer some cost savings they typically come with additional problems. Storage and handling are potential problems with some of these ingredients. Additionally, some of these non-traditional products pose a high risk of creating acidosis or digestive upsets; others contain high levels of minerals or other compounds that can reduce performance, become toxic, and even cause death. If considering non-traditional feeds, check with a nutritionist to determine if and how these ingredients can be used in your operation.

Conclusion

In conclusion, to reduce/control supplement costs only supplement when nutrients are lacking in the diet for the desired level of performance. Make sure to match the nutrient requirements of your cattle to your given resources by establishing a calving season to coincide with periods of high levels of quality forage production as well as matching hay resources to cattle requirements. Additionally, always make sure to compare feeds based on their cost per pound of nutrient. While we are likely to be faced with relatively high feed costs in the foreseeable future, we can take steps to minimize the cost of our supplementation programs.

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