ROUNDUP 1995

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Marc A. Johnson, Director

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KAES Report of Progress 731

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Statement of Purpose

Roundup is the major beef cattle educational event sponsored by the Agricultural Research Center–Hays. The 1995 program is the 82nd staging of Roundup. The purpose is to communicate timely research information to producers and extension personnel.

The research program of the Agricultural Research Center–Hays is dedicated to serving the people of Kansas by developing new knowledge and technology to stabilize and sustain long-term production of food and fiber in a manner consistent with conservation of natural resources, protection of the environment, and assurance of food safety. Primary emphasis is on production efficiency through optimization of inputs in order to increase profit margins for producers in the long term.

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Agronomic Performance And Silage Quality Traits of Sorghum Hybrids in 1992 and 1994

Keith K. Bolsen and Mark Young
Professor of Cattle Nutrition and Graduate Research Assistant, Kansas State University

Introduction

Forage sorghum has become an increasingly important silage crop for beef and dairy producers in the High Plains. In Kansas, about 80,000 acres were harvested for silage in 1992, producing nearly 1,300,000 tons with a value of over $21 million. In several earlier studies, we have shown that harvesting forage sorghums at the late-dough stage optimizes silage yield and feeding value (KAES Report of Progress 623, page 65) and that the growing season and hybrid (or variety) have huge effects on the agronomic and quality traits of forage sorghum silages (KAES Report of Progress 568, page 12).

The objective of these two studies was to continue to document the effects of growing season and hybrid on the agronomic performance and silage quality traits of forage sorghums.

Methods

1992. Ten forage sorghum hybrids were selected to represent a range of phenotypic characteristics and season lengths (Table 1). All were grown under dryland conditions near the Kansas State University campus. A grain sorghum hybrid (DeKalb 42Y) was included for comparison. The forage sorghum plots were planted on June 19, and each hybrid was assigned randomly to three replications. The grain sorghum was planted on June 8. The 6-row plots were in a Reading silt loam soil, and this was the first crop after a 5-year stand of alfalfa. No fertilizer was applied. Rows were 30 ft long with a 30-inch spacing, and plots were thinned to uniform stands of 34,800 plants/a.

Hybrids were harvested at the late-dough stage of kernel maturity. The two outside rows in each plot were borders, and whole-plant DM yield was measured by harvesting the 2nd and 3rd rows with a precision chopper. All heads in the 4th and 5th rows were clipped for grain yield determination. A sample of the whole-plant material from each plot was analyzed for DM, crude protein (CP), and acid detergent fiber (ADF).

1994. Nine forage sorghum hybrids and one grain sorghum were grown under dryland conditions near the Kansas State University campus. The forage and grain sorghum plots were planted on May 26, and each hybrid was assigned randomly to three replications. Anhydrous ammonia was applied at 100 lb of N/a, Furadan 15 G was applied in the furrows at planting, and Ramrod-atrazine was applied on the day after planting as a preemergent herbicide. All other methods were identical to those described for the 1992 study.

Results and Discussion

1992. Agronomic performance of the 11 hybrids is presented in Table 1. Days to half bloom for the 10 forage sorghums ranged from 62 to 82. The late planting date and the cool, wet weather in July, August, and September delayed the harvest for all hybrids. Plant heights were relatively tall, and, as expected, two of the late-season forage sorghums (DeKalb FS-25E and

Golden Harvest H-68) were the tallest. The two dual-purpose hybrids (Northrup King 300 and Golden Harvest H-45) were the shortest.

Five of the 10 forage sorghums contained at least 32% whole-plant DM at harvest (late-dough stage). This is important, because hybrids with less than 30% DM are preserved less efficiently as silage and can produce large amounts of effluent during the initial aerobic and fermentation phases.

The two dual-purpose forage sorghums had the highest silage and grain yields; the early-season (Cargill 200F) and male sterile (Golden Harvest H-1) forage sorghums and the grain sorghum had the lowest silage yields. A storm with high winds on October 7 and 8 caused severe lodging in all six mid- and late-season hybrids. Earlier-season hybrids had been harvested already.

The grain sorghum had the highest CP (8.8%) and lowest ADF (28.2%). Among the 10 forage sorghums, CP ranged from 6.3 to 7.5% and ADF, from 30.4 to 38.3%.

1994. Agronomic performance of the 10 hybrids is presented in Table 2. Days to half bloom for the nine forage sorghums ranged from 61 to 88. Plant heights were near normal. The two late-season forage sorghums and DeKalb FS-5 were the tallest, whereas the three dual-purpose hybrids were the shortest among the forage sorghums. Eight of the nine forage sorghums contained at least 32% whole-plant DM. Whole-plant DM yield was highest for two of the dual-purpose forage sorghums (Northrup King 300 and Golden Harvest H-45), whereas the male-sterile and the grain sorghum had the lowest silage yields. Grain yields were excellent for all hybrids and ranged from 97 to 146 bu/a. High winds during the first week in September caused severe lodging in three of the four tall, mid- and late-season hybrids (DeKalb FS-5 and Golden Harvest H-2 and H-68). The earlier hybrids had been harvested already, and two of the dual-purpose hybrids were not affected by the strong winds.

As expected, the grain sorghum had the highest CP (8.5%) and the lowest ADF (30.7%). Among the forage sorghums, CP values ranged from 6.5 to 8.4%, and ADF, from 33.0 to 40.2%.

Conclusions

Rainfall was much above and temperature much below normal during the 1992 growing season. However, both whole-plant DM and grain yields were excellent for all 11 hybrids. The 1994 growing season was characterized by near normal rainfall and temperatures. Again both whole-plant DM and grain yields were excellent for all hybrids.

In both years, the forage sorghum hybrids differed significantly in three important silage quality traits: whole-plant DM, CP, and ADF. However, no significant correlations occurred between these quality traits and days to half bloom, plant height, or grain yields.

Forage sorghums can be grown under a wide range of moisture and temperature conditions, have drought tolerance, and have the ability to recover from drought and still produce satisfactory yields with relatively low inputs. Results from earlier studies have indicated that several forage sorghum hybrids compared favorably to corn and grain sorghum hybrids for both agronomic traits and nutritive value of silage (KAES Reports of Progress 539, pages 167 and 172 and 678, page 16). However, the tremendous genetic and phenotypic diversities of forage sorghum make it essential that producers plant more than one hybrid. Early-season cultivars can have drastically low silage yields, if summer growing conditions are dry, and late-season cultivars can be affected adversely by early frost or wet fall weather. Most importantly, choose silage hybrids that fit both the cropping program and cattle feeding requirements of your operation.

Table 1. Agronomic performance and quality traits of 10 forage sorghum hybrids and a grain sorghum.

				Whole-Plant[3]				
Hybrid[1]	Days to Half Bloom	Plant Height, inches[2]	Harvest Date	DM, %	CP, %	ADF, %	DM Yield, tons/acre	Grain Yield, bu/acre[4]
DeKalb 42Y (grain sorghum)	55	54 (0)	Sept. 24	34.5	8.8	28.2	6.0	108
Cargill 200F	62	108 (2)	Sept. 24	36.9	7.4	37.0	6.9	105
DeKalb FS-5	65	115 (0)	Sept. 28	28.9	7.7	31.9	7.8	96
Pioneer 947	72	110 (0)	Oct. 5	37.5	7.5	31.7	8.1	133
Northrup King 300	76	72 (67)	Oct. 15	32.7	7.2	35.0	8.8	173
DeKalb FS-25E	81	125 (88)	Oct. 20	27.3	6.3	37.5	8.0	98
Golden Harvest								
H-1	---	107 (0)	Sept. 25	26.0	7.2	30.4	6.6	---
H-2	80	111 (82)	Oct. 20	29.9	6.4	38.3	8.7	133
H-45	76	71 (57)	Oct. 15	32.7	7.0	33.2	9.3	140
H-68	82	125 (90)	Oct. 20	32.2	6.3	33.4	8.2	125
EX-1216	68	113 (13)	Sept. 28	26.5	7.1	31.4	7.8	102
Mean[5]	74	106 (40)	Oct. 8	31.1	7.0	34.0	8.0	123
LSD (P<.05)[6]	2.4	6 (34)	---	2.1	3	1.3	2.1	21

[1]EX is experimental. Golden Harvest H-1 is a male sterile, and paper bags were placed over the emerging heads to prevent grain development in the two harvested rows. [2]Percent lodging on the day of harvest is shown in parentheses. [3]Crude protein (CP) and acid detergent fiber (ADF) are expressed on a DM basis. [4]Adjusted to 14.5% moisture. [5]Mean values include only the 10 forage sorghum hybrids. [6]The LSD (least significant difference) is valid only within a column.

Table 2. Agronomic performance and quality traits of nine forage sorghum hybrids and a grain sorghum in 1994.

					Whole-Plant[4]				
Hybrid[1,2]	Days to Half Bloom	Plant Height, inches[3]	Harvest Date	Days from 1/2 Bloom to Harvest	DM, %	CP, %	ADF, %	DM Yield, tons/acre	Grain Yield, bu/acre[5]
DeKalb 42Y (grain sorghum)	62	44 (0)	Aug. 25	32	33.6	8.5	30.7	5.6	119
DeKalb FS-5	66	99(85)	Sept. 6	39	32.3	6.5	32.8	8.1	98
Pioneer 947	68	92 (0)	Sept. 6	38	38.1	7.8	35.6	8.0	146
NK 300	79	89 (0)	Sept. 13	34	35.8	7.6	33.4	8.9	128
Golden Harvest									
H-1	---	91 (0)	Aug. 25	---	26.2	6.9	35.3	5.5	---
H-2	84	97(90)	Sept. 15	31	33.6	6.5	40.1	8.1	116
H-45	79	78 (0)	Sept. 9	30	34.7	7.4	34.2	8.5	114
H-68	88	99(100)	Sept. 15	27	34.3	6.7	35.2	8.3	98
EX-217	81	84 (0)	Sept. 6	25	33.5	7.5	36.5	8.1	97
EX-218	61	77 (0)	Aug. 22	30	32.9	8.4	33.0	6.4	115
Mean[6]	76	89.5(31)	Sept. 2	32	33.5	7.25	35.1	7.75	114
LSD (P<.05)[7]	1.7	13.7(39.2)	---	1.7	5.7	.9	4.1	1.8	14.7

[1]NK is Northrup King and EX is experimental. [2]Golden Harvest H-1 is a male sterile, and paper bags were placed over the emerging heads to prevent grain development in the two harvested rows. [3]Percent lodging on the day of harvest is shown in parentheses. [4]Crude protein (CP) and acid detergent fiber (ADF) are expressed on a DM basis. [5]Adjusted to 14.5% moisture. [6]Mean values include only the nine forage sorghum hybrids. [7]The LSD (least significant difference) is valid only within a column.

Knowing the Quality of Your Forages Is Critical for Feeding Program Efficiency

Dale A. Blasi, Extension Livestock Specialist
John E. Boyer, KSU Statistician
Dennis H. Hogan, Chemist, Peterson Laboratories
Carl H. Garten, Saline County Extension Agent
Jon C. Baker, Cowley County Extension Agent
Marvin D. Reynolds, Pratt County Extension Agent

Introduction

Astute cow/calf and stocker operators recognize that a sound and dependable forage base is necessary for sustaining their operation in today's challenging beef market sector. The results of several recent university studies suggest that producers intent on surviving into the 21st century must emphasize the utilization of grazed forages and crop residues vs. harvested feeds to minimize excessive input costs. Beef production systems that emphasize the use of grazed forages also must have harvested feeds to be prepared for unpredictable environmental conditions in which forage supplies are low or times when animal nutrient requirements are higher than what can be provided by grazing alone.

In order to increase harvested feed use and economic efficiency, producers rely heavily upon results of nutrient analyses conducted by commercial laboratories to properly construct nutrient-balanced backgrounding rations and cow supplementation programs. For this reason, university and commercial laboratory personnel have stressed the importance of submitting a composited forage sample obtained from 10 to 15 large bales that are representative of the forage lot being analyzed. A forage lot consists of forage harvested from one field at the same cutting and maturity within a 48-hour period and usually contains fewer than 100 tons of hay. A forage lot should be similar for: type of forage, field (soil type), cutting date, maturity, variety, weed contamination, type of harvest equipment, weather during growth and harvest, and storage conditions.

Because we do not know if existing sampling recommendations sufficiently account for all of the potential variation in nutrient content that may exist in Kansas forages typically harvested as hay, a study was conducted to determine the extent of nutrient variation present in first- and third-cutting alfalfa, prairie, and sorghum-sudan forages harvested in large round bales. Variations in forage nutrients as affected by environmental conditions in the windrow (rain damage vs. normal) and location (three Kansas counties) after an 8-month outdoor storage period were evaluated. Based on the estimates of nutrient variation, sample sizes were determined to achieve various degrees of precision and confidence intervals.

Methods

Across each of the three counties, large round bales (n=25) from homogeneous lots that represented each forage and harvest condition were core-sampled individually with a 24-inch Forageurs Corp. hay probe in two locations and submitted to an NFTA-accredited commercial laboratory. Dry matter, crude protein, calcium, phosphorus and acid detergent fiber content were determined using traditional wet chemistry and near infrared spectrophotometry (NIRS). All samples were analyzed statistically to derive estimates of nutrient variation as affected by forage type, harvest condition, and laboratory method employed. The maximum standard deviation determined across the three counties for each forage type and harvest condition was used as a collective measure of variability to estimate sample sizes necessary to obtain 80, 95, and 99% confidence intervals at various degrees of precision for both methods of laboratory analyses. Sample size was determined from the expression:

$$N = (2Z \times \text{Std Dev}/W)^2$$

Where:

- N is sample size of large round bales from one forage lot,
- Z is an appropriate normal deviate corresponding to a desired level of confidence, and
- W is the width of the resulting confidence interval.

Results and Discussion

The significant variation for each nutrient that existed across forage type, harvest condition, and county location emphasize the importance of obtaining a representative sample. Based on the precision of the estimates for any of the nutrients tested, wet chemistry had no apparent advantage of over NIRS. Furthermore, no consistent pattern in nutrient content or its variation occurred among rain damaged vs. undamaged forages. Possibly the 8-month exposure to outside storage conditions minimized the compositional differences that might have existed at harvest.

Table 1 recommends the number of bales by forage type that constitute a well-defined forage lot to be subsampled and composited into one sample based on a desired degree of precision and confidence level for crude protein content. The precision estimates were computed as percentage units not as fractions of the mean. For example, a forage lot of third-cutting alfalfa estimated to average 20% crude protein would range from 19 to 21% with 1% precision and 19.5 to 20.5% with .5% precision. Admittedly, the number of bales necessary to subsample is considerably higher than current university and commercial laboratory recommendations. However, the conservative approach undertaken for the statistical analysis should ensure that intended precision and confidence levels are reached.

Users of this table may find that recommended sample sizes exceed, or constitute a large proportion of, the number of bales in the forage lot being sampled. Producers should subsample the recommended number of bales as long as that number is less than 20% of the forage lot. If the recommended amount is greater than 20%, producers are advised to subsample 20% of their forage lot.

The recommended numbers of prairie and sorghum-sudan bales to subsample at a given precision and confidence level are approximately one-half the numbers of bales required for first- and third-cutting alfalfa hay. These results were anticipated, because the ranges in crude protein content of both prairie and sorghum-sudan hays are typically smaller than those observed for alfalfa.

Implications

Improper forage sampling technique affects profitability and productivity from two different perspectives: 1) a false high analysis of crude protein which actually is low, will result in a potential crude protein deficiency and 2) a false low analysis of crude protein, which actually is high, can result in excessive supplementation expenses. Table 2 contains the range and average crude protein content determined from 25 sorghum-sudan bales that were sampled individually at one county location. To demonstrate the potential implications of improper forage sampling, the minimum, maximum, and average crude protein estimates were each used to individually augment the protein requirements for a spring-calving beef cow grazing winter native grass from November through mid-April. If crude protein requirements were still deficient with expected forage intake levels of the weathered native grass and sorghum-sudan hay, a commercial 38% supplement valued at $246/ton was included.

The results of this simulation suggest that feed costs may vary by $40/cow when a sorghum-sudan hay ranging from 6.2 to 11.9 percent in crude protein content is used (Table 2). Stated another way, a cost savings occurs of approximately $7.00 per 1% increase in crude protein content, which emphasizes the importance of striving for production of quality forage. The first step towards efficient feed-cost control is knowing the quality of the harvested hay used. The key to getting that information is submitting a forage sample that is representative of the forage used in the feeding program.

Acknowledgment

Appreciation is extended to Peterson Laboratories, Inc. for graciously providing the NIRS and wet-lab analyses for this study.

Table 1. Recommended number of large round bales to subsample and composite based upon desired degree of precision and confidence interval for crude protein content.

Forage Type	Precision of Average Crude Protein Estimate, %	Confidence Interval 99%	95%	80%
1st Cutting Alfalfa	± 1	19	11	5
	± .5	76	44	19
3rd Cutting Alfalfa	± 1	12	7	3
	± .5	47	27	12
Prairie Hay	± 1	4	2	1
	± .5	15	9	4
Sorghum-Sudan Hay	± 1	7	4	2
	± .5	28	16	7

Table 2. Effect of sorghum-sudan hay protein content on beef cow winter feed costs[a]

	Crude Protein Content[b]		
	Minimum	**Average**	**Maximum**
Nutrient:			
Crude Protein, %	6.2	9.1	11.9
Cow Feed Cost:			
Gestation Period	$51.00	$42.00	$26.00
Lactation Period	$39.00	$33.00	$24.00
Total Cost	$90.00	$75.00	$50.00

[a] Scenario: 1,150-lb. cow, average body score, grazing native range (crude protein content = 3%) from late November through mid-April.

[b] Minimum, average and maximum crude protein content determined from 25 individually sampled sorghum-sudan bales arising from one lot.

Effect of Stocking Rate and Cultivar on Productivity and Chemical Composition of Old World Bluestems in West-Central Kansas

Eric S. Vanzant and Dan Oeding
Range Scientist and Student Intern

Introduction

Old World bluestems have received considerable attention in Oklahoma and Texas as forages for reseeding marginal cropland. Research at experiment stations in these locations has demonstrated the potential of Old World bluestems to support considerably more beef production per acre than native warm-season grasses. However, use in Kansas has been limited by negative publicity (particularly with respect to potential to invade native pastures), questionable tolerance to winterkill, and unknown benefits relative to indigenous species. Preliminary research from the Agricultural Research Center–Hays suggests that some varieties of Old World bluestem are adapted to the area and, as seen at other locations, when managed properly, can provide more beef per acre than the native species of the region. This experiment was designed to determine the productive capacity of Old World bluestems in west-central Kansas and to develop forage quality profiles to aid in the proper nutritional management of cattle grazing Old World bluestems.

Methods

Eight established pastures (approximately 14 acres each) containing one of two cultivars of Old World bluestems were used in this experiment. Both cultivars were developed by the USDA Southern Plains Range Research Station at Woodward, OK. WW-Spar has demonstrated better drought tolerance and easier stand establishment than WW-Ironmaster, whereas WW-Ironmaster has been shown to have greater winter-hardiness, greater leaf:stem ratio, and higher crude protein and digestibility values than WW-Spar, suggesting greater feeding value. In mid-May, all pastures received 35 lb N/a. Each of the two cultivars was grazed at both high (440 lb live weight/a) and low (220 lb live weight/a) stocking rates from May 25 until October 7 using crossbred steers (average initial wt = 755 lb). Each stocking rate/cultivar combination was replicated twice. Steers were weighed at monthly intervals, following an overnight stand without access to feed or water. At the same times, 10 forage samples per pasture were obtained by clipping to ground level all forage contained within a 1 ft x 2 ft frame. The dry weights of these samples were used to estimate standing forage biomass, and samples were pooled within pastures and sampling dates for subsequent determination of crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL).

Results and Discussion

Interactions between sampling date, cultivar, and stocking rate were not significant for chemical constituents in the bluestem samples (Tables 1 and 2). Crude protein and ADL concentrations were slightly greater for WW-Spar than for WW-Ironmaster and were unaffected by stocking rate. Concentrations of ash-free ADF and NDF were unaffected by either cultivar or stocking rate. The lower ADL value for WW-Spar is consistent with other research demonstrating its greater leaf:stem ratio. Although the difference in CP concentrations between the cultivars does not appear to fit this explanation, the average difference between the cultivars (0.7 % CP) was small and would not be expected to have much impact on the overall nutritive value of the forages. Crude protein concentrations were lower than expected, particularly during the early growing season (Table 2) and decreased linearly across the growing season. Because of selective grazing, cattle likely consumed diets that were slightly greater in CP than the clipped samples. The low values for CP were likely results of the dry growing conditions at Hays in 1994. With limited precipitation during the early growing season, applied N was unavailable for uptake by the plants. Concentrations of NDF, ADF, and ADL across the grazing season were in agreement with previously reported values for these constituents. Neutral detergent fiber concentrations remained fairly constant until October 7, when the concentration increased by about 9%. However, acid detergent fiber and lignin concentrations declined steadily from early June through August, followed by an increase for the remainder of the growing season. This decrease likely was associated with above-normal precipitation in July (5.5 in. vs. 3.25 in. normal July precipitation) combined with relatively dry growing conditions in the remainder of the summer. The July precipitation would have allowed for a burst of forage regrowth, thus lowering average concentrations of ADF and ADL. Standing forage increased steadily from June through September and declined in October (Figure 1). The amount of standing forage was similar between the two cultivars at all sampling times and was not affected by stocking rate until August. From August through October, standing forage averaged 59% greater under the low stocking rate than under the high stocking rate.

Individual steer gains were not different between the two cultivars and were greatest with low stocking rates (Figure 2). The 36% greater late-season average daily gain compared with early-season gains was likely an artifact of weighing conditions. Steers were shrunk overnight at each weighing to minimize differences caused by fill. However, cattle had been fed silage-based diets before the beginning of the experiment, which characteristically result in greater levels of ruminal fill than grazed forage. Thus, the initial weight likely represented a larger degree of fill than other weights, resulting in a lowered estimate of gain during the early grazing season. Gain per acre was not affected by cultivar, but was 50% greater with the high, than with the low stocking rate (96 and 64 lb/a, respectively). However, the degree of forage removal was quite extensive in the heavily grazed pastures.

Conclusions

Only small differences in chemical composition were found between WW-Spar and WW-Ironmaster Old World bluestems. Low CP concentrations across the growing season indicated that steer performance would have benefitted from protein supplementation. No differences in amount of standing forage across the grazing season or in gains by grazing steers were found between the two cultivars. Gain per acre was greater for Old World bluestem pastures stocked at a high rate of 440 lb/a than for pastures stocked at 220 lb/a. However, individual steer gains were depressed, and degree of forage removal was substantial under the heavy stocking rates. Future studies will determine the ability of these Old World bluestems to sustain these stocking rates.

Table 1. Influence of cultivar and stocking rate on average chemical composition of Old World bluestems from samples clipped at five times during the growing season.

	Cultivar		Stocking Rate		
Item	WW-Ironmaster	WW-Spar	High	Low	SE[a]
CP	4.3[b]	5.0[c]	4.7	4.6	.14
Ash-Free NDF	68.5	68.4	68.7	68.2	.48
Ash-Free ADF	37.8	37.6	37.6	37.7	.35
ADL	5.1[b]	5.8[c]	5.5	5.4	.07

[a]SE = standard error (n = 10).
[b,c]Means within cultivar columns with different superscripts differ ($P < .05$).

Table 2. Influence of sampling date on average chemical composition of two varieties of Old World bluestems under two stocking rates.

	Sampling Date						
Item	June 1	June 30	Aug 8	Sept 6	Oct 7	SE[a]	Contrasts[b]
CP	6.3	5.7	4.8	3.6	2.8	.17	L
Ash-Free NDF	66.9	66.3	67.4	68.0	73.5	1.02	L,Q
Ash-Free ADF	38.8	37.0	34.9	38.4	39.3	.40	Q
ADL	5.4	5.2	4.6	6.0	6.1	.11	L,Q

[a]SE = standard error (n = 10).
[b]Sampling date effect ($P < .01$): L = linear effect; Q = quadratic effect.

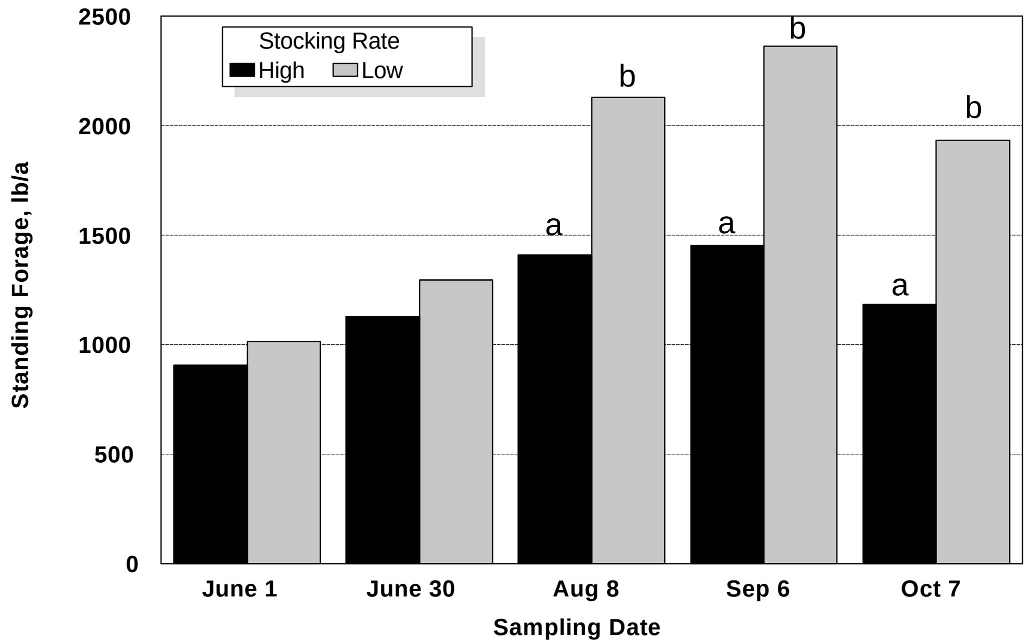

Figure 3. Influence of sampling date and stocking rate on standing forage biomass. Sampling date x stocking rate interaction (P = .05). Quadratic (P = .07) effect of sampling date within high stocking rate. Cubic (P = .04) effect of sampling date within low stocking rate. Values within a sampling date with different letters differ (P < .10).

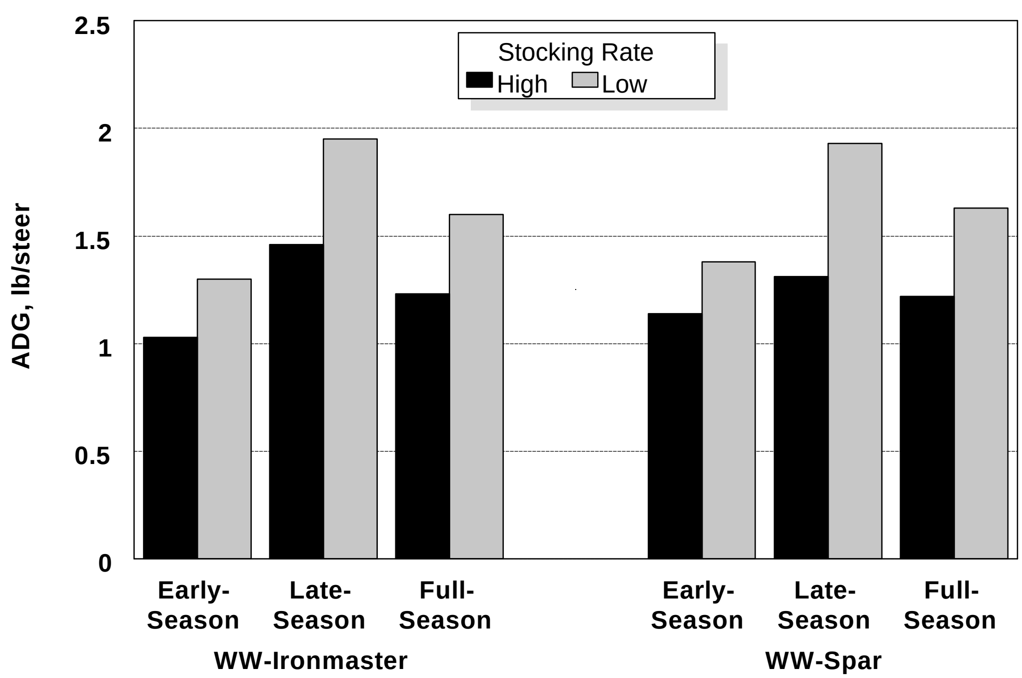

Figure 4. Steer average daily gains during early, late, and full grazing season. Cultivar x stocking rate interaction not significant (P > .10) for any measurement. Stocking rate effect significant (P < .10) for each measurement. Cultivar effect not significant (P > .10) for any measurement.

Influence of Protein and Energy Supplementation on Intake and Utilization of Low-Quality Forage Sorghum Hay by Beef Steers

Eric S. Vanzant and John R. Jaeger
Range Scientist and Former Assistant Scientist

Introduction

Addition of protein supplements to low-quality forage diets typically increases the voluntary intake of forage, thereby increasing energy intake of cattle. Furthermore, providing additional nitrogen in the form of supplemental protein enhances the ability of ruminal microorganisms to degrade the forage, thus releasing energy and other nutrients for use by the host animal. Forage sorghum and other summer annuals conserved as hay are important forage sources for beef cattle producers in central and western Kansas. These forages are typified by large variability in nutrient content and feeding value. Under the wet growing conditions of 1993, crude protein (CP) concentrations and overall nutritive value were particularly low in the forage sorghum crop. This situation was exacerbated further by late harvests because of the wet conditions. Under such conditions, we would expect a favorable response to protein supplementation. However, little research has been done to allow quantitative estimates of the responses to protein and/or energy supplementation by beef cattle consuming forage sorghum hay. This experiment was conducted to determine the intake and forage utilization responses by beef cattle to supplemental protein and energy when consuming low-quality forage sorghum hay.

Methods

Four Angus x Simmental beef steers (avg weight = 635 lb) with permanent ruminal cannulas were used. The experiment was conducted using a 4 x 4 Latin square design, such that each steer received one of four treatments in each of four periods. Treatments were arranged in a 2 x 2 factorial structure (Table 1). Steers were fed individually in metabolism stalls and had free access to water. Each steer received 36 g/d of a salt/mineral mixture. Periods lasted 28 days. Steers were adapted to diets for 14 days, followed by 6 days of voluntary intake measurement. Steers were fitted with fecal collection bags for the next 6 days for total collection of feces. Following this, ruminal fermentation characteristics were measured at 3-h intervals for 12 h, and on the following day, ruminal fill of dry matter (DM) and liquid was determined by manually emptying the ruminal contents. The Canex (Sharp Bros., Healy, KS) forage sorghum hay was fertilized with 45 lb N/a, seeded at a rate of 25 lb/a on June 27, swathed from September 22 - 30, and baled on October 11 - 15, 1993. The large round bales were stored outside with no cover until April, at which time the hay was ground through a tub grinder with a 2.5 in. screen and stored inside a barn. This hay was fed to each steer once daily at 150% of the previous 5-d average intake to ensure opportunity for diet selection. Supplements were fed once daily just before feeding hay. Refused feed was weighed back from feed bunks daily just before feeding and sampled for determination of chemical composition. Samples of feed, supplements, and feces were obtained daily and immediately dried at 122° F in a forced-air oven. To characterize the nutritive value of the hay without supplementation, a second experiment, involving the same four steers and one period, was conducted using the same protocol, except that no supplements besides minerals were fed.

Results and Discussion

The composition of the forage sorghum hay, as well as intake and digestibility measured in nonsupplemented steers (Experiment 2) are shown in Table 2. The intake value of the unsupplemented forage was better than expected considering the low CP concentration. In other work with warm-season grasses with CP concentrations below 4%, intakes of less than 1% BW have been measured. However, forages used in those studies also had considerably greater NDF concentrations, compared with the 61% measured in the present experiment, which would account for some of the difference.

Interactions between CP and energy levels, which would signify that the response to energy level depended on the amount of CP in the supplement, were not significant for most variables. Voluntary intake of forage sorghum hay was influenced by both CP and energy levels (Table 3). Increasing the amount of supplemental CP from .3 to .6 lb per day resulted in a 17% increase in hay consumption and a 13% increase in total DM intake. Increasing the amount of supplemental energy from 2.3 to 4.6 Mcal ME depressed hay intake by a similar amount. The additional DM fed with the high energy treatments offset depressions in forage intake, such that total DM intake was not affected by supplemental energy level. However, energy supplementation reduced digestibility of both DM and fiber (indicated by NDF digestibility), so that intake of digestible DM tended to be reduced with the high level as compared with the low level of energy. The high level of supplemental CP stimulated digestibility of fiber and DM, resulting in a 27% improvement in consumption of digestible DM as compared with the low level of CP. Differences in consumption of digestible DM give us a good indication of the net energy consumption by the steers. Thus, we would expect the high level of CP to support greater levels of animal performance than the low level and the high level of energy to be a detriment to animal productivity. Ruminal fill of DM was decreased with the high level of energy and tended to be depressed with the high level of CP, and ruminal liquid fill also was depressed with the high level of CP. The depression in DM fill with increased energy supplementation would be expected, based on observed differences in forage intake. The lower ruminal fill values with high levels of CP likely were due to an increased rate of digesta passage out of the rumen. Previous research has demonstrated that CP supplementation of low-quality forage diets will increase ruminal passage rates.

Ruminal fermentation characteristics were in general agreement with intake and digestibility responses. No interactions with time were noted for fermentation variables, and, although ruminal pH showed a significant interaction between CP and energy levels, pH varied within a fairly narrow range that was unlikely to affect ruminal fiber digestion. Thus, only responses to the main effects of CP and energy levels are shown in Table 4. Ruminal pH was depressed with the high level as compared with the low level of CP. The degree of response was small, but the direction of this shift was in agreement with the greater degree of digestion and greater VFA concentrations with the high CP treatment. Energy level only tended to affect ruminal pH and VFA concentrations. Acetate:propionate ratios tended to be larger with increased CP supplementation, as would be expected if a greater proportion of the ruminally degraded nutrients were derived from fibrous sources. Differences among treatments with respect to acetate:propionate ratios were predominantly functions of changing acetate proportions, because no treatment effects on ruminal propionate proportions were noted. The relatively minor fluctuations in ruminal pH and acetate:propionate ratios do not give any indication as to the nature of the negative associative effects on ruminal fiber degradation or intake. Often, depressions in ruminal pH are thought to cause such negative associative effects. However, in this experiment, changes in ruminal pH were not of sufficient magnitude to play a major role in depression of fiber digestion. Another explanation for negative associative effects involves competition between starch- and fiber-digesting bacteria for nitrogen. When starch is added to the rumen, starch-degrading bacteria, which rapidly ferment their energy source, can outcompete fiber digesters for uptake of N from the ruminal environment. However, had this been the responsible mechanism, we should have seen interactions between CP and energy supplementation, with the larger amount of CP offsetting some of the negative effects of grain on fiber use. This was not the case. Thus, some other mechanism likely is involved. One possibility is competition for some nutrient other than N, although potential candidates are not apparent at this time.

Conclusions

Results from this experiment demonstrated the benefits of CP supplementation and the disadvantages of grain supplementation for a 4% CP forage sorghum hay. Benefits to forage intake and digestibility from an additional .3 lb supplemental CP were of similar magnitude regardless of the amount of supplemental energy fed and resulted in a 27% improvement in digestible DM intake. Additionally, a 6% depression in digestible DM intake occurred when supplemental energy was increased from 2.3 to 4.6 Mcal ME (equivalent to approximately 1.7 and 3.4 lb supplement, respectively) at both levels of CP supplementation, due to depressions in forage intake and digestibility.

Table 1. Arrangement of treatments, supplement composition, and amounts of dry matter fed to each steer daily.

	Crude Protein Amount	
Energy Amount	.3 lb	.6 lb
2.3 Mcal ME	1.32 lb sorghum grain 0.36 lb soybean meal 17.4% CP supplement	0.61 lb sorghum grain 1.07 lb soybean meal 34.8% CP supplement
4.6 Mcal ME	3.36 lb sorghum grain 8.7% CP supplement	2.64 lb sorghum grain .72 lb soybean meal 17.4 % CP supplement

Table 2. Composition, intake, and digestibility of forage sorghum hay.

Item	Amount
Voluntary Intake, % of body weight[a]	1.65
Dry Matter Digestibility, %[a]	53.5
Dry Matter, %	90.0
	---------------------% of Dry Matter--------------------
Organic Matter	90.1
Crude Protein	4.0
Ash-Free Acid Detergent Fiber	36.2
Ash-Free Neutral Detergent Fiber	61.3
Acid Detergent Lignin	4.5

[a]Measured in Experiment 2, using steers fed forage sorghum hay and mineral supplement but no protein or energy supplements.

Table 3. Influence of protein and energy supplementation on DM intake, digestibility, and ruminal fill in beef steers fed low-quality forage sorghum hay.

	Protein[a]		Energy[b]			Probability of a Greater F[c]		
Item	High	Low	High	Low	SEM	P×E	P	E
Weight, lb	634	637	638	632	3.7	.32	.57	.32
DM Intake, % BW								
Forage	2.06	1.76	1.77	2.05	.021	.13	<.01	<.01
Supplement	.39	.40	.53	.26	-	-	-	-
Total	2.45	2.16	2.29	2.31	.021	.16	<.01	.52
Digestible DM	1.38	1.09	1.20	1.27	.019	.14	<.01	.06
Digestibility, %								
DM	56.2	50.5	52.1	54.6	.69	.51	<.01	.05
NDF	52.9	45.1	45.6	52.4	.71	.88	<.01	<.01
Ruminal Fill								
DM, % BW	2.11	2.24	2.06	2.29	.070	.99	.24	.06
Liquid, mL/kg BW	166	178	170	174	3.6	.57	.06	.50

[a]High protein = .6 lb CP/steer daily; Low protein = .3 lb CP/steer daily.
[b]High energy = 4.6 Mcal ME/steer daily; Low energy = 2.3 Mcal ME/steer daily.
[c]P×E = protein × energy interaction; P = protein main effect; E = energy main effect.

Table 4. Influence of protein and energy supplementation on ruminal fermentation in beef steers fed low-quality forage sorghum hay.

	Protein[a]		Energy[b]			Probability of a Greater F[c]		
Item	High	Low	High	Low	SEM	P×E	P	E
pH	6.69	6.81	6.77	6.73	.018	.03	<.01	.17
VFA, mM	77.2	65.4	69.3	73.3	1.86	.25	<.01	.17
Acetate:Propionate	3.72	3.15	3.31	3.56	.20	.31	.09	.41
	--------------------moles/100 moles-----------------							
Acetate	65.9	61.9	61.9	65.9	1.12	.29	.04	.04
Propionate	18.0	21.3	20.6	18.7	1.59	.28	.19	.45

[a]High protein = .6 lb CP/steer daily; Low protein = .3 lb CP/steer daily.
[b]High energy = 4.6 Mcal ME/steer daily; Low energy = 2.3 Mcal ME/steer daily.
[c]P×E = protein × energy interaction; P = protein main effect; E = energy main effect.

Influence of Protein and Energy Supplementation on Performance of Beef Cows Consuming Low-Quality Forage Sorghum Hay

Eric S. Vanzant and John R. Jaeger
Range Scientist and Former Assistant Scientist

Introduction

Forage sorghum hay is a major feed resource for beef cattle producers in western and central Kansas. However, little research has been done to document the feeding value of forage sorghum hay, particularly as it interacts with protein and energy supplements. The previous article indicates that, based on intake and digestibility changes with protein and energy supplements, performance by beef cows consuming low-quality forage sorghum could be enhanced by supplemental crude protein (CP) and could be depressed by feeding increasing amounts of supplemental energy (grain). In this study, we evaluated weight, body condition, reproduction, and calf performance responses as affected by different levels of supplemental CP and energy fed to cows during the last third of gestation.

Methods

One hundred sixty crossbred beef cows (average initial wt = 1023 lb; average initial body condition = 4.2 on 1-9 scale) were divided into eight groups of 20 cows each. Each of four supplements (Table 1) was fed to two randomly assigned groups on alternate days from November 30 until just before calving (February 11). Previous research conducted in Manhattan demonstrated only minimal effects on cow weight and condition and no influence on reproductive or calf performance by offering supplements three-times-weekly as opposed to daily. Each group of cows was kept in a 40 acre native grass pasture and had free-choice access to low-quality forage sorghum hay, water, and a salt/mineral mixture. At the beginning of the experiment, each cow received an intramuscular injection of 2 million I.U. of vitamin A. Cows were weighed and body condition scores (1 - 9 scale) were obtained following an overnight stand without access to feed or water at approximately 30-d intervals during the precalving supplementation period, within 4 d after calving, at the beginning of the breeding season (May 6), and 365 d after the beginning of the study. During the precalving period, the amount of hay fed to each group was recorded, and standing forage biomass in each pasture was measured at monthly intervals using a disk-meter technique to provide an estimate of forage disappearance across the winter. Following calving, all cows were grouped within a common pasture and treated similarly. Serum samples were obtained 11 d and 1 d before breeding by AI for progesterone assay to determine the number of cows cycling by the beginning of the breeding period. Pregnancy rates were determined by rectal palpation in late September.

Results and Discussion

An average of 19.0 lb DM from forage sorghum hay was provided per cow daily across the prepartum supplementation period. This amount was not different among the treatments, even though each group consumed hay ad libitum. The hay averaged 80% DM, and, on a DM basis, 3.4% CP, 57.0% ash-free NDF, 33.6% ash-free ADF, and 4.1% lignin. Rate of pasture forage disappearance across the prepartum period was not affected by treatment and averaged 14.7 lb DM/cow daily. Based on previous research, we assumed that half of this forage disappearance was due to trampling, weathering, etc., and that 25% of the hay offered was wasted, resulting in a rough estimate of total forage DM intake of 21.6 lb per cow, or 2.11% of body weight, daily.

Interactions between CP and energy were not significant for cow weight (Figure 1) or body condition (Figure 2) changes. During the prepartum supplementation period, cow weight and body condition responded favorably to the high level of CP supplementation. By February 10 (d 70), cows receiving the high level of CP had gained an average of 72 lb more than those receiving the low level of CP. Body fat apparently was mobilized to support gestation approximately 30 d earlier for the low-CP, than for the high-CP groups, as suggested by the earlier decline in body condition for the low-CP groups. Conversely, cows receiving the high level of energy had gained 28 lb less and had gained .2 units less body condition than those receiving the low level of energy after 70 d on treatments. This large positive response to supplemental CP and moderate negative response to increasing energy supplementation are in agreement with expectations based on forage intake and digestibility reported in the previous article. Just after calving (d 108), cows receiving 1.0 lb of CP had gained an average of 28 lb compared with a 34 lb cumulative weight loss by those groups receiving .5 lb of CP. These differences diminished somewhat by the beginning of the breeding season (d 155), with cows receiving high levels of CP prepartum maintaining a 41 lb cumulative weight change advantage over the low-CP groups. Weight differences were maintained across the summer and fall, such that 257 d after treatment supplements had been discontinued, cows that had received high prepartum CP exhibited a 23 lb weight advantage compared with those that had received low-CP supplements. Differences in cow body condition followed similar trends. Just after calving, high-CP-supplemented cows had gained .2 units of body condition, compared with a .3 unit loss for the low-CP supplemented cows. At the beginning of the breeding season, a .4 unit difference in body condition due to level of prepartum CP supplementation was maintained. Cows consuming high-energy supplements gained slightly more body condition from calving to the beginning of the breeding season than cows receiving low-energy supplements. This possibly was due to lower milk production by the high-energy supplemented groups. Observed weaning weights within the low-CP groups tended to support this explanation, because weaning weights were 20 lb lower with high prepartum energy supplementation within these groups. However, no difference in weaning weights related to energy level occurred with the high-CP supplemented groups. Similar trends were evident for calf ADG. Low weaning weights across all treatments likely were due to a combination of dry conditions during the summer grazing period and early weaning of calves.

Treatments did not significantly affect the proportion of cows cycling by the beginning of the breeding season (avg = 38.2%) or the total pregnancy rate (79.2%).

Conclusions

Beef cows consuming low-quality forage sorghum hay showed improved body weight and condition with the provision of 1.0 lb as compared with .5 lb, supplemental CP per day during the last trimester of gestation. Increasing the amount of supplemental energy during this period from 3.5 to 6.9 Mcal ME (equivalent to approximately 2.5 and 5 lb supplement, respectively) apparently reduced forage intake and(or) utilization sufficiently to depress weight and condition responses during the supplementation period. Although some compensation for the differences caused by energy and CP supplementation were observed postpartum, significant differences in cow body weight caused by prepartum CP supplementation were still evident 257 d after treatments ended. Additionally, with low CP levels, 6.9 Mcal ME provided prepartum resulted in lower calf weaning weights than 3.5 Mcal ME. Although responses would be expected to vary with forage quality, these results highlight the importance of providing supplemental protein, rather than energy, for beef cattle consuming low-quality forages.

Table 1. Arrangement of treatments, supplement composition, and amounts of dry matter fed per cow daily[a].

	Crude Protein Amount	
Energy Amount	.5 lb	1.0 lb
3.5 Mcal ME	1.87 lb sorghum grain 0.63 lb soybean meal 18.7% CP supplement	0.60 lb sorghum grain 1.90 lb soybean meal 38.8% CP supplement
6.9 Mcal ME	5.00 lb sorghum grain 8.7% CP supplement	3.75 lb sorghum grain 1.25 lb soybean meal 18.7% CP supplement

[a]Amounts are shown for each cow daily although supplements were fed every other day.

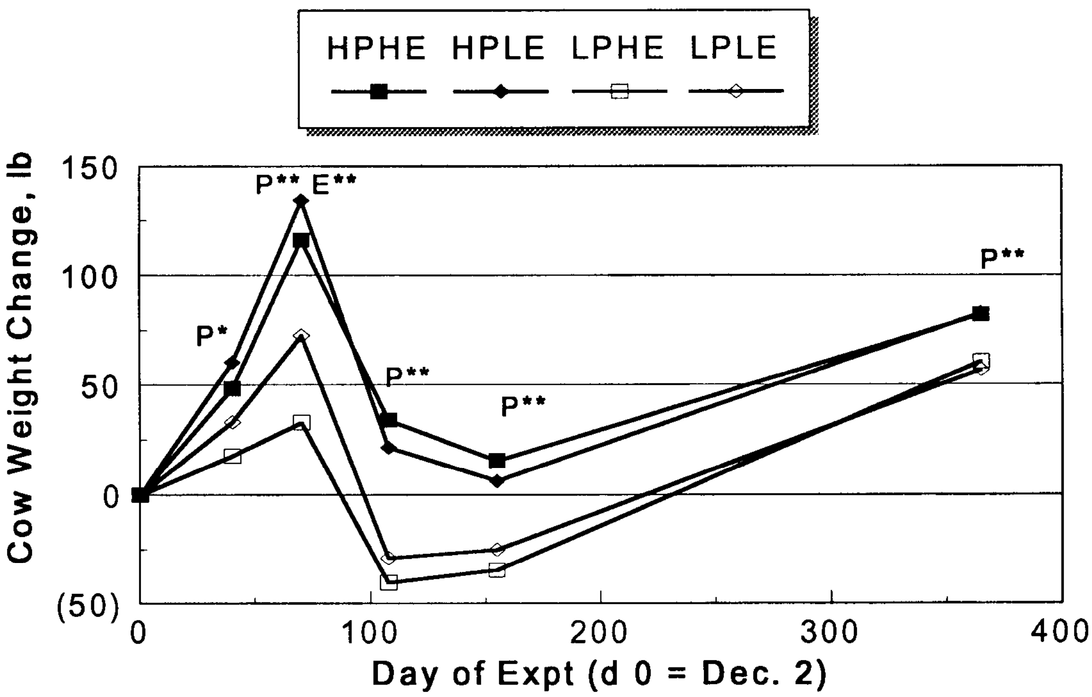

Figure 1. Influence of prepartum supplements on cow body weight change. Average initial body weight = 1023 lb. HP = high protein; LP = low protein; HE = high energy; LE = low energy; P* = protein effect (P < .10); P = protein effect (P < .05); E** = energy effect (P < .05) for cumulative body weight change.**

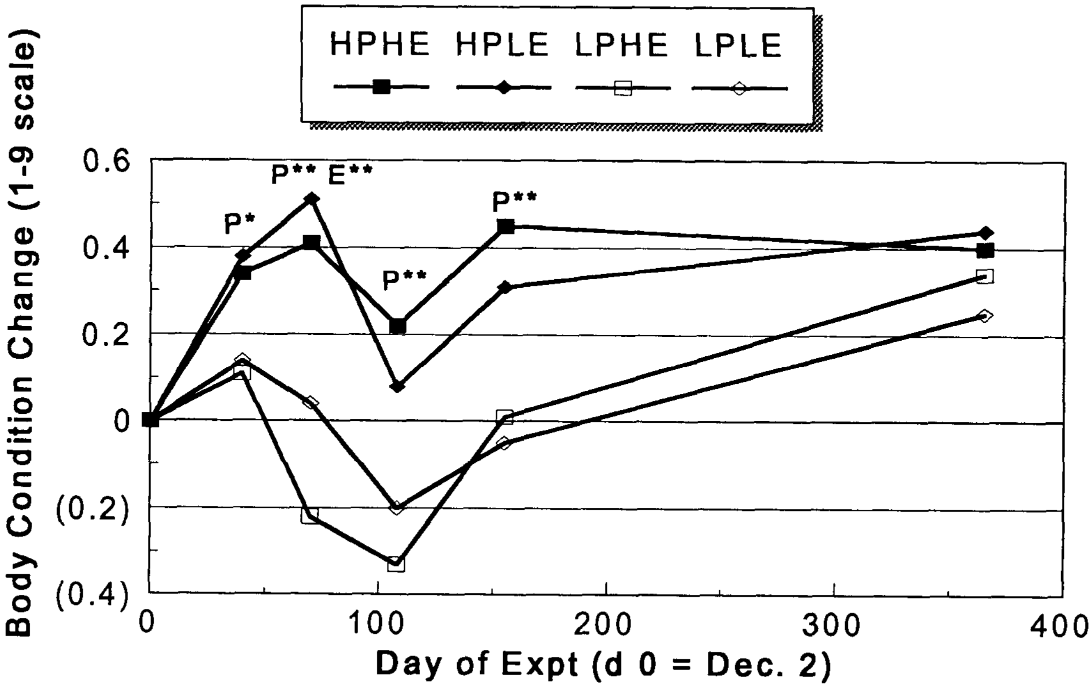

Figure 2. Influence of prepartum supplements on cow body condition change. Average initial body condition =4.2. HP = high protein; LP = low protein; HE = high energy; LE = low energy; P* =protein effect (P < .10); P = protein effect (P < .05); E** = energy effect (P < .05) for cumulative body condition change.**

Table 2. Influence of prepartum protein and energy supplementation on birth weights, weaning weights, and average daily gains of calves.

	Supplement Treatment[a]					Probability of a Greater F[c]		
Item	HPHE	HPLE	LPHE	LPLE	SE	P*E	P	E
Birth weight, lb	82	80	78	84	2.1	.14	.86	.54
Weaning weight, lb	442[cd]	433[cd]	429[c]	449[d]	4.7	.04	.27	.81
ADG, lb	1.94	1.93	1.87	1.98	.029	.12	.71	.16

“HP = high protein; LP = low protein; HE = high energy; LE = low energy,
[b]P*E = protein x energy interaction; P = protein main effect; E = energy main effect.
[cd]Means without similar superscripts differ (P < .05).

Tracking Marbling Development in Feedlot Steers

John R. Brethour
Beef Cattle Scientist

Introduction

Marbling in beef is the predominant attribute in assigning USDA quality grade and is considered to be an indicator of desirable eating qualities such as flavor, juiciness, and tenderness. Marbling is an important economic factor to the cattle feeder. Choice carcasses average about $40 more than Select carcasses, whereas even greater premiums may be paid for High Choice and Prime carcasses. Little research has been done on marbling, because no way was available to measure that trait in the live animal. However, technology has been developed at the KSU Agricultural Research Center-Hays (ARCH) to measure marbling accurately in the live animal with ultrasound. This procedure was used to evaluate marbling in 338 feedlot steers at approximately 28-day intervals during the feedlot period.

Methods

Steers for this study were purchased out of sale barns in Central Kansas during July and early August, 1994. Marbling evaluations were begun in September after the cattle were acclimated and brought up to full feed. The average interval from arrival to the first measurement was 52 days. The cattle averaged 990 lb and had 0.14 inch backfat when they were first measured. They were fed a high concentrate finishing ration composed primarily of finely rolled milo. They were implanted with Synovex-S on arrival and again when the first ultrasound evaluation was made, but no additional implanting was performed, even though some cattle were not slaughtered until February 2, 1995. Ancestry of cattle was not known, although there was no Brahman or dairy breeding. Most animals appeared to be crosses of Continental and British breeds. Exact age was also unknown, but cattle were presumably about 20 to 23 months old when slaughtered.

Each animal was measured for marbling at least three times during the experiment; the final measure was performed a few days before slaughter. A total of 1098 live marbling estimates was made for the 338 cattle used in this study.

Cattle were clustered into four marketing groups and slaughtered 109, 130, 159, and 195 days after arrival. Marketing date for each individual was chosen to avoid over-fat and overweight carcasses rather than randomizing for serial slaughter. The average carcass weight for all groups was 831 lb, equivalent to 1300 lb live weight. There were no Yield Grade #4 carcasses, but two carcasses exceeded the desired maximum of 950 lb (they weighed 953 and 954 lb). Even though cattle averaged 145 days on feed, 65% were Yield Grade #1 or #2. Virtually no difference occurred in average carcass marbling score among the four slaughter groups, and 59% graded USDA Choice (plus one Prime and one Standard).

The ultrasound measurement was performed with the method developed at ARCH. It is an automated system that involves novel procedures to parameterize texture patterns in the ultrasound image, which has been digitized for computer analysis. Those values then are subjected to neural network procedures that enhance the accuracy of the method. Figure 1 shows the relationship of marbling estimated from a linear projection of the three or four ultrasound measures taken on each animal and the actual carcass marbling. The average error of those projections was 0.36 of a marbling score unit. Carcass marbling is a subjective estimate by meat graders. At least a 0.2 unit discrepancy ocurs between two skilled graders independently evaluating the same carcasses.

Accuracy of the procedure is portrayed in a different manner in Figure 2. The average interval from the second measure on each animal until slaughter was 47 days. This figure correlates the machine value for marbling at that time with whether or not the animal actually graded Choice when slaughtered. For example, the chart shows that 29 cattle had a machine value of 5.2 (small 20) or higher and all of them graded Choice. On the other hand, 74 head had a marbling score less than 4.2 and 95% of them graded Select. There are four components of error in projecting future marbling in cattle:

* Error in the capture and automated interpretation of the ultrasound image.
* Error in ascertaining the rate of marbling increase over time.
* Biological variability among animals in carcass development.
* Subjectivity in assigning carcass marbling score after slaughter.

A portrayal such as Figure 2 identifies those regions of values that can be used to predict future carcass grade with high degrees of certainty and also indicates that borderline values will occur for which estimates of future carcass grade will be uncertain. However, we found that the objective determination of probabilities is a powerful tool in building a stochastic model to determine the optimal number of days to continue to feed an animal after evaluation.

Figure 3 shows the distribution of marbling scores among the 338 cattle in this study. The distribution is obviously not bell shaped (normal, Gaussian), which is usually expected of experimental data. The distribution is flat on top (negative kurtosis) and skewed. Conventional statistical procedures assume a normal distribution for analysis. However, nonparametric statistical procedures probably should be used for marbling score data.

Results and Discussion

The primary objective of this project was to ascertain the rate of marbling increase in cattle, so that future carcass grade could be estimated from an upstream ultrasound evaluation. The procedure of serial measures allowed rates of increase to be calculated for each steer. The distribution of those rates is shown in Figure 4. The average rate was 0.01 marbling units per day. That means that it took the average steer 100 days on feed to progress from slight marbling (Low Select) to small marbling (Low Choice). However, a large amount of variability occurred in rates among individual animals, with some cattle showing very little marbling increase throughout the experiment and a few making a step increase in 40 or 50 days.

Unfortunately, animal breed was not known, so we had no opportunity to determine if marbling rates were associated with breed type. Earlier research found that cattle representing British breeds had faster backfat increase rates than Continental breeds. However, a correlation occurred between marbling rate and average (for that individual) marbling score (Figure 5). In other words, marbling increased at a faster rate in cattle with more marbling.

Serial measures on each animal provided an opportunity to examine nonlinearity in marbling increase. No strong indication of a departure from linearity (backfat thickness increases at an exponential rate) was observed. Calculating the derivatives of the individual rate equations indicated a small, but probably unimportant, tendency for marbling rate to increase with days-on-feed.

Finally, Figure 6 shows that virtually no relationship occurred between carcass marbling score and carcass backfat thickness. That contradicts the prevailing opinion that the two traits are correlated and that improving quality grade must result in over-fat cattle. It also is in conflict with the contention that a progression of fattening occurs in which subcutaneous fat is followed by deposition of intramuscular fat.

Implications

This research indicates that marbling is formed at an excruciatingly slow pace in feedlot cattle and that it takes an average of 100 days to advance marbling score one step. Consequently, holding cattle for a few more weeks in the feedlot likely will increase only slightly the proportion grading Choice. On the other hand, because subcutaneous fat, the dominant factor in determining yield grade, increases at an exponential rate, continued feeding will adversely affect yield grade much more than it will improve quality grade. This research emphasizes the importance in focusing on marbling in seed stock selection, because the trait seems to be affected much more by the genetics of an animal than by management.

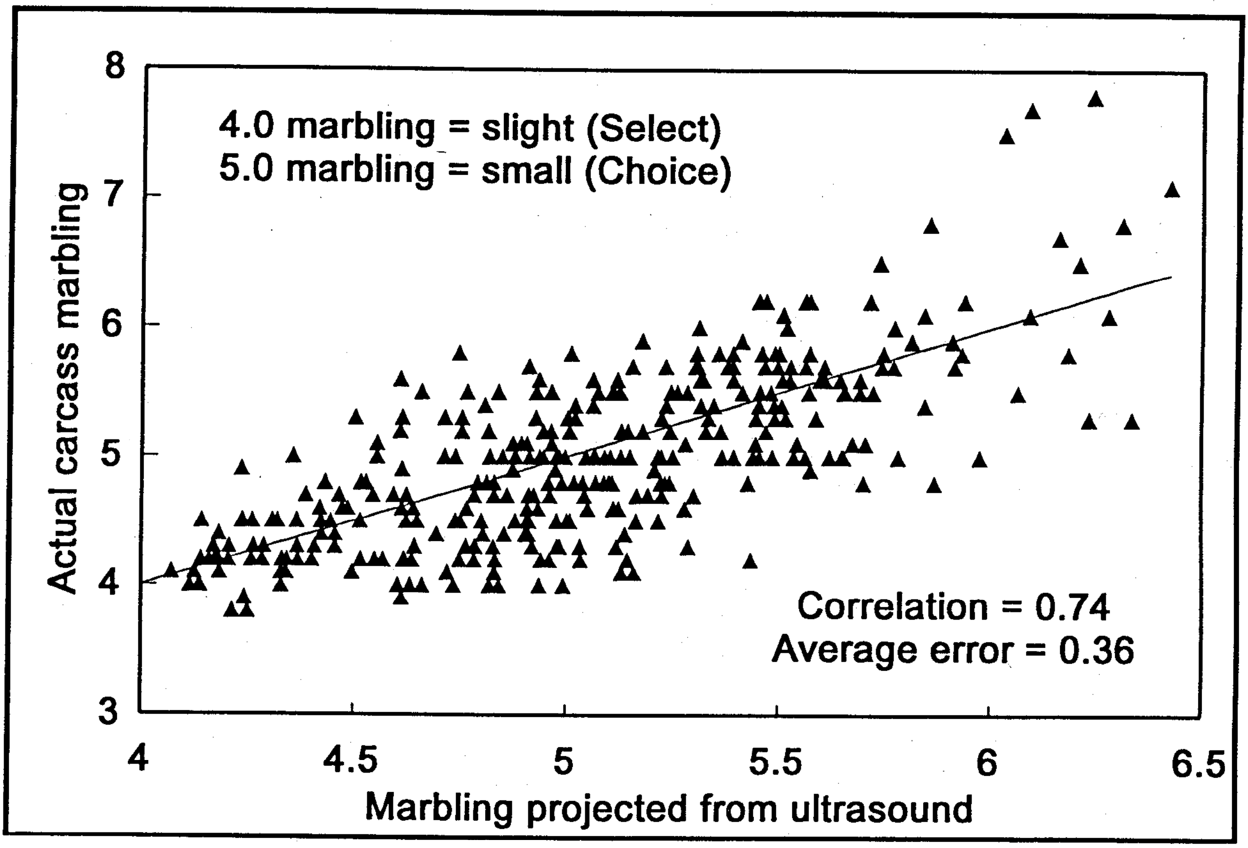

Figure 1. Projecting carcass marbling with serial ultrasound measures.

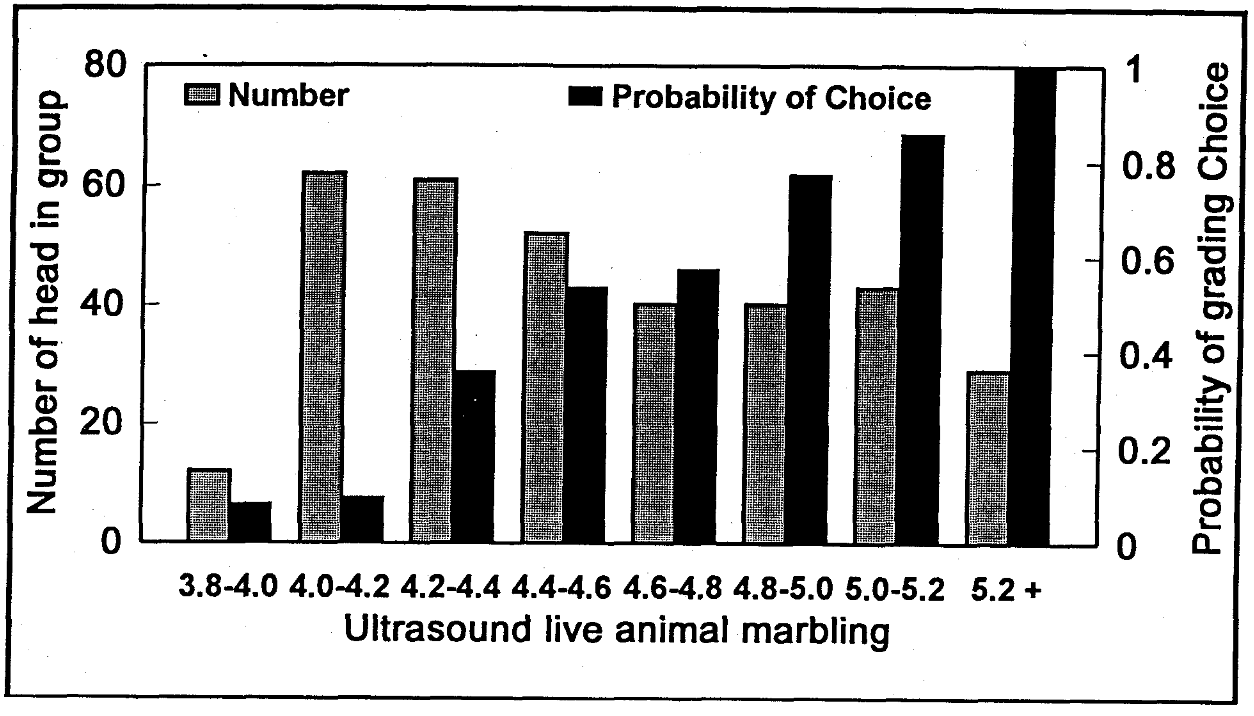

Figure 2. Relationship of ultrasound marbling estimate and likelihood of carcass grading USDA Choice 47 days later.

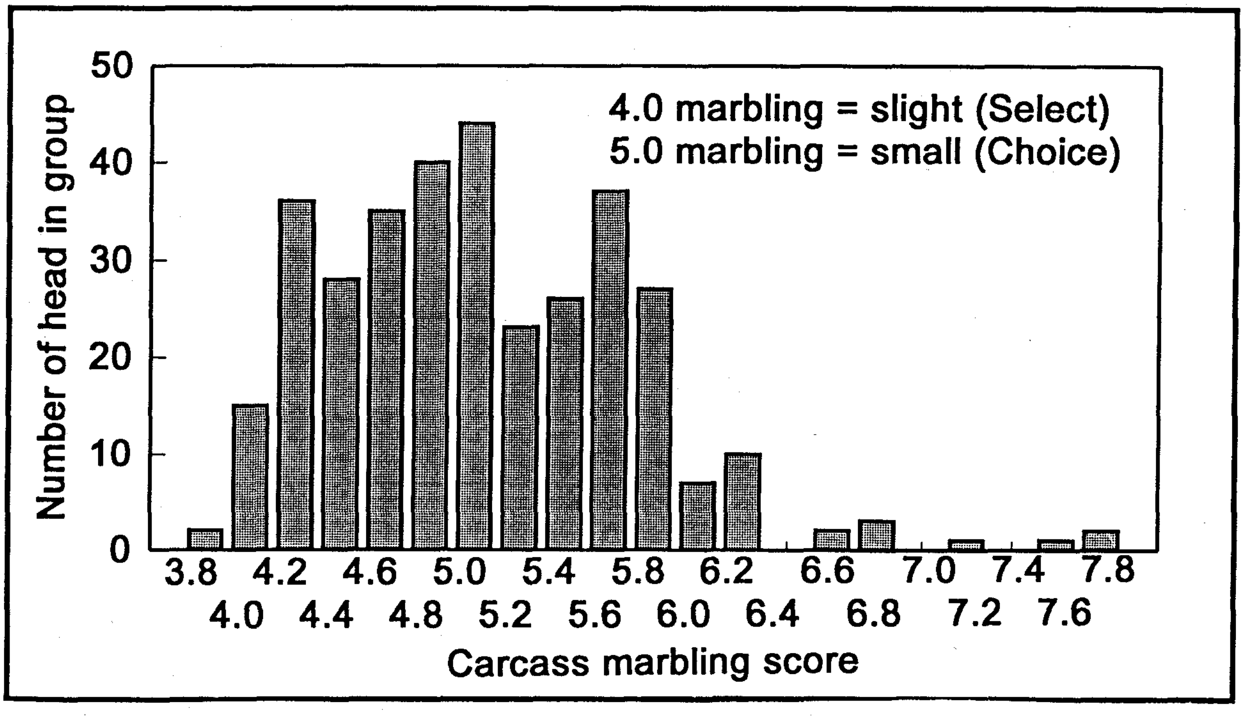

Figure 3. Distribution of marbling scores among 338 steers.

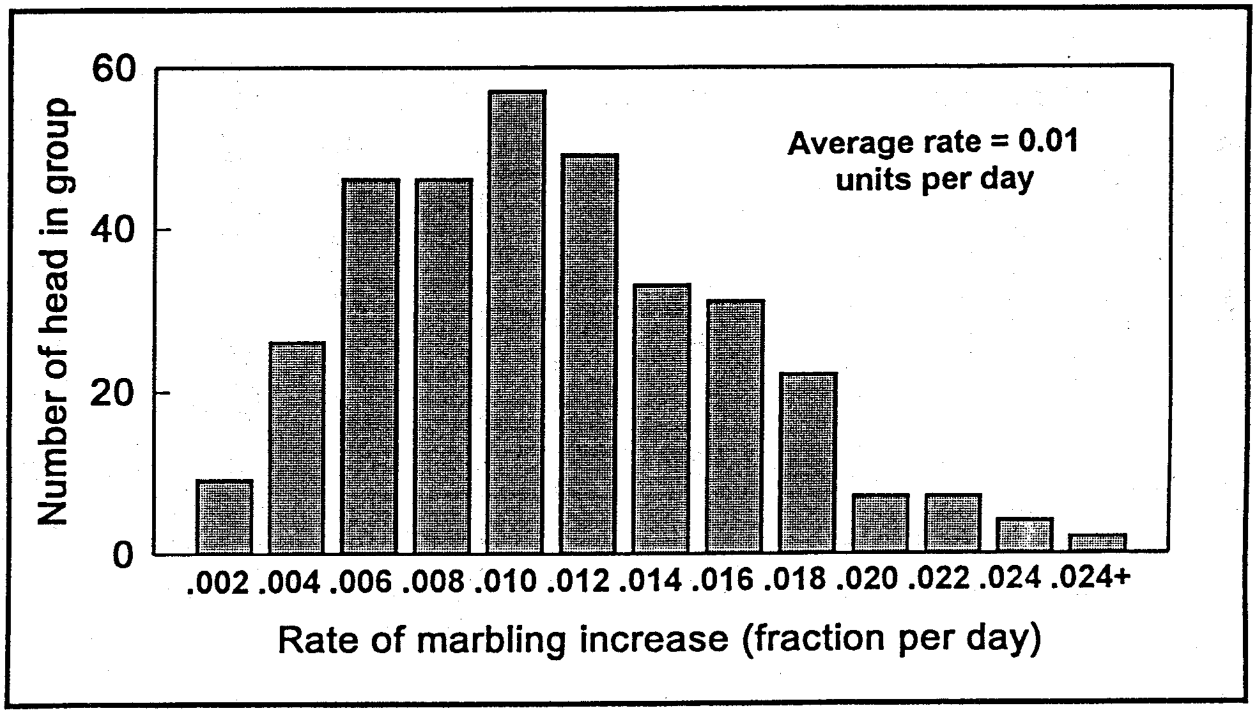

Figure 4. Distribution of marbling rates among 338 steers.

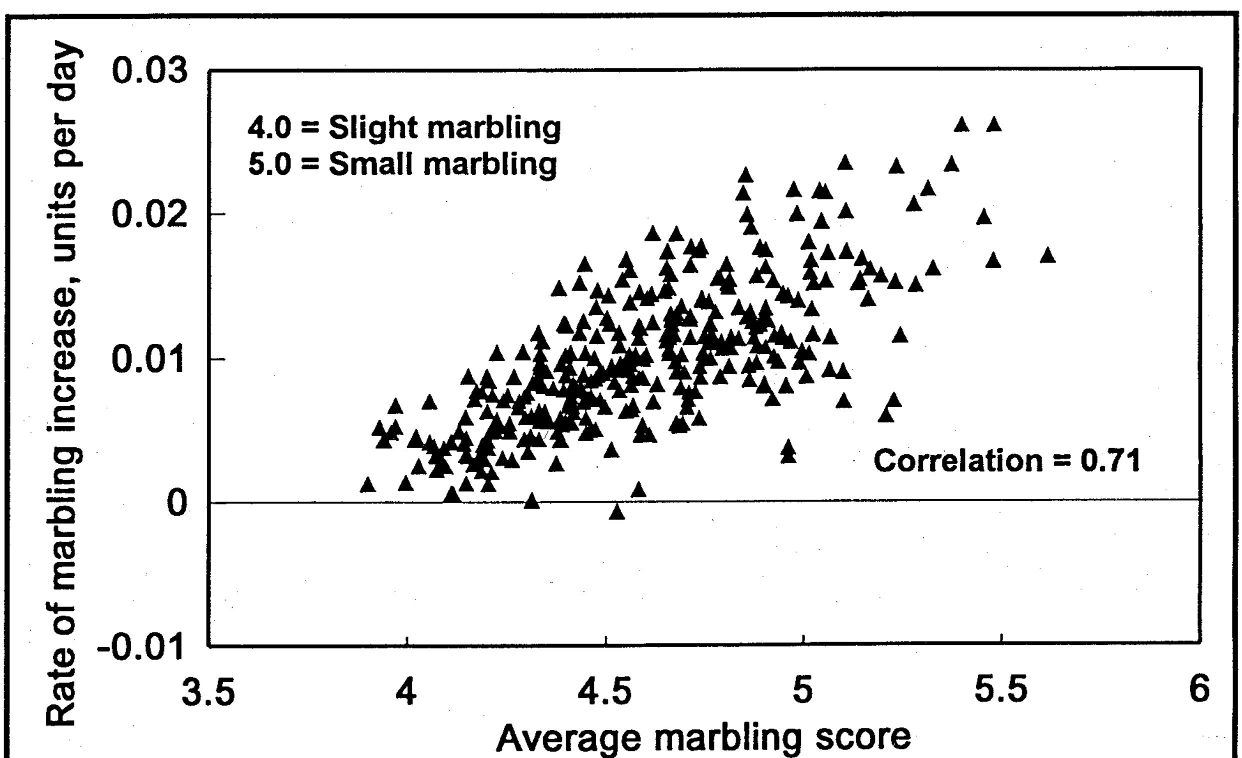

Figure 5. Relationship of marbling rate and average marbling score.

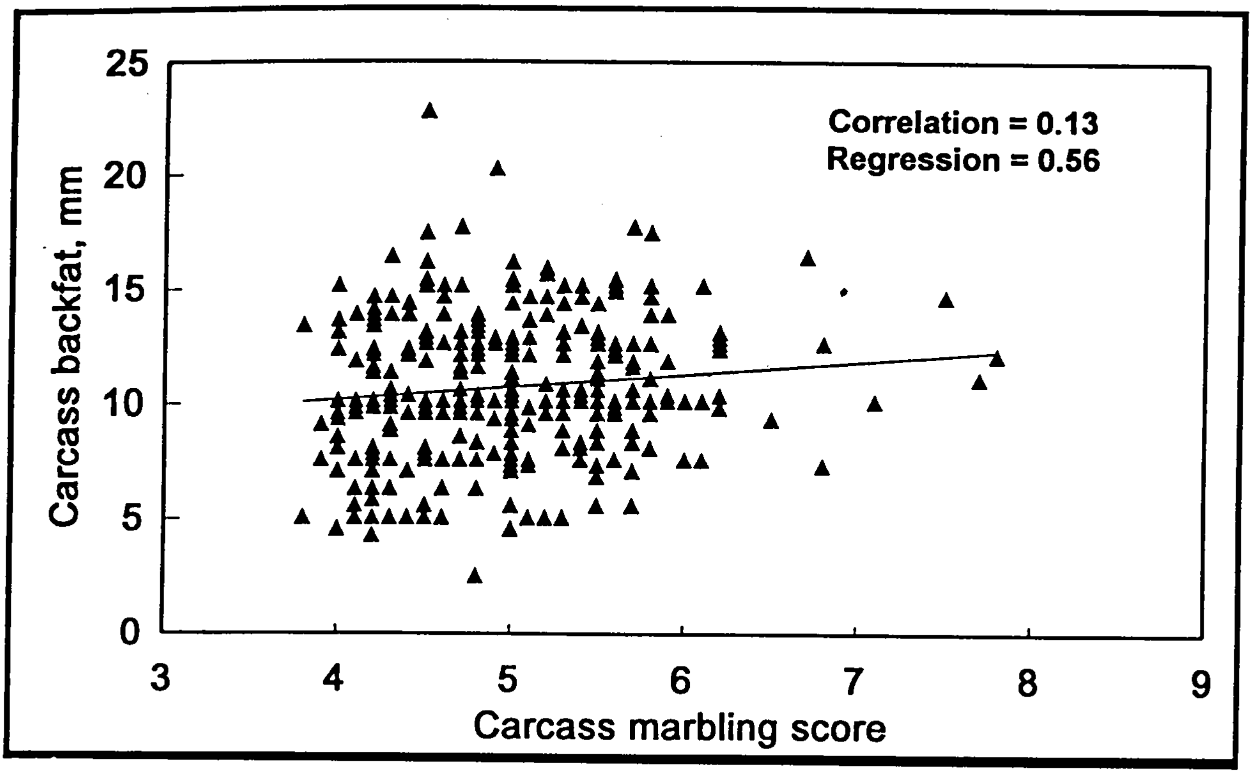

Figure 6. Relationship of carcass backfat and carcass marbling score.

Agricultural Experiment Station, Kansas State University, Manhattan 66506-4008

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