Beef Systems Research: Effect of Weaning Date, Weaning Method, and Cow Wintering Method on Beef Cow and Calf Performance

Progress Report

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Abstract

Preliminary results of this beef systems evaluation indicate that significantly altering weaning date can have a positive impact on business profitability. The total beef system effect was determined when spring-born calves were either weaned in August or at a more typical November date and then both cows and calves were followed through wintering and postweaning for two years. The cows were evaluated under two wintering scenarios: hay vs winter grazing of native range or winter grazing of unharvested corn. Performance and economic implications were determined for steer calves at weaning, after an 84-day backgrounding period, and when ownership was retained through final harvest.

Compared to cows weaned normally, altering weaning date by weaning calves 91 days earlier resulted in cows that were heavier and in better body condition. And terminating lactation early, by putting calves in the feedlot, reduced forage demand and consistently reduced herbage disappearance by 36.9%.

Wintering by grazing stockpiled native range resulted in an equal nutrient balance when compared to wintering with hay. Unrestricted winter grazing of unharvested corn, however, resulted in a very positive nutrient balance compared to cows wintered with hay. Regardless of weaning date or wintering method, the number of cows that were cycling at the start of each subsequent breeding season was similar. Based on the data from this investigation, modeling strategic restriction of corn access for winter grazing will result in a normal nutrient balance, while maintaining desirable body condition and estrous cyclicity without daily feeding. Both hay production and feeding are expensive operations that rely heavily on fuel consumption. At the time this progress report was prepared, crude oil futures were trading at $128 per barrel and off-road diesel fuel was approximately $4.00 per gallon. Both winter grazing of stockpiled native range and unharvested corn reduced the total hay requirement (hay was fed during calving) and eliminated the need for daily feeding.

In lieu of selling calves at either the early or normal weaning dates, steer calves were fed from weaning to final harvest. For economic purposes, budgets were prepared as though the steers had been sold at the normal weaning date, at the end of an 84-day backgrounding period, and finally when the steers were finished. The finished steers were fed for a high quality grid and were marketed on a grid basis in Colorado. Had early weaned steers been marketed out of the feedlot at the time the normal weaned steers were weaned, they would have netted more income due to lower feedlot entry cost and improved animal performance. Had the steers been marketed at the end of an 84-day backgrounding, performance and cost of gain were determined to be similar. And, had the steers been retained until final harvest, normal weaned steer performance was determined to be improved compared to early weaned steers; however, net return was greater for the early weaned steers because initial calf cost and freight to the feedlot were lower, HCW was greater, dressing percent was greater, and carcass grid value was higher.

While components of this beef systems investigation indicate that altering weaning date is more profitable, a more extensive systems economic analysis is being prepared and will appear in the next annual report.

Introduction

According to the North Dakota Farm Business Management program average net return per beef cow during the 10-year period from 1998 to 2007 was $109 per cow, ranging from a low of $40 to a high of $212 (ND Farm & Ranch Business Management Program, 2007). Profit volatility fluctuates widely and is influenced by many extenuating factors; most notably the effect of drought that influences the national cow herd size and unpredictable national and international events (grain and fuel price, disease, country of origin req., trade agreements) combine to create unpredictable market situations that can have a profound impact on profitability. Drought is especially important to cattlemen in the northern Great Plains where limited precipitation during the critical spring growing season is common. Since drought can challenge conventional grazing and weaning production management, this research effort is investigating the effect of early weaning and the subsequent impact that decision may have on managing the cow-calf enterprise and profitability.

Although early weaning is generally only considered as crisis management during drought situations, scientists have become interested in investigating mechanisms whereby early weaning may become a routine management procedure that positions producers to always be ready for drought instead of only considering early weaning as a crisis management procedure.

Our multi-state research team has previously evaluated the effects of weaning date (Early Wean in August - EW versus Normal Wean in November - NW) among spring-born calves on economic returns to retained ownership programs, forage utilization of dry versus lactating cows during the fall, and impacts of weaning on cow body condition score during the fall. Weaning spring-born calves early reduced forage utilization, improved cow body weight and body condition score, improved backgrounding performance and finishing feed efficiency, reduced the number of days from birth to harvest, and yielded similar finishing performance (Landblom et al. 2006). Early weaning improved feedlot production efficiency by reducing per day and per pound feedlot production costs (Fausti et al. 2007).

The greatest contribution to annual cow production costs in the Northern Plains is harvested and purchased feed (Taylor and Field, 1995). Hay is not only expensive to purchase, but it is expensive to put up and feed. Dunn (2002) showed that interest and depreciation on capital (required to handle hay) were major factors limiting profitability of ranching operations. Low input systems, or systems that reduce hay feeding, may contribute to profitability. It is not clear whether cow productivity can be maintained, however, with the absence of hay feeding.

Cows that are thin are at higher risk for reproductive failure (Pruitt, 1988), and must either be fed more or suffer the expensive consequences of failed reproduction. Time of weaning may be used to manipulate cow body condition score (Lamb et al., 1997). Adams (2003), working in the Nebraska Sandhills, reported that cows that had calves weaned in August that were not supplemented during the winter had higher net returns than November weaned cows. Adams (2003) also reported supplementation during the winter decreased net return at weaning, but increased net return at slaughter due to higher carcass weights of calves. Does early weaning allow cows managed in low input systems to be more productive and profitable than those in a normal weaning program? Is production improved enough in high input (conventional) systems to offset the elevated costs?

The objective of this current multi-state investigation has been to determine the relationship between weaning date, retained ownership market timing, and cow wintering method.

Materials and Methods

All procedures used in this investigation were approved by the North Dakota State University Institutional Animal Care and Use Committee.

Cows:

This 2-year investigation used March-April calving crossbred cows and their calves at three research stations in the 'four-state' region: the North Dakota State University Dickinson Research Extension Center (**DREC**); the South Dakota State University Antelope Range Livestock Research Station (**ANT**); and the University of Wyoming Animal Science Beef Unit (**UW**). Cows at each research facility were assigned to one of two weaning treatments, early wean (**EW** – 150 days of age) or normal wean (**NW** – 225 days of age). For wintering at each location, one-half of the cows from each weaning treatment were further assigned to one of two winter management programs, a high input (**HI**) or low input (**LI**) winter management (2 x 2 factorial). The HI cows were managed in a conventional manner, grazing range in the fall and receiving hay during the winter. At ANT and UW, cows in the LI system grazed stockpiled native range in the fall and winter and receive a dried distiller's grain-based supplement with no hay fed until calving. At the DREC, cows on the LI program winter grazed standing unharvested corn during the fall and winter. Hay feeding began when the supply of unharvested corn for winter grazing was depleted. Regardless of whether cows in the study grazed winter stockpiled native range or unharvested corn, the objective was to reduce harvested hay and fuel consumption. Cow weight and body condition score (BCS) were recorded in August, November, and prior to calving; and the percentage of cows cycling at the start of the breeding season was determined each year based on circulating progesterone levels.

Cow production data from Antelope and UW has been analyzed as a Randomized Complete Block design, with location as the block, weaning date and winter management as the factorial treatments, and year as a replication within location. DREC cow production data has been analyzed as a Completely Randomized design with weaning date and winter management as the treatments and year as a replication with the interaction between weaning date and cow management system being tested.

Range Biomass:

A subset of cows and calves grazed replicated native range pastures at the DREC to measure biomass and the magnitude of forage disappearance. A section of native range (640 ac.) previously subdivided into twelve uniform 50 acre pastures and an ungrazed 40 acre center cell was used to conduct the biomass and forage disappearance evaluation. Three pasture replicates of cows and calves (n=8/replicate; 24 pairs/treatment) were randomly assigned to the early weaning treatment and three similar replicated pasture groups were assigned to the normal weaning group. A switch-back grazing method was used in which the east one-half of the section was grazed until early weaning in August and then the rested west half of the section was grazed after the early weaning date. The turnout pasture was reversed for the second year of the study. Forage biomass samples were taken (1 per acre) prior to the pasture rotation in August and again in November when the cows and calves were removed from the pastures. Vegetation disappearance was calculated as the difference between pre-grazing biomass and the biomass available when grazing was terminated in November. Statistically, the biomass evaluation and forage disappearance were conducted as a completely randomized design in which treatment was weaning date and pasture served as the experimental unit. Data were analyzed using ANOVA procedures of SAS to determine differences in forage disappearance (utilization plus destruction) due to treatment.

Calves:

An additional and important component of this alternative systems investigation is the performance and economics associated with calf management and marketing. Prior to weaning, calves involved in the investigation were administered modified-live vaccinations before spring turnout, 3-4 weeks before each weaning date, and a final immunization at weaning for IBR, BVD types I and II, PI_3, BRSV plus Mannhiema haemolytica, and a 7-way Clostridial vaccine that included H. somunus. In addition, the calves were poured with a parasiticide for control of internal and external parasites. After weaning, steer calves were randomly assigned to replicated feedlot pens and managed together at the University of Nebraska Panhandle Feedlot, Scottsbluff, Nebraska. Steer weight, frame size, and backfat depth of 0.50 inch were used to determine final harvest endpoint. Measurement for backfat depth taken between the 12^{th} and 13^{th} rib was conducted 60 days before final harvest using an Aloka ultrasound machine and 3.5 MHz probe. Backgrounding and finishing growth performance, carcass closeout values, and economics were recorded. These data were analyzed using the MIXED procedure of SAS (2003).

Immune Response:

The effect of weaning date on immune response was evaluated based on humoral antibody titers. Using the immunization protocol described above, blood samples were collected each time the calves were vaccinated. After standing overnight and centrifugation (3,000 rpm) for 5 minutes, serum was recovered and placed into 1.8 ml screw-top transfer tubes, and frozen. Humoral serum antibody titer levels were determined for Infectious Bovine Respiratory disease (IBR) and Bovine Virus Diarrhea Types I and II at the Texas A & M Veterinary Diagnostic Laboratory, Amarillo, Texas. These data were analyzed using the MIXED procedure of SAS (2003).

Economic Analysis:

Data on costs and returns for cows and calves were collected. For calves, cost and returns were prepared for early and normal weaned calves through to the normal weaning date, and then cost and returns were prepared for retained ownership through backgrounding and finishing. These data were used to determine the economic returns to management associated with each alternative management system.

Results and Discussion

The overall objective of this multiple-year beef systems investigation is to measure the combined effect of an atypical early weaning date and annual forage grazing on reducing over grazing and production input costs. Intuitively, one would expect direct animal harvesting would reduce input cost associated with producing backgrounded calves. Weaning spring-born calves in August as compared to weaning at a more typical date in November has result in an energy allocation shift and forage sparing. During a typical 7-month lactation period in the northern Great Plains, nutritional value of native range declines over time until the cow's nutrient requirements for maintenance and lactation cannot be met, and body reserves are drawn down. Terminating lactation after a shortened 5-month nursing period has been beneficial for both cows and the range resource. Terminating lactation reduces cow nutrient requirements by approximately 38% and when timed to occur with declining forage quality, a positive cow and range response has been observed. During the 84d period between early and normal weaning dates, our research team documented that early weaned cows increased body weight ($P < 0.002$) and body condition score was improved (SDSU: $P = 0.005$; NDSU $P = 0.31$) as shown in Figs. 1 and 2. Likewise, early weaning and termination of lactation consistently reduced herbage disappearance by an average 36.9% (Fig. 3). These data do not suggest a replacement for best management practices that incorporate rotational grazing, but reallocates how the spared forage may be utilized by range managers. Early weaning and the resultant spared forge can be used initially to improve plant vigor and provide for stocking flexibility, i.e. increase winter grazing capabilities, extensive heifer development at lower cost, and/or increased cow herd size when the amount of spared forage is factored into the ranch's annual carrying capacity.

During the wintering period after cows were removed from native range, high input (HI) control cows were wintered on hay and low input (LI) cows either grazed stockpiled native range or unharvested standing corn. Early weaning improved cow body condition as shown in Fig. 2 and resulted in early weaned cows going into the winter period in better nutritional status. Comparing nutrient balance between cows wintered with hay or those that grazed stockpiled native range, nutrient balance was similar based on cow weight ($P = 0.47$) and BCS ($P = 0.94$) (SDSU: Fig. 4 and 5). However, when comparing nutrient balance between cows wintered with hay or unrestricted grazing access to unharvested standing corn, a large nutrient imbalance was observed resulting in significant weight (+183 lbs; $P = 0.07$) and BCS (+1.2 BCS Points; $P = 0.08$) increases (Fig. 4 and 5). Unrestricted dry matter corn consumption was 41.42 pounds per cow per day the 1st year of the study and 29.74 pounds per cow per day the 2nd year of the study (Fig. 6). Hay and corn grazing cost per cow from the start of grazing in November to turnout on spring pasture during May of each year is shown in Fig. 7. Despite limited precipitation and poor dry-land corn production, cow weight and BCS increased sufficiently requiring corn access restriction. Based on data from this study and NRC requirements for third-trimester dry pregnant cows, a model for restricting corn access to approximately 30 pounds of dry matter per cow per day would provide adequate growth without excessive body condition increase. And employing a model that would restrict winter unharvested corn grazing access to approximately 30.0 pounds of dry matter per cow per day would cost \$0.85 per day (Season: \$147/cow) without the cost of daily feeding as compared to \$0.98 (Season: \$169/cow) per day for daily hay feeding.

The effect of winter corn grazing compared to winter hay feeding on estrous cyclicity at the start of the breeding season is shown in Fig. 8. While the cows that grazed unharvested corn increased weight and BCS compared to cows wintered with hay only, the number of cows cycling at the start of the breeding season did not differ ($P = 0.12$), indicating that the elevated BCS of cows that grazed corn did not improve estrous cyclicity at the start of the breeding season.

Early weaned steers were removed from their mothers in August and shipped directly to the University of Nebraska Panhandle Feedlot, Scottsbluff, Nebraska. The normal weaned steers continued to nurse their mothers, while grazing native range, and were shipped to the Panhandle Feedlot in November. Compared to NW steers, EW steers gained more, grew faster in the feedlot, and were heavier when NW steers were weaned in November ($P < 0.01$) (Table 1). For postweaning feedlot rearing, feedlot cost per pound of gain was \$0.3801 compared to \$0.2513 per pound of gain for steers that remained on pasture. After weaning, the steers were backgrounded for 84 days. Early weaned steers were heavier at the start of the backgrounding period, but 84d gain and ADG did not differ ($P = 0.36$). Feed efficiency, however, favored the NW steers ($P = 0.01$), but feed cost per pound of gain did not differ ($P = 0.57$).

Retained ownership steer performance for the entire period from weaning to final harvest is shown in Table 3. Early weaned steers weighed 386 when weaned and were 190 pounds lighter than the NW steers that entered the feedlot weighing 576 pounds. Early weaned steers were in the feedlot 280 days; 88 days longer than the NW steers; however, steer age at final harvest was the same ($P = 0.66$). Early weaned steers gained 842 pounds in the feedlot compared to 659 pounds for the NW steers. Normal weaned steers grew faster ($P < 0.01$), consumed more feed ($P < 0.01$), and tended to be more feed efficient ($P = 0.069$). Feed and yardage cost per head for the early weaned steers was greater due to the additional 88 days on feed costing $392.28 compared to $315.76 for the NW steers. Feed and yardage cost per pound of gain was very similar; i.e. $0.466 for the EW compared to $0.479 for the NW steers.

Carcass closeout values, as shown in Table 4, did not differ for HCW, REA, fat depth, and percent choice quality grade. Early weaned steers had higher dressing percent ($P < 0.05$) and greater yield grade ($P < 0.01$), which is a numerical score from 1 to 5 based on the percent yield of boneless, closely trimmed, retail cuts from the round, loin, rib, and chuck. These data for HCW weight do not agree with our previously reported results in which we found that EW steer HCW weight was lighter resulting in lower gross and net carcass revenue (Fausti et al. 2007). This change in outcome across studies, we suspect, is due to the differences in age at harvest between EW and NW steers. In the earlier study EW steers were harvested 50 days younger than NW steers, but in the later study EW and NW steers were harvested at approximately the same age.

Weaning, backgrounding, and finishing budgets for EW and NW steers are shown in Tables 5, 6, and 7. Had steers been sold either off pasture or out of the feedlot at the NW time, EW steers would have been more profitable; netting $17.78 more per steer (Table 5). In the systems budgets, negative price slide associated with increasing weight gain has a substantial influence on calf value at the end of backgrounding (Table 6). When priced at feedlot entry, the lighter weight EW calves would be expected to be priced at a much higher price per pound; however, the total calf value would also be expected to be lower than the heavier weaning weight NW calves. In the analysis, EW calves were priced at $150.00 per hundredweight as compared to the NW calves that were 190 pounds heavier and priced at $117.00 per hundredweight. When comparing backgrounding budgets for the two weaning dates, EW steers cost less cost less to place and ship to the Nebraska feedlot, but because EW steers were on feed 91 days longer, feed, yardage, and interest costs were higher than for the NW steers. For the NW steers, the placement cost for heavier steers and freight to the feedlot were both higher; however, since the NW steers were on feed for only 84 days, feed, yardage, and interest were less. Therefore, offsetting system costs for EW and NW steers resulted in very similar net returns of $7.02 and $7.51, respectively.

Postweaning retained ownership budgets for the EW and NW systems from the time calves were weaned in each system through final harvest are shown in Table 7. Budget similarities are evident between the two weaning systems, i.e. both steer age and HCW were nearly identical, and the gross carcass value was separated by a narrow $10.17 margin that favored the EW steers. Since the EW steers entered the feedlot as younger than normal calf-feds, EW steers were on feed 88 days longer and the corresponding feed, yardage, and operating interest were higher than the NW system. While these components of the budget were higher for the EW steers, EW steers were 190 pounds lighter, were valued $94.92 less than the NW steers, and due to their lighter weight, shipping costs for the EW steers to the Nebraska feedlot was $6.36 less than the NW steers. Considering these and other expenses shown in Table 7, total expenses for the EW and NW retained ownership were $1,057.15 and $1,066.80, respectively. When these expenses are deducted from the gross carcass revenue, the EW system netted $19.82 more per steer than the NW system.

The effect of weaning date on humoral antibody titer change is shown in Table 8. For IBR, antibody titer was more pronounced within the EW steers, when compared to the NW steers, and was greater over time as well. Comparative treatment BVD Types I ($P = 0.375$) and II ($P = 0.71$) did not differ between EW and NW steers. Pulls and treatment in the feedlot were low and similar.

Fig. 1

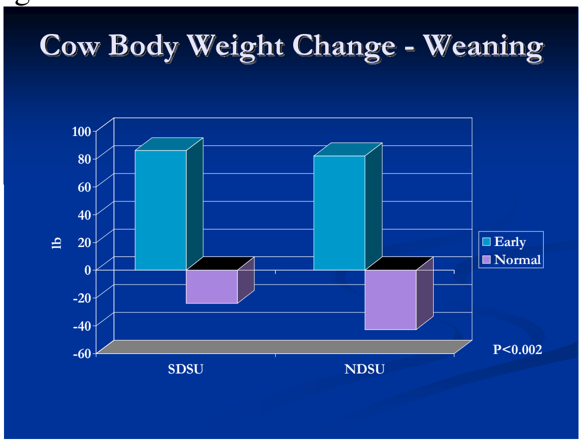

Fig. 2

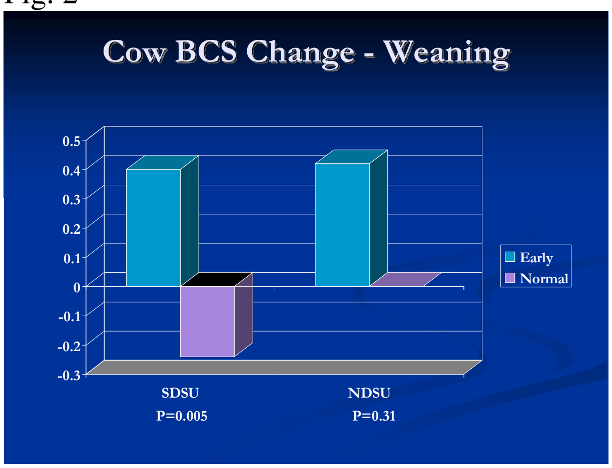

Fig. 3

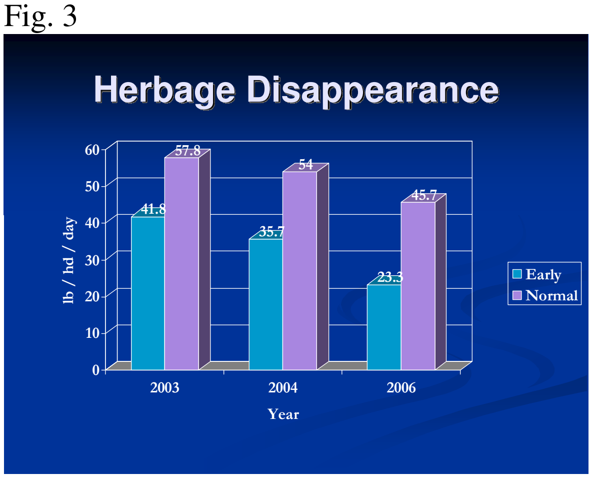

Fig. 4

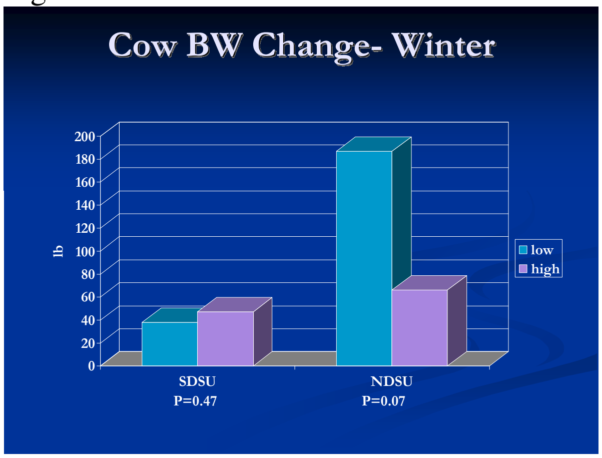

Fig. 5

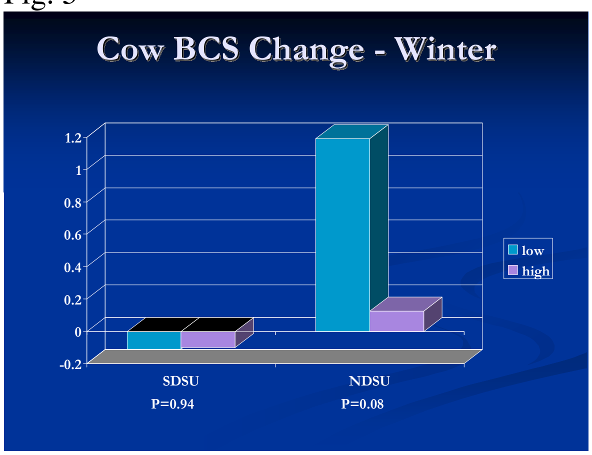

Fig. 6

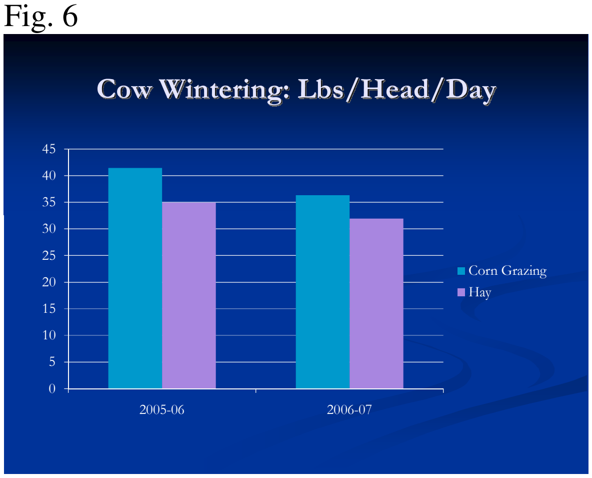

Fig 7. Cow wintering: hay vs unharvested corn grazing

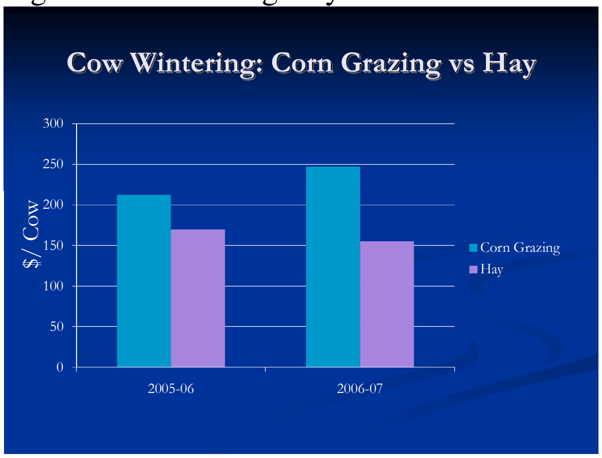

Fig. 8

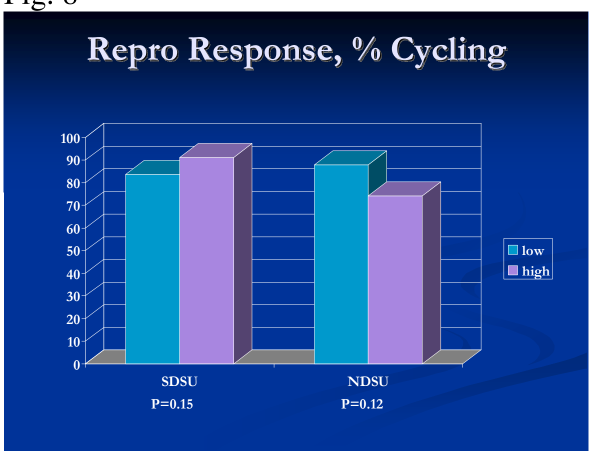

Table 1. Steer performance comparing NW grazing with EW feedlot rearing

	Early Wean	Normal Wean	P-Value
August Wt., lb.	399	401	0.75
Feedlot Start Wt., lb	386		
Wt. at Nov. Normal Weaning, lb	622	576	0.036
Pasture and Feedlot Gain, lb	236	175	<0.01
ADG, lb	2.59	1.92	0.008
Feed/Head/Day (As Fed), lb	23.27		
Feed/Head/Day (D. Matter), lb	12.67		
Feed DM/Lb. of Gain, lb	4.89		
Feedlot Cost/Head, $	59.99		
Pasture Cost/Head, $		44.10	
Feed or Grazing Cost/Lb of Gain, $	0.3801	0.2513	

Table 2. Comparison of steer performance after an 84-day backgrounding period

	Early Wean	Normal Wean	P-Value
Weight at Normal Weaning, lb	622	576	0.04
84d Backgrounding End Wt., lb	928	877	0.11
Gain, lb	306	301	0.36
ADG, lb	3.64	3.58	0.36
Feed/Head/Day (As Fed), lb	26.75	26.67	0.91
Feed/Head/Day (Dry Matter), lb	17.81	15.56	0.04
Dry Matter Feed:Gain, lb	4.889	4.35	0.01
Feed Cost/Lb of Gain, $	0.3584	0.3645	0.57

Table 3. Comparison of steer performance through finishing

	Early Wean	Normal Wean	P-Value
Start Wt., lb	386	576	<0.01
Shrunk Finished End Wt., lb	1228	1235	0.80
Percent Shrink, %	4.19	3.49	
Days on Feed	280	192	<0.01
Kill Age, Days	401	402	0.66
Gain, lb	842	659	<0.01
ADG, lb	3.01	3.43	<0.01
Feed/Head/Day (As Fed), lb	27.72	30.44	<0.01
Feed/Head/Day (Dry Matter), lb	17.87	19.42	<0.01
DM Feed:Gain, lb	5.94	5.66	0.069
Feed and Yardage Cost/Head, $	392.28	315.76	<0.01
Feed and Yardage Cost/Lb of Gain, $	0.4659	0.4792	0.301

Table 4. Comparison of steer carcass closeout values

	Early Wean	Normal Wean	P-Value
Hot Carcass Wt., lb	771	767	0.57
Carc. Dressing Percent, %	62.3	61.9	0.023
Ribeye Area, sq. in.	11.77	11.91	0.175
Fat Depth, in.	0.59	0.56	0.31
Yield Grade[a]	2.90	2.63	0.003
Percent Choice Carcasses	84.6	74.1	0.68

[a]Yield Grade correlation to percentage of boneless, closely trimmed retail cuts: 1 = 54.6%, 2 = 52.3%, 3 = 5.0%, 4 = 47.7%, and 5 = 45.4%

Table 5. Weaning budget (Selling at weaning)

	Early Wean	Normal Wean
Days from weaning to normal weaning	91	0.0
Wt. at early weaning, lb	399	401
Wt. at normal weaning, lb	622	576
Steer Value:		
Early Weaned Steer @$113.60	706.59	
Normal Weaned Steer @117.00		673.92
Rearing Cost from Early Wean Date:		
Early Weaned Steer - Feedlot	59.99	
Normal Weaned Steer - Pasture		44.10
Net Return/Steer, $	646.60	628.82

Table 6. Backgrounding budget: August vs November weaning

	Early Wean	Normal Wean
Days Backgrounded From Weaning	175	84
Steer Start Wt., lb	386	576
Steer Shrunk (3%) Sale Wt., lb	900	845
Sale Price, $/CWT	$93.00	$98.00
Gross Return, $	$837.00	$828.10
Expenses:		
Feed Cost, $	$150.36	$80.13
Yardage Cost, $	$52.50	$25.20
Feeder Steer Cost, $		
Early Weaned Steer @ $150/CWT	$579.00	
Normal Weaned Steer, $117/CWT		$673.92
Implant, $	$2.38	$2.38
Freight/Hd to Feedlot, $4/loaded mile; 400 mi, $	$12.90	$19.28
Health Cert. & Brand Insp., $	$2.70	$2.70
Treatment Cost, $	$4.72	$4.72
Interest @ 6.5%	25.42	12.26
Total Expenses, $	$829.98	$820.59
Net Return, $	$7.02	$7.51

Table 7. Retained ownership budget: August vs November weaning to final harvest

	Early Wean	Normal Wean
Days: Weaning to Finishing	280	192
Steer Start Wt., lb	386	576
Steer Shrunk (3%) Finished Wt., lb	1228	1235
Carcass Wt., lb	771	767
Carcass Value, $	$1124.26	$1114.09
Expenses:		
Feed Cost, $	$306.36	$252.99
Yardage Cost, $	$85.92	$62.77
Feeder Steer Cost, $		
Early Weaned Steer @ $150/CWT	$579.00	
Normal Weaned Steer, $117/CWT		$673.92
Implant, $	$2.38	$2.38
Frt/Hd to Feedlot, $4/loaded mile; 400 mi, $	$12.90	$19.28
Frt/Hd to Packer, $4/loaded mile; 120 mi, $	$12.30	$12.30
Health Cert. & Brand Insp., $	$2.70	$2.70
Treatment Cost, $	$4.72	$4.72
Interest @ 6.5%	50.87	35.74
Total Expenses, $	$1,057.15	$1,066.80
Net Return, $	$67.11	$47.29

Table 8. Effect of weaning date on humoral antibody titer change [a, b]

	Pre-Wean	Weaning	30-Day Post-Weaning			
	Initial	Booster				
August Wean (Early)						
Serum Recovery Date	**7/19**	**8/11**	**9/9**	**10/10**	**11/11**	**12/9**
IBR	28.0	14.2	9.3	4.0	4.0	4.0
BVD Type I	43.1	23.1	42.6	12.0	33.8	18.2
BVD Type II	30.2	52.0	114.7	27.1	22.7	12.8
November Wean (Normal)						
Serum Recovery Date	**10/20**	**11/10**	**12/9**	**1/6**	**2/3**	**3/3**
IBR	5.7	4.4	5.8	4.4	4.0	4.0
BVD Type I	5.7	5.7	9.8	14.2	21.8	12.9
BVD Type II	4.4	33.3	87.1	52.9	71.1	36.0

[a]Treatment means differ significantly:

IBR: Treatment (P = 0.062); Treatment * Time (P = 0.030), BVD Type I: Treatment (P = 0.375); Treatment * Time (P = 0.0001), BVD Type II: Treatment (P = 0.71); Treatment * Time (P = 0.15)

[b]Serum antibody titer change over time was significant.

IBR: Time (P = < 0.0001), BVD Type I: Time (P = < 0.0002), BVD Type II: Time (P = < 0.68)

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