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Modification to Native Range Vegetation by Grazing Management to Affect Grasshopper Populations, 1993-1994

Llewellyn L. Manske PhD

Associate Range Scientist
North Dakota State University
Dickinson Research Extension Center

Grasshopper population outbreaks whether on small or large scale are extremely detrimental to the region they occur and are economically costly to individual land owners and society in the lost or destroyed vegetation production and also in the expenses of the treatment program. It would be, presumably, less devastating and costly if cultural management practices could be used to reduce or eliminate the occurrences of pest grasshopper population outbreaks.

Grasshopper egg laying and development of nymphs can be altered by modifications in vegetation structure and density (Onsager 1995, and pers. comm.). Grazing management can be used to modify vegetation structure and density. Grazing research in western North Dakota has shown that the twice-over rotation grazing system on native range as described by Manske and Conlon (1986) can increase herbage production (Manske 1992), grass basal cover (Manske, Barker, and Biondini 1988), and livestock performance (Manske *et al.* 1988) compared to seasonlong grazing treatments and long-term nongrazed (idle) areas. This research project was conducted to determine if the beneficial changes in vegetation structure and density that resulted when defoliation was regulated by twice-over rotation grazing management would be sufficient to negatively affect grasshopper nymphal development and adult egg laying. This was a cooperative project between the Range Research Laboratory at the NDSU, Dickinson Research Center, Dickinson, North Dakota and the Rangeland Insect Laboratory, USDA-ARS, Bozeman, Montana. The range laboratory team was responsible for the grazing management and vegetation data and the insect laboratory team was responsible for the grasshopper and micro-climatic data. The basic premise that we are working with is that most of the rangeland pest grasshopper species are favored by open canopy and bare areas which are used by the grasshoppers to provide access to solar radiation during nymphal development for thermoregulation and by some species for egg laying sites. The assumption that we have made from this premise and are testing with this project is that if defoliation management treatments using grazing can be developed that decrease open areas in the vegetation canopy then grasshopper development should be affected and should be shown as a change in population density or species composition. The alternative to this first assumption is that if management can not be developed that causes a decrease in the canopy open areas for the entire year, then we should find management practices that annually change the time when the open areas occur and are available for grasshopper use. This should, presumably, disrupt the natural patterns of the grasshoppers' phenological development enough to affect the populations and assure that no single pest grasshopper species would be strongly favored for successive years.

The changes in the vegetation that are presently expected to negatively affect grasshopper populations are: increases in live plant basal cover, decreases in open areas in vegetation canopy cover, and increases in plant biomass. These vegetation parameters should yield lower temperatures, higher relative humidity, and reduced irradiation within the grasshopper microhabitat. These changes in the grasshopper microhabitat should affect nymphal growth and development and affect changes in the population. This report will include a summary of the native range vegetation data collected during the 1993 and 1994 field seasons (Manske 1993, Manske 1995).

Methods and Materials

Study sites were located in the McKenzie County Grazing District of the Little Missouri National Grasslands, 21 miles west of Watford City between 47^{o}35' and 47^{o}50' N. lat. and 104^{o}00' and 103^{o}45' W. long., North Dakota. This study was conducted with the cooperation of the USDA Forest Service and the McKenzie County Grazing Association. The project was funded by USDA, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Cooperative Grasshopper Integrated Pest Management Project.

The four native rangeland treatments were designed with two replications. The rotation grazing treatments had four pastures with each grazed for two periods, one period between the third leaf stage and anthesis phenophase, 1 June - 15 July, followed by a second period between anthesis and winter dormancy, 15 July - 31 October. The dates for the four pastures during 1993 were: Grazed 1st, 1-15 June and 16-31 July; Grazed 2nd, 16-24 June and 1-31 August; Grazed 3rd, 25 June - 4 July and 1-30 September; and Grazed 4th, 5-15 July and 1-31 October. The dates for the four pastures during 1994 were: Grazed 1st, 1-13 June and 16 July - 16 August; Grazed 2nd, 14-27 June and 17 August - 1 September; Grazed 3rd, 28 June - 8 July and 2-30 September; and Grazed 4th, 8-15 July and 30 September - 22 October. Calves were weaned 22 October and placed in dry lot. The dry cows were rotated through the pastures for a third rotation. The dates for the third rotation were: Grazed 1st, 7-14 November; Grazed 2nd, 31 October - 6 November; Grazed 3rd, 15-25 November; and Grazed 4th, 22-30 October. The first grazing period for the rotation system was designed to stimulate grass tiller development and activity of soil organisms in the rhizosphere. The second grazing period was designed to harvest some of the increased herbage biomass and secondary tillers (Manske 1994).

The seasonlong grazing treatments consisted of two pasture study locations each with two replications. Each study location was grazed as a single pasture from 1 June to 31 October 1993 and 1994. The ungrazed treatments consisted of two pasture study locations each with two replications. The ungrazed treatments had no livestock grazing during the 1993 and 1994 growing season but had grazing during the winters of 1992-1993 and 1993-1994. The ungrazed treatment was used as the control treatment for the vegetation data and used as the control to determine percent utilization. The long-term nongrazed treatment had not been grazed, mowed, or burned for over 35 years. A large barbed wire exclosure had been constructed on the study area in 1958. Only nondestructive sample data was collected on the long-term nongrazed exclosure treatments. Nongrazed herbage biomass data was collected in 1994 on nongrazed areas that had been excluded from grazing for a 5 year period near the nongrazed exclosure.

Vegetation data were collected on similar range sites for each replication. Aboveground plant biomass was collected on five dates from May to October 1993 by clipping five .25m^2 quadrats and on four dates from May to August 1994 by clipping four .25m^2 quadrats to ground level (Cook and Stubbendieck 1986). The major components were separated into live material (by growth form), standing dead material, and litter. Plant biomass samples were oven dried at 60^{o}C. Values reported represent amount of aboveground herbage dry matter remaining on the site on each sample date after grazing. Plant species composition was determined by the ten pin point frame method (Cook and Stubbendieck 1986) between mid July and mid August 1993 and 1994 and reported as percent basal cover. Line intercept method (Canfield 1941, Cook and Stubbendieck 1986) was modified to measure linear length of intercepted open areas not covered by vegetation canopy. Each replication was sampled four times between June and August 1993 and May and August 1994 with ten 2000 cm transects. Total percent open area not covered by canopy and a frequency distribution of the length of open areas placed in 5 cm categories ranging from 0 cm to 60 cm were determined from the line intercept data. Statistical methods used to analyze differences between means were a standard paired plot t-test (Mosteller and Rourke 1973). Each treatment except the ungrazed treatments had coordinated sample plots for micro climatic data and for grasshopper population and phenology data, which were collected and will be reported by the Rangeland Insect Laboratory research team at Bozeman.

Results and Discussion

Seasonlong grazing for five and six months during the summer has been a commonly used grazing practice in western North Dakota since the 1920's and has been regarded as a standard for vegetation responses to grazing. The seasonlong grazing treatments used during this study had not been abused in the past and were in very good condition. The basal cover was significantly ($P<0.05$) greater on the seasonlong grazing treatment than on the nongrazed treatment in 1993 but not different than the ungrazed treatment (Table 1). The basal cover was significantly ($P<0.05$) greater on the seasonlong treatments compared to the nongrazed and ungrazed treatments in 1994 (Table 2). The percent open ground on the seasonlong grazing treatments was not different than on the nongrazed and ungrazed treatments in June 1993 but percent open areas was significantly ($P<0.05$) lower in July and August than on the nongrazed treatment (Table 3). The percent open ground not covered by vegetation canopy on the seasonlong treatments was significantly ($P<0.05$) lower than the percent open ground on the ungrazed and nongrazed treatments in 1994 (Table 4).

Table 1. Percent basal cover and percent greater than nongrazed control on native range treatments, 1993.

Treatments	% Basal Cover	% Greater Than Nongrazed
Nongrazed	29.4a	0.0
Ungrazed	34.6ab	17.9
Seasonlong	36.2b	23.3
Rotation	41.6b	41.9
Grazed 1st	34.4	
Grazed 2nd	42.4	
Grazed 3rd	42.9	
Grazed 4th	46.9	

Means of same column followed by the same letter are not significantly different ($P<0.05$).

Table 2. Percent basal cover and percent greater than nongrazed control on native range treatments, 1994.

Treatments	% Basal Cover	% Greater Than Nongrazed
Nongrazed	28.3a	0.0
	±0.4	
Ungrazed	27.6a	-2.4
	±1.1	
Seasonlong	34.5b	22.2
	±0.5	
Rotation	33.2b	17.3
	±2.1	
Grazed 1st	32.6	
Grazed 2nd	31.4	
Grazed 3rd	32.0	
Grazed 4th	35.2	

Means of same column followed by the same letter are not significantly different (P<0.05).

Table 3. Percentage of ground not covered by vegetation canopy on the native range treatments, 1993.

Treatments	Early June	Late June	Mid July	Mid August
Nongrazed	-	21.1a	12.0a	11.5a
Ungrazed	-	14.8a	-	-
Seasonlong	10.5a	14.1a	7.8b	6.0b
Rotation	6.5b	3.9b	6.1b	5.9b
Grazed 1st (4)	8.0	6.4	7.3	6.3
Grazed 2nd (7)	8.2	4.8	5.3	7.9
Grazed 3rd (6)	6.9	2.0	8.1	3.8
Grazed 4th (5)	2.9	2.5	3.6	4.6

Means of same column followed by the same letter are not significantly different (P<0.05).

Table 4. Percentage of ground not covered by vegetation canopy on the native range treatments, 1994.

Treatments	Mid May	Mid June	Mid July	Mid August
Nongrazed	9.3a	-	-	-
	±1.2			
Ungrazed	9.1ab	8.6a	13.8a	18.8a
	±2.3	±1.9	±2.0	±7.4
Seasonlong	4.1c	3.6a	4.1b	5.5b
	±1.6	±1.4	±1.6	±1.1
Rotation	4.0bc	3.5b	3.6b	4.8b
	±3.2	±2.9	±2.1	±2.2
Grazed 1st (5)	0.6	0.7	1.6	2.7
Grazed 2nd (4)	4.5	2.5	3.9	5.7
Grazed 3rd (7)	4.8	4.0	3.2	5.0
Grazed 4th (6)	5.9	6.9	7.7	7.0

Means of same column followed by the same letter are not significantly different (P<0.05).

There was 70% less plant biomass on the seasonlong treatments on 15 October 1993 than on the ungrazed treatments (Table 5). The herbage biomass on the seasonlong grazing treatments in 1994 was significantly (P<0.05) lower than the herbage biomass on the ungrazed treatments in July and August and significantly (P<0.05) lower than the herbage on the nongrazed treatment in August (Table 6). The herbage biomass on the seasonlong grazing treatments was significantly (P<0.05) lower than on the rotation grazing treatments in June, July, and August (Table 6). The seasonlong grazing treatment generally had greater basal cover and lower percent open ground areas than the ungrazed and nongrazed treatments, but the seasonlong grazing treatments do not provide the changes in the vegetation that were expected to negatively affect pest grasshopper populations.

Grazing management can be used to manipulate changes in native range vegetation structure and density. Changes in vegetation on native range that were expected to show beneficial affects by negatively altering pest grasshopper habitat have been shown to occur on the twice-over rotation grazing management treatment. The twice-over rotation grazing treatment stimulates secondary tiller development which increases plant basal cover, decreases open ground not covered by vegetation canopy, and increases herbage biomass. The basal cover on the rotation treatments was 42% greater than on the long-term nongrazed treatment in 1993 (Table 1), which was significant (P<0.05). Percent plant basal cover was significantly (P<0.05) greater on the rotation treatments than the nongrazed and ungrazed treatments in 1994 (Table 2). The percentage of open ground was significantly (P<0.05) lower on the rotation treatments in 1993 than on the nongrazed and ungrazed treatments (Table 3). The percentage of open ground not covered by vegetation canopy was also significantly (P<0.05) lower on the rotation treatments in 1994 than on the nongrazed treatments (Table 4) and significantly (P<0.05) lower than on the ungrazed treatments in June, July, and

August (Table 4). The amount of plant biomass remaining on the ground on 15 October 1993 at the end of the grazing season was only 14% less on the rotation treatments than on the ungrazed treatments (Table 5). The herbage biomass remaining on the rotation treatments in 1994 was not significantly different than the amount of herbage biomass present on the ungrazed treatments in May, June, and July but was significantly ($P<0.05$) lower than the ungrazed treatments in August (Table 6). The herbage biomass remaining on the rotation treatments was significantly ($P<0.05$) greater than the amount of herbage biomass on the nongrazed treatment in May and not different than the herbage on the nongrazed treatment in June, July, and August (Table 6). The amount of herbage that was removed by livestock on the rotation treatments was not included in these data. The amount of herbage that remained on the rotation treatments after grazing was similar to the total amount of ungrazed vegetation on the ungrazed and nongrazed treatments. The amount of herbage that was removed by livestock on the rotation treatments was the amount that the herbage production had been increased as a result of the stimulation effects from the twice-over rotation grazing treatment. Increases in secondary tiller development and growth on native range grass plants can be effectively manipulated with management if a 7 to 15 day period of grazing defoliation can be coordinated on each pasture to occur some time between the third leaf stage and flowering phenological stage which generally occurs from 1 June to 15 July in western North Dakota for the major native range grass species.

The herbage biomass on the rotation pastures was significantly ($P<0.05$) greater than on the seasonlong treatments in June, July, and August (Table 6). The seasonlong treatments may also stimulate grass growth at the same phenological stages as the rotation treatment but the grass tillers were generally consumed before they could develop. The twice-over rotation system stimulates plant growth on native prairie and can be used to manipulate the vegetation in the direction that should be less suitable as grasshopper habitat.

Table 5. Total aboveground plant biomass in pounds/acre and percent utilization on native range treatments, 1993.

Treatments	1 Jun	24 Jun	19 Jul	12 Aug	Sep	15 Oct
Nongrazed	Destructive sampling data not collected on this treatment.					
Ungrazed						
lbs/acre	-	1382	1410	1152	-	1655
% utilization						
Seasonlong	I---I[a]					
lbs/acre	557	923	1094	609	-	504
% utilization		33.2	22.4	47.2		69.6
Rotation	I---I					
lbs/acre	897	998	1131	952	-	1424
% utilization		27.8	19.8	17.4		13.9
Grazed 1st (4)	I---------I		I-----------I			
lbs/acre	1024	919	818	644	-	1184
% utilization		33.5	42.0	44.1		28.4
Grazed 2nd (7)		I---------I		I------------I		
lbs/acre	819	809	829	799	-	1797
% utilization		41.4	41.2	30.6		-8.6
Grazed 3rd (6)		I----------I		I-----------------I		
lbs/acre	876	1182	1579	1048	-	1521
% utilization		14.5	-12.0	9.0	-	8.1
Grazed 4th (5)			I------I			I--------------I
lbs/acre	869	1080	1298	1314	-	1193
% utilization		21.8	7.9	-14.1		27.9

Negative percent utilization values indicate greater herbage remaining after grazing compared to ungrazed control plots.

[a]Dashed lines indicate period of grazing.

Table 6. Total aboveground plant biomass in pounds/acre and percent utilization on native range treatments, 1994.

¤ Treatments	25 May	23 Jun	20 Jul	11 Aug	Sep	Oct
Nongrazed (5 years)						
lbs/acre	589	726	974	1301	-	-
% difference	31.2	54.1	31.3	42.3	-	-
Ungrazed						
lbs/acre	857	1584	1418	2254	-	-
% utilization	-	-	-	-	-	-
Seasonlong	I--I[a]					
lbs/acre	810	835	854	749	-	-
% utilization	5.5	47.3	39.8	66.8	-	-
Rotation	I--I					
lbs/acre	875	1313	1239	1343	-	-
% utilization	-2.1	17.1	12.6	40.4	-	-
Grazed 1st (5)	I-----I		I------------I			
lbs/acre	907	1142	1539	1243	-	-
% utilization	-5.9	27.9	-8.5	44.9	-	-
Grazed 2nd (4)		I------I		I------I		
lbs/acre	912	1522	1306	1724	-	-
% utilization	-6.5	3.9	7.9	23.5	-	-
Grazed 3rd (7)		I------I		I------------I		
lbs/acre	922	1813	1196	1027	-	-
% utilization	-7.7	-14.5	15.6	54.5	-	-
Grazed 4th (6)			I----I		I-------------- I	
lbs/acre	759	775	915	1380	-	-
% utilization	11.5	51.0	35.5	38.8	-	-

Negative percent utilization values indicate greater herbage remaining after grazing compared to ungrazed control plots.

[a]Dashed lines indicate period of grazing.

Table 7. Responses of grasshoppers to the changes in vegetation caused by grazing on two grazing management systems in the Little Missouri National Grasslands near Watford City, North Dakota, 1993.

	Grazing Management		
Grasshopper Population Parameter	**Seasonlong**	**Twice Over Rotation**	**% Difference**
Density of nymphs (per yd^{-2})	17.91	3.75	-79.06
Nymphal development time (# days)	26.20	36.60	+39.69
Average daily mortality rate (%)	6.15	7.05	+14.63
Density of adults (per yd^{-2})	3.40	0.26	-92.35
Egg production (per yd^{-2})	32.70	1.80	-94.50

From J.A. Onsager, 1995.

Interpretation of the grasshopper population and phenology data for 1993 (Kemp and Onsager 1993, Onsager 1995) (Table 7) indicates a positive trend for the potential use of livestock grazing management as a tool to alter structure and density of vegetation and cause negative impacts on grasshopper populations. Generally, the nymph and adult population on the native range pastures grazed with the rotation system had lower numbers of grasshoppers than the pastures grazed with seasonlong management. The length of time required for the nymph grasshoppers to develop through their 5th instar stage was longer on the rotation pastures than on the seasonlong pastures. This increase in time is desirable and indicates that the increase in vegetation reduces the quantity of solar radiation that reaches the nymph grasshoppers and retards their growth rate. This exposes the nymph grasshoppers to numerous causes of mortality for a longer period of time. The average daily mortality rate was greater on the rotation system. The longevity of the adult grasshoppers was slightly shorter on the rotation pastures than on the seasonlong pastures. It is not known at this time if this difference in longevity is significant or not but the trend is desirable and would mean that the adults would have a shorter period of time to develop, mate, and lay eggs. With a decreased longevity, some of the adult females may not successfully lay eggs. The predicted number of eggs laid on the seasonlong pastures was eighteen times greater than on the rotation pastures.

Preliminary interpretation of the grasshopper population data for 1994 (Kemp and Onsager 1995) indicates that there were 75% fewer nymphs at the 3rd instar stage and 96% fewer adults on the rotation treatments compared to the seasonlong treatments on native range.

Conclusions

These two years of data are very promising and exciting. The data show that defoliation management with twice-over rotation grazing can cause significant changes in vegetation structure and density by timing the grazing treatments differently in relation to the phenological development of the plants. Rotation grazing defoliation treatments can be used to increase the plant density, decrease open areas, and increase plant biomass. These changes in vegetation seem to retard development of nymph grasshoppers, decrease longevity of adult grasshoppers, and reduce the numbers of living grasshoppers. The future years of this study will be able to determine if these changes in vegetation structure and density and grasshopper populations can provide long-term negative affects on the rangeland grasshopper species that are economically important.

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Modification to Crested Wheatgrass Vegetation by Grazing and Mowing Management to Affect Grasshopper Populations, 1993-1994

Llewellyn L. Manske PhD

Associate Range Scientist
North Dakota State University
Dickinson Research Extension Center

Millions of acres in the northern Great Plains exist as mixtures or monocultures of crested wheatgrass (*Agropyron cristatum* (L.) Gaertn., *A. desertorum* (Fisch.) Schult., and related taxa) because it has been the principal grass selected for use during revegetation of previously plowed rangelands in the United States and Canada (Lorenz 1986). During the first 20 years of the 20th Century, millions of acres of rangeland were turned over with the use of the steel plow in order to fulfill the compliance requirements of the Homestead Acts and because of the high demand for wheat, flax, and a few other crops. The region was experiencing favorable climatic conditions during this period and cropland production was generally successful, which stimulated the plowing of additional acres of rangeland. During the 1930's and 1940's, both Canada and the United States suffered many years of severe drought conditions and economic depression. Much of the cropland areas were abandoned and exposed to wind and water erosion. Crested wheatgrass was successfully seeded into these areas primarily because of its seedling vigor, and it helped reduce erosion problems and stabilized the land. Crested wheatgrass plants have persisted on these revegetated cropland areas because of their ability to survive unfavorable conditions of low precipitation and cold winters. Some of these areas that have been revegetated with crested wheatgrass are large enough to be used and managed as separate units. These larger areas are currently being used primarily as hay fields and as spring and summer pastures. Much of the revegetated areas are small parcels located within management units that consist mainly of some other type of plant cover. These small parcels of crested wheatgrass usually can not be isolated and managed separately because the cost of fence material and separate livestock watering facilities can not be economically justified. Proper management of these small parcels of crested wheatgrass is a problem in the northern Great Plains.

Crested wheatgrass is a very beneficial grass and is still the most often selected grass for reseeding cropland. Crested wheatgrass hay fields and pastures have made significant contributions to the production of livestock in the northern Great Plains and will continue to be an important forage grass long into the future (Lorenz 1986).

Some crested wheatgrass hay fields and pastures may provide suitable habitat for pest grasshopper population development. The natural growth form of crested wheatgrass is primarily widely spaced large bunches or widely spaced single tillers and small bunches. These growth characteristics of open canopy provide favorable habitat for several pest grasshopper species (Onsager 1995, and pers. comm.). Many of the grasshopper "hot spots" in the northern Great Plains are found on crested wheatgrass hay fields and pastures. If grazing and mowing management practices could be developed to manipulate the crested wheatgrass plants to grow, increase in tiller development, and decrease the size of the open canopy areas, then we may be able to negatively affect the pest grasshopper species' populations.

This research project was conducted to determine if cultural management practices can be used to manipulate beneficial changes in vegetation structure and density and negatively affect grasshopper nymphal development and adult egg laying. This was a cooperative project between the Range Research Laboratory at NDSU, Dickinson Research Center, Dickinson, North Dakota, and USDA-ARS, Rangeland

Insect Laboratory, Bozeman, Montana. The range laboratory team was responsible for the grazing management and vegetation data and the insect laboratory team was responsible for the grasshopper and micro-climatic data.

The basic premise that we are working with is that most of the rangeland pest grasshopper species are favored by open canopy and bare areas which are used by the grasshoppers to provide access to solar radiation during nymphal development for thermoregulation and by some species for egg laying sites. The assumption that we have made from this premise and are testing with this project is that if defoliation management treatments using grazing and/or mowing can be developed that decrease open areas in the vegetation canopy then grasshopper development should be affected and should be shown as a change in the population density or species composition. The alternative to this first assumption is that if management can not be developed that causes a decrease in the canopy open areas for the entire year, then we should find management practices that annually change the time when the open areas occur and are available for grasshopper use. This should, presumably, disrupt the natural patterns of the grasshoppers' phenological development enough to affect the populations, and assure that no single pest grasshopper species would be strongly favored for successive years.

The changes in the vegetation that are presently expected to negatively affect grasshopper populations are: increases in live plant basal cover, decreases in open areas in vegetation canopy cover, and increases in plant biomass. These vegetation parameters should yield lower temperatures, higher relative humidity, and reduced irradiation within the grasshopper microhabitat. These changes in the grasshopper microhabitat should affect nymphal growth and development and affect changes in the population. This report will include a summary of the crested wheatgrass vegetation data collected during the 1993 and 1994 field seasons (Manske 1993, Manske 1995).

Methods and Materials

Study sites were located in the McKenzie County Grazing District of the Little Missouri National Grasslands, 21 miles west of Watford City between 47°35' and 47°50' N. lat. and 104°00' and 103°45' W. long., North Dakota. This study was conducted with the cooperation of the USDA Forest Service and the McKenzie County Grazing Association. The project was funded by USDA, Animal and Plant Health Inspection Service, Plant Protection and Quarantine, Cooperative Grasshopper Integrated Pest Management Project.

The four crested wheatgrass management treatments were designed with two replications each. The mowing treatments had been mowed for hay production with one annual cutting in late June or early July and had not been grazed. The mowing treatments were cut in late June 1993 and 1994. The mowing plus spring grazing treatments were used as spring pasture during 1 to 31 May 1993 and from 28 April to 1 June 1994. A large portion of this spring pasture was mowed for hay in late July and early August of 1992 but not mowed in 1993 or 1994. The spring grazing treatments were used as spring pastures during 1 to 31 May 1993 and from 28 April to 1 June 1994 and have not been mowed or burned. The seasonlong grazing treatments were part of a large pasture of native range interspersed with several areas of seeded crested wheatgrass grazed from 1 June to 31 October 1993 and 1994.

Vegetation data were collected on similar range sites for each replication. Aboveground plant biomass was collected on five dates from May to October 1993 by clipping five .25m^2 quadrats and on four dates from May to August 1994 by clipping four .25m^2 quadrats to ground level (Cook and Stubbendieck 1986). The major components were separated into live material (by growth form), standing dead material, and litter. Plant biomass samples were oven dried at 60°C. Values reported represent amount of aboveground herbage dry matter remaining on the site on each sample date after grazing or mowing. Plant species composition was determined by the ten pin point frame method (Cook and Stubbendieck 1986) between mid July and mid August 1993 and 1994 and reported as percent basal cover. Line intercept method (Canfield 1941, Cook and Stubbendieck 1986) was modified to measure linear length of intercepted open areas not covered by vegetation canopy. Each replication was sampled four times between June and August 1993 and three times between June and August 1994 with ten 2000 cm transects. Total percent open area not covered by canopy and a frequency distribution of the length of open areas placed in 5 cm categories ranging from 0 cm to 60 cm were determined from the line intercept data. Statistical methods used to analyze differences between means were a standard paired plot t-test (Mosteller and Rourke 1973). Each treatment had coordinated sample plots for micro climatic data and grasshopper population and phenology data which were collected, and will be reported by the Rangeland Insect Laboratory research team.

Results and Discussion

Mowing crested wheatgrass for hay generally occurs after the plants have passed the flowering (anthesis) phenological stage of development in late June and July. The plants under this type of management develop into large widely-spaced bunches. The basal cover of the mowing treatment in this study was significantly ($P<0.05$) lower than on the other crested wheatgrass treatments in 1993 and 1994 (Table 1 and 2). The percentage of open ground not covered by vegetation canopy was significantly ($P<0.05$) greater on the mowing treatments than the other treatments during June and July in 1993 and 1994 (Table 3 and 4). The differences in treatments are not as clear for the early stages of growth in May and late stages of growth in August.

The mowed treatments and the grazed seasonlong treatments had the greatest amount of plant biomass remaining on 15 October 1993 (Table 5). The aboveground herbage biomass on the mowing treatments was not significantly ($P<0.05$) different than the mowing and grazing, and spring grazing treatments in mid July 1994 (Table 6). The aboveground herbage biomass on the grazing seasonlong treatments was significantly ($P<0.05$) greater than on the other treatments in mid July 1994 (Table 6).

Mowing crested wheatgrass in late June or July would not be the management treatment selected as the tool to manipulate the vegetation to reduce the open areas and increase basal cover and negatively affect habitat for most pest grasshopper species on crested wheatgrass.

Many crested wheatgrass areas are used as hay fields and mowed in late June or July and also used as pastures and grazed in early spring or late summer and early fall. Very little quantitative information is available of the effects of this double use management on plant basal cover and percent open canopy. A large area in a spring crested wheatgrass pasture was mowed for hay in late June of 1992 and not mowed in 1993 or 1994 but grazed during the spring of 1993 and 1994. The mowing and grazing treatment had significantly ($P<0.05$) lower basal cover in 1993 than the spring grazing treatment (Table 1) and the mowing and grazing treatment had significantly ($P<0.05$) greater percent open ground not covered by vegetation canopy than the spring grazing treatment for June, July, and August in 1993 (Table 3). In 1994, basal cover (Table 2) and percent open ground not covered by vegetation canopy (Table 4) was not significantly different between the mowing and spring grazing treatments and the spring grazing treatments. The additional pressure of grazing and mowing crested wheatgrass during the same year caused a decrease in plant basal cover and an increase in percent open ground not covered by vegetation canopy. These negative effects were measurable during the entire growing season of the year following treatment.

The double use treatment of grazing crested wheatgrass in the spring and mowing the same area for hay later that same year would not be the management treatment selected as the tool to manipulate the vegetation to reduce the open areas and increase basal cover and negatively affect habitat for most pest grasshopper species on crested wheatgrass.

The spring grazing treatments had significantly ($P<0.05$) greater basal cover (Table 1) and significantly ($P<0.05$) less open ground not covered by vegetation canopy in June and August than the other three treatments in 1993 (Table 3). In 1994, the spring grazing treatments had significantly ($P<0.05$) greater basal cover than the mowing treatments but not the other grazing treatments (Table 2). The spring grazing treatments had significantly ($P<0.05$) less open ground than the mowing treatments in June and July but not the other grazing treatments (Table 4).

Spring grazing of crested wheatgrass is the management treatment that reduces the size of the bunches and increases the number of tillers when the defoliation period occurs between the third leaf stage and flowering (anthesis) phenological growth stage. In western North Dakota, these phenological stages for crested wheatgrass generally occur during the month of May but can start during the last week in April and go until the second week in June.

The crested wheatgrass spring grazing treatments at the Dickinson Research Center have been grazed during the month of May for 12 years (1983-1994) and had very high basal cover of 44.8% in 1993 and very low percent open ground values of 6.5% and 6.4% in July of 1993 and 1994, respectively. The spring grazing treatment is a tested management treatment that is currently available that can be used to manipulate the vegetation on crested wheatgrass pastures to increase plant basal cover and reduce the percentage of open ground not covered by vegetation canopy. Spring grazing crested wheatgrass during the month of May between the third leaf stage and anthesis (flowering) phenological growth stage would be the management treatment selected as the tool to negatively affect habitat for most pest grasshopper species.

The grazing seasonlong treatment is not a desirable management strategy for use of crested wheatgrass pastures but it is a commonly used grazing practice in the northern Great Plains. The grazing seasonlong treatments had significantly ($P<0.05$) lower basal cover (Table 1) and significantly ($P<0.05$) greater open ground than the spring grazing treatments in June and August 1993 (Table 3). In 1994, the basal cover was similar between the grazing seasonlong and spring grazing treatments (Table 2) and the percentage of open ground was significantly ($P<0.05$) lower on the grazing seasonlong treatments than the spring grazing treatments in May and July (Table 4). The vegetation on the grazing seasonlong treatment had lower basal cover and more open ground than the spring grazing treatments in 1993 and provided more suitable habitat for pest grasshoppers. The vegetation on the grazing seasonlong treatments moved in a desirable direction between 1993 and 1994 to be less suitable as grasshopper habitat. The vegetation on the spring grazing treatments moved in a less than desirable direction between 1993 and 1994 to be more suitable as grasshopper habitat. In 1994, there was no difference in basal cover between grazing seasonlong and spring grazing treatments, and there was no difference in the percent open ground for one third of the sample periods. The changes in the vegetation on the seasonlong grazing treatment between 1993 and 1994 are believed to be not caused by effects of defoliation by grazing for a five month period but rather primarily due to timely precipitation patterns and relatively low grazing pressure from late June through August. The seasonlong grazing treatment may be able to develop favorable basal cover and percent open ground values similar to the spring grazing treatments during some years but the seasonlong grazing treatment on crested wheatgrass is not a desirable management practice for livestock production.

Conclusions

The changes in the crested wheatgrass vegetation that are expected to negatively affect grasshopper populations can be accomplished by the spring grazing treatment. The spring grazing treatment stimulates plant tiller development, which increases basal cover, and this in turn reduces the percentage of open ground not covered by vegetation canopy. Defoliation of crested wheatgrass with grazing after the third leaf stage and before anthesis (flowering) phenological growth stages stimulates tiller development.

Mowing treatments in late June and July after the anthesis (flowering) phenophase do not stimulate tiller development and do not manipulate changes in the vegetation that were expected to negatively affect pest grasshoppers. These data do not eliminate all mowing treatments as beneficial management tools. Mowing before the flowering phenophase may stimulate beneficial tiller development similarly to grazing defoliation at that same growth stage. Mowing at the early boot stage, for example, may stimulate tiller development and increase basal cover. Mowing at an earlier date and growth stage may also increase the amounts of harvested crude protein per acre.

Mowing and grazing crested wheatgrass during the same year puts stress on the plants that causes reductions in basal cover and increases in percent open ground. Double-use treatments on crested wheatgrass are not management tools that beneficially manipulate the vegetation to have negative effects on the pest grasshopper populations.

The effects of seasonlong grazing on the crested wheatgrass vegetation are difficult to interpret from the data collected during this study. The basal cover and percent open ground were different than the spring grazing treatments in 1993 but generally not different in 1994. The changes in the vegetation on the seasonlong grazing treatments are believed to be not due to a treatment effect from five months of grazing but rather primarily due to timely precipitation patterns and relatively low grazing pressure from late June through August. The seasonlong grazing treatment on crested wheatgrass is not a desirable management practice for livestock production.

Spring grazing of crested wheatgrass can be used as a management tool to increase plant basal cover, decrease percent open areas not covered by vegetation canopy, and increase herbage biomass.

Table 1. Percent basal cover and percent greater than mowed treatment on crested wheatgrass treatments, 1993.

Treatments	% Basal Cover	% Greater Than Mowed
Mowed	28.9a	0.0
Mowed/Grazed	35.5b	22.9
Grazed Spring	39.8c	37.6
Grazed Seasonlong	36.0b	24.7

Means of same column followed by the same letter are not significantly different (P<0.05).

Table 2. Percent basal cover and percent greater than mowed treatment on crested wheatgrass treatments, 1994.

Treatments	% Basal Cover	% Greater Than Mowed
Mowed	17.6a	0.0
	±0.6	
Mowed/Grazed	25.0b	42.1
	±3.4	
Grazed Spring	24.1b	36.9
	±2.6	
Grazed Seasonlong	26.1b	48.3
	±2.3	

Means of same column followed by the same letter are not significantly different (P<0.05).

Table 3. Percentage of ground not covered by vegetation canopy on the crested wheatgrass treatments, 1993.

Treatments	Early June	Late June	Mid July	Mid August
Mowed				
Pretreatment	26.4a	36.0a	-	-
Post treatment	-	50.9a	20.1a	23.1a
Mowed/Grazed	9.6b	8.3b	7.7b	13.5a
Grazed Spring	3.3c	4.6c	10.7c	7.8b
Grazed Seasonlong	-	17.3d	10.9c	13.9a

Means of same column followed by the same letter are not significantly different (P<0.05).

Table 4. Percentage of ground not covered by vegetation canopy on the crested wheatgrass treatments, 1994.

Treatments	Mid May	Mid June	Mid July	Mid August
Mowed				
Pretreatment	10.2a	17.5a	-	-
	±4.6	±5.5		
Post treatment	-	-	21.9a	-
			±6.4	
Mowed/Grazed	8.5a	8.3b	10.5b	-
	±3.8	±3.5	±2.6	
Grazed Spring	6.0a	6.9b	10.5b	-
	±2.4	±5.0	±3.5	
Grazed Seasonlong	2.6b	3.6b	3.9c	-
	±0.9	±1.2	±0.5	

Means of same column followed by the same letter are not significantly different (P<0.05).

Table 5. Total aboveground plant biomass in pounds/acre on crested wheatgrass treatments, 1993.

Treatments	1 May	1 Jun	24 Jun	19 Jul	12 Aug	Sep	15 Oct
Mowed			I				
Pretreatment							
lbs/acre	-	1307	1441	-	-	-	-
Post treatment							
lbs/acre	-	-	1005	1663	1392	-	1652
Mowed/Grazed	I-------------I[a]						
lbs/acre	-	828	727	1060	669	-	914
Grazed Spring	I--------------I						
lbs/acre	-	1097	735	837	1560	-	888
Grazed Seasonlong		I---I					
lbs/acre	-	-	1164	1364	1131	-	1331

[a] Dashed lines indicate period of grazing.

Table 6. Total aboveground plant biomass in pounds/acre on crested wheatgrass treatments, 1994.

Treatments	1 May	23 May	21 Jun	18 Jul	11 Aug	Sep	Oct
Mowed				I			
Pretreatment							
lbs/acre	-	2029	2293	-	-	-	-
Post treatment							
lbs/acre	-	-	-	547	693	-	-
Mowed/Grazed	I---------------------I[a]						
lbs/acre	-	451	495	467	572	-	-
Grazed Spring	I----------------------I						
lbs/acre	-	397	490	441	470	-	-
Grazed Seasonlong			I--I				
lbs/acre	-	1217	1122	840	706	-	-

[a] Dashed lines indicate period of grazing.

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Grazing Annual Forage Pastures

Llewellyn L. Manske and James L. Nelson

Associate Range Scientist and Animal Scientist
North Dakota State University
Dickinson Research Extension Center

North Dakota is famous worldwide for its agricultural production and has ranked as a major leader in our nation's production of flaxseed, durum wheat, spring wheat, sunflowers, barley, oats, beans, and rye for numerous years. North Dakota State University agricultural research has made major contributions towards the continued advancement in agricultural science and technology that has helped North Dakota agricultural producers maintain the state's leadership in agriculture. Even with these advancements from research, agriculture production in western North Dakota is not problem free. The present economic situation in our country is such that the prices received for agricultural commodities are relatively low compared to the relatively high costs of production which gives many producers of traditional agronomic crops relatively low net returns per acre from their capital investment. There are numerous different potential avenues to pursue through research to address these problems and several dedicated scientists are presently pursuing some of these many lines of study.

One avenue of study would be to look at the potential for increasing net return per acre by investigating the alternative use of cropland by growing annual forages for livestock production which would be harvested as forage in the form of hay or silage, or grazed in the field during the growing season. A study has been started at the Dickinson Research Extension Center to investigate the possibility of using traditional crop production land for livestock production by seeding cropland acres to annual forages and grazing cow-calf pairs during the summer. Two years of this study have been completed and the information collected has been included in this report.

There are numerous factors that are unknown at the present time about the management strategies of grazing annual forages. Research results are needed to evaluate which forage types and varieties will work best during the different seasonal periods of the growing season. Scientific studies are needed to determine the seeding rates and the ratios of each forage type when used in mixtures and on the seeding dates to match a desired target grazing date. Scientific studies are also needed to understand the growth rate of forage types when seeded at different times and the phenological stage of growth to initiate grazing. Research results are needed to determine the length of time that the forage types can be grazed and to determine the optimum period of grazing during the growing season. Quantitative analyses are needed on the nutritional quality of the forages at various stages of growth. The level of stocking rate on the forages and the rate of growth of the cows and calves when grazing annual forages at various stages of plant growth needs to be determined, in addition to determining potential net returns per acre and how they compare to grazing native range or to traditional crop production on similar acres. Grazing annual forages in western North Dakota traditionally has been recommended as an emergency use measure during periods when perennial plant forage is expected to be limited. If this research project can address and resolve the inherent problems, we should be able to develop recommendations for management strategies for grazing annual forages to be used as standard livestock production practices for western North Dakota.

Methods and Materials

The study site is located 20 miles north of Dickinson in southwestern North Dakota, U.S.A. (47^o 14' N. lat., 102^o 50' W. long.) on the Dickinson Research Extension Center ranch operated by North Dakota State University. Soils are primarily Typic Haploborolls. Long-term monthly temperature and precipitation data are shown in table 1. Average annual precipitation is 15.3 in. (389 mm) with 75% falling as rain between April and September. Temperatures average 66^o F (19^o C) in summer with average daily maximums of 80^o F (27^o C). Winter average daily temperatures are 16^o F (-9^o C) with average daily minimums of 2^o F (-17^o C).

Table 1. Long-term monthly temperature and precipitation at the Dickinson Research Center Ranch Headquarters for the years 1982 – 1994.

	1982 - 1994	
	Average F°	**Inches**
	Temperature	**Precipitation**
January	14.6	0.44
February	18.7	0.33
March	30.7	0.79
April	42.6	1.46
May	54.7	1.81
June	63.5	3.07
July	68.6	2.26
August	68.2	1.45
September	56.2	1.39
October	44.1	1.37
November	27.1	0.53
December	16.1	0.41
Total Precipitation		**15.31**

The grazed annual forage fields were designed with two replications of four treatments for a total of eight fields. The fields were numbered 1-8 with fields #1-4 making up the north replication and fields #5-8 making up the south replication. Each replicated field was 8.3 acres in size. The annual forages selected for the 1993 and 1994 preliminary trial were: oats-peas, siberian millet, pearl millet, and winter rye. The original intent was to graze oats-peas in June, early pearl millet in July, siberian millet in August, late pearl millet in September, and winter rye in October and the following May, and then repeat the entire sequence the following year. This management strategy required double cropping on some of the fields. The winter rye treatment was intended to be seeded on the oats-peas fields and the second pearl millet treatment was intended to be seeded on the winter rye fields after the livestock had finished grazing each of the previous treatments. The seeding dates were initially set to be six weeks ahead of initial grazing start dates for each forage treatment. The desired phenological stage of growth at the initial grazing date was pre-boot with three to five leaves. The management strategies that were designed to be tested initially during this study were developed during a two day conference from the collective knowledge of several agronomists, animal scientists, economists, and range scientists that work in western North Dakota.

Vegetation data were collected similarly on each forage treatment. Aboveground plant biomass was collected on initial and final grazing dates by clipping ten .25m^2 quadrats to ground level (Cook and Stubbendieck 1986) distributed across the length of each field. The major components were separated into seeded forage plants and unseeded weeds. Plant biomass samples were oven dried at 140^o F (60^o C). Values reported represent amount of aboveground herbage dry biomass present on the site on each sample date. The differences in herbage biomass between the initial and final grazing dates were considered to be the quantity of herbage used by the livestock. The term herbage use in this report follows the definition used by the Society for Range Management (Jacoby 1989), which refers to herbage use as "the proportion of current year's forage production that is consumed or destroyed by grazing animals". Herbage use should not be confused with herbage dry matter intake which would be just the amount of herbage consumed by the livestock. Herbage use includes the amount of herbage that was trampled, broken off, defecated on, etc., plus the amount of herbage consumed. Animal dry matter consumption was not measured during this study and is assumed to be 2% of body weight (Holechek, Pieper, and Herbel 1989). Percent use was determined by using the difference in herbage weight between the initial and final grazing dates as a percentage of the initial herbage weight.

Individual animals were weighed on and off each treatment. Liveweight performance of accumulated weight gain, average daily gain, and average gain per acre for cows and calves were used to evaluate each treatment. Body condition scores (Wagner *et al.* 1988) for cows were evaluated on each weigh date in 1994.

Commercial crossbred Angus-Hereford (baldy) cows with Charolais sired calves were used on this study. Seventeen cow-calf pairs were used in 1993 and twelve pairs were used in 1994. Bulls were turned out with the cows from 5 June to 24 August in 1993, and from 7 June to 8 August in 1994. Calves were born between 4 February and 21 April 1993, and between 14 March and 9 April 1994. Herd health management programs followed North Dakota State University recommendations. All cows were vaccinated with Scourguard-III^R prior to calving and were given an injection of Preg-guard 9^R prior to breeding in 1993 and 1994. Calves were vaccinated with 7-way clostridial vaccine and injected with Type C and D antitoxin as a booster in 1993 and 1994. Calves were branded, castrated, and dehorned as needed in late April prior to turn out on pasture. Cattle had access to a free-choice salt (2 parts) and di-calcium phosphate (1 part) mixture while on pasture. Horn flies were controlled with insecticides applied as a pour-on along the backs of cows and bulls on weigh dates during the summer.

Results

Weather Data

Weather conditions during this study (1993 and 1994) and the preceding year (1992) are summarized in table 2. Mean monthly temperatures in 1992 for the six month period of April - September were near long-term means. Mean monthly temperatures for July and August were below long-term means. Precipitation for April - September was less than 75% of the long-term mean which indicates that the growing season of 1992 was under drought conditions. Precipitation in April, May, June, and September was less than 50% of the long-term mean. Precipitation in July and August was 127% of the long-term mean.

Mean monthly temperatures in 1993 for the six month period of April - September were near long-term means. Mean monthly temperatures for June, July, August, and September were all below long-term mean temperatures. Precipitation for April - September was above long-term means. Precipitation in June and July was over 181% of the long-term mean. Precipitation in April, May, August, and September was below the long-term mean.

Mean monthly temperatures in 1994 for the six month period of April - September were near long-term means. April, May, June, and September had above long-term mean temperatures. Precipitation for April - September was below the long-term mean. June was the only month that precipitation levels were greater than the long-term mean. Precipitation in April, July, and August was only 43% of the long-term mean which caused considerable water stress for growing plants during those months.

Table 2. Monthly temperature and precipitation at the Dickinson Research Center Ranch Headquarters for the years 1992, 1993, and 1994.

	1992			1993			1994	
	Average F° Temperature	**Inches Precipitation**		**Average F° Temperature**	**Inches Precipitation**		**Average F° Temperature**	**Inches Precipitation**
January	25.6	0.46		7.8	0.40		1.9	0.86
February	28.5	0.30		12.8	0.37		5.5	0.33
March	35.6	0.72		33.9	0.37		34.2	0.38
April	41.5	0.81		42.3	1.41		43.1	0.86
May	56.8	0.68		55.0	1.71		57.8	1.46
June	64.6	1.59		58.8	4.57		63.6	4.51
July	62.4	2.70		61.9	5.10		67.0	1.07
August	64.4	2.02		64.3	1.24		67.6	0.31
September	56.2	0.72		53.8	0.18		61.7	1.08
October	46.5	0.16		42.6	0.05		46.3	4.58
November	26.9	0.91		25.8	1.28		29.5	0.52
December	9.4	0.16		21.1	0.68		22.0	0.18
Total Precipitation		**11.23**			**17.36**			**16.14**

Seeding Techniques

Table 3 shows the seeding information. Two replications of oats-peas were seeded each year of the study by conventional tillage practices. A commercially prepared mixture with inoculum was seeded. Two replications of siberian millet were seeded in early June each year of the study. A third treatment of siberian millet was seeded in August 1994 onto one treatment of winter rye after the livestock had been removed. This treatment was not successful and not grazed in 1994. Two treatments of pearl millet were seeded in 1993. One treatment was intended to be grazed early in July and the second was intended to be grazed late in September. The first treatment was not successful and not grazed. The second was low in herbage production but grazed. Pearl millet was not seeded in 1994 because of growth and stand establishment problems in 1993. These inconsistent growth problems with pearl millet indicate that additional small plot work with pearl millet on agronomic management techniques and seeding dates are needed for western North Dakota.

Winter rye was seeded on two treatments in August 1993. The plants were slow to develop primarily because August through October had low precipitation in 1993. In the fall of 1993, early growth of winter rye plants was consumed by grasshoppers to ground level. The growth on these treatments was slow in the spring of 1994 and required some additional time to develop. The treatments were grazed in July with the initial grazing started after the plants had reached flowering stage, which was too mature. Field #2-6 was seeded to siberian millet by reduced-till techniques over the winter rye but was not successful. Some winter rye plants were present in the spring of 1995 but were not numerous enough for grazing. Field #3-7 was mowed with a rotary mower and then worked with a tandem disk in August 1994. Field #3-7 did not have an adequate quantity of herbage to be grazed in October 1994. Field #3-7 had a successful stand of winter rye plants in spring 1995.

Table 4 shows the desired and actual seeding and initial grazing dates. We had considerable difficulty in matching the actual seeding date with the desired seeding date because of work schedule priorities and weather conditions during this study, which confounded the problem of matching the actual initial grazing date near to the intended desired grazing date. Generally, the initial grazing dates have been at phenological stages of growth that were more mature than desirable. This in effect shortened the grazing period as the plants had little or no tillering and reached mature phenological stages and became less desirable as forage by livestock which resulted in removal of the livestock while considerable herbage still remained in the field. The original plan of having the seeding date about 6 weeks ahead of the desired initial grazing date still seems to be a viable model to follow. Weather conditions around the seeding date and during early development stages cause variable rates of plant growth and seem to be the major problem that hinders the actual implementation of this concept into practice.

Grazing Data

Table 5 shows the grazing dates and stocking rates. These values should be considered as preliminary and they are expected to improve as the study develops. It was expected that each treatment could be grazed for a 30 day period, and based on herbage yields from agronomy plot data collected from hay production studies it was expected that only 0.50 acre would be required to carry one cow-calf pair for a month. This assumption was too optimistic. The field herbage yields did not match the agronomic plot yields primarily because of differences in soil type and management levels. All of the herbage production can not be considered as forage for the livestock. Some portion of the total herbage production will need to be allotted as residual vegetation because the livestock will not be able to consume all of the herbage. The amount of vegetation that will be left in the field after grazing is not known at the present time.

Table 3. Seeding information for grazed annual forage fields.

Treatment Year	Field #	Variety	Type of Tillage[1]	Germin-ation %	Seed Rate PLS[2] lb/ac	Seed Rate Bulk lb/ac	Price $/lb	Seed Cost $/ac
Oats-Peas								
1993	3-7	Otana-Trapper	Conventional	90	99	110[3]	0.17	18.70
1994	1-5	Otana-Trapper	Conventional	90	99	110[3]	0.17	18.70
Siberian Millet								
1993	1-5	Common	Conventional	95	19	20	0.35	7.00
1994	4-8	Common	Conventional	95	19	20	0.35	7.00
	2-6	Common	Reduced-till	95	19	20	0.35	7.00
Pearl Millet								
1993	2-6	Hybrid Pearl	Conventional	95	19	20	0.45	9.00
	4-8	Hybrid Pearl	Conventional	95	19	20	0.45	9.00
1994	Treatment not seeded							
Winter Rye								
1993	2-6	Dacold	Reduced-till[4]	97	58.2	60	0.085	5.09
	3-7	Dacold	Conventional[4]	97	58.2	60	0.085	5.09
1994	2-6	Dacold	No agronomic management					
	3-7	Dacold	Mowed & Disked					

1 All treatments fertilized at seeding date with 60 lbs/acre of 28-28-0
2 Pure live seed
3 Commercially prepared mixture with inoculum
4 Plus heavy duty disk

Table 4. Seeding and grazing dates for annual forage fields.

Treatment Year	Field #		Desired Seed Date	Desired Initial Graze Date	Desired Age of Stand # Weeks		Actual Seed Date	Actual Initial Graze Date	Actual Age of Stand # Weeks
Oats-Peas									
1993	3-7		E Apr	1 Jun	6		24 Apr	13 Jul	11.4
1994	1-5		E Apr	1 Jun	6		7-8 May	13 Jul	9.6
Siberian Millet									
1993	1-5		Mid Jun	1 Aug	6		1-7 Jun	1 Sep	13.1
1994	4-8		Mid Jun	1 Aug	6		E Jun	23 Aug	12.0
	2-6						Aug	Not Grazed	
Pearl Millet									
1993	2-6		Mid May	1 Jul	6		1-7 May	Not Grazed	
	4-8		L Jun	1 Sep	9		Mid Jul	15 Sep	8.9
1994	Treatment not seeded								
Winter Rye									
1993	2-6		Mid Aug	1 Oct	6		E Aug	Oct[1]	
				1 May	34				
	3-7		Mid Aug	1 Oct	6		E Aug	Oct[1]	
				1 May	34				
1994	2-6		Mid Aug	1 May	34		Aug 1993	15 Jun	43.4
	3-7		Mid Aug	1 May	34		Aug 1993	1 Jul	45.6
	3-7		Mid Aug	1 Oct	6		Aug[2]	Oct[1]	
				1 May	34				

1 Not grazed
2 Mowed and disked

Table 5. Stocking rates for grazed annual forage fields.

Forage Year	Dates	Number of Days	Number of Cow-Calf Pairs	AUMs[1]	AUM/ac	Acre/AUM
Oats-Peas						
1993	13 Jul – 27 Jul	14	17	7.80	0.94	1.06
1994	13 Jul – 8 Aug	26	12	10.23	1.23	0.81
Siberian Millet						
1993	1 Sep - 15 Sep					
	and	20	17	11.15	1.34	0.74
	8 Oct - 14 Oct					
1994	23 Aug - 6 Sep	14	12	5.51	0.66	1.51
Pearl Millet						
1993	15 Sep - 8 Oct	23	17	12.82	1.54	0.65
1994	-	-	-	-	-	-
Winter Rye						
1993	-	-	-	-	-	-
1994						
Field #2-6	15 Jun - 1 Jul	14	12	5.51	0.66	1.51
Field #3-7	1 Jul - 14 Jul	13	12	5.11	0.62	1.62

1 Animal Unit Months

Herbage Production and Animal Performance

Herbage production for each annual forage treatment was evaluated from oven dried samples clipped before and after grazing. The change in herbage biomass between those dates was considered to be the quantity of herbage used by the livestock. Exclosure cage samples were not available to help evaluate the quantity of herbage biomass produced while the livestock were grazing each treatment. A value of 8.3 acres was used as the size of the seeded annual forage for each treatment. Each field also had small areas of perennial grass that were used as travel lanes to water. The quantity of forage on the travel lanes was not measured.

Animal performance on each treatment was evaluated as independent events and considered to be the change in liveweight between the initial grazing date and the final grazing date. Animal dry matter intake was assumed to be 2% of body weight which would mean that a 1200 pound cow would be expected to consume 24 pounds of dry forage per day.

Oats-Peas

Oats-peas were grazed for 14 days in 1993 and 26 days in 1994 (Table 5). This treatment required an average of 0.94 acres for each animal unit month (AUM) of grazing. The target grazing period for the month of June was not met. The grazing period in 1993 was from mid July to late July and in 1994 from mid July to early August. The phenological stage of growth for the oats plants at the initial grazing date both years was past head emergence in the milk or soft dough stage and the peas were past flowering with peas already formed in the pod. The phenological stages of growth after the boot stage and before hard dough stage would be ideal for harvest as hay or silage for oats plants. These late stages of growth appear to be too mature to be used as an optimum initial grazing date. Presently, it is felt that a vegetative stage before boot for the oats would be a more advantageous time to start grazing. This growth stage would coincide closely with the 5^{th} leaf stage as was recommended by Dodds (1986).

The herbage production (Table 6) for the oats-peas treatment was 2684 lbs/acre at the initial grazing date in 1993. Some additional growth from the oats-peas apparently occurred after mid July while livestock were grazing the fields because only 593 lbs/acre of plant biomass was used by the livestock. This quantity of herbage provided only 20.69 pounds of herbage use per cow-calf pair per day which seems to be low. A wet period existed in 1993 while the livestock were grazing the oats-peas treatment. Precipitation in July 1993 was 5.10 inches which was 226% of the long-term mean. Livestock were taken off of this treatment early because of muddy conditions. A large portion of the herbage had been trampled and 2091 lbs/acre of oats-peas were left in the field. The percent use on the oats-peas was only 22.1% in 1993.

The herbage production (Table 6) for the oats-peas treatment was 1692 lbs/acre on the initial grazing date in 1994. Livestock used 1222 lbs/acre of the herbage which provided an average of 32.5 pounds of herbage use per cow-calf pair per day. At the end of the grazing period, 470 lbs/acre of oats-peas were left in the field. The percent use on the oats-peas was 74% in 1994. The herbage that remained on the field in 1994 was mainly oats stems.

Animal performance (Table 7) on the oats-peas treatment was very good both years. The calves accumulated an average of 53 pounds per head while on the field and averaged a daily gain of 2.75 pounds and a gain per acre of 89.7 pounds. The cows accumulated an average of 48 pounds per head while on the oats-peas treatment with an average daily gain of 2.34 pounds and an average gain per acre of 78.5 pounds.

Table 6. Aboveground biomass on oats and peas grazed annual forage fields.

		lbs/acre			
Year	**Forage**	**Initial Date**	**Final Date**	**Difference**	**Percent Use**
1993		**13 Jul**	**27 Jul**		
	Oats	1326.4	1030.4	296.0	22.3
	Peas	1357.5	1060.2	297.2	21.9
	Weeds	427.6	496.0	-68.3	-16.0
	TOTAL	3111.5	2586.6	524.9	16.9
1994		**13 Jul**	**8 Aug**		
	Oats	1316.8	383.7	933.0	70.9
	Peas	375.4	86.2	289.1	77.0
	Weeds	91.0	107.1	-16.1	-17.7
	TOTAL	1783.1	577.1	1206.1	67.6

Negative values indicate growth exceeded use.

Table 7. Animal performance on oats and peas grazed annual forage fields.

<u>Year</u> Livestock	Initial Date	Final Date	Number of Days	Gain per Head	Average Daily Gain	Gain per Acre
1993	**13 Jul**	**27 Jul**	14			
Cow LW[1] lbs	1160.0	1189.0		29.0	2.07	59.34
BCS[2]	-	-		-		
Calf LW lbs	323.9	366.0		42.1	3.01	86.27
1994	**13 Jul**	**8 Aug**	26			
Cow LW lbs	1075.2	1142.7		67.5	2.60	97.65
BCS	5.8	6.3		+0.5		
Calf LW lbs	278.7	343.1		64.4	2.48	93.13

1 Liveweight
2 Body condition score

Siberian Millet

Siberian millet was grazed for 20 days in 1993 and 14 days in 1994 (Table 5). This treatment required an average of 1.13 acres per animal unit month of grazing. The original goal to graze siberian millet during August was not met. The grazing period in 1993 was from early September to mid October and in 1994 from late August to early September. The phenological stage of the initial grazing dates for both years was past head emergence during seed development. The seed developing stages of growth would be good for harvesting as hay or silage. These late stages of growth appear to be too mature to be used as an optimum initial grazing date for siberian millet. Presently, it is felt that a phenological stage of early growth before boot stage would be a more advantageous time to start grazing siberian millet.

A third treatment of siberian millet was seeded in August 1994 by reduced tillage techniques on top of the winter rye field #2-6. No herbicide treatments were used to reduce the winter rye plant population. The siberian millet developed poorly on this late seeding and the stand did not have adequate herbage to permit grazing in the fall of 1994. Some volunteer winter rye plants grew on the field in spring 1995 but were not dense enough to provide adequate herbage for spring grazing.

Herbage production (Table 8) for the siberian millet treatment was 1301 lbs/acre on the initial grazing date in 1993. Livestock used 745 lbs/acre of herbage which provided an average 18.20 pounds of millet use per cow-calf pair per day. In addition, 9.38 pounds of weed herbage was used per cow-calf pair per day. At the end of the grazing period 556 lbs/acre of siberian millet were left in the field. The percent use on siberian millet was 57.3% in 1993.

Herbage production (Table 8) for the siberian millet treatment was 1648 lbs/acre on the initial grazing date in 1994. Livestock used 379 lbs/acre of herbage which provided an average of 18.70 pounds of siberian millet use per cow-calf pair per day. An additional 3.12 pounds of weed herbage was used per cow-calf pair per day. At the end of the grazing period 1270 lbs/acre of siberian millet were left in the field. The percent use on the siberian millet was 23% in 1994. Millet does not have an extensive root system and can be easily pulled out of the ground while livestock are grazing the pasture (Helm 1988). No additional growth occurs after plants have been pulled out of the ground and the plants desiccate the same as if cut for hay. This phenomenon happened on the siberian millet fields in 1994 and the livestock were removed early. The quantity of herbage that was left in the field when the livestock were removed was 0.64 tons/acre. Of this amount, 223 lbs/acre (17.6%) remained standing with roots in the ground, and 1047 lbs/acre (82.4%) remained as dry hay. If the livestock would have been permitted to remain on the treatment and if they would have consumed 50% of the herbage (percent use was 57.3% in 1993), the standing millet would have provided 2.4 days of additional grazing and the dry millet would have provided 11.2 additional days of grazing. The estimated additional days of grazing were determined by using 1200 lbs as the average weight of the cows and 420 lbs as the average weight of the calves and they were assumed to consume 2% body weight daily which would be 32.4 lbs/day of dry matter per cow-calf pair. The siberian millet treatment had the potential of 27.6 days of grazing in 1994 if the 14 days of actual grazing are combined with the 13.6 days of estimated additional grazing. The fact that livestock can easily pull the short rooted millet plants out of the ground has been previously known but we do not know at the present time if this is a major problem or a minor problem.

Animal performance (Table 9) on siberian millet treatment was very good both years, but better in 1993. The calves accumulated an average of 50.4 pounds per head with an average daily gain of 2.94 pounds and a gain per acre of 91.27 pounds. The cows accumulated an average of 31.0 pounds per head while on the field, with an average daily gain of 1.72 pounds and a gain per acre of 58.77 pounds.

Table 8. Aboveground biomass on siberian millet grazed annual forage fields.

		lbs/acre			
Year	**Forage**	**Initial Date**	**Final Date**	**Difference**	**Percent Use**
1993		**1 Sep**	**14 Oct**		
	Siberian	1301.4	556.1	745.4	57.3
	Weeds	705.0	320.9	384.1	54.5
	TOTAL	2006.5	877.0	1129.5	56.3
1994		**23 Aug**	**6 Sep**		
	Siberian	1648.4	1269.9	378.5	23.0
	Weeds	154.5	91.4	63.1	40.9
	TOTAL	1803.0	1361.3	441.7	24.5

Table 9. Animal performance on siberian millet grazed annual forage fields.

Year Livestock	Initial Date	Stop Date[1]	Start Date[2]	Final Date	Number of Days	Gain per Head	Average Daily Gain	Gain per Acre
1993	**1 Sep**	**15 Sep**	**8 Oct**	**14 Oct**	20			
Cow LW[3] lbs	1202.6	1226.4	1168.6	1191.1		46.3	2.32	94.83
BCS[4]	-	-	-	-		-		
Calf LW lbs	451.8	492.7	522.4	542.9		61.4	3.07	125.60
1994	**23 Aug**			**6 Sep**	14			
Cow LW lbs	1189.9			1205.6		15.7	1.12	22.71
BCS	6.6			6.7		+0.1		
Calf LW lbs	379.9			419.3		39.4	2.81	56.93

1 Intermediate stop date
2 Intermediate start date
3 Liveweight
4 Body condition score

Pearl Millet

Pearl millet was grazed for 23 days in 1993 and not grazed in 1994 (Table 5). This treatment required 0.65 acres for each animal unit month of grazing. The target grazing period for pearl millet was for one early seeded field to be grazed in July and a second later seeded field to be grazed in September. The first target period was not met. The second target period was late by about two weeks. The grazing period in 1993 was from mid September to early October. Sedivec and Schatz (1991) recommend a period of 4-6 weeks of growth between the seeding date and the initial grazing date or to wait until the plants are 24 to 30 inches in height. We waited nearly 9 weeks and most of the plants on this study headed out before reaching 24 inches in height. Using plant height as the criterion to determine initial grazing date does not seem to work under all conditions in western North Dakota. The phenological stage of the pearl millet on the initial grazing date was past head emergence during the seed development stage. This late stage of growth would be good for harvesting as hay or silage, but it appears to be too mature to be used as the optimum initial grazing date for starting grazing on pearl millet. Presently, it is felt that a vegetative stage before boot stage would be more advantageous to start grazing pearl millet which would be about 6 weeks after seeding for an early grazing date, but it may require a longer growing period for a late grazing date.

Herbage production (Table 10) for the pearl millet treatment was 671 lbs/acre on the initial grazing date in 1993. Livestock used 449 lbs/acre of the herbage which provided an average of 9.53 pounds of millet use per cow-calf pair per day. The level of herbage dry matter intake was considered not to be adequate on this treatment. It would appear that some growth did occur on the pearl millet field while livestock were grazing. At the end of the grazing period, 222 lbs/acre of pearl millet were left in the field. The percent use on the pearl millet was 67% in 1993.

Livestock performance (Table 11) on pearl millet was much less than desirable. The calves accumulated an average of 30 pounds per head with an average daily gain of 1.29 pounds and a gain per acre of 61 pounds. The cows lost 58 pounds per head while on the field with an average daily gain of -2.51 pounds and a gain per acre of -118 pounds. The reason that the cows lost weight is not fully known at the present time. The actual quantity of daily forage dry matter intake is not known but assumed to be low and not sufficient for the cows. It is not likely that the amount of additional growth on the millet after the initial starting date was adequate to provide 24 pounds of dry matter for a 1200 pound cow. The poor livestock performance most likely can be attributed to low herbage production, mature phenological stage of growth, and low dry matter intake.

Table 10. Aboveground biomass on pearl millet grazed annual forage fields.

		lbs/acre			
Year	**Forage**	**Initial Date**	**Final Date**	**Difference**	**Percent Use**
1993		**15 Sep**	**8 Oct**		
	Pearl	671.0	222.1	448.9	66.9
	Weeds	230.3	450.5	-220.1	-95.6
	TOTAL	901.3	672.6	228.7	25.4
1994					
	Pearl	-	-	-	-
	Weeds	-	-	-	-
	TOTAL	-	-	-	-

Negative values indicate growth exceeded use.

Table 11. Animal performance on pearl millet grazed annual forage fields.

Year Livestock	Initial Date	Final Date	Number of Days	Gain per Head	Average Daily Gain	Gain per Acre
1993	**15 Sep**	**8 Oct**	23			
Cow LW[1] lbs	1226.4	1168.6		-57.8	-2.51	-118.38
BCS[2]	-	-		-		
Calf LW lbs	492.7	522.4		29.8	1.29	60.96
1994						
Cow LW lbs	-	-		-	-	-
BCS	-	-		-		
Calf LW lbs	-	-		`-	-	-

1 Liveweight
2 Body condition score

Winter Rye

Winter rye was grazed for 14 and 13 days on two treatments (fields #2-6 and #3-7), respectively, during the early summer of 1994 (Table 5). These treatments required an average of 1.57 acres for each animal unit month of grazing. The target grazing period for winter rye was for a fall period in October 1993, a spring period in May 1994, and a fall period in October 1994. The fall grazing of 1993 was not successful on either field #2-6 and #3-7 because when the young plants were developing their third leaf, grasshoppers moved into the fields and consumed all of the aboveground herbage. A desired early spring grazing period in May 1994 was not met because of the slow growth of the winter rye presumably as a result of the previous damage from the grasshoppers. The grazing period in the spring of 1994 was from mid June to late June on field #2-6 and from late June to mid July on field #3-7. The phenological stage on the initial grazing date was past head emergence, with many plants at the flowering stage and some at the early seed development stage. These late development stages appear to be too mature to start grazing on winter rye. Presently, it is felt that a vegetative stage of 3 to 5 leaves would be more advantageous to start grazing winter rye. The fall grazing period of 1994 was not successful on either field #2-6 or field #3-7. Field #2-6 was seeded to siberian millet in August 1994 and not grazed in fall of 1994 because the amount of herbage was not adequate for grazing. Field #3-7 was mowed with a rotary mower and worked with a tandem disk in August 1994. The quantity of herbage on field #3-7 was not adequate for grazing in fall 1994 but a successful stand was started in early spring of 1995.

Herbage production (Table 12) for the winter rye treatment on field #2-6 was 1040 lbs/acre on the initial grazing date in spring 1994. Livestock used 99 lbs/acre of the herbage which provided an average of 4.88 pounds of winter rye use per cow-calf pair per day. They also used 9.39 pounds of weed herbage per day. The quantity of herbage on the ungrazed field #3-7 increased 70% during the same period that livestock were grazing field #2-6. It can be assumed that some additional growth occurred on field #2-6 while the livestock were grazing. At the end of the grazing period on field #2-6, 941 lbs/acre of winter rye were left in the field. Percent use on winter rye was 9.5% and percent use on weed herbage was 64.4%.

Herbage production (Table 12) for the winter rye treatment on field #3-7 was 1686 lbs/acre on the initial grazing date. Livestock used 41 lbs/acre of winter rye herbage and 67 lbs/acre of weed herbage which provided an average of 2.20 pounds of winter rye and 3.55 pounds of weeds per cow-calf pair per day. The quantity of herbage on the ungrazed field #2-6 increased 16% during the same period that livestock were grazing field #3-7. It can be assumed that some additional growth occurred on field #3-7 while the livestock were grazing. At the end of the grazing period on field #3-7, 1645 lbs/acre of winter rye herbage were left in the field. Percent use on the winter rye was 2.5% and percent use on weed herbage was 46.2%.

Livestock performance (Table 13) on winter rye was less than desirable. The calves accumulated 14 and 18 pounds on fields #2-6 and #3-7, respectively. Calf average daily gains were 1.01 and 1.41 pounds and calf gains per acre were 20 and 27 pounds on fields #2-6 and #3-7, respectively. Cows lost 120 and 4 pounds on fields #2-6 and #3-7, respectively. Cow average daily gains were -8.59 and -0.28 pounds and cow gains per acre were -174 and -5 pounds on fields #2-6 and #3-7, respectively. The poor livestock performance on the winter rye treatments can most likely be attributed to mature phenological stage of growth and low dry matter intake of winter rye plants. Livestock did not seem to desire to consume the mature winter rye plants.

Table 12. Aboveground biomass on winter rye grazed annual forage fields.

		lbs/acre						
Year	**Forage**	**Initial Date**	**Intermediate Date**	**Final Date**	**Difference**	**Percent Use**	**Difference**	**Percent Use**
1993								
	Rye	-	-	-	-	-	-	-
	Weeds	-	-	-	-	-	-	-
	TOTAL	-	-	-	-	-	-	-
1994		**15 Jun**	**1 Jul**	**14 Jul**				
Field #2-6		*Grazed*	*Ungrazed*		*Grazed*		*Ungrazed*	
	Rye	1040.3	941.4	1095.0	98.8	9.5	-153.6	-16.3
	Weeds	294.9	104.9	143.3	190.0	64.4	-38.4	-36.6
	TOTAL	1335.2	1046.3	1238.3	288.8	21.6	-192.0	-18.4
Field #3-7		*Ungrazed*	*Grazed*		*Ungrazed*		*Grazed*	
	Rye	990.7	1686.4	1645.0	-695.8	-70.2	41.4	2.5
	Weeds	84.9	144.5	77.8	-59.6	-70.2	66.8	46.2
	TOTAL	1075.6	1830.9	1722.8	-755.4	-70.2	108.2	5.9

Negative values indicate growth exceeded use.

Table 13. Animal performance on winter rye grazed annual forage fields.

Year Livestock	Initial Date	Final Date	Number of Days	Gain per Head	Average Daily Gain	Gain per Acre
1993						
Cow LW[1] lbs	-	-		-	-	-
BCS[2]	-	-		-		
Calf LW lbs	-	-		-	-	-
1994	**16 Jun**	**30 Jun**	14			
Field #2-6						
Cow LW lbs	1199.1	1078.8		-120.3	-8.59	-173.86
BCS	6.8	6.2		-0.6		
Calf LW lbs	246.2	260.3		14.1	1.01	20.36
	30 Jun	**13 Jul**	13			
Field #3-7						
Cow LW lbs	1078.8	1075.2		-3.7	-0.28	-5.30
BCS	6.2	5.8		-0.4		
Calf LW lbs	260.3	278.7		18.4	1.41	26.57

1 Liveweight
2 Body condition score

Discussion

Grazing Annual Forages

The data collected during these two years of preliminary study show that development of guidelines for grazing annual forages throughout the growing season in western North Dakota will be difficult. This study shows more procedures that do not work than do work. There are numerous inherent problems in designing guidelines for grazing management strategies on annual forages. One major problem is trying to coordinate the seeding date and the plant growth rate to have the forage plants at the desired phenological stage of growth on a selected initial grazing date. Another major problem is trying to match the period of grazing with the stages of growth of the plants that provide adequate nutritional quality for the livestock. And another problem is trying to match the number of cow-calf pairs (AUMs of grazing pressure) to the quantity of available herbage. The relationships among these factors are variable and the relationships seem to change with time during the growing season. A considerable amount of information must still be collected in order to understand the complexities of management strategies for grazing annual forages.

We do not know what forage types or which varieties will work best during the different seasonal periods throughout the growing season. Oats-peas and siberian millet had good results during this study and, with minor adjustments, these two forage types can be improved. Winter rye did not perform very well during this study, but with some changes and adjustments it should be possible to improve this treatment. Pearl millet did not perform very well during this study, but is a forage type that has considerable potential if agronomic management guidelines can be developed that provide herbage production levels that are relatively consistent from year to year within the variable parameters set by the climate of western North Dakota.

Seeding date information for forages intended to be harvested by grazing animals has not previously been collected by research station agronomists. Plant rate of growth and length of time required to develop to specific phenological stages are different for different seeding dates. The intention to have four or five different types of annual forages grazed at selected periods require that sequential forage types need to be at the desired phenological growth stage at the same time the previous forage type is depleted of herbage quantity and/or quality. This seeding date information is not at the present time under study but some seeding date information can be extracted from the present grazing study. The general premise that we have been working with is that it requires about 6 weeks between the seeding date and the date of initial grazing. We were not successful in starting grazing on the treatments six weeks after the seeding dates in 1993 and 1994. The six week period between seeding date and the initial grazing date should be fairly close to being valid as a general guideline for the forage types with initial grazing dates between 1 June and 1 August. It will most likely require a greater growing period for late season initial grazing dates of 1 September and 1 October. We were not able to properly coordinate the fall grazing on summer seeded winter rye in 1993 and 1994 because of less than adequate time for plant growth. The pearl millet treatment was not very successful but its growth rate also indicates that greater than 6 weeks would be required for the 1 September grazing date.

The phenological stage of growth at the initial grazing date was not specifically studied. All of the initial grazing dates for all of the forage treatments in 1993 and 1994 were at phenological stages of growth that were too mature. The oats, winter rye, siberian millet, and pearl millet were past the boot stage and at seed development stages of growth. The peas were past flower stage and peas were formed in the pods. The phenological stage of growth at the initial grazing date should be advanced enough to handle grazing pressure but not past the boot stage. At the present time, we speculate that it would probably be best if the growth stage was between the three to five leaf stage. Grazing before the boot stage should promote some tillering if the forage type has that potential. Very little tillering would be expected of plants that were more mature than the boot stage. The nutritional quality of the herbage would be expected to decrease fairly rapidly after the boot stage. Additional research will be required to determine the proper phenological stage of growth for each forage type to start grazing.

Length of time that the forage types can be grazed and the optimum period during the grazing season that the forage types can be grazed were not specifically studied during these two years. The initial grazing periods for this study were selected as a result of a general collective consensus from many scientists of several disciplines working in western North Dakota and based upon the best information available at the time. The length of the grazing period and the optimum period during the grazing season for each forage type will depend on the phenological stage of growth in which grazing can start, the quantity of stimulated tillers, the length of time that plant growth can keep up with grazing, the number of livestock, the stage of growth in which livestock selectivity terminates, and time or growth stage when the nutritional quality drops below the requirements of the livestock. The preliminary expectations were to graze each forage type for 30 days. Several years of research will be required before we will have a working understanding on the length of grazing period and the optimum period of the grazing season for the forage types.

Stocking rates during this study ranged from 0.74 acre per AUM on siberian millet to 1.62 acres/AUM on winter rye field #3-7. The preliminary expectation was optimistically estimated at 0.50 acre per AUM. Some forage types may eventually be able to reach that level of stocking but currently most forage types require 1.00 acre or more per AUM. With only two years of data we are a long way from determining the stocking rate levels of the forage types.

Livestock growth was very good on the oats-peas and siberian millet treatments which gives optimism for the potential weight gains by livestock on annual forage pastures. With adjustments in the management strategies, the gain per acre of the calves should improve.

Net Returns Grazing Annual Forages

We have two years of data on animal performance while grazing annual forages which are expected to improve as adjustments are made in the grazing strategies. We don't know the optimal initial starting date, the expected duration of a grazing period, or the stocking rate, but these two years of production values can give us some general expected net return values if interpretations of comparisons are viewed cautiously and considered preliminary. The costs and returns used in this report are not intended to be complete economic analyses of the treatments, but just simple comparisons of a relative dollar value of the different production levels from the various treatments. Table 14 shows the projected general costs and returns for the grazing annual forage treatments in 1993 and 1994.

Oats-Peas

Calf gains of 86 and 93 lbs/acre were reached during this study on oats-peas and were considered to be very good (Table 14). With the present costs of cropland rent and seed, the net return per acre for oats-peas ($9.00 - $31.00) (Table 14) would be comparable to net returns from spring or durum wheat ($13.00 - $21.00) (Table 15). Seed costs per cow-calf pair ($68.00 - $89.00) are high in relation to other treatments and in effect reduce net return per acre. Eventually, seed peas should become more readily available and the price should be reduced which would increase the net return per acre for this treatment. The initial starting date of grazing should be changed to an earlier phenological growth stage which should lengthen the grazing period and increase the expected calf gain per acre.

Siberian Millet

Calf gains of 126 and 57 lbs/acre were good (Table 14). With the stocking rate of 1993, the net return per acre ($48.00 - $73.00) for siberian millet was very impressive (Table 14). The early removal of cattle in 1994, reduced the stocking rate and the calf gain per acre which caused considerable reduction in return per acre for this treatment ($-1.00 - $10.00) (Table 14). With some adjustments in the management strategies for siberian millet, this treatment should be able to produce net returns per acre that would be greater than for traditional crop production on the same land. The initial starting date of grazing should be changed to an earlier phenological growth stage which should lengthen the grazing period and increase the calf gain/acre.

Pearl Millet

Pearl millet would be a highly desirable annual forage if agronomic management techniques could be developed for western North Dakota that would assure consistent production results. Because of the difficulty to get consistent growth production in western North Dakota, pearl millet may not be a good selection for this type of project. We had low herbage production (671 lbs/ac), low calf performance (1.29 lbs/day), and low net return per acre ($1.00 - $13.00) (Table 14). The net return per acre would be expected to be comparable to other annual forage types, during years with growing conditions that were favorable for pearl millet herbage production in western North Dakota. The net return during years with unfavorable conditions would be expected to be very low or negative.

Winter Rye

We had a problem with the initial turn out date which allowed plants to reach a mature stage of growth which livestock did not prefer to consume and subsequently resulted in low calf gain per day and gain per acre. The low calf gain per acre did not cover the land rent and seeding costs during this study (Table 14). The net returns per acre were negative and ranged from ($-25.00 - $-15.00) (Table 14). Winter rye is more palatable to livestock at an early growth stage and if grazed early should provide respectable performance of calf gain per acre. This treatment requires some major changes in management strategies but it has very good potential. When these problems are solved during the future work of this study, the net return per acre on this treatment should improve and be very good. The calf gains per acre on the winter rye of 20 and 27 pounds (Table 14) are expected to greatly improve when the proper period of grazing is used.

Calf gains per acre for some of the annual forage treatments were very impressive ranging from 126 to 57 pounds (Table 14) on the oats-peas, siberian millet, and pearl millet annual forage treatments. The net returns per acre ranged from $9.00 - $73.00 per acre for oats-peas 1993 and 1994 and siberian millet 1993 (Table 14). Grazing annual forages should be very profitable after effective management strategies have been developed to address the current problems identified through this preliminary study.

Net Returns from Cereal Crop Production

This project was designed to investigate the potential of using cropland acres for grazing livestock on annual forages to receive a return equal to or greater than current net returns received for traditional cereal crops. The costs and returns for cereal crops were determined from county averages reported in ND Ag Statistics 1993 and 1994. The fifteen counties of southwestern North Dakota were used in this study. We used the reported county grain yields, open market prices received, reported county cropland cash rent values, and average state custom farm work rates (Aakre 1993), to standardize the values (Manske and Nelson 1995). Individual farm values will vary from these county average values. Using cash rent for land values and custom farm work rates for labor and machinery, the net returns for spring and durum wheat ranged from $13.13 to $20.77 per acre (Table 15). Barley net returns were $2.69 and $4.97, and oats net returns were negative values in 1993 and 1994 (Table 15) without government subsidized payments. If the amount of government subsidized payments is reduced in the future, the use of cropland for livestock production grazing annual forages may look very attractive. The net returns from grazing oats-peas 1993 and 1994 and siberian millet 1993 (Table 14) show that the potential of grazing annual forage can surpass the net returns of traditional cereal crops. A few additional years of research should obtain enough usable data to show animal gains to be very good and profitable on annual forages. Additional research on forage type and varieties, and seeding dates and techniques should help to determine optimal management strategies for grazing annual forages and further improve net returns from livestock production by grazing annual forages.

Table 14. Projected general costs and returns for cow-calf production on cropland annual forages in southwestern North Dakota.

		Oats-Peas 1993	Oats-Peas 1994		Siberian Millet 1993	Siberian Millet 1994		Pearl Millet 1993		Winter Rye 1994 Fld #2-6	Winter Rye 1994 Fld #3-7
PRODUCTION											
Acres/Month	(ac)	1.06	0.81		0.74	1.51		0.65		1.51	1.62
Acres/4.5 Months	(ac)	4.77	3.65		3.33	6.80		2.93		6.80	7.29
Calf ADG	(lbs)	3.01	2.48		3.07	2.81		1.29		1.01	1.41
Calf Gain/Acre	(lbs)	86.27	93.13		125.60	56.93		60.96		20.36	26.57
Calf Gain/4.5 Months	**(lbs)**	**411.51**	**339.46**		**418.25**	**386.84**		**178.31**		**138.35**	**193.70**
GROSS RETURNS											
Gross per C-C pr 4.5M											
@ 0.90/lb	($)	370.36	305.51		376.42	348.16		160.48		124.51	174.33
@ 0.80/lb	($)	329.21	271.57		334.60	309.47		142.65		110.68	154.96
@ 0.70/lb	($)	288.06	237.62		292.77	270.79		124.82		96.84	135.59
COSTS											
Cropland Rent per C-C pr 4.5M @ 20.43/ac & 21.18/ac	($)	97.45	77.31		68.03	144.02		59.86		144.02	154.40
Seeding Costs @ 12.53/ac	($)	59.77	45.73		41.72	85.20		36.71		85.20	91.34
Seed Costs	($)	89.20	68.26		23.31	47.60		26.37		34.61	37.11
Total Cost/C-C pr	**($)**	**246.42**	**191.30**		**133.06**	**276.82**		**122.94**		**263.83**	**282.85**
NET RETURNS											
Net Return per C-C pr 4.5M											
@ 0.90/lb	($)	123.94	114.21		243.36	71.34		37.54		-139.32	-108.52
@ 0.80/lb	($)	82.79	80.27		201.54	32.65		19.71		-153.15	-127.89
@ 0.70/lb	($)	41.64	46.32		159.71	-6.03		1.88		-166.99	-147.26
Net Return per Acre											
@ 0.90/lb	($)	25.98	31.29		73.08	10.49		12.81		-20.49	-14.89
@ 0.80/lb	($)	17.36	21.99		60.52	4.80		6.73		-22.52	-17.54
@ 0.70/lb	($)	8.73	12.69		47.96	-0.89		0.64		-24.56	-20.20

Table 15. Projected general costs and returns for crop production in southwestern North Dakota, 1993 - 1994.

		Spring Wheat 1993	Spring Wheat 1994	Durum Wheat 1993	Durum Wheat 1994	Barley 1993	Barley 1994	Oats 1993	Oats 1994
PRODUCTION									
Grain Yield	(bu/ac)	19.40	21.10	20.40	22.10	27.80	29.60	33.80	36.90
Prices Received	($)	3.26	3.21	3.19	3.23	1.85	1.84	1.26	1.11
GROSS RETURNS									
Dollars per Acre	($)	63.24	67.73	65.08	71.38	51.43	54.46	42.59	40.96
COSTS									
Cropland Rent per Acre	($)	20.43	21.18	20.43	21.18	20.43	21.18	20.43	21.18
Custom Farm Work	($/ac)	25.68		25.68		25.68		25.68	
Seed Costs	($)	4.00		3.75		2.63		2.30	
Total Costs	**($)**	**50.11**	**50.86**	**49.86**	**50.61**	**48.74**	**49.49**	**48.41**	**49.16**
NET RETURNS									
Net Return per Acre	($)	13.13	16.87	15.22	20.77	2.69	4.97	-5.82	-8.20

Summary

Net returns per acre from traditional cereal crop production are relatively low because of low prices received and high costs of production. The use of cropland acres to grow annual forages and grazed by cow-calf pairs may provide greater net returns per acre than cereal crop production if government subsidized payments are reduced in the future.

Results from a two year study show that there are numerous inherent problems in grazing annual forages for an entire grazing season and these problems need to be addressed and resolved. Data from the oats-peas and siberian millet treatments showed that grazing annual forages has the potential to surpass the net returns per acre of traditional cereal crops. A considerable amount of information still needs to be collected and analyzed before recommendations for management strategies for grazing annual forages can be developed and before they can be used as standard livestock production practices in western North Dakota.

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Rangeland Reference Areas in Western North Dakota

Llewellyn L. Manske PhD

Associate Range Scientist
North Dakota State University
Dickinson Research Extension Center

Introduction

Long-term rangeland reference areas are important in understanding the dynamics of rangeland ecosystems. Reference areas are intended to allow natural biological and physical processes to occur unhindered. The primary biological and physical forces affecting rangeland ecosystems are: geologic material, topography, soil parent material, climate (precipitation, temperature, wind, and sunlight), seasonal precipitation patterns, fire, plant competition, and herbivory (mammals, birds, insects, and micro-organisms). These biological and physical forces act together on rangeland ecosystems over the long-term and determine the structure and functions of a stable ecosystem. Long-term reference areas represent the stable rangeland ecosystem for a region with a specific set of biological and physical forces.

Rangeland reference areas can be used to evaluate the effects of mammalian herbivores on the ecosystem if a portion of the reference area is fenced with an exclosure. The exclosures can be designed to exclude all mammals, just large mammals, or just livestock. Reference areas that have a livestock exclosure and a similar area exposed to grazing are categorized as "two-way" reference areas. These "two-way" rangeland reference areas are designed to show the dynamics of a stable rangeland ecosystem with all the biological and physical forces except livestock grazing and also a stable rangeland ecosystem with all the biological and physical forces including livestock grazing.

Rangeland Reference Areas

Western North Dakota has four "two-way" rangeland reference areas that are 58 years old. These reference areas were established by Dr. Warren C. Whitman in the Pyramid Park Region on the eastern edge of the breaks of the Little Missouri River Badlands in 1936-1938. The sites were selected to represent four of the major grassland types of the region (Hanson and Whitman 1938) which would be labeled as range sites in today's terminology. All four sites are located in Billings County, south of the city of Medora.

The Sandy Upland Rangeland Reference Area was classified as the Sandgrass grassland type (Sandy range site) with prairie sandreed (*Calamovilfa longifolia*) as the dominant grass. The reference area is located in Section 15, T138N, R102W, has slopes of 2% east, northeast, and west, an exclosure of 6.3 acres, and was established in 1938.

The Badlands Upland Rangeland Reference Area was classified as the Grama-needlegrass-sedge grassland type (Shallow range site) with blue grama (*Bouteloua gracilis*), needleandthread (*Stipa comata)*, and upland sedges (*Carex filifolia* and *C. heliophila*) as the dominant grasses. The reference area is located in Section 5, T138N, R101W, has a slope of 3% north, an exclosure of 6.2 acres in two parts, and was established in 1937.

The Badlands Slope Rangeland Reference Area was classified as the Western wheatgrass-grama-sedge grassland type (Silty range site) with blue grama (*Bouteloua gracilis*), western wheatgrass (*Agropyron smithii*), and upland sedge (*Carex filifolia*) as the dominant grasses. The reference area is located in Section 3, T138N, R101W, has a slope of 3% south, an exclosure of 14 acres, and was established in 1937.

The Sagebrush Flat Range Reference Area was classified as the Sagebrush type (Overflow range site) with silver sage (*Artemisia cana*) as the dominant shrub and western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), and green needlegrass (*Stipa viridula*) as the dominant grasses. The reference area is located in Section 11, T138N, R101W, has a slope of less than 1%, an exclosure of 4.2 acres, and was established in 1937.

Whitman (1953) reported that these four rangeland reference areas were established by an informal agreement in 1936 with the United States Department of Agriculture Resettlement Administration. When the USDA Soil Conservation Service took over the administration of the Land Utilization Project, a formal lease agreement was signed in 1939 by the North Dakota Agricultural Experiment Station and Soil Conservation Service. The lease agreement was for 50 years and automatically renewable every eight years. When the USDA Forest Service took over the administration of the Little Missouri National Grassland, they honored the previous lease agreement and issued an Occupancy Permit in 1955 which was a Terminable Permit that was annually renewable as long as the requirements and conditions were met. In 1987, the USDA Forest Service issued a Special Use Permit to North Dakota State University Agricultural Experiment Station for scientific study of the four Grassland Ecosystem Reference Areas. This special use permit is valid until 31 December 2004 and is assumed to be renewable if the requirements and conditions of the permit are met.

These four rangeland reference areas are the oldest and best scientifically documented reference areas in North Dakota and possibly in the northern Great Plains. Dr. Whitman established these rangeland reference areas for the purpose of studying the long-term effects of grazing on four typical grassland ecosystems by monitoring changes in herbage production, plant species composition, and soil characteristics. Eight years of data were collected by Dr. Whitman during the years following establishment on locations within the exclosures and similar areas outside the exclosures that were exposed to grazing. Six years of additional data were collected by Dr. Whitman after 1952, but this data collection was not as intensive as the data collection before World War II.

Dr. Michael Brand continued this project with intensive research data collection at these sites from 1976 through 1978 to document the changes in vegetation and soils of the exclosures and adjacent grazed areas after 40 years. A summary of Dr. Brand’s data reported in Brand 1980, and Brand and Goetz 1986 is included in this report.

Methods and Treatments

Dr. Brand collected data on aboveground herbaceous production, belowground biomass, and plant species composition. The aboveground herbaceous production was sampled by clipping ten $0.5m^2$ quadrats per plot per year to ground level in August, 1976-1978. Species categories were separated on one quadrat and estimated on nine quadrats. Belowground biomass was sampled with 20 soil cores, 2.1 cm in diameter, per plot to a depth of 4 feet in August 1978. Plant species composition was sampled using the 10-pin point frame with 3000 points per plot per year in June and July, 1976-1978 (Brand 1980, Brand and Goetz 1986).

The barbed wire fence on the exclosures has stayed intact fairly well over the years. There have been a few brief periods with broken wire in which cattle have entered the exclosures. These incidents have been so infrequent that it is assumed that no changes to the range ecosystem have been made as a result of livestock within the exclosures. All exclosure fences had major replacement and repair work done in 1987 and 1988 and are in good condition. The Badlands Slope exclosure was observed to have a patch of leafy spurge (*Euphorbia esula*) in 1982, which was sprayed several times with Tordon 22K until 1987 when the stem density was determined to be 90 to 95% reduced. This patch has again increased in recent years. The portion of the reference areas within the exclosures represents stable rangeland ecosystems for western North Dakota with all the biological and physical forces except large grazing herbivores.

The portions of the reference areas that are outside the exclosures have been annually exposed to seasonlong grazing by livestock, primarily cow-calf pairs. The grazing treatments are part of larger grazing units which are allotments in the Little Missouri National Grassland, administered by USDA Forest Service and managed in cooperation with North Dakota Grazing Associations. Grazing permits for these allotments run from 1 May through 31 December but most years the grazing season has been shortened to seven months because of inclement weather conditions. The average utilization of the vegetation at these reference areas was determined by Dr. Whitman with Ocular Estimates to be 40 to 50% from 1952 through 1978. The portion of the reference areas outside the exclosures represents stable rangeland ecosystems for western North Dakota with all the biological and physical forces including large grazing herbivores and were managed with moderate seven to eight month seasonlong grazing treatments.

Discussion

Dr. Brand's data show that the aboveground herbage biomass was not very different between the exclosure and grazed treatments at each reference area (Table 1) except that the exclosure at the silty range site had greater graminoid herbage production primarily because of an increase in Kentucky bluegrass (*Poa pratensis*), and the exclosure at the shallow range site had a greater graminoid herbage production primarily because of an increase in upland sedges. The mulch biomass on each exclosure was significantly greater than the grazed treatments (Table 1) and was an accumulation of four or five years of herbage production. This mulch ties up some of the nutrients required for new plant growth and reduces the amount of sunlight reaching the soil surface.

Table 1. Mean aboveground herbage biomass in lbs/acre, 1976-1978.

	Sandy Upland Sandy Range Site		Badlands Upland Shallow Range Site		Badlands Slope Silty Range Site		Sagebrush Flat Overflow Range Site	
	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y
GRASSES								
Mid and Tall	775	726	267	195	937	1639	2022	1917
Short	161	13	323	223	371	66	109	5
Sedges	370	650	141	682	35	239	0	0
TOTALS								
Graminoids	1286	1390	731	1101*	1342	1944*	2131	1921
Forbs	78	70	382*	136	270	142	49	103
Herbage	1363	1460	1112	1237	1613	2085*	2179	2023
Mulch	1694	2746*	405	1722*	805	3392*	1578	4338*

*Significantly different from comparable treatment (P<0.05)
Brand 1980, Brand and Goetz 1986

The belowground biomass, which can have portions with variable ages from current year to about five years old, was generally greater on the grazed treatments of each reference area (Table 2) except on the shallow range site which had belowground biomass about the same on each plot. Whitman (1974) found that the belowground biomass was consistently greater on the grazed treatments than on the exclosures during his microclimate studies in western North Dakota.

Table 2. Mean belowground biomass in lbs/acre, 1978.

	Sandy Upland Sandy Range Site		Badlands Upland Shallow Range Site		Badlands Slope Silty Range Site		Sagebrush Flat Overflow Range Site	
	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y
0” - 12”	28,276	25,342	21,060	22,692	18,545*	13,300	25,172*	16,984

*Significantly different from comparable treatment (P<0.05)
Brand 1980, Brand and Goetz 1986

Shortgrasses made up a greater percentage of the aboveground biomass on all the grazed plots compared to the exclosures (Table 3). Sedges made up a greater percentage of the aboveground biomass on the exclosures than on the grazed plots (Table 3) except on the overflow range site. Mid and tall grasses made up a greater percentage of the aboveground biomass on the grazed plots of the sandy range site and shallow range site than on the exclosures (Table 3). Mid and tall grasses made up a greater percentage of the aboveground biomass on the exclosure of the silty range site than on the grazed plot (Table 3). This increase in biomass in the silty range site exclosure was primarily from Kentucky bluegrass. Aboveground biomass of mid and tall grasses on the overflow range site was about the same on the grazed plot and exclosure (Table 3).

Table 3. Percent composition of aboveground biomass by growth form, 1976-1978.

	Sandy Upland		**Badlands Upland**		**Badlands Slope**		**Sagebrush Flat**	
	Sandy Range Site		Shallow Range Site		Silty Range Site		Overflow Range Site	
	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y
GRASSES								
Mid and Tall	55.4	49.7	24.0	15.8	58.1	78.6	92.8	94.8
Short	11.8	0.9	29.0	18.0	23.0	3.2	5.0	0.2
Sedges	27.2	44.5	12.7	55.2	2.2	11.5	0.0	0.0
Forbs	5.6	4.8	34.3	11.0	16.8	6.8	2.3	5.1

Brand 1980, Brand and Goetz 1986

Basal cover of short grasses was greater on the grazed plots of all four reference areas compared to the exclosures (Table 4). Basal cover of upland sedges was greater on the exclosures compared to the grazed plots on all reference areas except the overflow range site which did not have upland sedge (Table 4). Basal cover of mid and tall grasses was about the same on the grazed plots and exclosures of the sandy range site and overflow range site (Table 4). Basal cover of mid and tall grasses was greater on the grazed plot on the shallow range site and greater on the exclosure on the silty range site (Table 4).

Table 4. Mean percent basal cover by growth form, 1976-1978.

	Sandy Upland		**Badlands Upland**		**Badlands Slope**		**Sagebrush Flat**	
	Sandy Range Site		Shallow Range Site		Silty Range Site		Overflow Range Site	
	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y
GRASSES								
Mid and Tall	1.2	1.2	1.0	0.2	1.3	1.5	2.0	1.9
Short	2.3	0.0	3.6	0.8	2.3	0.4	0.5	0.0
Sedges	3.3	4.6	0.8	2.7	0.3	0.5	0.0	0.0
Forbs	0.1	0.2	0.4	0.1	0.3	0.1	0.1	0.1

Brand 1980

Basal cover of total graminoids and total herbaceous plants was greater on the grazed plots of all the reference areas compared to the exclosures (Table 5). Blue grama basal cover was greater on the grazed plots of all the reference areas and upland sedge basal cover was greater on the exclosures of all the reference areas (Table 5) except the overflow range site which did not have upland sedge. Kentucky bluegrass basal cover was greater on the exclosure of the silty range site and prairie sandreed basal cover was greater on the exclosure of the sandy range site (Table 5). Western wheatgrass showed a tendency to have greater basal cover on the grazed plots of all the reference areas (Table 5). Plains reedgrass showed a tendency to have greater basal cover on the grazed plots (Table 5) except on the overflow range site. Needleandthread showed a tendency to have greater basal cover on the grazed treatments of the shallow and overflow range sites (Table 5) and a tendency to have greater herbage production on the grazed treatments of the silty and overflow range sites (Brand and Goetz 1986). The basal cover and herbage production for needleandthread was about the same on each plot of the sandy range site (Table 5, Brand and Goetz 1986).

Table 5. Mean percent basal cover by species, 1976-1978.

	Sandy Upland Sandy Range Site		**Badlands Upland** Shallow Range Site		**Badlands Slope** Silty Range Site		**Sagebrush Flat** Overflow Range Site	
	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y	Grazed 8.0M	Not Grazed 40Y
GRASSES								
Western Wheatgrass	0.2	0.1	0.1	<0.1	0.7	0.5	0.9	0.3
Blue grama	2.3	0.1	3.3	0.8	2.2	0.4	0.5	0.0
Plains reedgrass	0.1	0.0	0.3	<0.1	0.1	0.0	0.4	1.0
Prairie sandreed	0.2	0.5	-	-	-	-	-	-
Kentucky bluegrass	<0.1	<0.1	-	-	<0.1	0.7	<0.1	0.0
Needleand thread	0.6	0.6	0.2	0.1	0.1	0.1	0.1	0.0
Green needle	-	-	<0.1	0.0	0.0	0.1	0.3	0.4
Other grasses	0.2	0.1	0.7	0.2	0.5	0.2	0.2	0.2
Upland sedge	3.3	4.6	0.8	2.7	0.3	0.5	-	-
TOTALS								
Graminoids	6.8	5.8	5.4	3.7	3.9	2.4	2.4	1.9
Forbs	0.1	0.2	0.4	0.1	0.3	0.1	0.1	0.1
Herbaceous	6.9	5.9	5.8	3.8	4.2	2.5	2.5	2.0

Brand 1980

Summary

These four reference areas show the differences in rangeland ecosystems on sandy, shallow, silty, and overflow range sites after 40 years without livestock grazing and 40 years of 7 to 8 months of moderate seasonlong grazing. Generally, the aboveground herbage production was about the same for most categories on the grazed plots and exclosures except Kentucky bluegrass and upland sedge production which were great enough on the exclosures of the silty range site and shallow range site, respectively, to show an increase in total graminoid production on the respective exclosures. Mulch biomass was greater on all exclosures than on grazed plots. Belowground biomass was greater on grazed plots except the shallow range site which was about the same as the exclosure. Graminoid and total herbaceous plant basal cover was greater on all grazed plots of the reference areas. Blue grama basal cover was greater on the grazed plots. Upland sedge basal cover was greater on the exclosures. Kentucky bluegrass and prairie sandreed basal cover were greater on the exclosures of the silty and sandy range sites, respectively.

Moderate seven to eight month seasonlong grazing management is generally considered by most range managers not to be beneficial to the rangeland ecosystem, and several other grazing management practices have been found to be improvements over this type of seasonlong grazing practice (Sarvis 1941, Manske *et al* 1988, Manske 1994). Forty years of seven to eight months of moderate seasonlong grazing at these reference areas has not reduced the aboveground herbage production as would be expected. This grazing treatment has greater belowground biomass and graminoid basal cover compared to the ecosystems inside the exclosures. The exclosures at the reference areas have eliminated one important biological force from the rangeland ecosystem which is the large grazing herbivore. Most rangeland plants have evolved mechanisms that permit the plants to coexist and thrive with grazing herbivores (Manske 1994). Large grazing herbivores have been an intricate part of the rangeland ecosystem for 20 million years, and need to continue to be a part of the rangeland ecosystem.

Conclusions

The seven to eight month seasonlong grazing management treatment is generally considered to be inferior to many other grazing management practices, but Dr. Brand's data points out that even with this type of grazing treatment, the rangeland ecosystems with large grazing herbivores showed ecological benefits over ecosystems that have eliminated the large grazing herbivores. When improved grazing management practices are used to manage the grazing herbivores, the ecological benefits to the rangeland ecosystems are even greater than with the eight month seasonlong grazing treatment. Management practices and recommendations that eliminate the large grazing herbivores will develop ecosystems that are not as ecologically healthy over the long-term as rangeland ecosystems that included large grazing herbivores. Rangeland management practices must be ecologically beneficial to the ecosystem or the practice will not be sustainable for the long-term.

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Economic Returns as Affected by Grazing Strategies in Southwestern North Dakota

Llewellyn L. Manske PhD

Associate Range Scientist
North Dakota State University
Dickinson Research Extension Center

Abstract

A simulation study was conducted to evaluate costs and returns for five selected grazing management strategies from the birth of a calf to weaning. The strategies included drylot feeding, spring domesticated grass pastures, native range pastures, and a fall domesticated grass pasture. The objectives of the study were to determine if there were economic advantages and disadvantages for the different grazing strategies and to develop a general grazing strategy that has biological and economic advantages. Drylot feeding showed a positive economic return from mid March to early May. Crested wheatgrass pastures added weight to calves at a lower cost than drylot. Grazing crested wheatgrass spring pastures in May showed economic advantage over grazing native range early during the same period. Fertilized crested wheatgrass pastures showed an advantage in net return per acre over unfertilized crested wheatgrass pastures. Native range grazing management with multiple pastures and multiple grazing periods showed economic advantage over native range grazed as a single pasture with a single grazing period. Grazing an altai wildrye fall pasture showed positive economic return and lowest costs per pound of gain.

The type of grazing system or management strategy used in cow-calf production on native range and domesticated grass pastures is very important. Grazing systems affect the biology of the growth of vegetation and the performance of cow-calf pairs which are shown as changes in stocking rate, acres for cow-calf pair per grazing season, calf and cow average daily gain and gain per acre, and total calf and cow gain per grazing season. These values in turn affect costs of pasture per cow-calf pair which affects net return per cow-calf pair and net return per acre.

Most grazing management research is designed to evaluate biological differences in vegetation (herbage production, species composition, plant density, stocking rate, etc.) and animal performance (average daily gain, gains per acre, milk production, etc.) between treatments. It is difficult to evaluate how the combination of biological advantages and disadvantages of the vegetation growth and livestock performance affect entire grazing strategies. This study attempts to evaluate five grazing strategies by analyzing the costs and returns for cow-calf production from calf birth to weaning. The objectives of this study are to determine if there are economic advantages and disadvantages with five selected grazing strategies and to develop a workable general grazing strategy that has biological and economic advantages.

Methods and Materials

A simulation study to evaluate general costs and returns for mean cow-calf pair production from calf birth to weaning was conducted at the Dickinson Research Extension Center in southwestern North Dakota, U.S.A. The simulation strategies started at the date of birth of a calf. An average birth date of 16 March and the average birth weight of 95 pounds was used for all simulation strategies. The cow and calf pair were simulated to move sequentially through a series of forage types. All five strategies had a drylot feeding period and a summer native range grazing period, four strategies had a spring domesticated grass pasture period, and one strategy had a fall domesticated grass pasture period. All strategies ended at the weaning of the calf. The five strategies were named after the type of grazing system used on the native range portion of the strategy and are: 6.0 month seasonlong, 4.0 month deferred, 4.5 month seasonlong, 4.5 month short duration, and 4.5 month twice-over rotation.

The five management strategies were simulated for this study but each treatment has supporting data collected at the Dickinson Research Extension Center. The grazing dates, stocking rates, and calf average daily gain used in the five different simulated management strategies are means for cow-calf pairs from data collected during several years of grazing research. The mean cow and calf performance data used in this simulation study was collected primarily from 1982 to 1987 for the drylot, crested wheatgrass and altai wildrye portions of the five strategies, and the native range portion for four strategies. These data were taken from grazing system projects reported by Manske *et al.*1984, Manske and Conlon 1986, Manske *et al.* 1988, Manske 1994a and unpublished data in the Dickinson Research Extension Center files. The mean cow and calf performance on the native range portion of the 4.5 month short duration strategy was taken from the data reported for 1982 to 1987 by Kirby, Conlon, and Krabbenhoft 1991. Two strategies were not simulated for the full 244 day season because research data was not available to completely cover each of the simulated forage periods. Stocking rates were set to be full use of the grazable portion of the forage.

Commercial Hereford and Angus-Hereford cows with Charolais sired calves were used on this study. Individual cows with calves were allocated to treatments each spring on the basis of age of cow, sex and age of calf. Pasture rent values ($8.76 per acre) used were the means of 1993 and 1994 from the 15 counties in southwestern North Dakota (ND Ag Statistics 1993 and 1994). One treatment of crested wheatgrass was fertilized annually with 50 pounds of nitrogen per acre at an average cost of $12.50 per acre. The native range vegetation was the Wheatgrass-Needlegrass type (Barker and Whitman 1988) of the mixed grass prairie. The crested wheatgrass and altai wildrye pastures were seeded as monocultures but had developed a small assortment of other grass and forb species as minor components. Average annual precipitation was 15.3 in. (389 mm) with 75% falling as rain between April and September. Temperatures averaged 66°F (19°C) in summer with average daily maximums of 80°F (27°C). Winter average daily temperatures were 16°F (-9°C) with average daily minimums of 2°F (-17°C).

Five different management system strategies were evaluated for forage and pasture costs and compared to the gross and net returns of the accumulated live weight of the calf while grazing each forage type and for the total simulation season using three calf market values at weaning. This study was intended to be a comparison of feed and pasture costs and relative dollar value for the different calf weight production levels from the five management strategies. This study was not intended to be a complete economic analyses of the grazing treatments nor a study in market strategies. The five simulated management strategies are described below and in table 1 and figure 1.

The 6.0 month seasonlong (6.0 M SL) management strategy was started on 16 March in drylot and a balanced lactation ration was fed for 61 days. The grazing portion started on 16 May with one native range pasture grazed for 183 days at a stocking rate of 0.25 animal unit months (AUM's)/acre until 15 November when the calves were weaned at 244 days of age.

The 4.0 month deferred (4.0 M Def) management strategy was started on 16 March in drylot and a balanced lactation ration was fed for 46 days. The grazing portion started on 1 May with grazing on an unfertilized crested wheatgrass pasture for 76 days at a stocking rate of 0.60 AUM's/acre. The livestock were moved to one native range pasture on 15 July and grazed for 122 days at a stocking rate of 0.45 AUM's/acre until 15 November when the calves were weaned at 244 days of age.

The 4.5 month seasonlong (4.5 M SL) management strategy was started on 16 March in drylot and a balanced lactation ration was fed for 46 days. The grazing portion started on 1 May with grazing on an unfertilized crested wheatgrass pasture for 46 days at a stocking rate of 0.55 AUM's/acre. The livestock were moved to one native range pasture on 15 June and grazed for 137 days at a stocking rate of 0.35 AUM's/acre until 30 October when the calves were weaned at 229 days of age.

The 4.5 month short duration (4.5 M SD) management strategy was started on 16 March in drylot and a balanced lactation ration was fed for 46 days. The grazing portion started on 1 May with grazing on an unfertilized crested wheatgrass pasture for 46 days at a stocking rate of 0.55 AUM's/acre. The livestock were moved to one of eight native range pastures on 15 June and rotated through the eight pastures on a 5 day graze, 35 day rest schedule for 137 days at a stocking rate of 0.47 AUM's/acre until 30 October when the calves were weaned at 229 days of age.

The 4.5 month twice-over rotation (4.5 M TOR) management strategy was started on 16 March in drylot and a balanced lactation ration was fed for 46 days. The grazing portions started on 1 May with grazing on fertilized (50 lbs N/acre on 1 April) crested wheatgrass pasture for 31 days at a stocking rate of 1.33 AUM's/acre. The livestock were moved to one of three native range pastures with each pasture grazed for two periods, one period of 15 days between 1 June and 15 July (third leaf stage to anthesis phenophase) followed by a second period of 30 days after 15 July and prior to mid October for 137 days at a stocking rate of 0.49 AUM's/acre. The first pasture grazed in the sequence was the last pasture grazed the previous year. The livestock were moved to an altai wildrye pasture on 15 October and grazed for 30 days at a stocking rate of 0.72 AUM's/acre until 15 November when the calves were weaned at 244 days of age.

Table 1. Dates, forage type, and period length for five cow-calf production management strategies from calf birth to weaning.

	Grazing Management Strategy				
	Seasonlong 6.0 M	**Deferred 4.0 M**	**Seasonlong 4.5 M**	**Short Duration 4.5 M**	**Rotation 4.5 M**
CALF BIRTH DATE	16 Mar	16 Mar	16 Mar	16 Mar	16 Mar
DRYLOT					
Start Date	16 Mar	16 Mar	16 Mar	16 Mar	16 Mar
Number of Days	61	46	46	46	46
CRESTED WHEATGRASS					
Start Date	-	1 May	1 May	1 May	1 May
Number of Days	-	76	46	46	31
NATIVE RANGE					
Start Date	16 May	15 Jul	15 Jun	15 Jun	1 Jun
Number of Days	183	122	137	137	137
ALTAI WILDRYE					
Start Date	-	-	-	-	15 Oct
Number of Days	-	-	-	-	30
CALF WEANING DATE	15 Nov	15 Nov	30 Oct	30 Oct	15 Nov
NUMBER OF DAYS FOR TOTAL SEASON	244	244	229	229	244

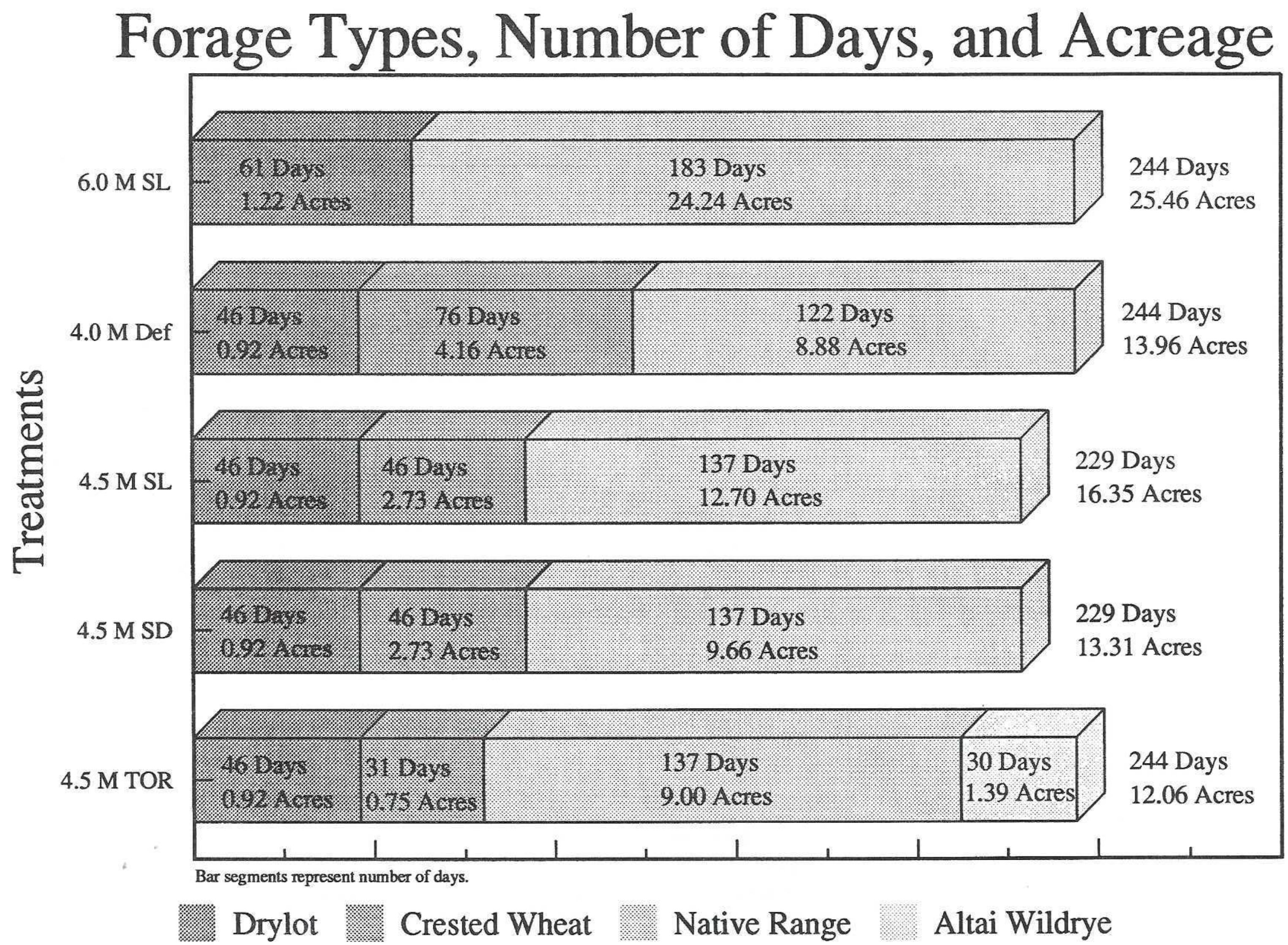

Fig. 1. Forage types, number of days, and acreage for five cow-calf production management strategies from calf birth to weaning.

Results

The net returns per cow-calf pair and per acre (Tables 2, 3, 4, 5 and Fig. 5 and 6) are different for the five simulated management strategies. The gross and net returns were determined for three potential market values of $0.90, $0.80, and $0.70 per pound of calf accumulated live weight and are included in the tables but only the $0.70/lb values will be discussed in this section. The birth weight of the calf has economic value at time of sale but only the accumulated weight gained was included in this discussion of costs and returns of the various forage periods of the respective strategies. The pasture costs were determined from the average rent value of $8.76 per acre for native range, crested wheatgrass, and altai wildrye pastures. Acreages for forage types (Fig. 1), and calf average daily gain (Fig. 2) were determined from previous grazing research projects for each of the five management strategies. Calf gain per acre (Fig. 2), calf accumulated weight gained (Fig. 3), feed and pasture costs (Fig. 4), and cost/day and cost/lb gain (Table 6) were determined during this study for the five management strategies.

The native range period (Table 4) of the 6.0 month seasonlong simulation strategy was 183 days with calf average daily gain of 1.80 lbs, gain per acre of 13.59 lbs and accumulated weight gain of 329.40 lbs. Each cow-calf pair was allotted 24.24 acres at a cost of $212.34. Assuming the calf accumulated weight sold at $0.70/lb, the gross return was $230.58 per calf and the net returns were $18.24 per cow-calf pair and $0.75 per acre on native range. The drylot portion (Table 2) of this strategy added an accumulated weight of 115.90 lbs to each calf at a cost of $48.80. The entire simulated 6.0 month seasonlong strategy (Table 5) had an accumulated weight gain of 445.30 lbs on 25.46 acres in 244 days at a cost of $261.14 per cow-calf pair. The net returns at $0.70/lb were $50.57 per cow-calf pair and $1.99 per acre.

The native range period (Table 4) of the 4.0 month deferred simulation strategy was 122 days with calf average daily gain of 1.80 lbs, gain per acre of 24.73 lbs, and accumulated weight gain of 219.60 lbs. Each cow-calf pair was allotted 8.88 acres at a cost of $77.79. Assuming the calf accumulated weight sold at $0.70/lb, the gross return was $153.72 per calf and the net returns were $75.93 per cow-calf pair and $8.55 per acre on native range. The drylot (Table 2) and spring domesticated grass pasture (Table 3) periods of this strategy added an accumulated weight of 87.40 and 136.04 pounds, respectively, to each calf at a cost of $36.80 and $36.45, respectively. The entire 4.0 month deferred strategy (Table 5) had an accumulated weight gain of 443.04 lbs on 13.96 acres in 244 days at a cost of $151.04 per cow-calf pair. The net returns at $0.70/lb were $159.09 per cow-calf pair and $11.40 per acre.

The native range period (Table 4) of the 4.5 month seasonlong simulation strategy was 137 days with calf average daily gain of 2.09 lbs, gain per acre of 22.55 lbs, and accumulated weight gain of 286.33 lbs. Each cow-calf pair was allotted 12.70 acres at a cost of $111.25. Assuming the calf accumulated weight sold at $0.70/lb, the gross return was $200.43 per calf and the net returns were $89.18 per cow-calf pair and $7.02 per acre on native range. The drylot (Table 2) and spring domesticated grass pasture (Table 3) periods of this strategy added an accumulated weight of 87.40 and 87.86 pounds, respectively, to each calf at a cost of $36.80 and $23.91, respectively. The entire simulated 4.5 month seasonlong strategy (Table 5) had an accumulated weight of 461.59 pounds on 16.35 acres in 229 days at a cost of $171.96 per cow-calf pair. The net returns at $0.70/lb were $151.15 per cow-calf pair and $9.24 per acre.

The native range period (Table 4) of the 4.5 month short duration simulation strategy was 137 days with calf average daily gain of 2.13 lbs, gain per acre of 30.21 lbs, and accumulated weight gain of 291.81 lbs. Each cow-calf pair was allotted 9.66 acres at a cost of $84.62. Assuming the calf accumulated weight sold at $0.70/lb, the gross return was $204.27 per calf and the net returns were $119.65 per cow-calf pair and

$12.39 per acre on native range. The drylot (Table 2) and spring domesticated grass pasture (Table 3) periods of this strategy added an accumulated weight of 87.40 and 87.86 pounds, respectively, to each calf at a cost of $36.80 and $23.91, respectively. The entire simulated 4.5 month short duration strategy (Table 5) had an accumulated weight of 467.07 pounds on 13.31 acres in 229 days at a cost of $145.33 per cow-calf pair. The net returns at $0.70/lb were $181.62 per cow-calf pair and $13.65 per acre.

The native range period (Table 4) of the 4.5 month twice-over rotation simulation strategy was 137 days with calf average daily gain of 2.21 lbs, gain per acre of 33.64 lbs, and accumulated weight gain of 302.77 lbs. Each cow-calf pair was allotted 9.00 acres at a cost of $78.84. Assuming the calf accumulated weight sold at $0.70/lb, the gross return was $211.94 per calf and the net returns were $133.10 per cow-calf pair and $14.79 per acre on native range. The drylot (Table 2), spring (Table 3), and fall (Table 3) domesticated grass pasture periods of this strategy added an accumulated weight of 87.40, 67.58, and 52.77 pounds, respectively, to each calf at a cost of $36.80, $15.95, and $12.18, respectively. The entire simulated 4.5 month twice-over rotation strategy (Table 5) had an accumulated weight of 510.52 lbs on 12.06 acres in 244 days at a cost of $143.77 per cow-calf pair. The net returns at $0.70/lb were $213.59 per cow-calf pair and $17.71 per acre.

Two factors that have considerable influence on the net returns per cow-calf pair and per acre are the number of acres required to carry a cow-calf pair and the calf gain per acre. These two factors are affected by stocking rate and calf average daily gain. The levels of stocking rate are affected by the quantity of herbage production. Stocking rates can be increased on any grazing system for the short-term but if the quantity of herbage production is not manipulated to increase proportionally, the plant community will suffer negative effects on the long-term basis. Stocking rates are variable on any given parcel of land depending on the type of grazing management used and the resulting effects on plant growth. Calf average daily gain is affected by the nutritional quality of the available forage consumed by the calf (assuming quantity is not a limiting factor) and also by the forage consumed by the cow because of its effects on the lactation rate. Grazing management strategies that provide forages that meet the nutritional requirements of the livestock for longer periods of time should have greater average daily gains and gains per acre. Grazing management strategies that provide an adequate quantity of forage at the required nutritional quality for the entire grazing season have the greatest chance to have the highest net returns per cow-calf pair and per acre.

The drylot feeding period showed positive economic returns for all five grazing management strategies from mid March to early May (Table 2). Crested wheatgrass pastures accumulated weight on calves at a lower cost per pound than drylot (Table 6). Grazing crested wheatgrass spring pastures in May showed positive economic returns (Table 3) and an advantage over grazing native range pastures early during the same period (Table 6). Fertilization of crested wheatgrass with 50 lbs N/acre showed advantages in increased stocking rates, calf average daily gain and gain per acre, and a reduction in the acreage required to carry a cow-calf pair which greatly improved the net returns per acre over unfertilized crested wheatgrass pastures (Tables 3 and 6 and Fig. 6). Native range grazing management strategies that incorporated multiple pastures with multiple grazing periods had economic advantages in net returns per cow-calf pair (Fig. 5) and per acre (Fig. 6) over strategies with single native range pastures grazed for one period (Tables 4 and 6). Data collected at the Dickinson Research Extension Center shows that the three pasture, twice-over rotation system on native range grazed between 1 June and 15 October has a biological (Manske *et al.* 1988, Manske 1994a, Biondini and Manske 1995) and economic advantage (Tables 4 and 6) over the single pasture seasonlong treatments. The short duration treatment with eight pastures grazed three or more times each shows economic advantage (Tables 4 and 6) and a biological advantage in maintaining livestock performance at a higher stocking rate (Kirby, Conlon, and Krabbenhoft 1991) over the single pasture seasonlong treatments.

Grazing native range for 6.0 months on one pasture shows an economic disadvantage (Tables 4 and 6) because of the low stocking rate and calf gain per acre, and high costs for a pound of weight gain. Grazing native range from mid July to mid November as on the 4.0 month deferred strategy improved the stocking rate over other seasonlong strategies but calf average daily gain was reduced compared to 4.5 month seasonlong (Table 4). Fall domesticated grass pastures provided an economic advantage in net return per acre (Tables 3 and 4) and had the lowest cost for a pound of weight gain (Table 6) compared to native range and unfertilized crested wheatgrass.

The 4.5 month twice-over rotation grazing strategy, with drylot, spring, native range, and fall pastures, from calf birth to weaning showed numerically higher values over the other strategies in calf weaning weight, calf weight per day of age, calf average daily gain, calf gain per acre, total calf accumulated weight gain per season, gross returns per calf, net returns per cow-calf pair, and net returns per acre (Table 5 and Fig. 1, 2, 3, 5, and 6) and lower numerical values in acreage required to carry a cow-calf pair per season, total feed and pasture costs, cost per day and cost per pound of gain (Tables 5 and 6 and Fig. 4).

Discussion

Selection of a biologically and economically successful grazing management strategy utilizing native range and domesticated grass pastures must consider several factors that are inherent in the Northern Great Plains grassland ecosystem and can be separated into three major problems: 1) plant growth is limited by several factors, 2) ungrazed grasses are low in nutritional quality during the later portion of the grazing season, and 3) some grazing starting dates cause negative effects. Perennial grass growth is limited by both low and high temperatures, variable precipitation levels, and seasonal precipitation patterns. The ambient climatic conditions result in frequent periods with plants under water stress. During the 12 year period, 1983-1994, 43% of the growing season months from mid April through mid October had low precipitation conditions that caused water stress in perennial plants (Manske 1994c). The short period of May, June, and July is when nearly all of the growth in graminoid leaf and flower stalk height occurs (Goetz 1963, Manske 1994c). Grazing after July on native range that has not been previously manipulated is primarily on residual vegetation. Ungrazed grasses are low in nutritional quality during the later portion of the grazing season and the major graminoids drop below 9.6% crude protein levels around mid July (Whitman *et al.* 1951, Manske 1994c, Sedivec and Manske 1994). Grazing native range too early causes negative effects on plant growth. Starting seasonlong grazing treatments on native range before early June results in a loss of 45-60% of the potential peak herbage biomass (Campbell 1952, Rogler *et al.* 1962, Manske 1994c).

The identification of these three major problems inherent in the native range ecosystem and the interpretation of the biological (Manske *et al.* 1988, Manske 1994a, Biondini and Manske 1995) and economic (this paper) evidence from grazing management research with perennial vegetation in western North Dakota suggests that a grazing strategy for cow-calf pairs from birth to weaning includes a drylot period after birth, a spring domesticated grass pasture period beginning in early May, a native range period from early June to mid October using a rotation system with multiple pastures and multiple grazing periods, and a fall domesticated grass pasture period from mid October to mid November.

A drylot period is needed for calves born before late April because at the present time a perennial grass forage species that is phenologically mature enough to withstand grazing pressure in March and April is not available. Under the conditions of this simulation study, the net returns per cow-calf pair and per acre were positive during the drylot period of the five management strategies (Table 2).

The purpose of a spring pasture is to provide forage during the period of May when grazing is detrimental to native range grass growth. Domesticated grass species that have very early phenological development can be used as a spring pasture. Crested wheatgrass reaches the third leaf stage around 20 April on the average eight out of ten years at Dickinson. Other cool season grass species could possibly be used as spring pastures also. Fertilization of the crested wheatgrass pastures improves the net returns per acre compared to unfertilized crested wheatgrass pastures (Table 3).

The cool season native range grass species generally reach their third leaf stage around 1 June in western North Dakota. Grazing ahead of that time reduces peak herbage production. Delaying the start of grazing until after mid July is positive for increasing stocking rate but is very negative for livestock performance as seen in the 4.0 month deferred strategy by the low calf average daily gain (Table 4).

Grassland plants have coevolved with herbivores for 20 million years (Manske 1994b) and have developed mechanisms to compensate for defoliation. Understanding these adaptive tolerance mechanisms and setting grazing periods to beneficially manipulate these mechanisms is the key to the development of useful grazing management systems. These mechanisms have been concisely described by Manske 1994a and Manske 1995.

Defoliation with grazing between the third leaf stage and anthesis phenological stage has beneficial stimulation of the two adaptive tolerance mechanisms and has been shown to have positive effects on the plant community, livestock performance, and wildlife habitat. Controlling defoliation by grazing with multiple pastures (3 to 6) and restricting access in each pasture to one period of grazing between the third leaf stage and anthesis phenophase and a second grazing period after anthesis and before winter senescence provides a grazing period for stimulation of the two adaptive tolerance mechanisms and a later period of grazing to harvest some of the increase in herbage production. The stimulation period has been found to be 1 June to 15 July in western North Dakota, which necessitates that, each of the three equal size pastures in the system be grazed for 15 days in sequence. The harvest period occurs during 15 July to 15 October with each of the pastures grazed a second time for 30 days in the same sequence. In successive years, the grazing sequence is rotated so that the first pasture grazed during the current year was the last pasture grazed the previous year.

The twice-over rotation grazing system has been able to manipulate the level of secondary tiller development and improve the nutritional quality of the forage available during the later portion of the grazing season. It has not, however, been able to extend this period later than mid October. A fall domesticated grass pasture is needed that can provide forage of adequate nutritional quality from mid October to mid November. Altai wildrye has provided that forage need at Dickinson, but other types of wildryes may be as good or better. A perennial forage type that can provide nutritional quality without supplementation that is adequate for maintenance of production by a lactating cow after mid November is currently not known. The calf average daily gain in the late portion of the grazing season was less than 2.00 lbs on altai wildrye but the net returns per acre were greater on the altai wildrye pastures than on the native range pastures between the period of mid October and mid November.

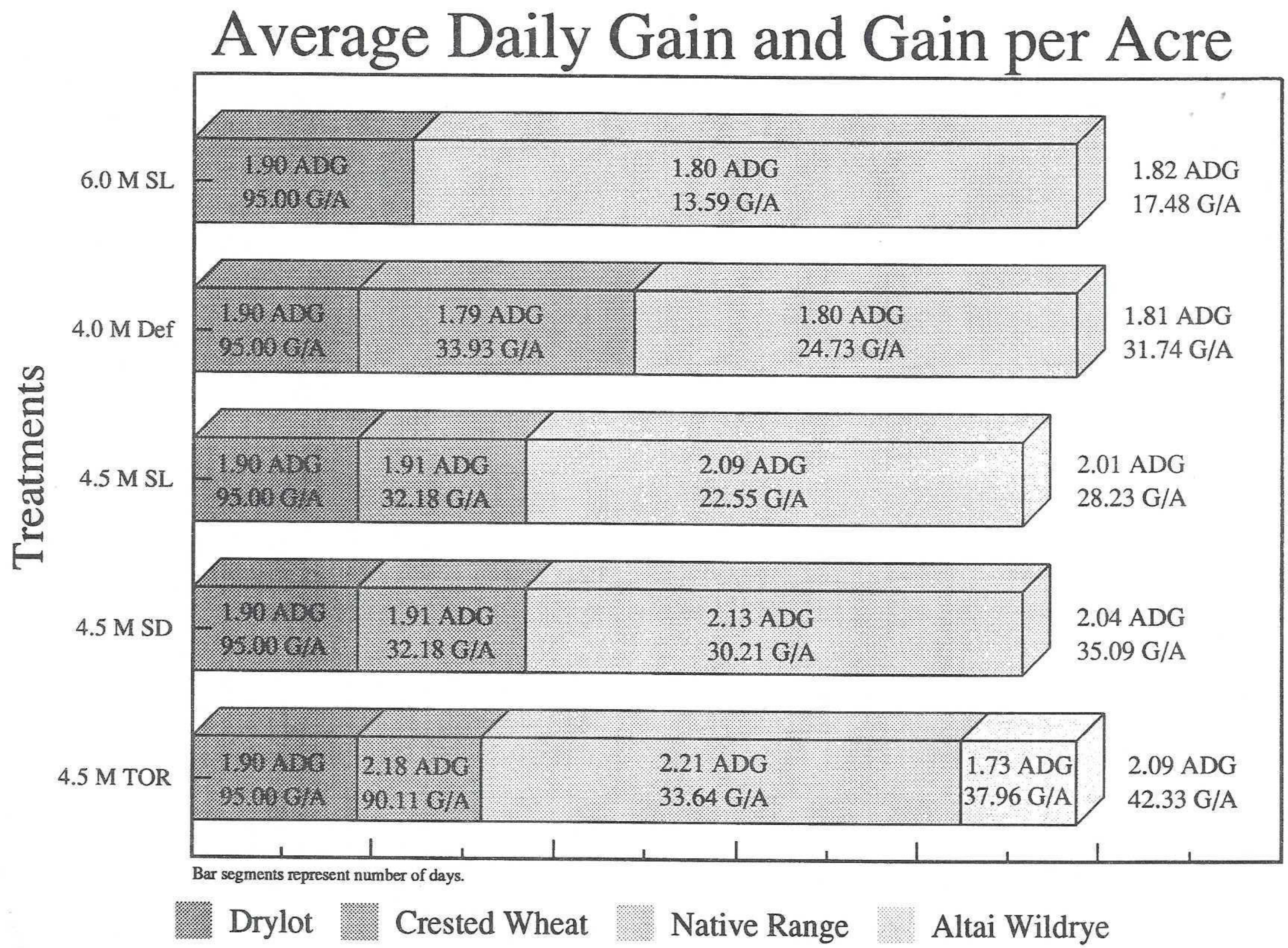

Fig 2. Calf average daily gain and gain per acre for five cow-calf production management strategies from calf birth to weaning.

Table 2. Projected general costs and returns for cow-calf production for drylot feeding on five management strategies in southwestern North Dakota.

		Grazing Management Strategy				
		Seasonlong 6.0 M	**Deferred 4.0 M**	**Seasonlong 4.5 M**	**Short Duration 4.5 M**	**Rotation 4.5 M**
LENGTH OF PERIOD	(days)	61.0	46.0	46.0	46.0	46.0
PRODUCTION						
Feed/Day	(lbs)	30.00	30.00	30.00	30.00	30.00
Feed/Period	(lbs)	1830.00	1380.00	1380.00	1380.00	1380.00
Acres/Period @ 1500 lbs/acre	(ac)	1.22	0.92	0.92	0.92	0.92
Calf ADG	(lbs)	1.90	1.90	1.90	1.90	1.90
Calf Gain/Acre	(lbs)	95.00	95.00	95.00	95.00	95.00
Calf Gain/Period	(lbs)	115.90	87.40	87.40	87.40	87.40
GROSS RETURNS						
Gross Return/C-C pr/Period						
@ 0.90/lb	($)	104.31	78.66	78.66	78.66	78.66
@ 0.80/lb	($)	92.72	69.92	69.92	69.92	69.92
@ 0.70/lb	($)	81.13	61.18	61.18	61.18	61.18
COSTS						
Ration/C-C pr @ $50.00/Ton	($)	45.75	34.50	34.50	34.50	34.50
Supplemernt @ $0.05/Day	($)	3.05	2.30	2.30	2.30	2.30
Total	**($)**	**48.80**	**36.80**	**36.80**	**36.80**	**36.80**
NET RETURNS						
Net Return/C-C pr/Period						
@ 0.90/lb	($)	55.51	41.86	41.86	41.86	41.86
@ 0.80/lb	($)	43.92	33.12	33.12	33.12	33.12
@ 0.70/lb	($)	32.33	24.38	24.38	24.38	24.38
Net Return per Acre						
@ 0.90/lb	($)	45.50	45.50	45.50	45.50	45.50
@ 0.80/lb	($)	36.00	36.00	36.00	36.00	36.00
@ 0.70/lb	($)	26.50	26.50	26.50	26.50	26.50

Table 3. Projected general costs and returns for cow-calf production for crested wheatgrass and altai wildrye pastures on five management strategies in southwestern North Dakota.

		Grazing Management Strategy					
		Crested Wheatgrass					Altai Wildrye
		Seasonlong 6.0 M	Deferred 4.0 M	Seasonlong 4.5 M	Short Duration 4.5 M	Rotation 4.5 M	Rotation 4.5 M
LENGTH OF PERIOD	(days)	0.0	76.0	46.0	46.0	31.0	30.0
PRODUCTION							
Acres/Month	(ac)	-	1.67	1.82	1.82	0.75	1.39
Acres/Period	(ac)	-	4.16	2.73	2.73	0.75	1.39
Calf ADG	(lbs)	-	1.79	1.91	1.91	2.18	1.73
Calf Gain/Acre	(lbs)	-	33.93	32.18	32.18	90.11	37.96
Calf Gain/Period	(lbs)	-	136.04	87.86	87.86	67.58	52.77
GROSS RETURNS							
Gross Return/C-C pr/Period							
@ 0.90/lb	($)	-	122.44	79.07	79.07	60.82	47.49
@ 0.80/lb	($)	-	108.83	70.29	70.29	54.06	42.22
@ 0.70/lb	($)	-	95.23	61.50	61.50	47.31	36.94
COSTS							
Pasture Rent							
C-C Pr, Period, @ 8.76/ac	($)	-	36.45	23.91	23.91	6.57	12.18
@ $12.50/ac Fert	($)	-	-	-	-	9.38	-
Total	**($)**	**-**	**36.45**	**23.91**	**23.91**	**15.95**	**12.18**
NET RETURNS							
Net Return/C-C pr/Period							
@ 0.90/lb	($)	-	85.99	55.16	55.16	44.87	35.31
@ 0.80/lb	($)	-	72.38	46.38	46.38	38.11	30.04
@ 0.70/lb	($)	-	58.78	37.59	37.59	31.36	24.76
Net Return per Acre							
@ 0.90/lb	($)	-	20.67	20.21	20.21	59.83	25.40
@ 0.80/lb	($)	-	17.40	16.99	16.99	50.82	21.61
@ 0.70/lb	($)	-	14.13	13.77	13.77	41.81	17.81

Table 4. Projected general costs and returns for cow-calf production for native range grazing systems on five management strategies in southwestern North Dakota.

		Grazing Management Strategy				
		Seasonlong 6.0 M	**Deferred 4.0 M**	**Seasonlong 4.5 M**	**Short Duration 4.5 M**	**Rotation 4.5 M**
LENGTH OF PERIOD	(days)	183.0	122.0	137.0	137.0	137.0
PRODUCTION						
Acres/Month	(ac)	4.04	2.22	2.86	2.15	2.04
Acres/Period	(ac)	24.24	8.88	12.70	9.66	9.00
Calf ADG	(lbs)	1.80	1.80	2.09	2.13	2.21
Calf Gain/Acre	(lbs)	13.59	24.73	22.55	30.21	33.64
Calf Gain/Period	(lbs)	329.40	219.60	286.33	291.81	302.77
GROSS RETURNS						
Gross Return/C-C pr/Period						
@ 0.90/lb	($)	296.46	197.64	257.70	262.63	272.49
@ 0.80/lb	($)	263.52	175.68	229.06	233.45	242.22
@ 0.70/lb	($)	230.58	153.72	200.43	204.27	211.94
COSTS						
Pasture Rent						
C-C Pr, Period, @ 8.76/ac	($)	212.34	77.79	111.25	84.62	78.84
NET RETURNS						
Net Return/C-C pr/Period						
@ 0.90/lb	($)	84.12	119.85	146.45	178.01	193.65
@ 0.80/lb	($)	51.18	97.89	117.81	148.83	163.38
@ 0.70/lb	($)	18.24	75.93	89.18	119.65	133.10
Net Return per Acre						
@ 0.90/lb	($)	3.47	13.50	11.53	18.43	21.52
@ 0.80/lb	($)	2.11	11.02	9.28	15.41	18.15
@ 0.70/lb	($)	0.75	8.55	7.02	12.39	14.79

Table 5. Projected general costs and returns for cow-calf production from calf birth to weaning for the entire season on five management strategies in southwestern North Dakota.

		Grazing Management Strategy				
		Seasonlong 6.0 M	**Deferred 4.0 M**	**Seasonlong 4.5 M**	**Short Duration 4.5 M**	**Rotation 4.5 M**
LENGTH OF SEASON	(days)	244.0	244.0	229.0	229.0	244.0
PRODUCTION						
Weaning Weight	(lbs)	540.30	538.04	556.59	562.07	605.52
Weight/Day of Age	(lbs)	2.21	2.20	2.43	2.45	2.48
Acres/Season	(ac)	25.46	13.96	16.35	13.31	12.06
Calf ADG	(lbs)	1.82	1.81	2.01	2.04	2.09
Calf Gain/Acre	(lbs)	17.48	31.74	28.23	35.09	42.33
Calf Gain/Season	(lbs)	445.30	443.04	461.59	467.07	510.52
GROSS RETURNS						
Gross Return/C-C pr/Season						
@ 0.90/lb	($)	400.77	398.74	415.43	420.36	459.47
@ 0.80/lb	($)	356.24	354.43	369.27	373.66	408.42
@ 0.70/lb	($)	311.71	310.13	323.11	326.95	357.36
COSTS						
Pasture Rent and Feed						
C-C Pr, Season	($)	261.14	151.04	171.96	145.33	143.77
NET RETURNS						
Net Return/C-C pr/Season						
@ 0.90/lb	($)	139.63	247.70	243.47	275.03	315.70
@ 0.80/lb	($)	95.10	203.39	197.31	228.33	264.65
@ 0.70/lb	($)	50.57	159.09	151.15	181.62	213.59
Net Return per Acre						
@ 0.90/lb	($)	5.48	17.74	14.89	20.66	26.18
@ 0.80/lb	($)	3.74	14.57	12.07	17.15	21.94
@ 0.70/lb	($)	1.99	11.40	9.24	13.65	17.71

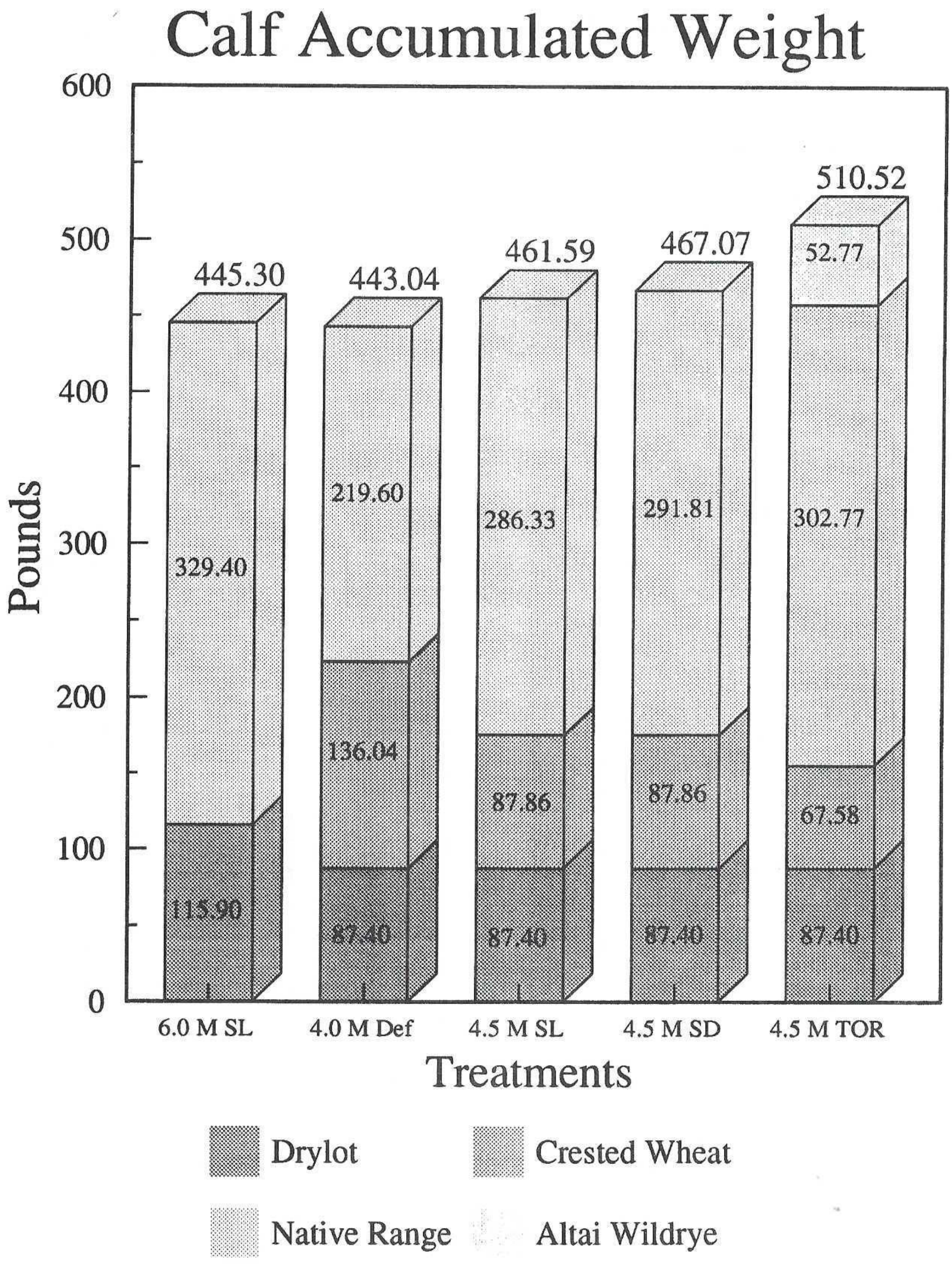

Fig 3. Calf accumulated weight gain for five cow-calf production management strategies from calf birth to weaning.

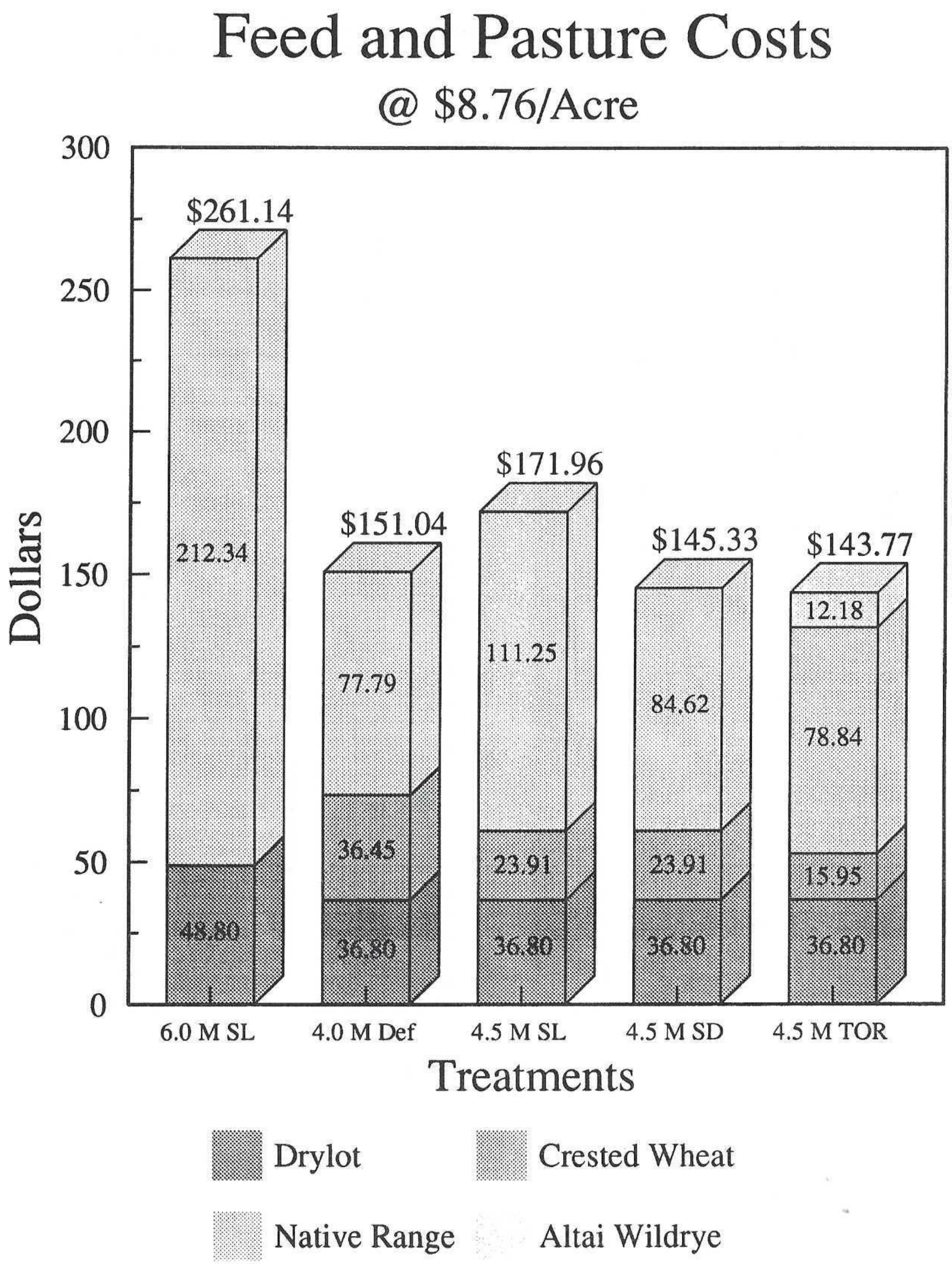

Fig. 4. Feed and pasture costs @ 8.76/acre for five cow-calf production management strategies from calf birth to weaning.

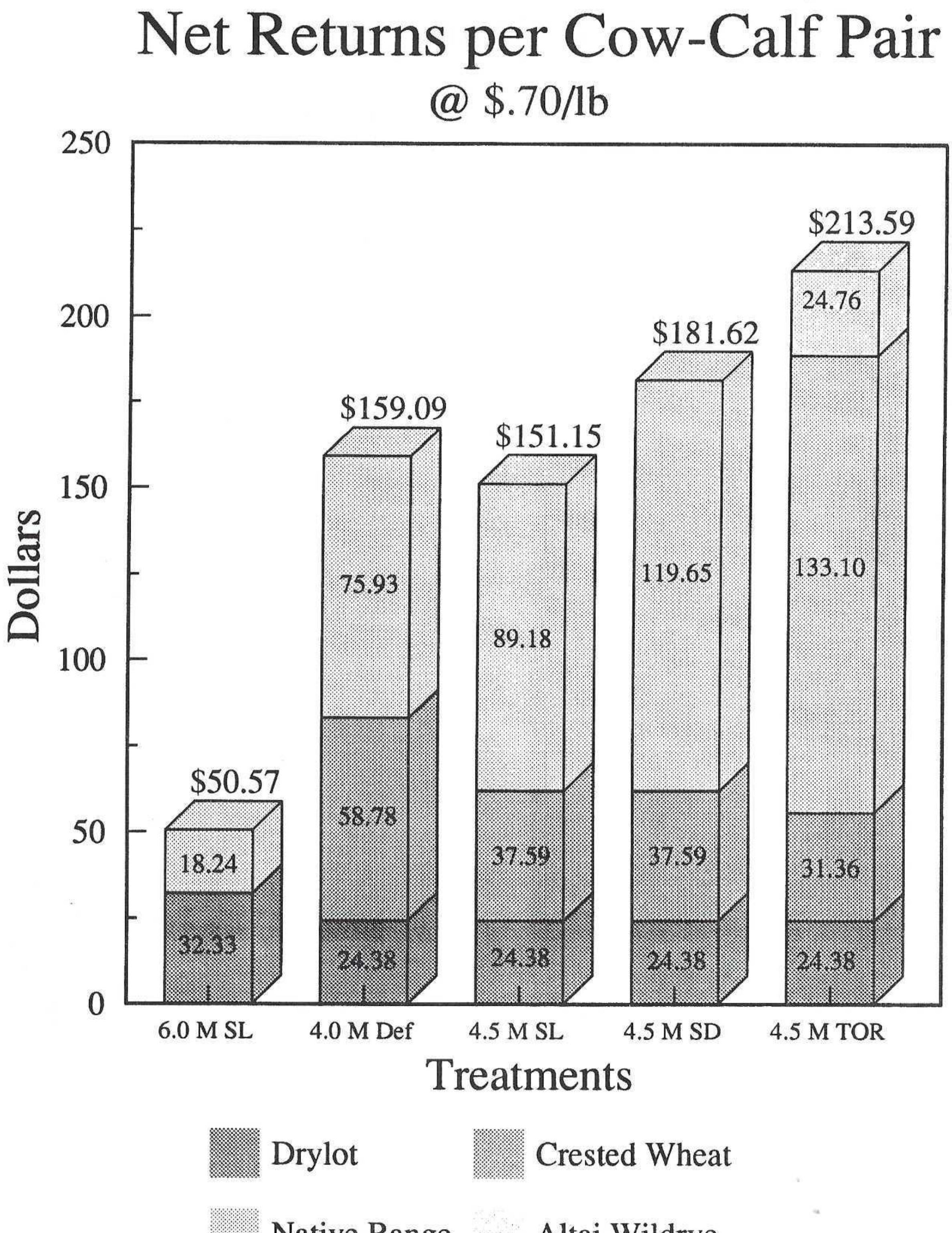

Fig. 5. Net returns per cow-calf pair @ $0.70/lb for five cow-calf production management strategies from calf birth to weaning.

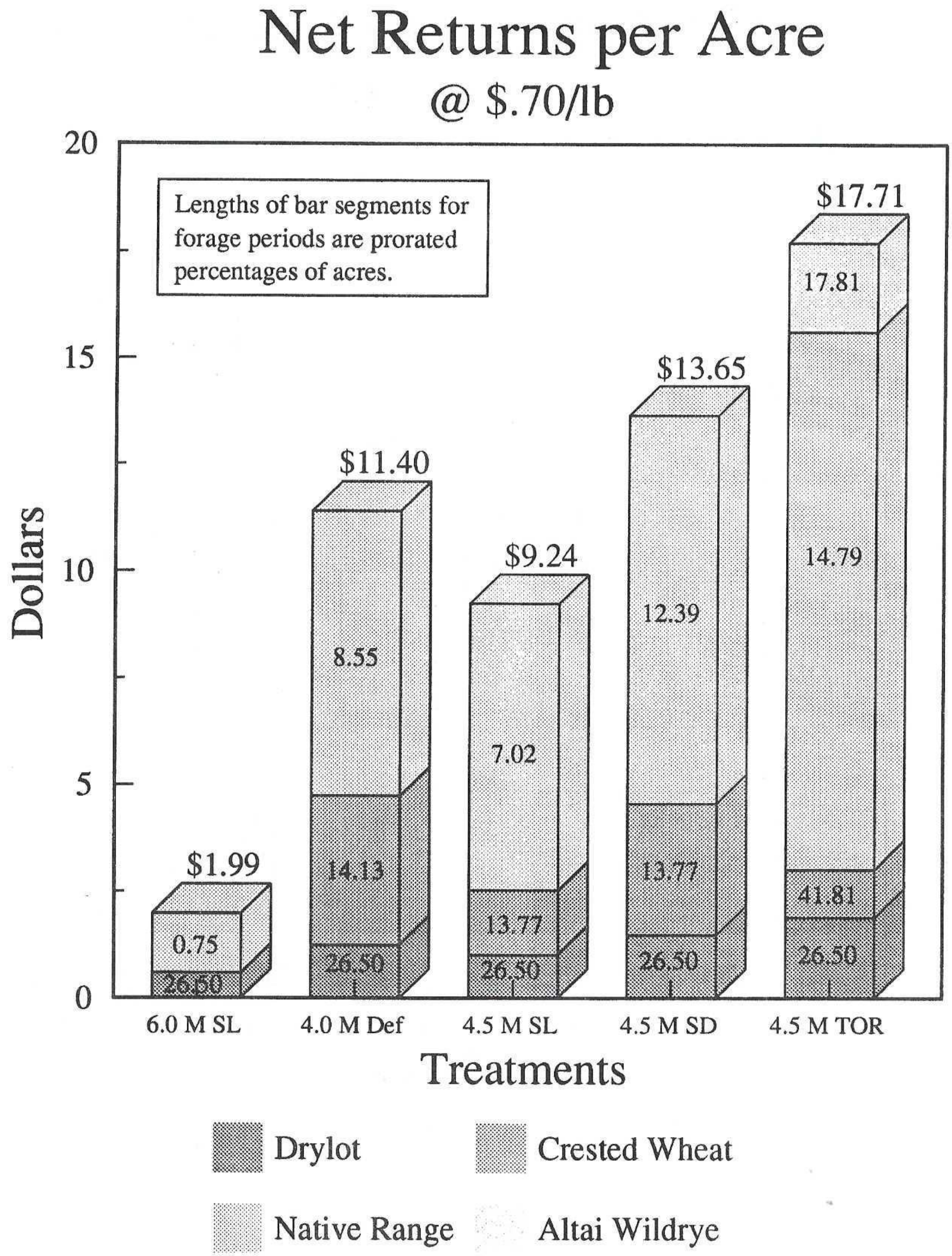

Fig. 6. Net returns per acre @ $0.70/lb for five cow-calf production management strategies from calf birth to weaning.

Table 6. Cost per day and cost per pound gain at $8.76 per acre for five cow-calf production management strategies from calf birth to weaning.

		Grazing Management Strategy				
		Seasonlong 6.0 M	Deferred 4.0 M	Seasonlong 4.5 M	Short Duration 4.5 M	Rotation 4.5 M
DRYLOT						
Cost /Day	($)	0.80	0.80	0.80	0.80	0.80
Cost/lb Gain	($)	0.42	0.42	0.42	0.42	0.42
CRESTED WHEATGRASS						
Cost/Day	($)	-	0.48	0.52	0.52	0.51
Cost/lb Gain	($)	-	0.27	0.27	0.27	0.24
NATIVE RANGE						
Cost/Day	($)	1.16	0.64	0.81	0.62	0.58
Cost/lb Gain	($)	0.64	0.35	0.39	0.29	0.26
ALTAI WILDRYE						
Cost/Day	($)	-	-	-	-	0.40
Cost/lb Gain	($)	-	-	-	-	0.23
ENTIRE STRATEGY						
Cost/Day	($)	1.07	0.62	0.75	0.63	0.59
Cost/lb Gain	($)	0.59	0.34	0.37	0.31	0.28

Conclusion

A grazing management strategy that is biologically and economically successful coordinates the grazing of various forage types with the phenological development and biological needs of the plants, as well as matching the forage types with the nutritional requirements of the livestock so that the livestock have adequate nutritional quality for the entire grazing season. A grazing management strategy utilizing perennial forages that works biologically and economically has a drylot period from calf birth to early May, a spring domesticated grass pasture from early May to early June, a native range grazing system with three to six pastures grazed twice per year, once during the stimulation period (third leaf to anthesis) and a second time during the harvest period (seed development to fall senescence), and a fall domesticated grass pasture from mid October to mid November. Economic returns received from cow-calf production on native range and domesticated grass pastures can be increased by implementing a grazing management strategy that beneficially affects the biology of the growth of vegetation and the performance of cow-calf pairs.

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Adaptive Tolerance Mechanisms in Grass Plants

Llewellyn L. Manske PhD

Associate Range Scientist
North Dakota State University
Dickinson Research Extension Center

Graminoid plant species respond differently to defoliation by grazing, mowing, and fire at various times during their growth cycles and stages of phenological development. These various responses are a result of compensation to defoliation during the long period of coevolution with herbivores and fire. Grass plants and grazing mammals appeared in the fossil record at the same time in the lower Miocene Epoch about 20 million years ago. Grass plants, grazing mammals, and grassland plant communities have evolved together. The adaptive tolerance mechanisms that grass plants developed to compensate for defoliation can be understood and manipulated with defoliation management at specific times or phenological growth stages to produce beneficial effects to grassland ecoosystems. Sampson (1914 and 1954) recognized the importance of basing grazing management on the growth requirements and life history of the vegetation. Recently, several greenhouse and laboratory studies (Anderson *et al.*1981, Clarholm 1985, Coleman *et al.* 1983, Ingham *et al.* 1985) have opened the way to a better understanding of the adaptive tolerance mechanisms that grassland plants have developed. These adaptive tolerance mechanisms can be separated into two general categories that function interrelatively. The first tolerance mechanism is numerous changes in the physiological responses within the grassland plant caused by defoliation. The second tolerance mechanism is numerous changes in the activity levels of the symbiotic soil organisms in the rhizosphere caused by defoliation.

The physiological responses within the plant caused by defoliation have been reviewed and grouped into nine categories by McNaughton (1983). Physiological responses to defoliation do not occur at all times, and the intensity of the response is variable. Responses can be related to different phenological stages of growth of the grass plants. The key to ecological management by effective defoliation is to match the timing of the defoliation to the phenological stage of growth that triggers the desired outcome. All of the relationships between the physiological responses and the application of the management treatment have not been fully developed with scientific research. One of the main physiological effects of defoliation is the temporary reduction in the production of the blockage hormone, auxin, within the meristem, and young developing leaves (Briske and Richards 1994). This reduction of plant auxin in the lead tiller allows either for cytokinin synthesis in the roots or crown, or its utilization in axillary buds, which stimulate the development of vegetative tillers (Murphy and Briske 1992, Briske and Richards 1994). Partial defoliation of young leaf material reduces the hormonal affects of apical dominance by the lead tiller, and allows some secondary tillers to develop from the previous year's axillary buds. Secondary tillers can develop without defoliation manipulation after the lead tiller has reached anthesis phenophase, but usually only one secondary tiller develops from the potential of five to eight buds because this secondary tiller suppresses additional axillary bud development hormonally by apical dominance. When the lead tiller is partially defoliated at an early phenological growth stage, several axillary buds can develop subsequently into secondary tillers. Apparently, no single secondary tiller is capable of developing complete hormonal apical dominance following defoliation of the lead tiller at this time. Some level of hormonal control from the older axillary buds still suppresses development of some of the younger axillary buds' development. With our present level of knowledge of this mechanism, we are unable to achieve the full potential for all axillary buds to develop into secondary tillers.

The second type of influence by defoliation on grassland plants are the changes in activity levels within the components of the rhizosphere. The rhizosphere is that narrow zone of soil around living roots of perennial grassland plants where the exudation of sugars, amino acids, glycosides, and other compounds affect microorganism activity (Curl and Truelove 1986, Whipps 1990, Campbell and Greaves 1990). Bacterial growth in the rhizosphere is stimulated by the presence of carbon from the exudates (Elliott 1978, Anderson *et al.* 1981, Curl and Truelove 1986, Whipps 1990). Protozoa and nematodes graze increasingly on the increased bacteria (Curl and Truelove 1986), and accelerate the overall nutrient cycling process through the "fast" pathway of substrate decomposition as postulated by Coleman *et al.* (1983). The activity of the microbes in the rhizosphere increases the amount of nitrogen available for plant growth (Ingham *et al.*1985 a.b., Clarholm 1985, Allen and Allen 1990). The presence of vasicular-arbuscular mycorrhizal (VAM) fungi enhances the absorption of ammonia, phosphorus, other mineral nutrients, and water (Moorman and Reeves 1979, Harley and Smith 1983, Allen and Allen 1990, Box and Hammond 1990, Marschner 1992). Rhizosphere activity can be manipulated by defoliation at early phenological growth stages when a higher percentage of the total nitrogen of the plant is in the aboveground parts and a higher percentage of the total carbon of the plant is in the belowground parts. At that time, partial defoliation disrupts the plant's carbon to nitrogen ratio, leaving a relatively high level of carbon in the remaining plant. Some of this carbon is exudated through the roots into the rhizosphere in order to readjust the carbon-nitrogen ratio. Bacteria in the rhizosphere are limited by access to simple carbon chains under conditions with no defoliation (Curl and Truelove 1986). The rhizosphere bacteria increase in activity in response to the increase in exudated carbon under conditions with defoliation (Lynch 1982, Ingham *et al.* 1985). The increases in activity by the bacteria triggers increases in activity in the other trophic levels of the rhizosphere organisms (Curl and Truelove 1986). This ultimately increases available nutrients for the defoliated grass plant (Ingham *et al.* 1985, Clarholm 1985). During middle and late phenological stages of growth, carbon and nitrogen are distributed more evenly throughout the plant. Defoliation at that time does not remove a disproportionate amount of nitrogen, and very little or no carbon is exudated into the rhizosphere. Soil water levels generally decrease during middle and late portions of the grazing season and also limit rhizosphere organism activity levels (Curl and Truelove 1986, Bazin *et al.* 1990).

Interpretation of data from these studies strongly suggests compensatory growth mechanisms on plants subjected to defoliation by grazing. One school of thought suggests that these plants may be dependent on grazing to optimize production (McNaughton 1983, Pieper 1994). Data from McNaughton (1979, 1985) indicate that grazing exclusion leads to a drastic decline in net primary productivity (NPP) and to a rapid ecotypical selection toward less productive, and less grazing resistant plants. McNaughton (1983) theorizes that grazing exclusion may lead to a net diminution of total energy and nutrient flow through the system. Plants capable of compensating for herbage removal may support a dense and complex trophic web which in turn may be essential to their existence. This in turn implies a critical role for the belowground trophic level (belowground NPP, soil microflora and soil fauna) in ecosystem function. Understanding the adaptive tolerance mechanisms at work in the physiology within a grassland plant and in the activity levels of the symbiotic soil organisms in the rhizosphere following defoliation and the beneficial manipulation of these mechanisms under field conditions are the key to the further development of ecologically sound recommendations for management of our grassland natural resources.

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BEEF RESEARCH

EFFECTS OF GAINPRO (BAMBERMYCINS) AND AMAFERM (ASPERGILLUS ORYZAE) FED TO GROWING HEIFER CALVES IN NORTH DAKOTA

D. V. Dhuyvetter, J. S. Caton, K. Ringwall and G. Ottmar

NDSU Animal and Range Sciences, Fargo, North Dakota
Dickinson Research Extension Center, Dickinson, North Dakota

Research Summary

Eighty-four Charolais crossbred heifers (571.4 ± 5.4 lb) were used to determine the effects of bambermycins (Gainpro) and Aspergillus oryzae (Amaferm) on calf performance when fed in high forage grower diets. Heifers were fed in 12 pens for 84 days at the Dickinson Research and Extension Center, Manning Ranch, from December 6, 1994, to March 1, 1995. Assigned treatment combinations were as follows: 1) no bambermycins + no Aspergillus oryzae (CONT); 2) 20 milligrams/head/day of bambermycins (GAIN); 3) 2 grams/head/day Aspergillus oryzae (AMA); or 4) AMA + GAIN (AMAGAIN). Treatments were formulated and delivered in a protein supplement comprised of soybean oil meal and sunflower meal fed daily (.86 lb/hd). Heifers were fed a corn-silage and oat hay based growing ration (63% of diet, DM basis) formulated for 2 lb ADG. An interaction between treatments for heifer DM intake was detected ($P = .03$). This can be interpreted to mean that intake responses due to Amaferm depended if the heifers received, or did not receive Gainpro. There were no treatment interactions ($P > .30$) for heifer performance measurements. Total ADG was improved ($P < .02$) by 5.1% for Amaferm and 6.0% for Gainpro compared to heifers that did not receive these feed additives. Feed efficiency was also improved by 6.0% for Amaferm and 6.2% for Gainpro ($P < .03$) fed heifers. Heifers that were fed both feed additives had higher daily gains and were the most efficient in feed conversion ($P < .10$) when compared to all other treatment combinations. Results indicate that both Amaferm and Gainpro have a positive effect on heifer growth when fed with high forage-based growing diets. When both feed additives were combined, heifer gain and feed conversions were further increased. Performance benefits in the current study would have easily paid for the feed additives and increased producer returns. Dietary additions of Direct Fed Microbials in conjunction with ionophores or antibiotics may warrant further investigations for improving calf performance and economic returns to feedlot cattle.

Introduction

Many types of feed additives exist from which producers can choose. Feed additives for growing cattle can assist producers by improving feed efficiency, calf performance and maintaining calf health. Bambermycins (Gainpro, Hoechst Roussel) has recently received FDA approval for increased rate of weight gain and improved feed efficiency in confined feedlot cattle and increased daily gain in pasture cattle. Although Gainpro is classified as an antibiotic and not an ionophore (such as Rumensin or Bovatec), it competes directly with these products. Hoechst Roussel has been targeting the use of Gainpro with high fiber diets typical of grazing stocker cattle and backgrounding programs that contain low levels of grain. The latter example can often be found on North Dakota ranches during the fall and winter months. Recent data indicated a growth response to Gainpro when compared to ionophores supplemented to grazing stocker steers (Keith et al, 1995).

Direct Fed Microbials (DFM) is a name given to a class of feed additives by the FDA in 1989, that contain a source of live (viable) naturally occurring microorganisms. This definition includes bacteria, fungi and yeasts. Although FDA has classified these products, they do not currently regulate their use. Commercial products available to producers at the present time will fall into both viable and non-viable categories. Aspergillus oryzae (Amaferm, Biozyme, Inc.) is a fermentation extract produced from a selected strain of enzyme-producing aspergillus. Responses observed when feeding DFM's have been variable and therefore, scientists have found it difficult to prove how they work. Primary actions of DFM's are proposed to be: Minimizing the growth of pathogenic bacteria; Increasing desirable microbial populations in the gut; Facilitating fiber digestion; and Inactivating toxins.

Much of the prior work with DFM's has focused on improving milk production in dairy cattle. Fewer studies have investigated the effects of DFM's when used in grower diets and in particular, when fed in combination with an ionophore. Diamond V Mills Inc. (Personal Communication) reported positive responses in feedlot cattle when DFM's were fed in combination with an ionophore (Laidlomycin propionate; Cattlyst).

The objectives of this study were to evaluate the effects of bambermycin (Gainpro) and Aspergillus oryzae (Amaferm) in growing diets fed to weaned heifer calves in North Dakota.

Materials and Methods

Eighty-four Charolais crossbred heifers, arranged in 2 X 2 treatment factorial, were used in a randomized complete block design to determine the effects of bambermycins and Aspergillus oryzae fed in high roughage grower diets. The experiment was conducted at the Dickinson Research and Extension Center, Manning Ranch, from December 6, 1994, to March 1, 1995. Heifers were stratified by body weight across 12 pens (7 calves/pen) and pens randomly assigned to treatment within one of three blocked locations in the feedyard. Heifers were assigned to receive one of the following treatments: 1) no bambermycins + no Aspergillus oryzae (CONT); 2) 20 milligrams/head/day of bambermycins (GAIN); 3) 2 grams/head/day Aspergillus oryzae (AMA); or 4) AMA + GAIN (AMAGAIN). Treatments were formulated and delivered in a protein supplement comprised of soybean meal and sunflower meal fed daily (.86 lb/hd). Heifers were fed a corn-silage and oat hay based growing ration (63% of diet, DM basis) formulated for 2 lb ADG. Assay results from Barrow-Agee Laboratories, Inc., Memphis, Tennessee, confirmed bambermycins concentrations of 25.47 and 16.70 milligrams/lb for GAIN and AMAGAIN supplements, respectively. Feed nutrient compositions are given in Table 1. Diet formulations and nutrient compositions are reported in Table 2. Approximately 4 wk prior to weaning, and again at weaning, heifers were vaccinated for IBR, BVD, BRSV and PI_3. Heifers were also treated for internal parasites with fenbendazole (Safe-Guard) according to label directions at the beginning of the experiment. Experimental protocol was approved by the NDSU Animal Care and Use Committee.

Heifer body weight measurements were collected on day -1, 0, 29, 56, 84 and 85 of the experiment. Initial and ending weights used for analyses were derived from the average of two 12 hour shrunk weights collected at the same time of the day, on two successive days. Feed intake was measured on a pen-basis and used to calculate feed efficiency. All heifers remained in good health throughout the study with no observed incidence of morbidity.

Pen was used as the experimental unit for data analyses. Treatment effects and their interactions were tested by analysis of variance using general linear models of SAS (1989). Analysis of covariance (SAS, 1989) with initial heifer weight as a covariate was used to test for the following variables: final weight, weight gain from day 0 to day 28, day 29 to day 56 and day 57 to day 84, ADG, and total weight gain.

Table 1. Nutrient composition of feeds (DM basis) used in experimental diets evaluating Amaferm and Gainpro.

	DM	**CP**	**ADF**	**Ca**	**P**	**NEg**
	------------------------------------%--------------------------					**Mcal/lb**
Corn Silage	50.0	7.80	24.90	.09	.20	.47
Barley	91.3	12.80	6.49	.08	.30	.64
Oat Hay	89.1	10.25	30.94	.32	.19	.40
Protein Supplement[a]	88.6	42.31	15.26	.30	.89	.53
Mineral/Vitamin Premix[b]	----	----	----	23.50	6.10	----

[a] Supplements (n = 4) were formulated to contain: no bambermycins + no Aspergillus oryzae (CONT), bambermycins (20 mg/hd/d; GAIN), Aspergillus oryzae (2 g/hd/d; AMA) or GAIN + AMA (AMAGAIN).

[b] Mineral/Vitamin Premix contained: 350,000 IU/lb Vitamin A, 20,000 IU/lb Vitamin D, 50 IU/lb Vitamin E, 270 ppm Cu, 18 ppm Se and 720 ppm Zn.

Table 2. Ration formulations and nutrient analysis (DM basis) of heifers fed Amaferm or Gainpro.

	CONT	AMA	GAIN	AMAGAIN
Corn Silage, %	38.43	37.90	38.52	38.29
Oat Hay, %	24.48	24.89	25.17	24.71
Barley, %	30.53	30.80	29.98	30.56
Protein Supplement, %	5.55	5.47	5.40	5.50
Mineral/Vitamin, %	.69	.63	.61	.63
Trace Mineral Salt, %	.32	.32	.32	.32
DM Intake, lb	15.81	15.78	15.95	15.56
Nutrient Composition				
Crude Protein, %	11.76	11.76	11.71	11.76
Calcium, %	.32	.30	.30	.30
Phosphorus, %	.31	.30	.30	.30
NEg, Mcal/lb	.50	.50	.51	.50

Results and Discussion

There were no differences ($P > .38$) in initial body weight (571.4 ±5.4 lb) at the start of the study for heifers assigned to Amaferm or Gainpro treatments. Furthermore, there were no treatment interactions ($P > .30$) for heifer performance measurements, although an Amaferm x Gainpro interaction was found for DM intake ($P = .03$; Table 3). When Amaferm or Gainpro were fed alone, DM intake was similar ($P > .16$) to control heifers. However, DM intake was lower ($P < .05$) when Amaferm and Gainpro were fed together compared to either Amaferm or Gainpro fed alone (Table 3).

No Amaferm x Gainpro interactions were noted in gain and efficiency. Therefore, main effects of either Amaferm or Gainpro are presented in Table 4. In the first 28 days heifers fed Amaferm had greater ($P < .03$; Table 4) weight gains than controls. However, during the next 28 day period these control heifers compensated, and gained more weight ($P < .09$; Table 4) than heifers fed Amaferm. This may partially be explained by differences in gut fill early in the experiment resulting from more variable intakes. Corn silage dry matter was also noted to be more variable early in the study. Moreover, interim weights were single day measurements which are much more variable than consecutive day weighing.

Total ADG was improved ($P < .02$; Table 4) for both Amaferm (5.1%) and Gainpro (6.0%) compared to control heifers. Feed efficiency was improved by 6.0% for Amaferm and 6.2% for Gainpro ($P < .03$) fed heifers compared to controls.

There were clearly additive effects when Gainpro and Amaferm were fed together for both ADG (Figure 1) and feed efficiency (Figure 2). Figures 1 and 2 presents all of the various treatment combinations (CONT, AMA, GAIN and AMAGAIN) and their effects on total ADG and feed efficiency, respectively. When heifers were fed both feed additives they had significantly higher daily gains and were the most efficient in feed conversion ($P < .10$) of all treatments. Numeric ranking of the data indicates that CONT heifers were the lowest in ADG and poorest in feed efficiency, with AMA and GAIN intermediate to the significantly higher performing AMAGAIN fed heifers. These data indicate that there were synergistic effects between the two feed additives and that they may be acting positively on separate digestive or metabolic functions to improve gains and feed conversions. Approximate cost of Gainpro additions to a supplement would be $.015 and Amaferm $.02 per daily animal dosage. Performance benefits in the current study would have easily paid for the feed additives and increased returns to the producer.

From these research results, it appears that both Amaferm and Gainpro have a positive effect on heifer growth when fed high forage-based growing diets. When both feed additives were combined, gain responses were further increased in addition to improved feed efficiencies. Additions of DFM's with ionophores or antibiotics may warrant further investigations for improving calf performance and economic returns to feedlot cattle.

Table 3. Amaferm x Gainpro interaction (P = .03) effects on DM intake for beef heifers fed forage based diets[a].

	Gainpro	
Lbs.	**Control**	**Gainpro**
Amaferm		
Control	15.81[b]	15.95[b]
Amaferm	15.78[b]	15.56[c]

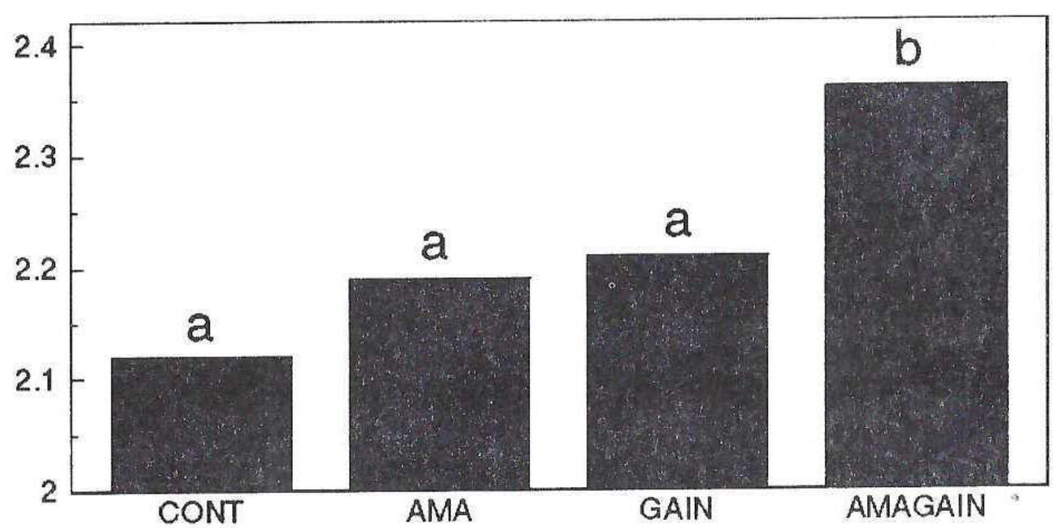
[a] SE = .063, n = 3.
[b,c] Row and column means with uncommon superscripts differ ($P < .05$).

Table 4. Influence of Amaferm and Gainpro on gain (lbs) and feed efficiency of heifers fed forage based diets.

	Amaferm		Gainpro		
Item	**Control**	**Amaferm**	**Control**	**Gainpro**	**SE**
Ending Wt	753.00^{a}	762.00^{b}	752.00^{a}	763.00^{b}	1.93
Gain, day 0-28	70.00^{a}	92.00^{b}	78.00	85.00	5.28
Gain, day 29-56	59.70^{a}	42.70^{b}	51.80	50.50	5.80
Gain, day 57-84	52.00	56.00	51.70	56.30	2.20
Total Gain	182.00^{a}	191.00^{b}	181.00^{a}	192.00^{b}	1.93
Total ADG	2.16^{a}	2.27^{b}	2.15^{a}	2.28^{b}	.023
Feed efficiency, lb/gain	7.36^{a}	6.92^{b}	7.37^{a}	6.91^{b}	.102

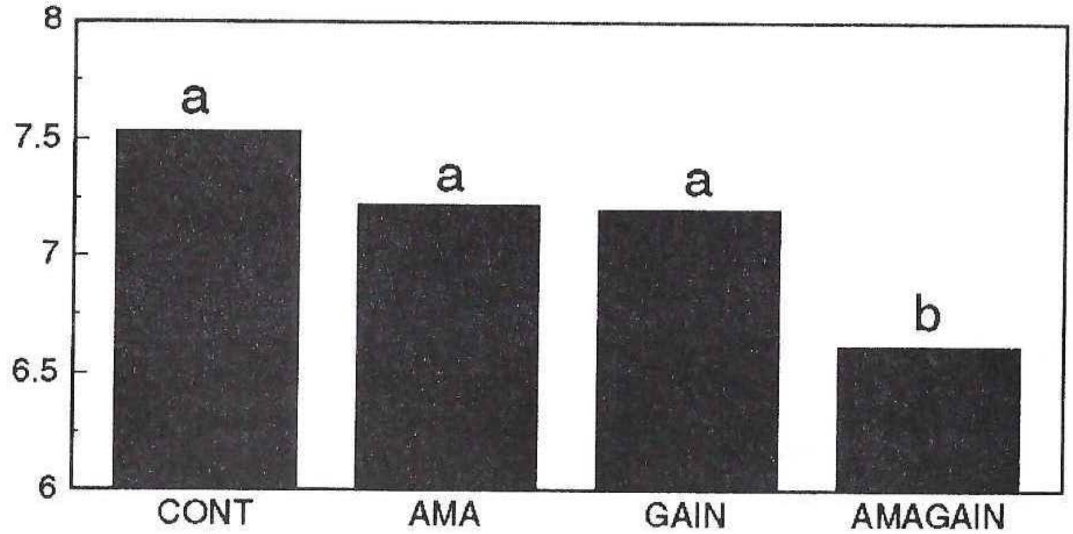
^{a,b} Row means within Amaferm or Gainpro having differing superscripts differ (P < .10).

Figure 1. Effects of Gainpro and Amaferm on beef heifer average daily gain (lbs).



Bars with unlike letters differ (P <.10)

Figure 2. Effects of Gainpro and Amaferm on beef heifer feed efficiency.



Bars with unlike letters differ (P <.10)

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1995 NCA-IRM-SPA COW-CALF ENTERPRISE SUMMARY OF REPRODUCTION AND PRODUCTION PERFORMANCE MEASURES FOR CHAPS COW-CALF PRODUCERS

K. Helmuth and K.A. Ringwall

Dickinson Research Extension Center
Department of Animal and Range Sciences
North Dakota State University

ABSTRACT:

Being competitive in current beef production requires that producers understand all details of their working operation. The North Dakota State University Extension Service in cooperation with the North Dakota Beef Cattle Improvement Association provide managerial reports generated through the Cow Herd Appraisal of Performance Software (CHAPS III). These reports assist producers with total herd evaluations which are utilized in North Dakota's Integrated Resource Management (IRM) program. For more effective utilization of individual herd data, production benchmark values utilizing the NCA-IRM-SPA calculations were obtained from 199 beef cow herds with a total of 96,880 cows exposed to bulls and processed through CHAPSIII from 1990 to 1994.

INTRODUCTION:

Performance and production data need to be collected and utilized for a sound beef operation to function in the 90's. The collection of data, such as birth date, birth weight, weaning weight, etc., is a common event, however the utilization of the data may vary considerably from one beef producer to the next. The purpose of this paper is to enhance the beef producer's ability to evaluate production records and increase the understanding and utilization of production data within the operation.

Beef performance data actually only comes in one form, but with two purposes. The purpose that most producers first think of and relate to, is performance data. Performance data is used within genetic evaluation programs to estimate the direction of genetic change and allows for accurate cow culling, heifer selection and bull buying. The second purpose is the appraisal of overall cow herd productivity which allows a beef producer to evaluate management decisions for the past year through changes in overall cow herd output. In other words, do the management regimes and selected individuals actually perform at the expected level.

The beef producer needs to first incorporate into the cow herd the CHAPS (Cow Herd Appraisal of Performance System) evaluation program and focus on both individual performance as well as overall herd productivity. The following evaluations are provided by CHAPS on individual performance data. The calf output is divided by sex and provides birth date, birth weight, calving ease, actual weaning weight, age in days, adjusted 205 day weight, adjusted 205 day weight ratio, frame score, average daily gain, weight per day of age, calf grade and parentage information on each calf. Averages presented are within sex and include an overall sex group average, individual sire averages and cow breed averages for all traits recorded.

A separate sire summary is included to provide trait averages by sire for birth weight, calving ease, actual weaning weight, adjusted 205 day weight, average daily gain, weight per day of age, calf age and frame score. Most probable producing ability (MPPA) values are calculated for all cows within the herd. The cow summaries include the cow identification, age of cow, cow breed, MPPA, number of calves born, number of calves weaned, calving interval, and sire of cow. All previous years individual calf records are available for review if needed.

The appraisal of overall cow herd productivity is accomplished within CHAPS through summarizing the calf data. The herd summary includes a reproductive analysis of the herd, a calving distribution report, an overall growth report, herd uniformity score and a cow culling report. The herd comparison report identifies those factors which are critical to the operation of the beef business. The last report includes the NCA-IRM-SPA cow-calf summary of reproduction and production performance measures values. The NCA-IRM-SPA performance values are standardized calculations based on guidelines established by National Cattlemen's Association National Integrated Resource Management Coordinating Committee Cow-Calf Financial Analysis Subcommittee.

MATERIALS AND METHODS:

The North Dakota Beef Cattle Improvement Association has processed beef cattle records since 1963. Individual calf records for 199 beef cow herds during 1990 to 1994 are processed through the CHAPS III computer program. Ninety six thousand eight hundred eighty individual records of cows exposed to bulls are combined into one large data set to generate typical CHAPS beef cow herd performance.

RESULTS AND DISCUSSION:

Although a producer's natural instinct is to review the individual performance data first, the initial step should be to review the overall herd productivity data. Once the total operation has been evaluated, the beef producer can initiate changes to the operation. Generally, the operation will need to modify some combination of management and cattle genetics. Annual trends in NCA-IRM-SPA production measures during 1990 to 1994 are listed in Table 1. Benchmark five year rolling average values are in Table 2. Table 3 summarizes the mean values for the top, middle, and bottom one-thirds for the 199 beef cow herds processed through CHAPS III from 1990-1994. These NCA-IRM-SPA reproduction and performance values are presented to encourage producers to critically evaluate their own operations. As each value is reviewed, a producer should ask if that information is available for their operation. If the data is available, then the producer should compare their operation to the data presented. If the data is not available, then the producer should consider how the data might be obtained.

Individual cow as well as herd performance records are a valuable and necessary tool for making accurate selection and culling decisions. However, beef producers must realize that these records need to be utilized in a comprehensive evaluation of herd productivity in order for the beef cattle operation to discover the greatest efficiency and profitability.

Table 1. ANNUAL NCA-IRM-SPA COW-CALF ENTERPRISE SUMMARY OF REPRODUCTION AND PRODUCTION PERFORMANCE MEASURES

Year	Pregnancy Percentage	Pregnancy Loss Percentage	Calving Percentage	Calf Death Loss	Calf Crop	Female Replacement Rate	Percentage Death Loss	Calving Distribution				Average		Pounds Weaned per exposed cow
								21	42	63	late	Calf Age	Wean Weight	
1990	94.0	0.2	93.8	2.4	91.6	17.8	2.6	58	87	96	4	195	557	505
1991	94.4	0.4	94.0	2.7	91.6	17.8	2.9	57	87	95	5	200	556	510
1992	94.9	0.2	94.7	3.3	91.4	17.7	3.5	57	83	94	6	202	569	522
1993	94.1	0.4	93.7	4.0	90.1	21.6	4.3	59	87	96	4	202	588	521
1994	94.3	0.6	93.7	3.8	90.3	20.0	4.1	60	87	96	4	202	559	497

Table 2. CHAPS NCA-IRM-SPA cow calf enterprise mean and standard deviation values for reproduction and production performance measures.

	Mean	Standard Deviation
Reproduction Performance Measures:		
Pregnancy Percentage	94.3	4.1
Pregnancy Loss Percentage	.4	.8
Calving Percentage	94.0	4.1
Calf Death Loss	3.3	3.0
Calf Crop or Weaning Percentage	90.9	5.1
Female Replacement Rate Percentage	19.1	8.8
Calf Death Loss - Based on Number of Calves Born	3.6	3.2
Calves Born During First 21 Days	58.3	17.0
Calves Born During First 42 Days	86.1	11.8
Calves Born During First 63 Days	95.6	6.7
Calves Born After First 63 Days	4.4	6.7
Production Performance Measures:		
Average Age at Weaning (days)	201	21.7
Actual Weaning Weight for Steers	577	66.4
Actual Weaning Weight for Heifers	548	55.8
Actual Weaning Weight for Bulls	619	86.5
Average Weaning Weight	567	59.0
Weight Weaned per Exposed Female	511	64.6
Culling Percentages Based on Total Cows Exposed:		
Total Percent Culled	13.5	8.9
Percent Dead	.6	.9
Percent Culled due to Age	2.1	3.5
Percent Culled due to Defects	1.6	2.7
Percent Culled due to Poor Fertility or Open	4.1	3.5
Percent Culled due to Inferior Calves	1.7	3.2
Percent Culled for Replacement Stock	2.3	6.4
Percent Culled for Unknown Reasons	1.2	4.2

Table 3. CHAPS NCA-IRM-SPA cow calf enterprise mean values for the top, middle, and bottom thirds for reproduction and performance measures. Selected on age adjusted weight weaned per exposed female.

	Top Third	Middle Third	Bottom Third
Reproduction Performance Measures:			
Pregnancy Percentage	95.1	94.6	93.6
Pregnancy Loss Percentage	.3	.4	.5
Calving Percentage	94.8	94.2	93.1
Calf Death Loss	2.6	3.2	4.8
Calf Crop or Weaning Percentage	92.5	91.3	88.7
Female Replacement Rate Percentage	18.1	19.7	20.7
Calf Death Loss - Based on Number of Calves Born	2.7	3.5	5.1
Calves Born During First 21 Days	59.4	58.0	58.1
Calves Born During First 42 Days	87.7	86.7	83.6
Calves Born During First 63 Days	96.8	95.7	93.3
Calves Born After First 63 Days	3.2	4.3	6.6
Production Performance Measures:			
Average Age at Weaning (days)	192	203	212
Actual Weaning Weight for Steers	593	577	549
Actual Weaning Weight for Heifers	565	553	522
Actual Weaning Weight for Bulls	635	636	578
Average Weaning Weight	585	574	538
Weight Weaned per Exposed Female	541	520	466
Age Adjusted Weight Weaned Per Exposed Female	566	514	442
Culling Percentages Based on Total Cows Exposed:			
Total Percent Culled	12.8	12.5	13.1
Percent Dead	.4	.6	.9
Percent Culled due to Age	2.2	1.6	2.0
Percent Culled due to Defects	1.5	1.3	1.9
Percent Culled due to Poor Fertility or Open	3.7	3.8	4.3
Percent Culled due to Inferior Calves	1.4	1.4	1.6
Percent Culled for Replacement Stock	2.1	2.5	1.0
Percent Culled for Unknown Reasons	1.5	1.2	1.2

INFLUENCE OF SEASON ON DIETARY COMPOSITION, INTAKE, AND DIGESTION BY BEEF STEERS GRAZING MIXED GRASS PRAIRIE IN WESTERN NORTH DAKOTA

Jacki Johnson, Joel Caton, and Chip Poland

NDSU Animal & Range Sciences, Fargo, North Dakota
Dickinson Research Extension Center, Dickinson, North Dakota

SUMMARY

Chemical and botanical composition data, when combined with estimates of intake and digestibility, contribute considerably to supplementation practices and sound nutritional programs of grazing cattle. Data in this regard is needed in western North Dakota and should result in improved supplementation strategies. Six cannulated beef steers are currently being used to evaluate changes in dietary composition of rangeland grazed by cattle in western North Dakota. Collections began June 16, 1995, and will run through December 16, 1995, for a total of six collection periods. Four collections have been completed. Seasonal changes in dietary composition, forage intake, and digestibility have been monitored. These values, in conjunction with data from the late fall and winter collections, should provide useful information for livestock producers to determine the appropriate times and rates of rangeland supplementation.

Current data suggests that nutrient quality of grazed forage declines ($P < .10$) from mid June to early September. Forage organic matter intake (% of BW) was higher ($P < .10$) in mid June compared with late July and early September. In vitro digestibility of grazed forage declined with advancing season. These data suggest that cattle grazing native range in western North Dakota from mid June to early September are consuming diets adequate for lactating beef cows. Late fall and winter data are yet to be collected and analyzed.

INTRODUCTION

North Dakota has over 13 million acres of grazing lands. Much of this area is located in the western half of the state. Many livestock producers in western North Dakota graze cattle on native range into late fall and early winter. In these situations supplementation is often practiced to offset forage quality and (or) quantity short falls, and to maintain livestock performance. Unfortunately, data regarding diet composition, intake, and digestion by cattle grazing western North Dakota rangelands is limited.

Research in the area of dietary composition of grazing cattle diets has been conducted at several locations in the United States (Funk et al., 1987; Kirby et al., 1986; Olson et al, 1994). This type of information, when coupled with estimates of intake and digestibility, is the foundation of late fall and winter supplementation practices and sound nutritional programs. Data in this regard is needed in western North Dakota and should result in improved supplementation strategies. Data collected from previous studies when updated with present information should provide a stronger data base from which to make sound management decisions. Therefore, our objectives were to determine seasonal patterns of dietary composition, intake, ruminal fill, digestibility, and rate of in situ NDF and protein degradability in beef cattle grazing mixed grass prairie in western North Dakota.

MATERIALS AND METHODS

This study is being conducted on approximately 120 acres of mixed grass prairie locate 1 mile west of Dickinson, North Dakota. Collections were taken June 16-26, July 21 to August 1, September 1-10, and September 28 to October 7, 1995. Two more collections are scheduled for November 9-18, and December 7-16, 1995, weather permitting. Six Angus X Hereford steers with an initial weight of 840 lb are being used to characterize seasonal dietary composition changes.

Collections begin on d 1 with ruminal evacuation of six cannulated beef steers. Ruminal contents are weighed and subsampled to determine DM and fluid fill. Omasal samples are also taken to determine escape protein concentration. Animals are then allowed to graze for 60 min. Rumens are evacuated again to collect a representative diet sample and original ruminal contents returned to the rumen.

Diet samples are divided into two parts. The first is used for determining chemical and botanical composition of the diet. Chemical analysis includes DM, organic matter (OM), total N, ADF, neutral detergent fiber (NDF), soluble and insoluble nitrogen, and in vitro digestibility. The second portion of the diet sample is used for in situ degradabilities using Dacron bags. Bags are incubated for 0, 4, 8, 12, 16, 24, 36, 48, and 72h. Rates of degradation will be calculated from this data.

During five days of each collection period, animals fitted with fecal bags were used for total fecal collection. Total intake was calculated by dividing fecal output by the diet in vitro indigestibility. Data was analyzed for seasonal effects using the GLM procedure of SAS (1985). Means were separated by the method of least significant difference.

RESULTS AND DISCUSSION

Organic matter (OM) intake decreased ($P < .10$) from 1.7% of body weight (BW) in mid June to 1.4% of BW in early September (Table 2). These values agree with Krysl et al. (1987), who reported voluntary intake in grazing steers averaged 1.5% of BW during dormancy and 2.2% of BW while plants were actively growing. Fecal output increased from late July to early September ($P < .01$; Table 2). Ruminal fill (% of BW) increased from June to July (.92 vs 1.39, respectively) and indicates that steers grazing range forage in July are consuming a more fibrous diet that is likely to pass to the lower tract at a slower rate when compared to steers grazing in June.

Ruminal in situ dry matter disappearance (ISDMD) for 12, 16, 36, and 48h incubation times was significantly higher ($P < .10$) for June and July than September and October (Table 3). Extent of ISDMD (as measured at 72h incubation) was highest during June which agrees with the results of Caton et al. (1993), and Olson et al. (1994).

In vitro organic matter disappearance (IVOMD) decreased from mid June to early September ($P < .01$). Similar results were observed by Kirby and Parman (1986), and Olson et al. (1994). These data demonstrate a decline in forage quality with advancing season.

ADF values increased from June to September ($P < .10$), which agrees with results from Krysl et al. (1987), Campbell and McCollum (1989), and Olson et al. (1994). Crude protein values increased from mid June to late July ($P = .02$). This disagrees with the findings of Kirby and Parman (1986), and Olson, et al. (1994), who found a decrease in dietary CP levels for this same period. These higher values may have resulted, in part, from higher than average precipitation during July delaying the onset of plant dormancy. Levels of CP for both mid June and late July were significantly higher than early September values ($P < .01$) which agrees with results of Kirby and Parman (1986). Escape protein percentage of the diet (as determined by 16h Dacron bags) was lower in late July compared with mid June. However, percentage of escape protein in the diet was high during both mid June and late July indicating that steers were receiving plenty of escape protein. These values suggest that ruminal degradable protein (total CP-escape CP) may be marginal for optimal microbial growth and livestock performance. These data agree with Olson et al. (1994) who reported suboptimal ruminal ammonia levels in steers grazing mixed grass prairie during late July and August.

Identification of deficiencies in diet and ruminal digestive capacity of grazing cattle is useful to determine specific supplementation needs (Olson et al., 1994). Being aware of seasonal trends in diet nutrient composition can enable a producer to make appropriate supplementation decisions in order to maintain animal performance. These preliminary data suggest that nutrient quality is adequate for cattle grazing rangeland in western North Dakota from mid June to early September. Moreover intake declines as the season advances. Data evaluating CP and escape protein levels in forage indicate that ruminal degradable protein may be marginal. Additional collection periods throughout the late fall and winter will add to this data base.

Table 1. Influence of advancing season on chemical composition of mixed grass diets grazed by beef cattle in western North Dakota (DM basis).

Item	Mid June	Late July	Early September	SE
No. of observations	6	6	6	----
OM	79.77[a]	86.30[a]	86.85[b]	.51
CP	12.89[a]	13.82[b]	9.89[c]	.26
Escape Protein	10.73[a]	9.57[b]	----	.41
ADF	35.71[a]	34.82[a]	40.28[b]	.59
NDF	59.50	----	----	1.0
In vitro digestibility	64.64[a]	57.45[b]	52.49[c]	.92

[abc] Means in a row that do not have common superscripts differ ($P < .10$).

Table 2. Influence of advancing season on organic matter (OM) intake, fecal output (OM basis) and ruminal fill (OM basis) by beef steers grazing mixed grass prairie in western North Dakota.

Item	Mid June	Late July	Early September	SE
Fecal output, lb	4.61[a]	4.94[a]	6.56[b]	.23
% BW	.55[a]	.53[a]	.64[b]	.02
OM Intake, lb	14.44[a]	12.55[b]	14.8[a]	.59
% BW	1.72[a]	1.35[b]	1.44[b]	.06
Ruminal fill, lb	7.64[a]	13.01[b]	----	.74
% BW	.92[a]	1.4[b]	----	.07
Steer wt, lb	840[a]	934[b]	1028[c]	20.60

[abc] Means in a row that do not have common subscripts differ ($P < .10$), n = 6.

Table 3. Influence of advancing season on in situ dry matter (DM) disappearance (%) in beef steers grazing mixed grass prairie in western North Dakota.

Incubation Time, h	Mid June	Late July	Early September	Early October	SE
0	16.5[a]	21.9[b]	15.8[a]	21.0[b]	1.10
4	24.0[a]	27.6[b]	20.7[c]	25.1[ab]	1.20
8	37.2[a]	40.6[a]	27.7[b]	33.9[ac]	1.44
12	48.6[a]	50.3[a]	37.6[b]	41.1[b]	1.57
16	53.9[a]	55.1[a]	45.8[b]	45.2[b]	1.95
24	64.5[ab]	57.7[ab]	55.9[abc]	56.2[bc]	3.38
36	72.4[a]	69.9[a]	63.0[b]	63.5[b]	1.40
48	77.0[a]	72.4[b]	67.1[c]	67.5[c]	1.24
72	80.2[a]	75.3[b]	70.3[c]	70.4[c]	1.18

[a,b,c] Means in a row that do not have common superscripts differ ($P < .10$), n = 6.

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A COMPARISON OF NAKED OATS TO BARLEY WHEN FED IN A GROWER DIET TO BEEF CALVES

Jacki Johnson, Dan Dhuyvetter, Brian Kreft, and Kris Ringwall

NDSU Animal and Range Sciences, Fargo, North Dakota
Dickinson Research Extension Center, Dickinson, North Dakota
Central Grasslands Research Center, Streeter, North Dakota

SUMMARY

The North Dakota Crop Improvement Association released a new variety of naked oats, "Paul," in 1994. This particular variety has a thin hull that is loosely attached to the seed and is easily separated or removed during mechanical harvesting. Hence, Paul is referred to as naked oats. Livestock producers have expressed an interest in Paul oats as a feed due to its high protein (16-18%) and fat (7-9%) content. Two studies were conducted during the fall and winter of 1994-95, to investigate how Paul might be used in feeder calf diets. Seventy-two lightweight feeder calves were used in the first study conducted at the Dickinson Research and Extension Center (DREC) from September 12, to November 7, 1994 (57 days). Effects of unprocessed naked oats compared to coarsely ground barley were evaluated with no differences ($P > .23$) in calf performance. Concentrate and forage portions were either delivered in a total mixed ration (TMR) or fed separately (FSR) to evaluate the effects of method of feed delivery on feeder cattle performance. TMR fed calves had a lower ($P < .04$) dry matter intake with no difference ($P = .64$) in calf weight gains. TMR fed calves also had a higher ($P < .03$) feed efficiency (7.3 lbs feed/lb gain) compared to FSR calves (8.9 lb feed/lb gain). A group of 80 steers were used in a second study to compare naked oats to barley at the Central Grasslands Research Center (CGRC), Streeter, North Dakota. The experiment began December 1, 1994, and ended January 31, 1995 (61 days). Both grains were coarsely ground in this study. Significant advantages in ADG ($P = .06$) and feed efficiency ($P = .07$) were observed for Paul oats fed steers as compared to steers fed barley. It appeared that naked oats provided more energy for growth as reflected in higher daily gains. By combining the results of both studies, it appears that processing Paul oats can have a major effect on feeder calf growth responses and feed conversions. Because of the magnitude of difference in calf growth between the two studies, additional feeder cattle performance information should be gathered before confident recommendations for use can be offered to producers.

INTRODUCTION

A market for naked oats has not yet been established and interest for its use as a livestock feed in North Dakota has been expressed by cattle feeders and producers. General feeding guidelines and recommendations for its use are lacking. Furthermore, naked oats has unique properties when compared to other cereal crops. Naked oats id high in crude protein (16-18%) and fat (7-9%), resulting in an increased energy value, (90-94% TDN) compared to barley (84% TDN) or hulled oats (78% TDN). This feed may prove useful in formulating diets for feeder cattle by providing required nutrients for growth with less required concentrate intake or supplemental protein compared to other grains. Naked oats could also provide extra energy for rapid gains in growing cattle diets.

Research conducted at South Dakota State University (Wagner et al., 1988) and the NDSU Carrington Research Center (Anderson, 1992) have demonstrated benefits for feeding backgrounding or finishing diets respectively, in a total mixed ration compared to concentrates and forages fed separately. These studies have suggested both an improvement in ADG and feed efficiency. Provision of a TMR requires additional equipment and therefore, increased animal performance and feed conversions must compensate for there additional expenses over the total number of cattle being fed. Wagner et al. (1988) stated that when feeder cattle are valued at $80/cwt and if corn, hay and corn silage were worth $90, $80 and $25 per ton respectively, producers would need to feed a minimum of 114 head for 133 days each year to pay for costs associated with owning a mixer wagon. Evaluation of feeds and feed delivery methods more commonly used by North Dakota producers are needed to localize these recommendations.

The main objectives at the DREC were to compare the feeding properties of unprocessed naked oats to coarsely ground barley when fed to lightweight feeder cattle and to evaluate lightweight feeder calf performance and feed efficiency as influenced by feed delivery in a total mixed ration or when concentrates and forages are fed separately. Objectives at the CGRC were to compare the value and feeding properties of naked oats to barley fed in a grower diet to beef steers when both grains were coarsely ground.

EXPERIMENTAL PROCEDURES

DREC Experiment: In the first study, 32 heifers and 40 steers were used to compare Paul oats and barley at the DREC. The study was conducted from September 12, to November 7, 1994 (57 days). Diets were formulated to provide approximately 2.3 lb average daily steer gains. Calves received either ground barley or unprocessed Paul oats in equal amounts daily. Soybean meal was included in the barley diets to equalize protein concentrations between the two grain treatments. Concentrate an forage portions were either supplied in a total mixed ration (TMR) or fed separately (concentrate was bunk fed and hay offered free choice in round bale feeders). Feed delivery treatments were equally distributed over the Paul oats and barley treatments. Calves were fed in one of 16 pens (4 heifers or 5 steers/pen) with 2 pens/feed delivery and grain treatment combination. Two calves died during the study and were not included in calculations and eight calves were treated for bloat. Nutrient composition of feeds used in the study are given in Table 1 and diet composition in Table 2.

CGRC Experiment: A group of 80 steers were used in a feeder cattle study to compare naked oats to barley at the CGRC, Streeter, North Dakota. Treatments were pound-for-pound substitutions of either coarsely ground Paul oats or barley. The experiment began December 1, 1994, and ended January 31, 1995 (61 days). Soybean meal was included in the barley diet to maintain similar concentrations for each of the treatments. Steers were fed in one of four pens (2 pens/treatment) and the barley diet was formulated to provide for a 3 lb ADG. Nutrient composition of the feeds used in the study are given in Table 3 and diet formulations and nutrient composition are reported in Table 4.

RESULTS AND DISCUSSION

Calf performance for lightweight feeder calves at the DREC is reported in Table 5. Gains for unprocessed Paul oats and barley were not significantly affected by treatment suggesting that similar ($P = .84$) calf performance can be achieved with either unprocessed Paul oats or rolled barley plus a protein supplement. Because Paul oats does not have a fibrous hull, and earlier studies were conducted without processing, we decided to feed the naked oats unprocessed. This may have been the primary reason we did not see an advantage in the Paul oats fed calves. These results prompted the next study conducted at the CGRC.

Average daily gain was affected by sex (P = .02) with heifers gaining 1.85 lb daily and steers 2.17 lb per day. TMR fed calves had a lower DMI (P < .04) and a higher feed efficiency (P < .03) than FSR fed calves with no difference in ADG (P = .75; Table 6). FSR fed calves utilized 8.9 lb feed/lb of gain, where as TMR calves used 7.3 lb feed/lb of gain (Table 6). Because of method of hay delivery (round bale feeders), we cannot be sure that this additional feed was utilized by the animal or was wasted. Either way, there is an additional feed cost for the FSR fed calves over the TMR fed calves. This equates to an economic decision in which a cattle feeder must calculate whether the added benefits of a TMR can cover the costs of owning a mixer wagon.

In the second study conducted at the CGRC, steers were weaned in late October, therefore diets were formulated to produce more rapid daily gains. Steer performance results are given in Table 7. One can not overlook the ADG advantage (nearly .6 lb/day) for the Paul oats fed steers compared to the steers fed barley. Treatment differences were significant (P = .06). Feed efficiency was also improved by replacing barley with Paul oats (P = .07). It appeared that naked oats provided more energy for growth as reflected in higher daily gains. Furthermore, steers fed naked oats did not require supplemental protein for improvements in ADG and feed efficiencies compared to barley fed steers. The combination of high energy and protein concentrations are a unique feature of Paul oats that many feed grains do not have.

These studies were a part of preliminary work that is continuing at NDSU Experiment Stations and the Department of Animal and Range Sciences (NDSU). Although Paul oats seed supplies are still in the seed increase program and may be somewhat limited, it is our intent to have solid research results on how it may be used in beef diet formulations once it is more available in the production setting. There are also plans at NDSU to evaluate naked oats in finishing cattle, swine and dairy diet formulations.

Table 1. Nutrient composition (DM basis) of feeds used in DREC lightweight feeder calf diets formulated with either barley or naked oats as the concentrate source.

Item	DM	CP	ADF	Calcium	Phosphorus
Naked Oats	91	18.72	4.3	0.39	0.4
Barley	91	13.99	7.5	0.75	0.47
Crested Wheat Hay	92	7.28	42.9	0.6	0.14
Soybean Meal	89	48.1	9.2	0.32	0.35
Bovatec	100	8	11	8.5	0.25
Vitamin/Mineral Supplement	100	0	0	24	6

Table 2. Composition of barley and naked oats diets (DM basis) fed, in either a total mixed ration (TMR) or with concentrate and forage portions fed separately (FSR), to lightweight feeder calves for 57 days at the DREC.

	Barley			Naked Oats	
Item, %	**TMR**	**FSR**		**TMR**	**FSR**
Barley	37.77	30.52		----	----
Naked oats	----	----		37.19	31.65
Crested Wheat Hay	54.04	62.39		57.2	63.91
Soybean Meal	5.57	4.75		2.65	1.94
Bovatec supplement	2.19	1.88		2.27	1.91
Vitamin/Mineral supplement	0.65	0.56		0.7	0.59
Dry matter intake, lb/day	15.1	17		13.7	17.2
Nutrient composition					
Crude protein	11.95	11.23		12.58	11.66
Acid detergent fiber	26.77	29.71		26.64	29.18
Calcium	0.97	0.91		0.86	0.82
Phosphorus	0.32	0.27		0.29	0.28

Table 3. Nutrient composition (DM basis) of feeds used in CGRC growing steer diets formulated with either barley or naked oats as the concentrate source.

Item	DM	CP	ADF	Calcium	Phosphorus
Barley	89.8	13	7.3	0.15	0.42
Naked oats	91.2	17	2.9	0.1	0.53
Corn silage	40.4	8.8	26	0.16	0.22
Chopped hay	84.3	11.7	40.7	0.77	0.2
Soybean meal	91.1	50.8	5.1	0.37	0.77
Mineral/Ionophore Supplement	93	13.4	12.3	12.8	0.63

Table 4. Composition of barley and naked oats diets (DM basis) fed to growing steers for 61 days at the CGRC.

	Barley			Naked Oats	
Item	**% DM**	**Lbs DM**		**% DM**	**Lbs DM**
Barley	49.84	10.55		----	----
Naked oats	----	----		51.48	10.63
Corn silage	26.93	5.7		29.08	6.01
Chopped grass hay	14.05	2.97		14.15	2.94
Soybean meal	4.07	0.86		----	----
Mineral/Ionophore supplement	5.12	1.08		5.19	1.07
Nutrient composition, %					
Crude protein	13.24			13.67	
Acid Detergent Fiber	17.19			15.49	
Calcium	0.9			0.87	
Phosphorus	0.36			0.4	

Table 5. Calf performance when fed diets containing similar amounts of either naked oats or barley at the DREC (57 days on feed).

Measurement, lb	Barley	Naked Oats	Significance[a]
In weight	448.3	442.9	0.78
Final weight	562	560.8	0.23
Average daily gain	1.97	1.98	0.84
Dry matter intake	16.07	15.47	0.38
Feed/lb gain	8.19	8.03	0.78

[a] Probability that the difference between the means was due to chance.

Table 6. Dry matter intake (DMI), average daily gain ADG) and feed efficiency of lightweight feeder calves fed either a total mixed ration (TMR) or concentrates and forage fed separately (FSR) at DREC.

Item, lb	TMR	FSR	Significance[a]
DMI	14.42	17.13	0.04
ADG	1.99	1.96	0.64
Feed efficiency, (feed/gain)	7.3	8.9	0.03

[a] Probability that the difference between the means is due to chance.

Table 7. Steer performance at the CGRC when fed diets containing similar amounts of either naked oats or barley (61 days on feed).

Measurement, lb	Barley	Naked oats	Significance[a]
In weight	681.2	680.3	0.52
Final weight	859	0.7892	0.04
ADG	2.92	3.48	0.06
Dry matter intake	21.1	20.7	0.2
Feed/lb of gain	7.2	6	0.07

[a] Probability that the difference between the means is due to chance.

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Creep Feeding Effects on Calf Performance and Udder and Carcass Composition of Charolais Sired Beef Heifers

J. E. McLennan, D. V. Dhuyvetter, J. S. Caton, K. Ringwall, G. Ottmar

NDSU Animal & Range Sciences, Fargo, ND
Dickinson Research Extension Center, Dickinson, ND

SUMMARY:

Fifty crossbred cows with Charolais sired calves at side were used in an experiment to evaluate creep feeding effects on carcass yield, quality and effects on beef heifer udder development. Treatments were randomly assigned (CREEP v.s. CONTROL) on Aug. 15, 1994 and applied for 74 days. At weaning cows were measured for average daily gain (ADG) and body condition score (BCS) change. There was no difference (P = .29) in ADG of BCS change for cows of either treatment. After weaning calves remained in assigned groups and fed similar diets through backgrounding (60 d) and finishing (180 d). At slaughter, udder composition was measured by determining total udder weight, dry matter (DM), lipid and protein content. Fat-free mass, carcass quality, yield grade, loin eye area (LEA) and back fat (BF) measurements were collected for all calves. Creep fed calves had higher weaning weights (P = .04) and higher ADG (P = .03) than control calves. Treatment did not effect (P > .29) yield grade, marbling score or LEA. However, creep fed calves had higher BF measurements (.32 v.s .26, P = .08) than did noncreep fed calves.

INTRODUCTION

Previous creep feeding research with replacement beef heifers has demonstrated increased fat deposition in the mammary gland, a decrease in milk production during future lactations, reduced progeny weaning weights and decreased cow longevity. Holloway and Totusek et al. (1979) reported heifers that were creep fed produced 0.31 lbs less milk/d during their first lactation than heifers that received no additional feed during the pre-weaning period. At the University of Florida, Prichard and Marshall et al. (1988) found that creep fed heifers had higher total lipid content (6.4 v.s. 5.2 lbs) compared to heifers that did not receive creep.

These studies were conducted 15-20 years ago using cattle that were different in frame size, body composition and growth potential compared to the genetic base of cattle today. The objectives of this study were to investigate the effects of creep feeding on carcass composition and quality in beef calves and to evaluate the effects of creep feeding on mammary tissue development in Charolais sired beef heifers.

MATERIALS AND METHODS

Preweaning Phase:

Fifty British crossbred cows with Charolais sired calves at side were used in the experiment. Cow-calf pairs were assigned to one of two pastures each consisting of two paddocks. Two dietary treatments were assigned randomly to paddocks within pastures designated A or B. Pasture A, consisting of two 160 acre paddocks with 13 calves (6 heifers, 7 steers) that were offered a high fiber creep ration (CREEP, Table 1) free choice beginning on day 0 of the experiment (August 15, 1994) in one paddock. The remaining 13 calves received no supplemental nutrition (CONTROL) other than native range forage and milk from their dams in the other 160 acre paddock. Treatments were assigned in the same manner for pasture B (two 160 acre paddocks) except 12 cow-calf pairs (6 heifers, 6 steers) were used for each treatment. On d 0 and 74 (weaning date) cows were measured for bodyweight (BW) and body condition score (BCS) and calves were measured for BW, BCS, hip height (HH). Resistance (Rs) and Reactance (Xc) were also measured with the use of Bio-Electrical Impedance Analyzer to develop accurate predictive equations to calculate amount of saleable product and intramuscular fat (marbling).

Postweaning Phase:

After weaning, heifers and steers remained in their assigned groups and were placed in one of four pens. Calves were fed similar diets through backgrounding (60d) and finishing (approximately 180 d). Udder composition was measured by determining total udder weight, dry matter (DM), lipid and protein content at slaughter. Fat-free mass, carcass quality grade, yield grade, loin eye area (LEA) and back fat (BF) measurements were collected on all calves.

RESULTS

Treatment did not affect ($P > .29$) final weight, ADG or BCS change for cows in the is study (Table 2). Cows lost 2.41 and 2.38 lb./d for creep and control groups, respectively. This is contradictory to work done by Prichard et al. (1989) who found that cows with calves offered creep feed gained more weight during lactation (49.5 lb) compared to cows with calves that received no supplemental creep (14.3 lb). Prichard et al. (1989) also reported that BCS was not affected by creep which is similar to the results found in this study.

Calf performance prior to weaning is presented in (Table 3). Creep fed calves were 46 lbs. heavier ($P = .04$) than calves receiving no supplementation at weaning. Calves that received creep consumed 7.3 lbs/d of feed prior to weaning. Every additional pound of gain above CONTROL calves required 11.8 lbs of creep feed. Average daily gains were 2.14 and 1.48 for CREEP and CONTROL calves ($P = .03$), respectively. Improved calf performance agrees with Faulkner et al. (1993) and Cremin et al. (1991). Hip height was measured to determine if frame size would be effected as a result of treatment. However, change in HH measurements during the creep feeding period was not influenced by treatment ($P = .32$).

Carcass measurements are given in (Table 4). Although backfat was lower ($P = .08$) for control calves, yield grade was not different between the two treatments ($P = .34$). Other studies show mixed results regarding backfat thickness. Increased backfat of creep-fed calves has been reported by Martin et al. (1981) and Prichard et al. (1980); however, no difference in backfat of creep v.s. noncreep calves was noted by

Rouquette et al. (1983) and Cremin (1989). Tarr et al. (1994) reported no significant difference in yield grade of creep v.s. noncreep calves. However, Slyter (1978) reported increased marbling score, yield grade, LEA, BF and kidney fat for creep v.s. noncreep fed calves.

IMPLICATIONS:

Cow performance was not affected as a result of treatment. Calves receiving creep feed gained more weight and had higher ADG than calves receiving no supplementation. Creep fed calves appeared to have higher yield grades and marbling scores. However, we do not have enough confidence statistically to draw this conclusion. Back fat was significantly higher for creep v.s. noncreep fed calves but statistically did not effect yield grade.

Creep feeding improved weaning weights but did not improve carcass yield or quality. The cost of the creep ration formulated for this experiment cost approximately $120/ton. Every additional pound of gain (that above control calves) for creep fed calves cost approximately $ 0.71. Treatment did not effect carcass quality or yield which are two elements in determining final value. If creep feeding does not positively effect carcass quality and yield perhaps it is more cost effective for the producer to develop calves with lower weight gains early, and then increase nutrition after puberty to achieve maximum efficiency in retained ownership situations.

Table 1. Creep feed formulation (As fed basis) used in the experiment.

Ingredients		Percent
Dry corn gluten feed[a]		54.5
Beet pulp[b]		42.5
Limestone		0.95
TM salt		0.95
Vitamin ADE		.075
Lacalocid[c]		0.04
Bentonite		0.85

[a] Dry corn gluten feed contributed by Archer Daniels Midland Co., Ceder Rapids Plant, Iowa.
[b] Beet pulp contributed by Midwest Agri-Commodities, Corte Madera, California.
[c] Ionophore premix supplied 30 mg lacalocid/lb of feed.

Table 2. Cow weight, average daily gain (ADG) and body condition score (BCS) measurements for creep v.s. control.

Measurement	Creep	Control	Significance[a]
In weight, lb	1237	1248	.78
Final weight, lb	1059	1072	.84
ADG, lb	-2.41	-2.38	.29
BCS change	-0.24	-0.04	.52

[a] Probability that the difference between the means was due to chance.

Table 3. Calf weights, average daily gain (ADG) and hip height (HH) measurements for creep v.s. control.

Measurement	Creep	Control	Significance[a]
In weight, lb	405	406	.69
Final weight, lb	562	516	.04
ADG, lb	2.14	1.48	.03
HH change, in	3.76	3.16	.32

[a] Probability that the difference between the means was due to chance.

Table 4. Carcass yield and marbling measurements for creep v.s. control.

Measurement	Creep	Control	Significance[a]
Yield grade[b]	2.43	2.24	.34
Marbling score[c]	446.8	416.8	.29
Loin Eye Area, in^2	12.14	12.49	.45
Back Fat, in	.32	.26	.08

[a] Probability that the difference between the means was due to chance.
[b] (1-5) 1 = lean, 5 = excess fat.
[c] (200 = standard; 300 = select; 400 = choice; 500 = prime)

Table 5. Udder composition for creep v.s. control heifers.

Measurement	Creep	Control	Significance[a]
Udder weight			
% Dry matter	80.6	79.3	.44
% Protein			
% Fat			

[a] Probability that the difference between the means was due to chance.

BIOELECTRICAL IMPEDANCE AS A METHOD OF PREDICTING AMOUNT OF SALEABLE PRODUCT AND CARCASS QUALITY OF BEEF CATTLE AND THEIR CARCASSES

J. E. McLennan, M. J. Marchello, D. V. Dhuyvetter, K. A. Ringwall, G. Ottmar

NDSU Animal & Range Sciences, Fargo, North Dakota
Dickinson Research Extension Center, Dickinson, North Dakota

SUMMARY:

Fifty Charolais crossed calves were used to evaluate the use of bioelectrical impedance as a method of predicting amount of saleable product in live animal and carcasses of beef cattle. The amount of saleable product was then correlated to yield grade to be able to serve as a possible method of determining value of the live animal and also beef carcasses. Resistance (Rs) and Reactance (Xc) were measured from live animals and carcasses using the Bioelectrical Impedance Analyzer. Regression equations were then developed using Rs, Xc, length, and weight as independent variables for live animal and hot and cold carcasses. Correlations for weights of IMPS cuts of hot and cold carcasses to actual yield grade were (P = .0026, .0049), respectively. With the ability to determine amount of saleable product of carcasses and live cattle, this research indicates that the use of bioelectrical impedance technology may be an effective method of determining animal value.

INTRODUCTION:

The cattle industry perpetually changes to increase product consumption and stay competitive in a marketing system that can fluctuate greatly from year to year. Consumer eating preferences, health concerns, and income have dictated the need to produce a leaner animal (Forrest et al. 1989). The meat processing industry itself has demanded leaner animals to reduce their own financial loss associated with excess fat trimmings (Wilson, 1992). Changes in the system are only made when an economic incentive can be realized. The importance of a value-based marketing system puts more emphasis on the predictability of carcass traits (Houghton and Turlington, 1992).

The most commonly used payment system is based on the weight of the animal. However, because of genetic and environmental variances, variation in the composition of carcasses occurs frequently. Therefore payment based on carcass merit is a possible marketing option in the cattle industry. Currently, livestock producers lack accurate methods to determine the value of animal carcasses before slaughter (Houghton and Turlington, 1992).

Ferrel and Cornelius (1984) stated that the ideal technique for measurement of body composition should be accurate, easily accomplished, inexpensive, applicable to a wide range of ages and compositions and capable of being applied to the live animal with minimal perturbation of subsequent performance. Bioelectrical impedance has shown promise as a nondestructive method to assess weight of muscle, fat-free muscle and retail-ready cuts of live and processed pigs, sheep, and beef. This method of measuring fat-free tissue requires the use of a Bioelectrical Impedance Analyzer (BIA). The BIA measures the components of impedance; resistance (Rs) and reactance (Xc). The four terminal impedance plethysmography introduces a constant current that provides a deep homogenous field in the variable conductor of the body. Differences in Rs measurements reflect differences in the transmitted field and should be due to differences in tissue mass. Four measurements such as; Rs, Xc, length between terminals and body weight have been used to predict fat-free skeletal muscle. In other words, the amount of lean tissue may be predicted in an individual carcass or live animal with the use of the bioelectrical impedance technology.

The objectives of this study were; 1) develop a predictive equation that would accurately estimate the amount of lean, saleable product in beef carcasses with the use of the BIA, 2) develop a predictive equation that would accurately estimate marbling in beef carcasses with the use of the BIA.

MATERIALS AND METHODS:

Fifty crossbred calves (26 steers and 24 heifers) were used to investigate the use of the BIA as an accurate method of estimating lean, saleable product and carcass quality from live cattle and bled beef carcasses. Calves were measured for body weight (BW), length between terminals, Rs and Xc on August 15 and October 28, 1995 (creep feeding period). Following weaning calves were fed in four pens and subjected to a grower diet for 60 days then advanced to a finishing diet for approximately 180 days (range = 179-207). Calves were measured for BW, length between terminals, Rs and Xc every 28 days until slaughtered. Time of slaughter was based on calf sex and weight for one of four dates (June 6, 13 and July 11, 18, 1995).

Animals were processed after an overnight withholding of feed at Valley Meat, Valley City, North Dakota. Prior to exsanguination (bleeding at slaughter) each animal was again measured for BW, length between terminals, Rs and Xc. Rs and Xc were measured by fully inserting electrodes into the live animal along the spine 3.9 and 7.9 inches from the top of the shoulder and at the tail head and 3.9 inches cranial to it (figure 1). The electrodes were inserted from the external side of the hot and cold (from a 48 hour chill) carcass (figure 2). Hot and cold carcass temperatures at time of measurement were obtained with a standard meat probe thermometer inserted (5 inches) behind the midpoint of the shoulder into the muscle. Temperature was measured for use as a possible variable for the development of predictive equations. Hot carcass measurements were collected approximately 45 min after slaughter from either right or left carcass sides.

One carcass side per animal (side from which all measurements were collected) was processed into Institutional Meat Purchasers Specification (IMPS) cuts and weighed. This is representative of the processing currently practiced in the meat packing industry. Actual muscle weight was then correlated to % retail cuts from the formula and predicted IMPS cuts weights of the hot and cold carcass. Prediction equation development used the many statistical techniques of PROC REG from SAS (1988).

RESULTS:

Equations developed to estimate saleable product are reported in (table 2).

Correlations and predictability of equations are reported in (Table 2). This table illustrates the probability of being able to predict the amount of saleable product from live cattle and hot and cold carcasses from equations listed in (Table 2).

IMPLICATIONS:

Bioelectrical impedance technology can be a rapid, nondestructive, and accurate method for determining the amount of saleable product in live cattle and carcasses. Predictive equations developed for live, hot and cold carcasses proved to be to be highly correlated to actual weight of salable product (.0003, .0026, .0049 respectively). This agrees with results that of Swantek et al. (1992) and Johns et al. (1994) Predictive equations have not been developed to estimate carcass quality. However, Rs measurements collected on the exposed end of the ribeye muscle and the weight of the carcass half were predictive of the percentage fat at the exposed end of the ribeye muscle (P = .03). These positive results with such a narrow range of fat percentage indicates that we should be able to predict intramuscular fat as well as leanness. Further refinement and validation of predictive equations must be done before bioelectrical impedance can be used as a tool for value based marketing.

Table 1. Equations for predicting amount of saleable product.

[a] Live Prediction = 11.87 + (.409 * Live Weight) – (.335 * Live Length) + (.0158 * Vol 1[d])
R^2 = .799*

[b] Hot Carcass Prediction = -58.84 + (.59 * Hot Weight) – (.85 * Rs) + (1.15 * Xc) + (.14 * Length) + (2.6 * Temperature)
R^2 =.948*

[c] Cold Carcass Prediction = 32.15 + (.63 * Cold Weight) + (.33 * Xc) + (.83 * Length) + (.68 * Vol 1)
R^2 = .931*

[a]Prediction based on live measurements taken prior to slaughter
[b] Prediction based on measurements taken 45 min. after bled.
[c] Prediction based on measurements taken at a 48 hour chill.
[d] Length squared/Rs
*An R^2 value of “1” would indicate the variables used in the equation could fully predict the amount of saleable product.

Example: Predicting amount of saleable product from live animal measurements.

Variables: Live weight = 1000 lb. (454.5 kg)
Length = 90 cm
Rs = 26
Xc = 3
Vol 1 = 312

Live Prediction = 11.87 + (409 * 454.5) – (.335 * 90) + (.0158 * 312)

= 172.2 kg or 378.8 lb.

Table 2. Correlations and probability between actual and predicted saleable product and yield grade.

Measurement	Yield Grade	Significance
Sum of actual IMPS	-.496	.0003
Predicted IMPS (hot)	-.418	.0026
Predicted IMPS (cold)	-.392	.0049

Figure 1.
Electrode placement on cattle

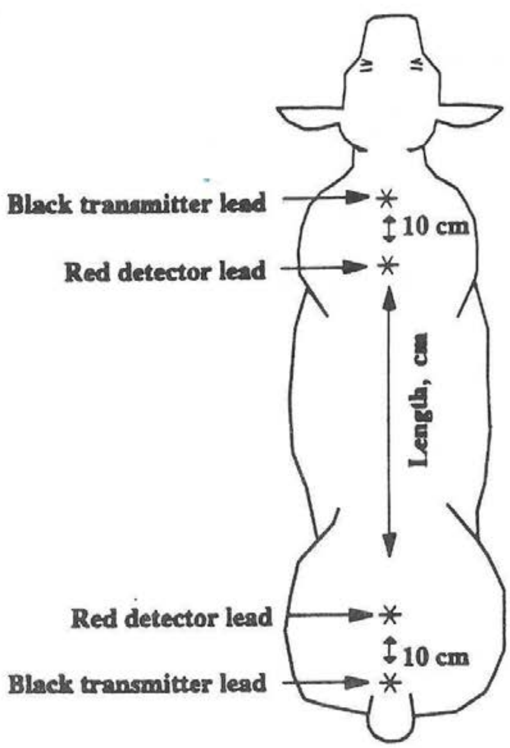
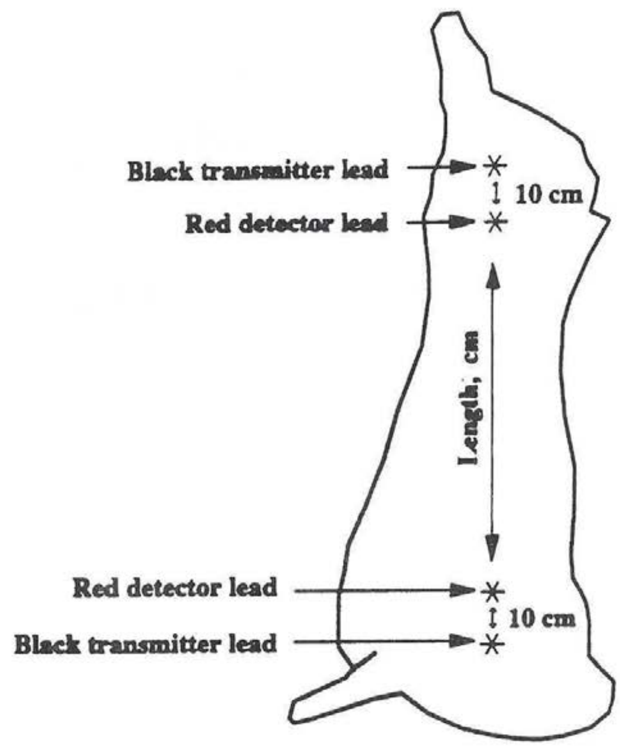


Figure 2.
Electrode placement on beef carcasses



Grazing Annual Forages on Cropland in Western North Dakota – Project Update

C. Poland, L. Tisor, and G. Ottmar
Dickinson Research Extension Center

INTRODUCTION

Manske and Nelson (1995) reported on the first two years of a four-year study designed to begin investigating the potential of grazing cattle on cropland seeded to annual forages. This update report will summarize the third year (**YR3**) of data from this study. The 1996 grazing season (**YR4**) will complete this study and a final report drafted that winter.

MATERIALS AND METHODS

The study site (47° 14' N. lat., 102° 50' W. long.) is located 20 m N and 2 m W of Dickinson, in southwestern North Dakota, U.S.A. The site is situated on the Manning ranch of the Dickinson Research Extension Center operated by North Dakota State University. Soils are primarily Typic Haploborolls. Long-term (1982 – 1994) weather data have been reported (Manske and Nelson, 1995).

Eight 8.3 acre pastures are being utilized in this study. Pastures are arranged into a north (4) and south (4) half, thus giving a set of four replicated pastures. Each set of pastures has access to a common waterer and salt box. Access to waterer is provided to each pasture by means of a grass alleyway.

The forages selected for grazing evaluation in YR3 and YR4 include: winter rye (*Secale cereale*; **WR)**, an oat (*Avena sativa*)/pea (*Pisum sativum arvense*) intercrop **(OP)**, barley (*Hordeum vulgare*; **BR**) and Siberian millet (*Setaria italica*; **SM**). The desired grazing management involves utilizing WR in May, OP in June, BR in July and SM in August. Expected seeding and initial grazing dates are presented in table 1. Generally, the tillage and seeding program outlined by Manske and Nelson (1995) was followed with the following exceptions. The oat variety Hytest was used as a replacement for Otana in OP. Horesford barley was included in BR to replace an earlier pearl millet (*Pennisetum glaucum*) treatment. The WR (pastures 3 and 7; Manske and Nelson, 1995) grazed in YR3 was actually seeded in early August, 1993. Pastures were grazed for 13 days in early July, 1994, and then mowed and disked in August, 1994. The resultant regrowth was grazed in May, 1995. Winter rye was seeded with OP in YR3 and spring growth will be grazed in YR4.

The collection of vegetative and animal data have been previously described (Manske and Nelson, 1995). Data in this update are reported as means or as means and standard deviations. A more complete analysis of the data will be presented next year following the final year of data collection.

RESULTS

Seeding and initial grazing dates.
Table 1 compares the desired and actual seeding and initial grazing dates for annual forage pastures in YR3. Spring grazing of WR was earlier in YR3 than in 1994 (15 May vs 15 June and 1 July). The seeding date of OP was later than desired, however it was similar to the previous two years of data. Initial grazing date on OP was later than desired, but earlier than in other years. Evaluations in 1993 and 1994 did not include BR. Seeding and initial grazing dates for BR in YR3 were delayed about 3 weeks, while the respective dates for SM were very close to their targets.

Grazing data.
Grazing intervals and stocking rates are shown in table 2. Ten cow/calf pairs were grazed per replicate in YR3, thus giving a stocking rate of 1.2 animal units per acre. While none of the pastures achieved the desired 30 days of grazing, OP was close with 27. Pasture animal unit months (AUM) ranged from 4.9 to 8.9. Expressed in terms of AUM per acre, pastures ranged from .59 to 1.07. Out of a possible 107 grazing days (15 May – 30 August), cows grazed a total of 77 days. The combined, 4-pasture system produced 25.2 AUM or .76 AUM per acre.

Herbage production and disappearance.
Herbage yield at the initial grazing date and at the end of grazing are presented in table 3. The initial aboveground biomass of WR was less than in previous years, however the present use (difference between initial and final herbage yields divided by the initial yield) was greater (41 vs 6%). Initial and final herbage yields of OP and SM pastures were roughly similar to other years. Initial herbage yields in BR were numerically similar to OP but the percent use of BR was greater (86 vs 50%). Days from seeding to the initiation of grazing averaged 57.3 ± 2.5 in YR3. The original intent of initiating grazing approximately 6 weeks after seeding is still desired, however observation and experience are suggesting closer to 8 weeks after seeding maybe a more practical value. Differences between these two values may relate to germination time during typical North Dakota spring weather. A target of 6 weeks will remain into YR4.

The disappearance of major forage types within each pasture is depicted in figure 1. On a pound basis, very few weeds were removed. Only the SM pastures experienced a final weed yield that was less than the initial, indicating some net disappearance from this treatment. Otherwise, weeds accumulated from 6 to 39 percent as much weight as was removed from the total pasture. Not only was the percent use of BR greater than the other forage types, but the total disappearance of BR was also numerically greater.

Animal performance.
Performance of cows grazing annual forages in YR3 is presented in figure 2. Cow liveweights (LW) increased early in the season, and then seemed to maintain this weight throughout the rest of the summer. Body condition scores (BCS) seem to follow LW patterns, except in late May when cows were grazing WR and their LW increased and BCS decreased. Actual mean LW and BCS were as follows: 15 May, 1127 ± 29, 6.3 ± .07; 30 May, 1171 ± 28, 6.1 ± .11; 29 June, 1280 ± 6, 6.5 ± .14; 26 July, 1234 ± 25, 6.1 ± 0; 11 August, 1290 ± 1, 6.38 ± .04; 30 August, 1273 ± 14, 6.2 ± .21.

Calf performance while grazing with their dams on annual forages in YR3 is presented in figure 3. Average daily gain was numerically highest for calves on BR (3.39 ± .42), lowest on OP (2.09 ± .06) and intermediate on WR (2.22 ± .07) and SM (2.48 ± .34). In terms of production per head and per acre, WR (33.4 ± 1.1 and 40.2 ± 1.3) numerically produced the least and BR (57.7 ± 7.1 and 69.5 ± 8.5) the highest. Production on OP (54.5 ± 1.6 and 65.6 ± 2.0) and SM (47.1 ± 6.4 and 56.7 ± 7.7) was intermediate. Overall, calves gained an average of 2.5 ± .002 pounds per day for 77 grazing days. Calves accumulated 192.6 ± .14 pounds per head and 58.0 ± .04 pounds per acre in YR3.

DISCUSSION

Results from the first three years of this study indicate that there are numerous managerial and biological problems associated with the grazing of seeded annual forages for an entire season. Preliminary data suggest that grazing livestock on land typically devoted to traditional cropping can be a viable option. However using average costs per acre ($20.81, cash land rent; $12.53, custom seeding; $10.00, seed), as presented by Manske and Nelson (1995), the production of 58 pounds of calf per acre would require $74.7 per cwt average calf prices to breakeven. More research is needed to increase the average output per acre if the grazing of annual forages is to be adopted large scale in western North Dakota, especially during troughs in the cattle price cycle. Forage selection and appropriate seeding and grazing management are essential for this type of grazing system to succeed.

Table 1. Desired and actual seeding and grazing dates in year 3 (1995) of annual grazing study.

		Desired				Actual		
Forage	**Field No.**	**Seeding Date**	**Initial Grazing Date**	**Age of Stand (wk)**		**Seeding Date**	**Initial Grazing Date**	**Age of Stand (wk)**
Winter Rye	3	--	early May[a]	--		Aug, 1993	15 May	--
Oat/Pea	4	early Apr	01 Jun	6		03 May	29 Jun	8
Barley	2	early May	01 Jul	6		01 Jun	26 Jul	8
Siberian Millet	1	mid Jun	01 Aug	6		12 Jun	11 Aug	8.5

[a] Grazing of fall regrowth may be possible.

Table 2. Grazing intervals and stocking rates in year 3 (1995) of annual grazing study.

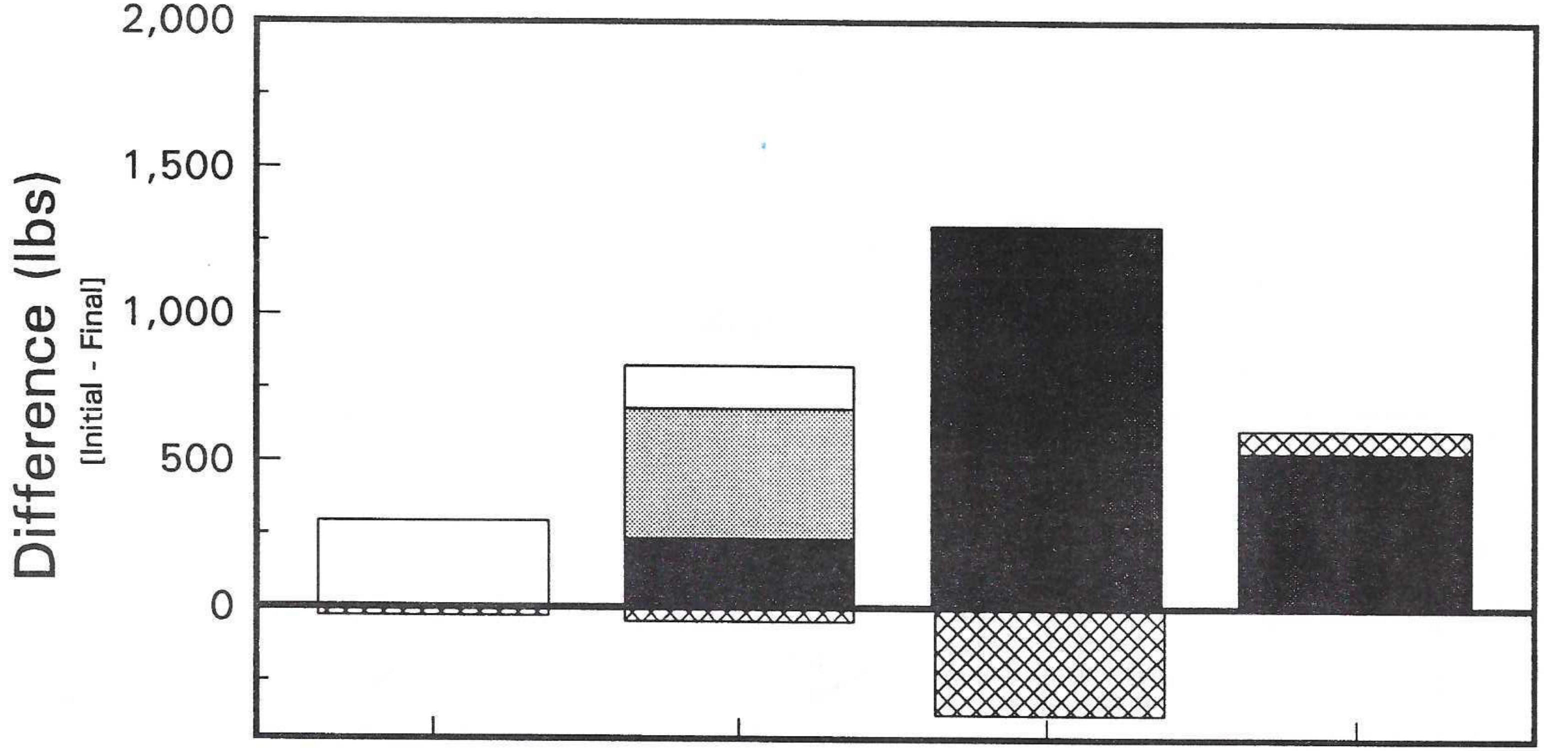
Forage	Grazing dates	Days	AU[a]	AUM	AUM/acre
Winter Rye	15 May – 30 May	15	10	4.9	.59
Oat/Pea	29 June – 26 July	27	10	8.9	1.07
Barley	26 July – 11 August	16	10	5.2	.63
Siberian Millet	11 August – 30 August	19	10	6.2	.75
Overall for season[b]	15 May – 30 August	77[c]	10	25.2	.76

[a] AU = animal unit (one cow/calf pair). AUM = animal unit month.
[b] Animals moved to crested wheatgrass (*Agropyron cristatum)* for 30 days (30 May – 29 June) after grazing winter rye for AI insemination and to wait for the oat in the oat/pea intercrop pastures to reach approximately the 5th leaf stage.
[c] 107 days desired

Table 3. Aboveground biomass (lb/acre) for forage pastures in year 3 (1995) of annual grazing study.

		Aboveground biomass[a]				
Forage	Days after seeding	Initial		Final		Difference[b]
Winter Rye	-----	718	(158)	455	(111)	263
Rye		718	(158)	425	(121)	293
Weeds		--	--	30	(9)	-30
Oat/Pea	57	1864	(268)	1087	(119)	777
Oat		580	(117)	348	(129)	233
Pea		518	(118)	72	(38)	446
Rye		548	(154)	403	(58)	145
Weeds		216	(115)	265	(10)	-49
Barley	55	1684	(391)	748	(82)	936
Barley		1518	(420)	215	(85)	1303
Weeds		166	(29)	532	(166)	-366
Siberian Millet	60	1999	(149)	1388	(176)	611
Millet		1902	(220)	1369	(182)	533
Weeds		97	(71)	19	(6)	78

[a] Values presented are means, with standard deviations in parentheses.
[b] Negative differences indicate growth exceeded disappearence.



Forage Type	Winter Rye	Oat/Pea	Forage Barley	Siberian Millet
Grass		30.0	139.2	87.2
Weed	-11.1	-6.3	-39.1	12.8
Pea		57.4		
Winter Rye	111.1	18.7		

Figure 1. Herbage differences between initial and final clips within a pasture. Values in graph are in pounds of major herbage components in each pasture. Values in table are individual percentages of overall herbage difference. Negative values indicate a negative differences or that final herbage yield was greater than initial.

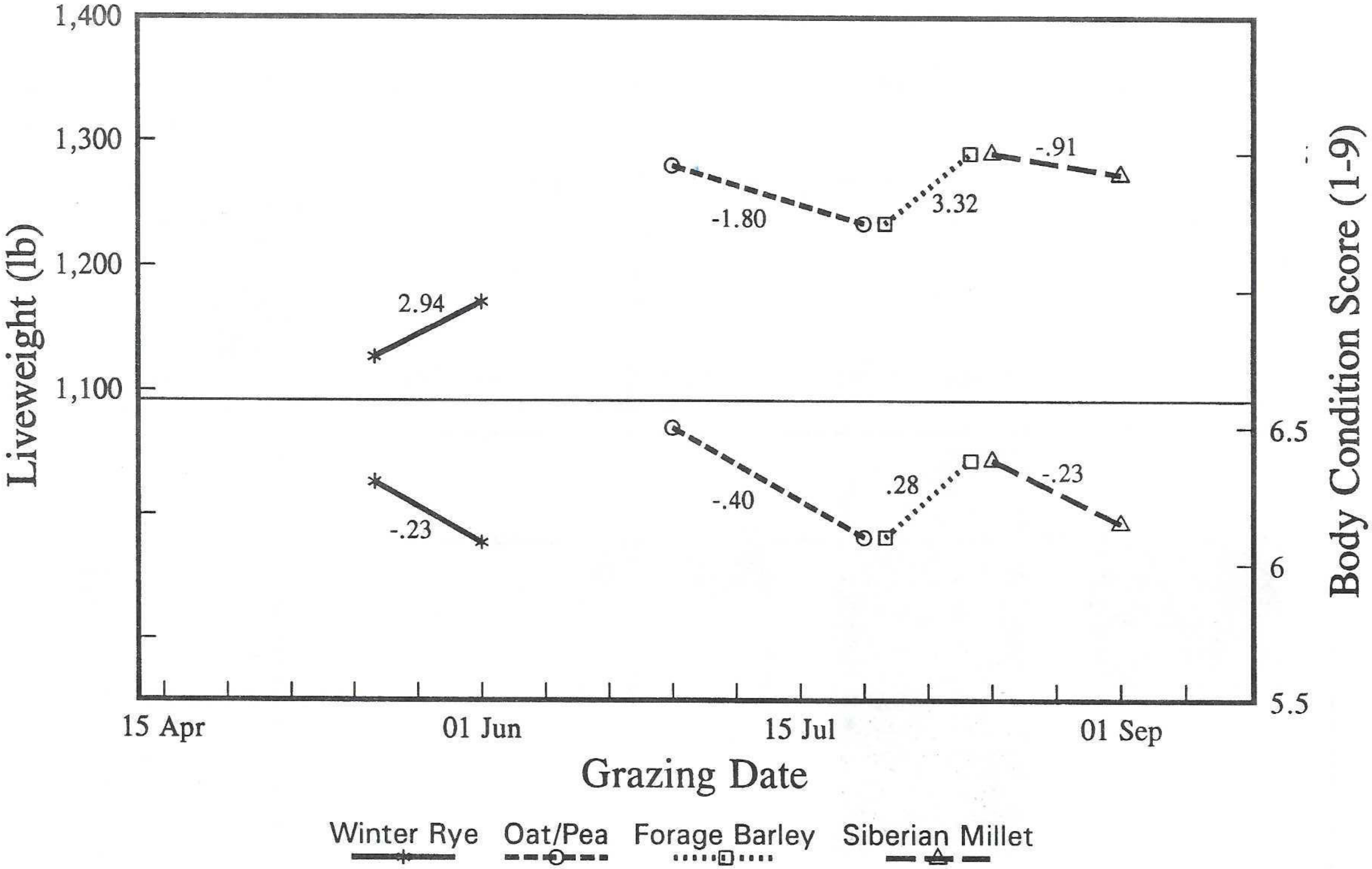


Figure 2. Cow performance while grazing various forage pastures in year 3 (1995) of annual grazing study. Means and standard deviations are presented in text.

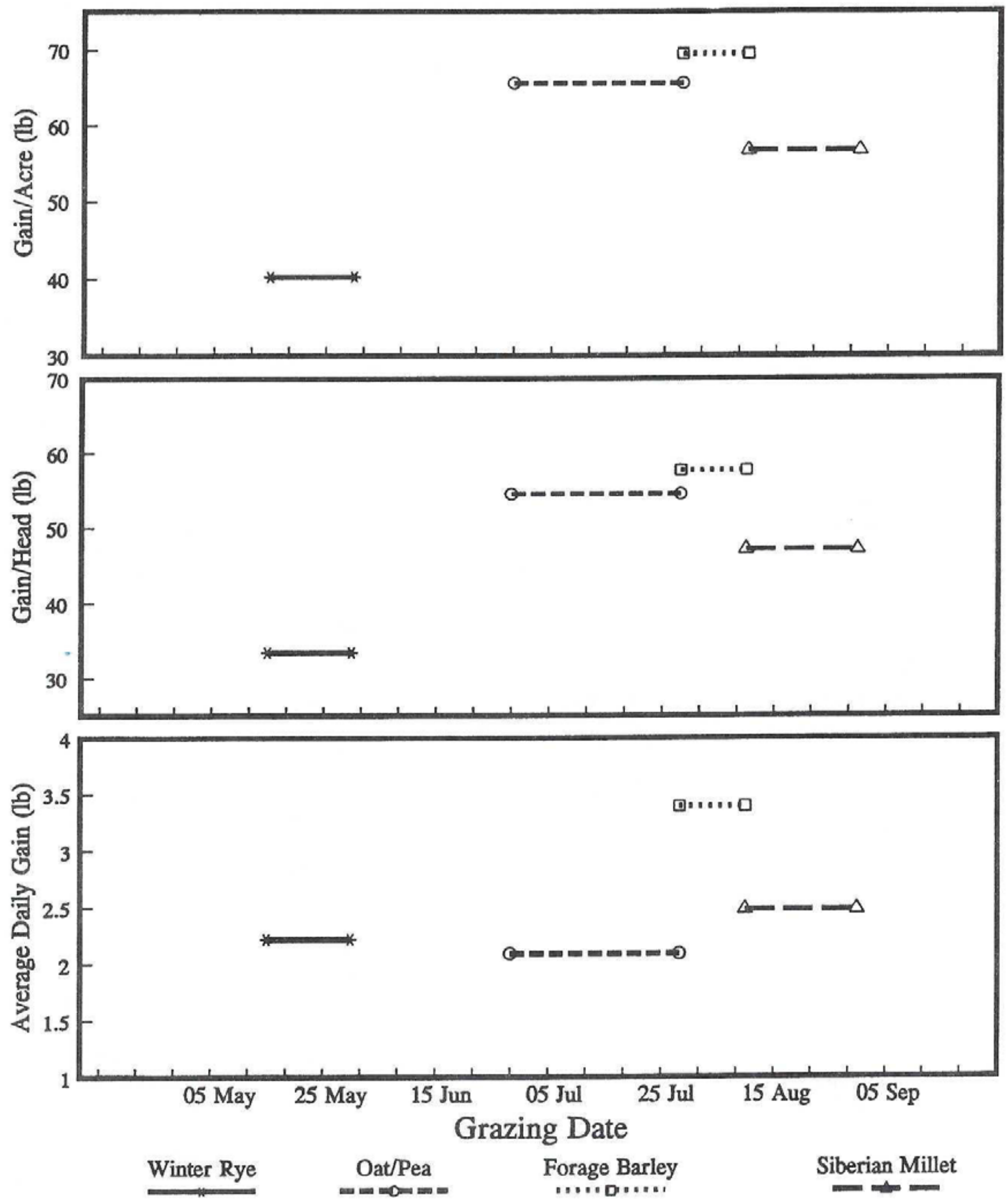


Figure 3. Calf performance from various forage pastures in year 3 (1995) of annual grazing study. Means and standard deviations are presented in text.

GRAZING VALUE AND MANAGEMENT OF CRP LANDS

James L. Nelson and Lee Tisor
Dickinson Research Extension Center

Summary:

Crossbred cow-calf pairs grazed on CRP acreage in southwest North Dakota (Bowman County) for a period of 123 days from May to September. Cows gained 13.26 lbs./acre and calves gained 50.97 lbs./acre on the seasonlong (SL) system. Gains on the Twice Over Rotation (TOR) system were 14.15 lbs./acre for cows and 47.0 lbs./acre for calves. The differences were not significant.

In 1993, the TOR system of grazing allowed cow gains of 17.3 lbs./acre and calf gains averaging 52.4 lbs./acre. The SL cow gain averaged 14.6 lbs./acre while calf gains averaged 41.9 lbs./acre.

Hay production in 1995 averaged 1.91 tons per acre for the first cutting and O.52 ton on the second cutting. The four year average hay yield from 1992 to 1995 averaged 1.38 tons per acre on the first cutting and 0.51 ton per acre on the second cutting. The overall quality of the hay has improved since 1992 when the first year's haying removed of dead material found in the hay the first year.

This trial is due to continue for one more year and the results may change.

Objectives:

The objectives of this study are to determine:

1. The floristic composition and structure of CRP lands and to note changes in floristic composition and structure due to grazing and haying over 5 years.
2. The production and utilization of CRP land vegetation under seasonlong and twice-over grazing.
3. The production and quality of hay from CRP lands.
4. The success of game and non-game wildlife species on CRP lands.
5. The erosion from CRP lands that have been variously grazed and hayed and to compare this with similar cropland.
6. The economic returns from grazing and haying CRP lands.

This trial involves several other research centers and government agencies. This report will only cover that information gathered by the Dickinson Research Center. A complete report entitled <u>Conservation Reserve Program (CPR) Grazing and Haying Study</u> by William Parker, Paul Nyren et. al. will be published.

Materials and Methods:

The forth year of a proposed five year project to study the effects of haying and grazing on Conservation Reserve Program acres was conducted by the Dickinson Research Center in 1995.

Fifty-seven pair of first calf crossbred (AXH) pairs were allotted to either a 131 acre pasture grazed for the entire season (SL) or to a set of three 75 acre rotation pastures (TOR). There were 22 pair on the seasonlong pasture and 35 pair on the rotation pastures. The cow-calf pairs grazed from May 25, 1995 to September 25, 1995, a period of 123 days. The cows rotated through the TOR pastures twice during the 123 day grazing period. The stocking rate was 1.48 acres/AUM on seasonlong and 1.59 acres/AUM on rotation pasture.

Artificial insemination, was used prior to the start of the grazing period. Purebred yearling Charolais clean-up bulls were turned in with the cows on May 25, 1995 and remained with them until July 28, 1995, a period of 65 days.

The cows were individually weighed and body condition scored at the start, finish, and at intermediate dates based on rotation times. Individual calf weights were collected at the same time. The TOR cattle started grazing in pasture #2, rotated to #1 and then to pasture #3, back to 2, 1, and finished in pasture #3. (see diagram). Animal performance and body condition scores (BCS) are shown in Table 1. Bull weights are not included in this report.

Discussion:

Results to date with both heifers and cow-calf pairs show satisfactory gains for both classes of cattle. The pastures contained a significant amount of alfalfa in the grass mixture which caused concern about the possibility of bloat. Therefore, during each of the four trial years, proloxalene (Bloat-Guard) has been mixed with the mineral mixture in an effort to reduce or prevent bloat. In 1993, one cow died of suspected bloat, although an autopsy could not confirm the cause of death.

Both the SL and TOR grazing programs have provided more than adequate forage at the stocking rates used to date. Forage quality deteriorates rather quickly after the first week of July. Late summer rains tend to revive the plant growth and add to the overall quality of the forage.

Pasture arrangement on Sec. 26 and 35-130-102

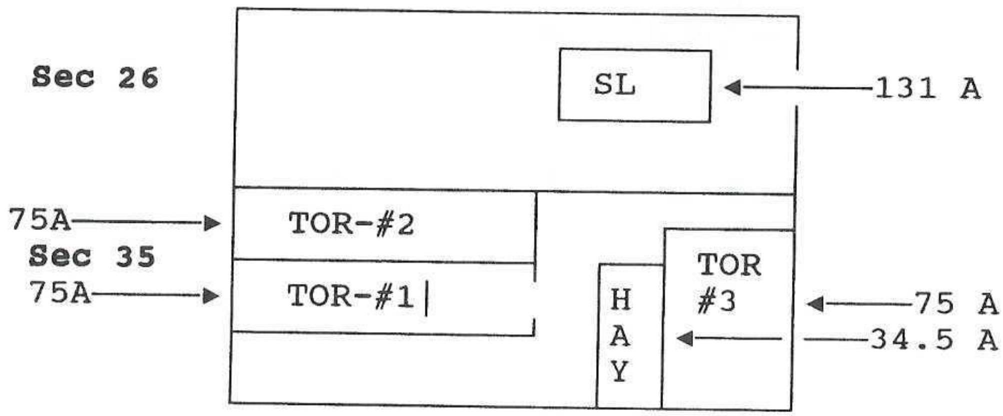


TABLE 1: COW AND CALF PERFORMANCE GRAZING CRP PASTURES IN 1995.

	SEASON LONG SYSTEM					TWICE OVER ROTATION			
Pasture Size - Acres			131					131	
No. of Pairs			22					35	
Days Grazed			123					123	
Stocking Rate Acres/AUM			1.48					1.59	
AUMs/Acre			0.68					0.63	
Date	**Cow Weight**	**Period Gain**	**ADG**	**BCS**		**Cow Weight**	**Period Gain**	**ADG**	**BCS**
May 25	1091.7			6.27		1101.7			6.34
June 15	1012.7	-18.95	-0.9	6.39		1074.3	-27.4	-1.31	6.51
July 5	1067.6	- 5.18	-0.26	6.61		1079.5	5.2	0.26	6.54
July 28	1153.1	85.5	3.72	6.50		1171.0	91.4	3.98	6.50
August 14	1158.9	5.86	0.34	6.48		1170.2	-0.8	-0.05	6.43
Sept. 8	1184.1	25.23	1.01	6.34		1199.2	28.9	1.16	6.47
Sept. 25	1170.6	-13.5	0.79	6.27		1192.7	- 6.43	-0.38	6.56
Total Gain/cow	78.90					91.00			
Gain/Acre	13.25					14.16			
Gain/Cow/Day	0.64					0.74			
Date	**Calf Weight**	**Period Gain**	**ADG**			**Calf Weight**	**Period Gain**	**ADG**	
May 25	215.1					205.9			
June 15	263.3	48.2	2.3			253.6	47.7	2.27	
July 5	319.1	55.8	2.54			304.6	51.0	2.55	
July 28	380.8	61.7	2.59			373.5	68.9	3.0	
August 14	423.3	42.5	2.57			409.8	36.3	2.13	
Sept. 8	480.2	56.9	2.5			477.8	68.0	2.72	
Sept 25	518.6	38.4	2.47			508.0	30.2	1.77	
Total Gain/calf	303.50					302.10			
Gain/Acre	50.97					46.99			
Gain/Calf/Day	2.50					2.41			

TABLE 1a. TWO YEAR COMBINED RESULTS OF COW-CALF PAIRS GRAZING CRP PASTURES

	SEASON LONG SYSTEM				TWICE OVER ROTATION		
Year	**1993**	**1995**	**Ave**		**1993**	**1995**	**Ave**
Cow gain/hd	112.60	78.90	95.75		111.40	90.97	101.19
Cow gain/acre	14.62	13.26	13.94		17.32	14.15	15.74
Cow ADG	0.88	0.64	0.76		0.87	0.74	0.81
Calf gain/hd	322.60	303.50	313.05		336.60	302.14	319.37
Calf gain/acre	41.86	50.97	46.42		52.37	47.00	49.69
Calf ADG	2.52	2.47	2.50		2.63	2.46	2.55
Combined gain lbs. per acre	56.48	64.23	60.36		69.69	61.15	65.42

TABLE 2. TWO YEAR AVERAGE PERFORMANCE OF BRED YEARLING HEIFERS GRAZING CRP ACREAGE.

	SEASON LONG SYSTEM				TWICE OVER ROTATION		
Year	**1992**	**1994**	**Ave**		**1992**	**1994**	**Ave**
Acres	131	131	131		225	225	225
Number	24	30	27		52	56	54
Days	125	127	126		125	127	126
Gain/hd	226	164	195		199	186	192.5
Ave Daily Gain	1.81	1.29	1.55		1.59	1.47	1.53
Gain/acre (lbs.)	41.45	37.52	39.49		45.93	46.39	46.16

TABLE 3. HAY YIELD ON CRP ACREAGE IN 1995

	1ST cutting	**2nd cutting**	**Total**
Date	July 5	Sept 8	
Acres	34.5	34.5	
Bales	139	38	177
Ave wt	950	950	950
Tons	66	18	84
Tons/acre	1.91	0.52	2.44
Return/acre at $45/T	85.95	23.47	109.80

TABLE 3a. FOUR YEAR RESULTS OF HAY PRODUCTION ON CRP ACRES SOUTH OF BOWMAN, ND.

Year	**1992**	**1993**	**1994**	**1995**	**Average**
Yield per acre-tons					
1st cutting	2.00	0.80	0.80	1.91	1.38
2nd cutting	0.87	0.63	0.00	0.52	0.51

1995 FINANCIAL AND PRODUCTION ANALYSIS OF HEIFER DEVELOPMENT – A PRELIMINARY REPORT

J. Dhuyvetter, K.A. Ringwall and K. Helmuth

North Central Research Extension Center
Dickinson Research Extension Center
Department of Animal and Range Sciences
North Dakota State University

ABSTRACT:

Management of replacement heifers represents the foundation upon which productive and profitable cow herds are built. Furthermore, all beef production systems start with heifers. The management and handling of those heifers directly determines their subsequent calving time and for all practical purposes defines their life time calving season. The traditional cattle system in North Dakota produces calves in March/April, with considerable attention and cost given to keeping mature cows calving within those predefined limitations. oThis paper is the initial summary of the 1995 performance and costs for developing heifers.

INTRODUCTION:

In recognition of the importance of heifer development and selection, last fall the North Dakota Beef Cattle Improvement Association, in conjunction with the NDSU Extension Service and Dickinson Research Extension Center, initiated a Heifer Development Project. The project involves conducting a centralized heifer test; taking producer consigned heifers from weaning through breeding to demonstrate existing recommendations related to the feeding, breeding, health, and management of replacement heifers.

In 1994, three entry options were available to allow comparison and study of alternative development strategies. Seven producers consigned 113 heifers to three development options differing in winter feeding systems.

Heifers consigned to Option 1 were developed through grouping and winter feeding a balanced bunk fed mixed ration utilizing silage, straw, hay grain, and supplements to achieve daily gains necessary to reach a target weight at breeding of 70% of the frame score projected mature weight. This option will be essentially the same as how last year's project was conducted (refer to 1994 Research Roundup publication).

Heifers consigned to Option 2 were developed using a winter feeding program based on free choice high quality hay supplemented with a free choice vitamin/mineral supplement and hand fed grain during critical receiving and prebreeding periods. This option provided a stair step pattern of heifer growth.

Consignors retained ownership of heifers in option 1 and 2 and were responsible for all incurred development costs, including feed, yardage, veterinary, breeding, etc. Upon completion of the test, heifers were released to the consignors upon settlement of outstanding charges.

A third option, in which the Dickinson Research Extension Center purchased heifers from the consignors on delivery based on weight an appraised market price. This option provided a comparable group of heifers for in which the heifers were fed long hay all winter, and provided supplemental protein. The protein was provided in a free choice block form.

All heifers, regardless of entry option, were managed for a concise, consistent breeding season, and mated to calving ease selected sires. A single AI service using estrus synchronization was used along with a natural clean-up service.

Specific entry requirements and project guidelines are explained in the materials and methods.

MATERIALS AND METHODS:

The following are the entry requirements that were utilized for the 1994 project as presented to North Dakota producers. Producers processing records through the CHAPS program are eligible to enter groups of 5 or more home raised heifers born between 2/1/94 and 5/1/94.

Preregistration of entries were required by October 1, 1994 by submitting a completed Entry Preregistration Form along with payment of a $50/head entry fee to CHAPS Heifer Project, attention Kris Ringwall, 470 State Avenue Suite 101 Dickinson, ND 58601.

The project was limited to 100 head accepted on a first entered basis. Consignors retained ownership of heifers entered and were responsible for all incurred development costs over the period of the test.

A suggested heifer for the project was a moderate framed crossbred of breeds strong in maternal traits, with a minimum in-herd weaning ratio of 95, out of a dam with a MPPA over 95, and free of any structural weakness. The heifers had the potential to make an excellent commercial beef replacement.

Consignors were required to deliver entered heifers to the Manning Ranch Unit of the Dickinson Research Extension Center the week of November 7-11, 1994. The Manning Ranch Unit is located 22 miles north and 2 miles west of Dickinson.

A signed and completed Entry Information Form accompanied the heifers on arrival providing information on animal identification, pre-delivery management and health history. In addition, a veterinarian signed health certificate was required.

FEEDING: On arrival all heifers were placed on a mixed receiving ration used to acclimate and bring heifers on feed over a several week period. Following acclimation, heifers were fed for appropriate average daily gains to achieve frame score projected mature weight according to research protocols defined by the North Dakota Agricultural Experiment Station. Weight gains were monitored and heifer groupings and rations evaluated and adjusted as necessary. Feed was delivered as a totally mixed ration in fenceline bunks.

Heifers entered in Option 1 were split into high and low gain groups and fed for appropriate average daily gains to achieve 70% of their frame score projected mature weight at the start of breeding. Weight gains were monitored and heifer groupings and rations evaluated and adjusted as necessary.

Heifers entered in Option 2 were provided free choice access to quality ground hay and hand fed grain in initial and prebreeding periods to produce a stair step pattern of growth and achieved the minimum of 70% of frame score projected mature weight at the start of breeding.

Heifers entered in Option 3 were placed on quality long hay and supplemented protein in a self fed block form, following an initial two week receiving program. These heifers were fed a commercial receiving diets for two weeks.

All heifers were fed an ionophore and provided supplemental vitamins and minerals to balance needs to those provided in base feeds. Rations were balanced using NRC guidelines and made up of available feeds and least cost supplements. Pasture were utilized following breeding.

HEALTH: It was required that heifers be dehorned and pre-vaccinated at least two weeks prior to delivery with IBR, BVD, BRSV, PI_3, Haemophilius Somnus, and 7-way clostridial with a history of pre-delivery health treatments and vaccinations provided on the Entry Information Form. Heifers suspected of being bred were aborted prior to delivery by administration of prostaglandin.

On arrival all heifers received booster vaccinations and treatment for internal and external parasites. Heifers not bangs vaccinated prior to arrival were bangs vaccinated once on feed. Prior to breeding, heifers were vaccinated with 5-way Lepto, Vibrio, IBR, PI_3 and BVD. As sickness was diagnosed, veterinary recommended treatments were administered.

BREEDING: Heifers were estrus synchronized to facilitate a single AI service followed by natural clean-up service for calving to begin March 1, 1994. Service of experienced AI technicians were utilized for breeding. Consignors were given the choice of high accuracy calving ease bulls for AI service selection. Following a 10 day lag period after the last AI breeding, calving ease selected bulls were run for a 30 day clean-up breeding period. Pregnancy examinations by use of ultrasound were conducted to determine pregnancy status, and if possible, project the sex of the fetus.

DATA: Heifers were weighed, frame scored, body condition scored (1-9) and disposition scored (1-5) throughout the project to monitor development. In addition, prebreeding pelvic measurements were obtained. Periodic reports were issued to consignors providing growth, health, feed, and reproductive performance.

CULLING: The right was reserved to remove any heifers from the project in which problems arose or were deemed unsuitable for replacement stock. Culled heifers could have been claimed by the consignor within one week of notification and payment of incurred development costs. No heifers were culled. In the case of a heifer identified as being pregnant through service prior to entry, arrangements were made to calve the heifer out at the owner's risk by the Dickinson Research Extension Center.

COMPLETION: The 1994 Heifer Development Project test is scheduled to terminate November 1, 1995 at which time consignors will be required to pay outstanding charges, or given the option to sell heifers.

Arrangements will be available to assist consignors in holding heifers at the Research Center for consignment to November bred heifer sales sponsored by local Dickinson auction markets.

COSTS: Consignors were/will be responsible for all costs associated with developing heifers entered into the development project. Cost items include: feed, yardage, transportation, veterinary products and services, and breeding fees, and supplies.

Actual feed costs were/will be determined by feed consumption records and market price of feeds.

Yardage was/will be accrued on a per head per day basis to cover labor, facilities, equipment, utilities, fuel, repairs, and management. Yardage costs were $.20/day in the drylot and $.10/day on pasture.

The actual cost of veterinary supplies and professional services were added to consignor bills. Veterinary costs included both preventative measures and treatments. Cost of bulls were shared by all heifers on test during the breeding period.

In the event a heifer died, the death loss was borne by the consignor. When arrangements are made to hold heifers after project completion for consignment to a fall sale, the additional feeding, yardage, and trucking costs will be borne by the consignor.

Consignors were required to sign the Entry Information form due on delivery conveying the consigned heifers as security against incurred charges. Consignors were billed on a quarterly basis for the periods of: delivery through December, January through March, April through June, and July through project completion and heifer pick-up. Entry fees were credited to the final period charges with all charges to be paid in full prior to heifer pick-up.

MANAGEMENT: Heifers were developed under the management and supervision of the NDSU Dickinson Research and Extension Center personnel. Consignors were welcome to stop by and view the heifers on test by contacting the project coordinator, Kris Ringwall, at (701)227-2348 or herdsman, Garry Ottmar at (701)573-4553.

RESULTS AND DISCUSSION:

As of this writing the results of this years test are not complete. This year’s results will be summarized and combined with the 1993-1994 results and be written up for the 1996 Research Roundup. Preliminary results are provided and will be discussed at field day.

Herd Replacement Cost Summary

NDBCIA Heifer Development Project	
Initial Heifer Value (631 lbs @ 70¢)	441.70
November – November Development Cost	253.83
Interest (10%)	56.86
Total Costs Per Heifer	752.39
Heifer Cost Adjustments	
Death Loss (.8%)	+ 6.06
Culling Rate (7% open), Cull Value ($600)	+ 11.93
Total Cost Per Heifer Retained	770.38

NDBCIA 1994-1995 HEIFER DEVELOPMENT TEST
PERFORMANCE COST SUMMARY

	Overall Summary	Summary by Management Group		
		1	2	3
Number	113	34	47	31
Birthdate	3/20	3/23	3/12	3/28
205 Day Weight	576	562	601	552
PERFORMANCE				
11/21 On Test Weight	631	571	690	607
Body Condition Score	6.3	5.8	6.7	6.2
Frame Score	6.4	6.2	6.6	6.4
Mature Weight	1235	1226	1270	1235
Target Weight	865	858	889	865
Target Gain	1.3	1.6	1.1	1.4
5/19 Breeding Weight	916	876	967	883
Body Condition Score	6.8	6.7	7.1	6.5
% Mature Weight	74%	71%	76%	71%
Actual Gain	1.6	1.7	1.5	1.5
Pelvic Area	183	173	188	185
49 Day Pregnancy Rate	96	100	96	94
Synchronization Response	89	100	93	71
AI Conception	61	71	61	50
FEED COST				
181 Day Winter Cost	94.55	82.95	84.03	123.21
Cost Per Day	.52	.46	.46	.68
AVERAGE RATION				
Corn Silage lbs (%)		9.7 (35.7)	.3 (1.7)	
Hay lbs (%)		9.2 (42.6)	15.3 (81.8)	21.0 (95.1)
Grain (Oats) lbs (%)		4.3 (19.8)	2.6 (13.8)	.2 (1.0)
Mineral & Salt lbs (%)		.1 (.3)	.1 (.3)	
Bovatec Supplement lbs (%)		.3 (1.5)	.4 (2)	
Block Supplement lbs (%)				.8 (3.4)
Pellet Supplements lbs (%)				.1 (.5)
SBOM		1 (.4)		
184 Day Pasture Costs	55.20	55.20	55.20	55.20
Cost Per Day	.30	.30	.30	.30
TOTAL	**149.75**	**138.15**	**139.23**	**178.41**

NDBCIA 1994-1995 HEIFER DEVELOPMENT TEST
PERFORMANCE COST SUMMARY
(continued from previous page)

	Overall	**Summary by Management Group**		
YARDAGE COST	**Summary**	**1**	**2**	**3**
181 Day Winter Period	31.19	36.20	36.20	18.10
184 Day Pasture Period	18.40	18.40	18.40	18.40
TOTAL	**49.59**	**54.60**	**54.60**	**36.50**
BREEDING COST				
MGA		1.50	1.50	0
Prostaglandin		2.05	2.05	4.10
Semen		11.72	11.25	8.32
Technician		6.00	5.76	4.26
Clean-up Bull		12.00	12.77	15.48
Ultrasound PG		2.00	2.00	2.00
TOTAL	**34.99**	**35.27**	**35.33**	**34.16**
HEALTH COSTS				
PREVENTION				
Bovishield	.79			
7 Way Clostridial	.25			
Nasal IBR	.36			
One Shot	2.00			
Preguard 9	.73			
Ivomec	2.60			
TOTAL	**6.73**			
TREATMENTS				
Number Treated (%)	15 (13)			
Cost Per Treatment	21.85			
Total Avg. Cost/Hfr	2.93			
DEATH LOSS				
Number Died (%)	1 (.8)			
MISCELLANEOUS				
Ear Tag	.84			
Trucking	9.00			
Total	4.84			
TOTAL COST	**253.83**	**247.52**	**248.66**	**278.57**

SWINE RESEARCH

Effect of Winter Gestation Energy Level on Sow Productivity

D.G. Landblom, W.D. Slanger, K.A. Ringwall, T. Winch and J. Kubik

Dickinson Research Extension Center, Dickinson, North Dakota
NDSU Animal and Range Sciences, Fargo, North Dakota

SUMMARY

Sow winter gestation energy levels are being evaluated in a long term study to identify the energy regime that interacts most favorably with the environment, farrowing production, and rebreeding performance. Performance longevity is an important criteria with respect to profitability. Therefore, project objectives focus on wintering production over four years because the information obtained will be inferred to the environments of subsequent years.

Data generated during the 1994-95 winter are shown in table 1. The discussion that follows, and data presented are provided as a project update only, since the data is too limited for comment.

INTRODUCTION

High-producing, genetically lean sows farrow and nurse more pigs, produce more milk and, consequently, have higher nutritional requirements than less prolific sows. Accessing energy requirements for lactation are difficult due to the confounding effects of one reproductive cycle on another.

Energy consumption during gestation affects voluntary energy consumption during lactation and, ultimately, the rebreeding period following lactation. Maintaining a proper gestational energy balance that keeps sows in desirable body condition is essential. Overfeeding energy during gestation causes sows to have reduced appetites during lactation resulting in weight loss. Insufficient energy during gestation does not prepare sows adequately for lactation. Sows that enter the farrowing room thin are unable to nurse litters larger than seven pigs and gain weight simultaneously. Inability of thin sows to gain weight during lactation results in extended weaning to rebreeding intervals.

The objective of this investigation is to determine winter gestation energy levels that will optimize sow farrowing body condition, minimize lactation weight loss, and improve rebreeding performance of sows gestated in outdoor facilities and managed in an All In/All Out management system.

MATERIALS AND METHODS

This is a long term study encompassing four winters. Pig Improvement Company (PIC), Camborough 15 sows are being managed in an All In/All Out continuous group farrowing management system. Each winter, within this continuous flow production system, two farrowing groups that have been previously assigned to three gestation energy levels [Low, Medium (Control), and High], in lifetime herd assignments, are being used to address the project's objectives. Due to the projects long term design, breeding group integrity is being strictly maintained. Females are not culled for production reasons, but, when culled for management reasons, are being replaced with gilts of similar type in lifetime assignments.

Pregnant sows are housed in outdoor dirt gestation pens (32' x 150') equipped with automatic frost-free waterers, portable steel shelters, constructed from discarded 400 barrel oilfield tanks, and bedded with straw. The respective energy levels are being fed once daily in individual feeding stalls. Due to the seasonal nature of the investigation, the time period of evaluation is from November through March. During non-recording seasons, those groups being studied will receive the control energy level.

Body condition scores are being taken visually at the beginning and end of gestation, within 12 hrs. after farrowing, and at weaning. Sows in all treatments are moved to farrowing crates 2 to 3 days prior to farrowing (based on breeding date) and fed the same gestation diet offered outside. At farrowing, feed is withheld for the first 24 hours. Beginning with an initial offering of 6 pounds (3 lbs. morning and evening), the sows are brought up to full feed by daily increases of 1 pound/head/day until the twice daily offerings are not completely consumed. Nutrient specifications of the lactation diet are 18.5% crude protein, .75% lysine, 1.0% calcium, .95% phosphorous, and 5% added vegetable oil.

Pigs in the study are being weaned at three weeks of age without access to creep feed. Piglets will have access to sow feed, but consumption is anticipated to be neglegible. At weaning, sows are weighed, condition scored, and placed in a common breeding pen with access to a self-fed postlactation breeding diet, and handmated using multiple sire breeding in a fourteen-day breeding period. Sows are mated morning and evening, in attended matings, until they will no longer stand for service.

Gestational data being recorded include: beginning and ending gestation weight and condition score. Farrowing data include: parity, sow weight and condition score, lactation days, feed/head, and condition score at weaning. Farrowing performance records include: pigs born alive, pigs weaned, litter birth weight, litter wean weight. Rebreeding performance will be monitored based on days to effective service (pregnancy) using Pigtales sow performance data.

Data will be analyzed using a model that includes gestation energy level, animal within gestation energy level, parity, parity x gestation energy level interaction, and error (SAS, 1988). When appropriate, sow weight will be used as a covariate.

RESULTS AND DISCUSSION

The first two gestation groups were wintered between November and March 1994-95. Due to the long term nature of the project, and limited data to date, it is inappropriate to make comparative remarks at this writing. This information is being made available as a report of progress to date. As more gestation groups are added to the database, strength and year to year variation will become apparent. Year to year winter variation is an important part of this study since conclusions and implications will be inferred to the environments of future years.

Table 1. Gestation, Farrowing and Rebreeding Response: Winter 1994-95.

	ENERGY LEVELS		
ITEM	**CONTROL**	**LOW ENERGY**	**HIGH ENERGY**
Gestation Energy KCal, ME/Day	7868	6681	8682
No. Sows	12	10	10
Parity	1.8	2.0	1.9
SOW WEIGHT CHANGE			
Gestation Starting Wt.	405	436	412
Prefarrowing Wt.	470	502	489
Postfarrowing Wt.	441	460	453
Sow Wean Wt.	427	438	441
Lactation Wt. Change	-14	-22	-12
LACTATION FEED CONSUMPTION			
Lactation Days	22.8	22.5	22.7
Lactation Feed/Head	329	316	324
Lactation Feed/Head/Day	14.4	14.0	14.3
SOW CONDITION SCORE			
Farrowing Condition	2.88	2.94	2.92
Weaning Condition	2.77	2.78	2.78
Condition Change	-.11	-.16	-.14
FARROWING PERFORMANCE			
Pigs Born Alive	11.2	11.7	11
Pigs Weaned	9.5	10.3	10.4
Litter Birth Wt.	36	39.3	41.1
Litter Wean Wt.	144.2	153.9	155.5
Litter Gain	108.2	114.6	114.4
ADG/pig	.49	.50	.48
REBREEDING PERFORMANCE			
Days to Effective Ser.	12.8	4.3	15.7

Feeding Management Strategies for Early Weaned Pigs Following Treatment for *S. suis* Infection Using Spray Dried Porcine Plasma and Pelleted Diets

D.G. Landblom, C. Poland[1], T. Winch[2] and J. Kubik[2]
Dickinson Research Extension Center, Dickinson, North Dakota

SUMMARY

Subsequent impact on weanling pig performance during the second and third dietary phases, following initial phase 1 exposure to a commercial pelleted starter (CS) diet or farm processed wheat/barley/dried whey based starter diets prepared with or without spray dried porcine plasma (PP), was evaluated in three experiments using 378 18-21 day old weanling pigs.

Experiment 1. No differences were measured between starter types for ADG, feed intake, and feed to gain ratio the first 7 days after weaning. In the second phase, also fed for 7 days, pigs that received control and pelleted CS during phase 1 gained faster than the PP group. When the common phase 3 diet was offered (14 days), no difference in ADG or feed efficiency were measured. For the full 28-day nursery period, no difference for ADG was recorded between treatments, but pigs started on pelleted CS consumed less feed/pound of gain ($P < .05$) compared to the control, and tended to be more efficient than the PP fed pigs. Although not significantly different, feed costs/head were $3.86, $3.96, and $4.14 for the control, PP and pelleted CS, respectively.

Experiment 2. Feeding time for the phase 2 and 3 diets were switched (phase 2 – 14 days; phase 3 - 7 days). Phase 1 ADG and feed intake for the pelleted CS and PP were similar and greater ($P < .05$) than the control, however, feed efficiencies were similar. Phase 1 feed costs were lower for the control. Subsequent performance in phases 2 and 3 favored the pelleted CS, in which, ADG, feed intake and gain cost efficiency were better than either the control or PP supplemented starters. For the full 28-day period, gain and feed consumption were higher for the pelleted CS pigs compared to the control starter. Plasma pigs were intermediate. Pig gain for the 28-day period translated into 27.7% and 16.8% heavier pigs in the CS and PP groups. Non-significant nursery feed costs/head were $3.66, $4.58, and $5.28 for the control, plasma, and pelleted CS, respectively.

Experiment 3. Phase 1 starters were fed for 14 days before being switched to phase 2 and 3 common diets for 7 days each. Average daily gain in phase 1 tended to be slightly greater for the pelleted CS, but the feed to gain ratio was significantly ($P < .05$) improved. Subsequent growth during phases 2 and 3 were very good for all starter types. Pelleted CS had faster gains ($P < .05$), though, and consumed less daily feed in phase 2, but phase 3 consumption was higher. For the full 28-day period, the pelleted CS resulted in faster ADG, increased feed intake, improved feed efficiency, and higher cost/pound of gain ($P < .05$). Compared to the pelleted CS, the control and PP supplemented pigs were 23.2% and 26.3% lighter, respectively. Significant feed costs/head were recorded in this experiment, and were $4.03, $4.70 and $6.38 for the control, PP, and pelleted CS, respectively.

Dietary phases contained progressively less dried whey. It would appear, in experiment 1, that the progression through phases 1 and 2 to phase 3 was too rapid for the immature digestive systems of young pigs in transition.

A 4% porcine plasma level was determined, going into the study, to be a practically priced level to add, but in these experiments the 4% level yielded inconsistent performance that was equal to, or slightly better than the controls, but was more costly/pound of gain.

Pig response in phase 2 appears to be a strong indicator of weaning transition success and nursery acclimitization. Following longer phase 1 and 2 feeding periods, consistently greater pig responses were preceded by the pelleted CS. Of the feeding management regimes evaluated, experiment 2 demonstrates the most desirable performance/economic balance. Preceding phases 2 and 3 with the pelleted CS gave weanling pigs, in this group of investigations, the strongest start at a reasonable price.

Pretreatment with the antibiotic amoxicillin and *S. suis* antiserum as a combination prevention method for the control of *S. suis* infection in weanling pigs was of no value with respect to animal performance. In fact, there was a trend toward poorer performance among those pigs receiving the two injections.

INTRODUCTION

Matching feeding management methods to the growth curve of young swine (18-21 days) can have a pronounced effect on post weaning growth and feeding economics. Physical form, dietary protein quality and energy are criteria that, when in proper balance, will allow pigs to grow at or near their genetic potential.

A review of the scientific literature reveals spray-dried porcine plasma and dried whey to be important ingredients for young weanling pigs. Pelleting, as well, is a beneficial processing method. Evaluated in numerous experiments, pelleting has repeatedly been shown to enhance growth performance. Factors attributed to improved performance include reduced feed waste, increased diet digestibility, improved growth rate and feed efficiency. A survey of 117 experiments revealed a 6.6% increase in growth rate and 7.9% increase in feed efficiency due to pelleting (Patience and Thacker, 1989). Greatest response to pelleting occurs when fibrous basal grains, like barley, are pelleted.

Animal protein supplements (porcine plasma, dried whey, dried skim milk, caesin, lactose/starch, porcine blood, bovine plasma and meat extract) have been evaluated in the diets of early-weaned pigs by Hansen and co-workers (1993). Of the supplement sources tested, porcine plasma (10.3%) fed in conjunction with dried whey (20%) and added lactose (10%) resulted in significantly higher average daily gain (ADG) and average daily feed intake, during the first two weeks after weaning, and for the entire 35 day post weaning period. Kats et al. (1994) investigated the effects of porcine plasma at various levels of inclusion ranging from 0 to 10%. Average daily gain and feed intake increased with increasing levels of porcine plasma, but gain to feed ratios were not affected.

Beneficial responses from dietary dried whey by young pigs has been known for some time. The trend toward earlier weaning of pigs has resulted in a greater reliance on whey in starter diets. Mahan et al. (1993) summarized the impact of dried whey and lysine inclusion in early-weaned pig diets, and concluded that good quality whey enhanced growth rates, feed intakes and gain:feed response. When .95% and 1.10% supplemental lysine was included in the corn-SBM diets formulated with and without dried whey, a positive growth response was obtained in the presence of dried whey. They concluded that lysine was not the first limiting nutrient, and predicted that the lactose component present in dried whey initated the observed growth response. The immature digestive system of very young pigs needs a constant but gradually declining supply of lactose which is most easily supplied in starter diets using dried whey.

A common practice among hog producers is to start freshly weaned pigs on a pelleted commercial weaning ration containing high levels of dried whey followed by switching to farm processed rations after the first 7 to 14 days. Since porcine plasma and dried whey are important ingredients in the initial diets of early-weaned pigs, and pelleting has repeatedly been shown to improve performance, feeding management strategies were evaluated around nutrient dense diets containing a full compliment of dried whey and 4% spray dried porcine plasma.

Objectives in this piglet feeding management investigation included:

1. Evaluate the subsequent impact on weanling pig performance during the second and third dietary phases following initial exposure to a commercial pelleted diet and farm processed wheat/barley/dried whey based starter diets prepared with and without spray-dried porcine plasma.

2. Evaluate pig response by phase and overall performance when the length of phase feeding time varied in a three phase feeding system.

3. To evaluate the effect on piglet performance following application of a *S. suis* prevention regime that included administration of a synthetic penicillin, amoxicillin, and *S. suis* antiserum.

MATERIALS AND METHODS

Three hundred seventy-eight (378) weanling pigs (18-21 days) were randomly allotted to three dietary treatments in three triple replicated experiments of 126 pigs each.

Experiment 1

A farm processed (FP) wheat/barley/dried whey based control diet was compared to a similar diet containing 4% spray dried porcine plasma (PP), and a pelleted commercial starter (CS) diet also containing dried whey and spray dried porcine plasma. The farm processed diets and nutrient analysis of all diets are shown in table 1.

Pigs used in each experiment were transferred immediately after weaning, weighing and vaccination (3-way vaccine; Schering-Plough) to a confinement nursery building and allotted to experimental treatments. Seven pigs were allotted per pen, and there were three replicates per treatment. Pen served as the experimental unit. The nursery building used is a modular 12’x 54’ structure equipped with stainless steel pens (16 sq. ft.) and feeders, Filter-eze^{R} flooring, “pull plug” type self contained manure pits, positive ventilation and computer modulated ventilation and heat control.

Initial nursery room temperature was 85°F. A computer ramping feature in the facilities environmental control system was set to lower room temperature one-half degree daily from 85°F to 75°F. Temperature ramping was turned off at 75°F where the room temperature was kept for the remainder of the nursery study.

The pelleted CS diet (Vigorstart 120 C – Med) was purchased from Vigortone Ag Products' local retailer, Steffan Feeds, Dickinson, ND 58601. The FP diets were prepared using a New Holland 355 grinder/mixer equipped with electronic scale and 1/8" screen. Diet porosity goal was 700-800 microns. The experimental diets were weighed into each pen and self-fed. Pigs and feed were weighed at the beginning and at the end of each dietary phase change.

Experiments 2 and 3

Diets and handling procedures in the second and third experiments were the same as those in experiment 1 except the length of time each phase was fed varied. Variations in phase length are shown in table 2.

Determining whether using a preventative treatment with an antibiotic and *S. suis* antiserum would reduce the influence of *S. suis* infection on performance was accomplished by adding an additional set of replicates to each treatment in the three experiments. Each piglet assigned to the additional treatment replicates received 1cc (15mg.) of amoxicillin and 1cc of *S. suis* antiserum subcutaneously in the neck when weaned.

Pigs in all treatments were fed for four seven day periods for a total feeding period of 28 days.

All data were analyzed using the GLM procedures of SAS (1985). Average daily gain, feed/head/day, feed/pound of gain, feed cost/head/day, and feed cost/pound of gain were analyzed with diet, phase, antibiotic/antiserum treatment, and rep as main effects. All possible interactions were tested. In all analyses, pen was the experimental unit.

RESULTS

Experiment 1

Control, plasma supplemented and pelleted commercial post-weaning starter diets were offered to 126 (14-15 pound) pigs during the first 7 days post-weaning. After an initial seven day exposure to the starter diets, the pigs were switched to a common farm processed phase 2 diet for seven days and a phase 3 diet for 14 days. Combined growth, antibiotic/antiserum treatment and piglet response to initial starter diet types and subsequent response to dietary phase changes are shown in table 3. No differences were measured between the starters for ADG, feed/head/day, and feed to gain ratio during the first seven days after weaning. Control feed cost/pound of gain was considerably less than the CS and PP groups. In the second phase, also fed for seven days, pigs that received the control and CS diets during phase 1 gained faster ($P < .05$) than the group supplemented with porcine plasma. Pigs offered common phase 2 diets that had previously received CS consumed less phase 2 feed/day ($P < .05$), and tended toward better feed and gain efficiency. When the common phase 3 diet was fed, no difference in ADG or feed efficiency was measured. Pig response for the combined 28-day period was variable depending on the criteria considered. There was no difference in ADG between treatments, but pigs started on pelleted CS consumed less feed/pound of gain compared to the control group, and tended to be more efficient when compared to the plasma diet. Feed cost/pound of gain favored the control starter. Feed costs/pound of gain were $.21, $.22, and $.23 for the control, commercial starter pellet, and plasma suplement, respectively, which translates into feed costs/pig of $3.86, $3.96, and $4.14 for the control, PP, and pelleted CS groups.

There was no advantage for using an antibiotic/antiserum treatment immediately post-weaning.

Experiment 2

Data for experiment 2 is shown in table 4. In this experiment, feeding time for common phase 2 and 3 diets was reversed. Following exposure to phase 1 diets for seven days, phase 2 was fed for 14 days and phase 3 for 7 days. In phase 1, ADG and feed/head/day for the CS and PP were similar and greater ($P < .05$) than the control diet, however, feed efficiency was similar. Feed cost/pound of feed for the short 7 day period was considerably lower ($P < .05$) for the control group. Subsequent performance in phase 2 and 3 following phase 1 experimental starters favored the pelleted CS, in which ADG, feed intake and gain cost efficiency were better than either the control or plasma supplemented starters. For the full 28-day period, gain and feed consumption were higher for the pelleted CS pigs compared to the control starter. Performance of plasma supplemented pigs was intermediate. Gain performance for the 28 days translated into pigs that were 27.7% and 16.8% heavier for the CS and PP pigs, respectively. Economic efficiency favored the control group. Gain costs were $3.66, $4.58, and $5.28 for the control, plasma, and pelleted CS, respectively.

As in experiment 1, there was no advantage for using the antibiotic/antiserum treatment at weaning.

Experiment 3

In the third experiment, phase 1 feeding time was extended to 14 days and phases 2 and 3 were 7 days each. Data has been summarized in table 5. Average daily gain in phase 1 tended to be slightly greater for the pelleted CS, but the feed to gain ratio was significantly better ($P < .05$). Feed cost/pound of gain for the CS was much higher ($P < .05$). Subsequent growth during phases 2 and 3 were remarkably good for all starter types. Pelleted starter groups had faster gains ($P < .05$), though, and consumed less daily feed in phase 2, but in phase 3 consumption was higher. Significant differences in feed efficiency were not measured during phases 2 and 3, however, a trend toward improved feed efficiency following the CS was recorded. Feed cost/pound of gain also tended to favor the pelleted starter, but was not of sufficient magnitude to offset the cost of feeding the pellet for 14 days in phase 1. For the 28-day nursery period, the pelleted CS resulted in faster ADG, increased feed consumption, improved feed efficiency and higher cost/pound of gain ($P < .05$). Compared to the pelleted CS, the control and plasma supplemented pigs were 23.2% and 26.3% lighter, respectively. Feed cost/pound of gain favored the control pigs that cost $.05 less/pound of gain than either the plasma or pelleted CS. Gain costs were $4.03, $4.70, and $6.38 for the control, PP, and pelleted CS groups.

Antibiotic/antiserum treatment was of no advantage in experiment 3 either.

DISCUSSION

These data are preliminary. Each experiment must be evaluated separately, since they were not conducted simultaneously. As preliminary studies, they provide the database from which future nursery studies can be developed.

Viewing the three separate experiments, one can easily detect dramatically different responses with respect to a desirable performance/economic balance. Piglet response in experiment 1 was unresponsive in the second and third phases. Subsequent response following starter diets didn't demonstrate sufficient amplitude, with respect to gain performance and associated parameters. Since each dietary phase contained progressively less dried whey, it would appear that the progression through phases 1 and 2 to phase 3 was too rapid for the immature digestive systems of young pigs in transition, and experiencing weaning stress.

Spray-dried porcine plasma was added at 4% of the diet as a replacement for nearly all of the fish meal. Hansen et al. (1993) found a progressive improvement over control pigs with each plasma addition from 2 to 10% of the diet. Kats et al. (1994) found that adding porcine plasma at levels greater than 4% of the diet did not improve gain to feed ratios. Since the 4% level was a practically priced level, and had been determined to be a pivotal level in other swine nursery research, it was selected to replace fishmeal at the 4% level in these experiments. Adding 4% plasma supported pig responses that were equal to, or slightly better than, the control diets, but were more costly/pound of gain.

Largest post-weaning pig responses were observed in experiments 2 and 3. Following longer phase 1 and 2 feeding periods, consistently greater pig responses were recorded for phases that were preceeded by the pelleted CS. Pig response in phase 2 appears to be a strong indicator of weaning transition success and nursery acclimitization.

Cost effective feeding management systems that give stressed weanling pigs a strong start are balanced systems. Of the feeding management regimes evaluated, experiment 2 demonstrated the most desirable performance/economic balance.

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1. C. Poland is Area Livestock Specialist, NDSU Extension Service.

2. T. Winch and J. Kubik are Research Technicians, Dickinson Research & Extension Center.

Table 1. Weanling pig diet composition fed during phase 1 and common diet formulations fed across treatments during phases 2 and 3.

EXPERIMENTAL DIET COMPOSITION, (%)

	PHASE I			PHASE II	PHASE III
	CTRL	CTRL + PLASMA	COMM-ERCIAL STRTR.		
Spr. Wheat	24.3	24.3		41.8	35.4
Barley	19.1	18.9		21.3	38.8
Whey	24.2	24.2		7.42	0.0
SBOM	19.2	19.2		17.8	18.0
Fish Meal	5.9	1.9		3.96	0.0
Soybean Oil	4.0	4.0		3.95	3.46
Tr. Mineral	1.45	1.45		1.7	2.0
Lysine	0.33	0.25		0.4	0.6
Vit B Comp.	0.164	0.164		0.197	0.166
Vit A, D&E	0.05	0.05		0.05	0.05
Copper Sulf.	0.08	0.08		0.08	0.05
Porcine Plasma	0.0	4.0		0.0	0.0
Mecadox Med.	1.22	1.22		0.62	0.62
--					
Analysis (%):					
Dry Matter	89.6	89.6	89.6	89.4	89.0
C. Protein	20.7	21.3	20.0	19.9	18.3
C. Fat	5.7	5.4	7.5	5.6	4.9
C. Fiber	3.0	3.0	2.5	3.5	4.2
Calcium	0.81	0.70	----	0.88	0.71
Total Phos.	0.78	0.73	----	0.68	0.58
Avail. Phos.	0.54	0.42	----	0.44	0.31
Lysine	1.50	1.50	1.50	1.38	1.29
Met. En (kcal)	3234	3253	----	3246	3179
--					
Cost/lb., $	.1915	.2777	.3600	.1309	.0939

Table 2. Feeding intervals evaluated in objective 2.

FEEDING INTERVALS (Days)

PHASE:	Phase I	PHASE II	PHASE III
Expt. 1	7	7	14
Expt. 2	7	14	7
Expt. 3	14	7	7

Table 3. Combined growth and antibiotic/antiserum treatment on performance and piglet response to dietary phase changes [Expt. 1]

Phase Lengths: Phase 1 = 7 Da, Phase 2 = 7 Da, Phase 3 = 14 Da

COMBINED PERFORMANCE				
Item	**Control**	**Pellet**	**Plasma**	**SEM**
Starting Wt.	15.1	14.4	14.5	
End Wt.	33.5	33.2	31.7	
Gain	18.4	18.8	17.2	
ADG	.66	.67	.61	.030
Fd/Hd/Da	1.22[a]	1.13[ab]	1.05[b]	.040
Fd:Gain	1.87[a]	1.68[b]	1.74[ab]	.058
Fd Cost/Hd/Da	$.14	$.15	$.14	.005
Fd Cost:Gain	$.21	$.22	$.23	.006

COMBINED PERFORMANCE – ANTIBIOTIC/ANTISERUM				
		WITH	**WITHOUT**	**SEM**
ADG		.63	.66	.30
Fd/Hd/Da		1.12	1.15	.493
Fd:Gain		1.80	1.74	.403
Fd Cost/Hd/Da		$.14	$.14	.668
Fd Cost:Gain		$.22	$.21	.195

PHASE PERFORMANCE										
	PHASE 1			**PHASE 2**			**PHASE 3**			
Days Fed	7			7			14			
Item	**Ctrl**	**Pel**	**Plas**	**Ctrl**	**Pel**	**Plas**	**Ctrl**	**Pel**	**Plas**	**SEM**
ADG	.35	.41	.41	.75[a]	.70[a]	.57[b]	.76	.79	.73	.034
Fd/Hd/Da	.50	.50	.61	1.13[a]	.95[b]	.91[b]	1.63[a]	1.53[a]	1.35[b]	.033
Fd:Gain	1.42	1.22	1.68	1.52	1.35	1.67	2.17	1.95	1.87	.127
Fd Cost/Hd/Da	$.10[a]	$.18[b]	$.17[b]	$.15[a]	$.12[b]	$.12[b]	$.15[a]	$.14[ab]	$.13[b]	.006
Fd Cost:Gain	$.27[a]	$.44[b]	$.47[b]	$.20	$.18	$.22	$.20	$.18	$.18	.023

a,b,c Values in same row with different superscripts differ (P < .05).

Table 4. Combined growth and antibiotic/antiserum treatment on performance and piglet response to dietary phase changes [Expt. 2]

Phase Lengths: Phase 1 = 7 Da, Phase 2 = 14 Da, Phase 3 = 7

COMBINED PERFORMANCE				
Item	**Control**	**Pellet**	**Plasma**	**SEM**
Starting Wt.	15	15.7	15.2	
End Wt.	30.9	37.7	33.5	
Gain	15.9	22.0	18.3	
ADG	$.56^{a}$	$.79^{b}$	$.65^{ab}$	.032
Fd/Hd/Da	$.99^{a}$	1.31^{c}	1.18^{b}	.036
Fd:Gain	1.79	1.68	1.81	.052
Fd Cost/Hd/Da	$\$.13^{a}$	$\$.19^{c}$	$\$.16^{b}$	.005
Fd Cost:Gain	$.23	$.24	$.25	.011

COMBINED PERFORMANCE – ANTIBIOTIC/ANTISERUM				
		WITH	**WITHOUT**	**SEM**
ADG		.63	.70	.091
Fd/Hd/Da		1.12^{a}	1.21^{b}	.044
Fd:Gain		1.79	1.74	.416
Fd Cost/Hd/Da		$\$.15^{a}$	$\$.17^{b}$	.047
Fd Cost:Gain		$.25	$.24	.504

PHASE PERFORMANCE										
	PHASE 1			**PHASE 2**			**PHASE 3**			
Days Fed	7			14			7			
Item	**Ctrl**	**Pel**	**Plas**	**Ctrl**	**Pel**	**Plas**	**Ctrl**	**Pel**	**Plas**	**SEM**
ADG	$.35^{a}$	$.47^{ab}$	$.51^{b}$	$.63^{a}$	$.88^{b}$	$.68^{a}$	$.64^{a}$	$.91^{b}$	$.74^{a}$	.035
Fd/Hd/Da	$.50^{a}$	$.62^{ab}$	$.71^{b}$	1.03^{a}	1.37^{b}	1.16^{a}	1.43^{a}	1.89^{c}	1.68^{b}	.038
Fd:Gain	1.49	1.32	1.42	1.66	1.56	1.73	2.34	2.09	2.28	.107
Fd Cost/Hd/Da	$\$.10^{a}$	$\$.23^{c}$	$\$.20^{b}$	$\$.14^{a}$	$\$.18^{b}$	$\$.15^{a}$	$\$.13^{a}$	$\$.18^{b}$	$\$.16^{c}$	.007
Fd Cost:Gain ADG	$\$.28^{a}$	$\$.48^{c}$	$\$.39^{b}$	$.22	$.20	$.23	$.22	$.20	$.21	.016

a,b,c Values in same row with different superscripts differ ($P < .05$).

Table 5. Combined growth and antibiotic/antiserum treatment on performance and piglet response to dietary phase changes [Expt. 3]

Phase Lengths: Phase 1 = 14 Da, Phase 2 = 7 Da, Phase 3 = 7

COMBINED PERFORMANCE

Item	Control	Pellet	Plasma	SEM
Starting Wt.	12.2	12.1	11.9	
End Wt.	29.7	34.9	28.7	
Gain	17.5	22.8	16.8	
ADG	.62[a]	.81[b]	.60[a]	.024
Fd/Hd/Da	1.06[a]	1.26[b]	1.03[a]	.035
Fd:Gain	1.71[a]	1.55[b]	1.72[a]	.035
Fd Cost/Hd/Da	$.14[a]	$.22[b]	$.17[a]	.005
Fd Cost:Gain	$.23[a]	$.28[b]	$.28[b]	.006

COMBINED PERFORMANCE – ANTIBIOTIC/ANTISERUM

		WITH	WITHOUT	SEM
ADG		.68	.68	.776
Fd/Hd/Da		1.10	1.13	.456
Fd:Gain		1.63	1.68	.167
Fd Cost/Hd/Da		$.18	$.18	.34
Fd Cost:Gain		$.26	$.27	.07

PHASE PERFORMANCE

	PHASE 1			PHASE 2			PHASE 3			
Days Fed	14			7			7			
Item	**Ctrl**	**Pel**	**Plas**	**Ctrl**	**Pel**	**Plas**	**Ctrl**	**Pel**	**Plas**	**SEM**
ADG	.43	.53	.43	.69[a]	.99[b]	.66[a]	.95[a]	1.21[b]	.88[a]	.042
Fd/Hd/Da	.64	.68	.68	1.22[a]	1.58[b]	1.13[a]	1.74[a]	2.11[b]	1.64[a]	.042
Fd:Gain	1.52[b]	1.29[a]	1.57[b]	1.80	1.60	1.75	1.85	1.74	1.90	.042
Fd Cost/Hd/Da	$.12[a]	$.25[c]	$.19[b]	$.16[a]	$.21[b]	$.15[a]	$.16[a]	$.20[b]	$.15[a]	.042
Fd Cost:Gain	$.29[a]	$.47[c]	$.43[b]	$.23	$.21	$.23	$.17	$.16	$.18	.042

a,b,c Values in same row with different superscript letters differ ($P < .05$).

Feeding value of field peas and naked oats for livestock - project description.

D. G. Landblom[a], C. Poland[a] and R. L. Harrold[b]

[a]Dickinson Research Extension Center, Dickinson
[b]Department of Animal and Range Sciences,
North Dakota State University, Fargo

SUMMARY

This project is a series of studies designed to evaluate the efficacy of using field peas or naked oats as substitutes for all or a portion of the grain and/or protein supplement (e.g. soybean meal) in diets for weaned and growing pigs and calves. Demonstration of the potential of North Dakota grown field peas and naked oats as a livestock feed for growing livestock should provide several benefits. If the results suggest that these alternatives are suitable substitutes for traditional feed grains, livestock feeders would be presented with a larger array of feedstuffs from which to formulate least cost diets. Additionally in rising soybean meal markets, peas may provide a lower cost protein supplement option. Data from this project will also help commercial feed manufacturers, nutrition consultants, extension personnel and individual producers formulate swine and cattle diets using field peas/naked oats as a protein/energy sources. Increasing marketing options for field peas and naked oats is the principal goal of this group of investigations. Given the ability of field peas and naked oats to fit well into small grain rotations, they provide a potential niche in systems of food/feed production that are sustainable and environmentally friendly for North Dakota.

INTRODUCTION

Late last year (1994), the North Dakota Dry Pea and Lentil Growers Association (DPLA) requested North Dakota State University to consider a regional evaluation of dry field pea grain as a domestic feedstuff. After reviewing the available literature, scientists at the Dickinson Research and Extension Center outlined to the association's board of directors possible work that could be conducted at the station. Potential projects were designed to address the DPLA request for research, while contributing to the body of knowledge regarding the use of legume seeds as livestock feeds. In addition to this specific request for research, station and extension personnel have become acutely aware of a growing interest in southwestern North Dakota for more information regarding the production and use of hulless, or naked, oat grain. The interest regarding naked oat grain has not been confined strictly to grain growers. Diversified operators, as well as straight livestock producers, have demonstrated an interest in this type of grain for use as a livestock feed. The goal of field pea and naked oat producers is to increase the marketing options for their grain. Livestock producers, on the other hand, are interested in developing low cost alternatives to expensive energy and protein supplementation. In order for these grains to expand into the feeding sector, producers feel that localized research focusing on domestic feed usage is essential.

Alternative crops are playing a greater role in North Dakota field crop production. Legume crops, such as field peas, fit well into conventional crop rotations and compliment soil fertility. Soil fertility enhancement reduces the amount of commercial fertilizer needed to meet crop yield goals. Peas have been regarded highly for their nutrient quality in human and animal food since they were first cultivated. During the last decade in North Dakota, there has been a renewed interest in the use of field peas as a livestock feed.

Common oats is lower in energy and more bulky than other feed grains, since it threshes with the hull intact. Oat groats (dehulled oats) are comparable to corn in feeding value, while containing more lysine and nearly twice as much crude protein. However, mechanical dehulling is expensive. Naked oats, by comparison, have loosely attached fibrous coats that are easily rubbed off during threshing. The resulting grain has a higher nutritional quality and could be a cost effective feed ingredient. Paul oats, a newly released naked oat variety from NDSU, which producers are very interested in, will be used in the proposed set of experiments.

PROJECT BRIEFS

Cattle feeding studies will focus on the potential use of field peas and Paul oats as feedstuffs for weaned calves. Specific objectives include:

1. Determine the effect of including field pea or naked oat grain in backgrounding diets for weaned calves on animal performance and efficiency of feed utilization.

2. Establish relative net energy concentrations for test feeds.

Individual experiments will involve either early (5.5 months) or late (7 months) weaned calves backgrounded for approximately 90 days. The studies will evaluate the potential of substituting all or a portion of the barley and soybean meal in a control diet with the test feeds. In addition to documenting animal performance and feed efficiencies, treatments are designed to establish relative net energy values for the test feeds. This information is vital when formulating rations using field peas and naked oats.

Swine feeding studies are designed to evaluate peas and oats in weanling pig diets and peas and lysine levels in split-sex fed growing-finishing pigs. Specific objectives of these studies include:

Weanling pigs –

1. Determine whether conventional farm grain dryers, steam rolling equipment or portable extruders will sufficiently heat field pea grain, without damaging, to deactivate antinutritional proteases that interfere with normal digestion, and identify the most favorable and cost effective method.

2. Determine the extent at which field peas can replace (0, 25%, 50% or 100%) soybean meal with respect to weanling pig performance.

Weanling Pigs (Continued):

3. Determine the extent at which naked oats can replace (0, 25%, 50% or 100%) corn with respect to weanling pig performance.

4. Based on results of the first three objectives, determine growth performance of weanling pigs when field peas and naked oats are included in the diet.

Grower and finishing pigs –

1. Evaluate growth and carcass performance following field pea substitution for soybean meal in split-sex fed barley based growing-finishing diets supplemented with two levels of lysine.

2. Evaluate seasonal (winter vs summer) variation in nutrient intake and subsequent impact on growth and carcass response.

Antinutritional factors (trypsin and chymotrypsin inhibitors, lectins and tannins) in raw field peas may limit the quantity of peas that can be included in weanling pig diets. When compared to raw soybeans, spring seeded white-flowered field peas contain 5-20 times less protease (trypsin and chymotrypsin) inhibitor activity. White-flowered, smooth, spring seeded pea varieties grown in North Dakota contain relatively low amounts of lectins and tannins, and based on other research would not appear to be a problem to the weanling pig.

Heating is a proven method for destroying the protease inhibiting factors that can depress swine performance when present in sufficient quantities. Therefore, the first of four experiments in the series of studies with weanling pigs will be to evaluate field pea heat treatment methods (dry heat, steam heat, and heat of extrusion) on pig performance. The second objective, based on results addressing the first objective, will be to determine the level of treated peas (0, 25%, 50%, 100%) that can be used to replace soybean meal in a corn based diet. The third objective will be to determine the level of naked oats (0, 25%, 50%, 100%) that can replace corn. In the fourth objective, based on the results of the first three experiments, a corn/soybean meal control diet will be compared to three experimental diets containing either: 1) field peas, 2) naked oats, or 3) field peas and naked oats.

In a second series of experiments, using split-sex fed growing-finishing pigs and a three phase feeding regime, the efficacy of replacing soybean meal with field peas will be evaluated. Additionally, two levels of lysine supplementation will be tested in the three phase feeding regime (Grower - .85% vs 1.0%; Finisher I - .75% vs .9%; Finisher II - .7% vs .85%). Effects of protein supplement type, sex and lysine level on various carcass measurements (fat depth, loin depth, loin area, percent lean, carcass yield, net carcass value) will be assessed. Carcass measurements will be obtained at the John Morrell & Company Packing Plant in Sioux Falls, SD.

RESULTS

In the first cattle experiment, calves were weaned and placed into lots on September 26. Calves are currently being brought up on feed. The introduction of test grains into respective diets began on October 25 and levels increased until desired diets are achieved. This experiment should be completed by the end of the year. Calves in the second experiment will start on feed in mid- to late November. All data collection in the cattle studies should be completed by April, 1996.

Weanling pig experiments (4) will be conducted as pigs are group weaned in December, January, February and March. Growing/finishing studies will evaluate dietary effects in both winter and summer environments. The winter study will begin in early December and the summer study will begin in early June. Data collection will be completed by the end of September.

DISCUSSION

Typically, field peas and hulless varieties of oats are not fed to livestock in North Dakota. As the acreage for these crops expands, producers are looking for alternative markets for their grain. The nutritional data on these two types of grain suggests that both crops have the potential for use as a feed for livestock. If feed barley is valued at $1.75 per bushel and soybean oil meal at $195 per ton, the feed value of field pea and naked oat, on an equivalent crude protein basis, would be approximately $3.50 and $1.80 per bushel, respectively. The value of naked oat per pound, using this type of substitution, is about 117% of the price for barley. This is similar to the value of naked oat (119%) relative to barley reported by Doyle and Valentine (1988) for the United Kingdom. No such comparison for field pea has been published. Current prices of field pea and feed oat indicate that either of these feeds has a potential for economically replacing a portion of the barley and protein supplement, if production is not comprised disproportionately. Additionally, decreasing the level of barley fed to cattle could reduce the negative affects (e.g. bloat, acidosis) occasionally experienced with barley feeding. Of the research data available, little work has evaluated the feeding value of either field pea or naked oat in beef cattle diets. Establishing feeding values is essential if the grains are to be used in least cost ration formulations for beef cattle.

The entire project is scheduled to be completed by September 30, 1996, and a final report prepared by the middle of November. The project was cosponsored by the DPLA, ND Grain Growers Association and several western ND grain and livestock producers. Grant funding in support of this project has been provided by the DPLA and the ND Agricultural Products Utilization Commission.

PIC Hogs: A Brief Summary

D.G. Landblom
Dickinson Research Extension Center

Less than two years ago, the Research Center repopulated its swine herd with Pig Improvement Company (PIC) Camborough-15 (C-15) females and Line 326 boars.

So far, the C-15 female has proven to be a prolific, heavy milking, durable pig that is easy to manage in semi-confinement. Since the Center's facilities are semi-confinement, and situated in an environment characterized as having cold winters and hot summers, a durable pig was essential. Many of the original sows are now in their fouth parity, and have demonstrated environmental durability and a solid ability to farrow and wean acceptably large litters. Post farrowing cyclicity and pregnancy have been encouraging. At this writing, the herd farrowing rate stands at 87%. Other sow performance parameters have been summarized in Table 1, of a separate report titled, "Effect of Winter Gestation Energy Level on Sow Productivity", found elsewhere in the Swine Section of this livestock report.

Feeder pigs produced in the All In/All Out group management system, are, for the most part, sold as feeder pigs. Those retained are utilized in growing/finishing studies. A sample of the C-15 x 326 matings were grown out and finished last winter to evaluate performance, especially, cold weather performance. One Hundred-fifteen barrows and gilts were fed and marketed through the John Morrell & Co., packing plant in Sioux Falls, SD. Feed consumption, growth performance, and return/pig have been summarized in Table 1, and a summary of slaughter data is shown in Table 2.

The data presented here characterizes the C-15 x 326 cross as a functional, meat pig with lean qualities, yet possess enough fat cover, for insulation, to perform well outdoors in North Dakota.

Table 1. PIC slaughter hog close out: Ingredients fed, growth performance, costs and returns.

FEED CONSUMPTION				
INGREDIENT	**%**	**LBS./PIG**	**COST/LB.**	**TOTAL**
Wheat	6.17	43.5	.0633	2.75
Barley	78.4	552.2	.035	19.33
SBOM	12.4	87.2	.099	8.63
Dical Phos.	1.02	7.2	.299	1.65
Calcium Carbonate	.85	6.0	.0692	.42
Trace Mineral Salt	.41	2.9	.0742	.22
Vitamin A, D & E	.05	.34	.6717	.23
Vitamin B Complex	.17	1.23	.40	.49
Zinc Sulfate	.01	.089	.22	.02
Lysine	.21	1.49	1.70	2.53
Sunflower Oil	.37	2.6	.27	.70
	100.00	704.75		$36.97

GROWTH PERFORMANCE			**COSTS AND RETURNS**	
Market Weight	245.0		Feed Cost/Head	$36.97
Feeder Pig Weight	42.0		Feeder Pig Cost	$32.90
Gain	203.0		**TOT. PRODUCTION COST**	**$69.87**
Days Fed	127.0			
ADG	1.60		Gross Slaughter Return	$84.40
Feed/Head/Day	5.55		Less Production Cost	$69.87
Feed/Pound of Gain	3.47		**RETURN/PIG**	**$14.53**

Table 2. PIC Slaughter Hog Summary. Winter 1995

NO	FAT*	LOIN*	LEAN %	HOT CARC %	YIELD	Y-PREM,$	LEAN PREM,$	SORT,$	GROSS	CK-OFF,	$INS,	$ FRT.,	$NET RETURN
14	.77	1.81	51	162	73.00	5.55	40.00	-32.00	1,191.55	4.17	2.62	58.90	1,125.86
20	.71	1.90	53	170	73.04	16.80	76.48	-11.91	1,739.17	6.09	3.83	87.50	1,641.75
30	.83	1.68	51	177	73.07	17.75	86.17	-.19	2,666.83	9.33	5.87	137.18	2,514.45
22	.67	1.98	55	179	73.10	64.78	108.05	-.58	2,049.65	7.17	4.51	99.09	1,938.88
21	.76	1.82	52	179	73.12	3.82	70.19	-13.86	1,857.40	6.50	4.09	97.57	1,749.24
8	.85	2.06	51	186	73.27	5.07	29.27	-5.40	819.82	2.87	1.80	38.29	776.86
115	**.77**	**1.88**	**52.2**	**176**	**73.10**	**18.96**	**68.36**	**-10.66**	**10,324.42**	**36.13**	**22.72**	**518.53**	**9,747.04**

*Fat-O-Meter Measurements