First Year Results - BEEF PRODUCTION ON IRRIGATED PASTURE IN NORTH DAKOTA

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Private irrigation development and construction of the Garrison Diversion Conservancy District irrigation project has created an interest in the potential of various irrigated forage crops in North Dakota. Irrigated pasture has received only limited study, primarily on irrigation development farms throughout the state (3, 9). Beef gains of 447 pounds per acre were reported at the Mandan irrigation development farm in 1950. The irrigated pasture had a carrying capacity rating of 6.2 animal unit months (AUM's) as compared to a rating of 9.8 AUM's in 1952 (4) when dairy cows were grazed.

The present study was designed to determine the beef production potential of yearling steers grazing an intensively managed irrigated grass-alfalfa pasture. The study was conducted in cooperation with the Standing Rock Sioux Tribe, Fort Yates, North Dakota; Bureau of Indian Affairs; and the Departments of Agronomy and Soils, North Dakota State University. The major contributions including land, irrigation equipment, power, fencing materials, grass seed, fertilizer, equipment repairs, labor assistance and steers for the grazing study were provided by the Standing Rock Sioux Tribe. Management of the grazing study and records were maintained by the NDSU Extension Irrigation Task Force and the Sioux County Extension Agent.

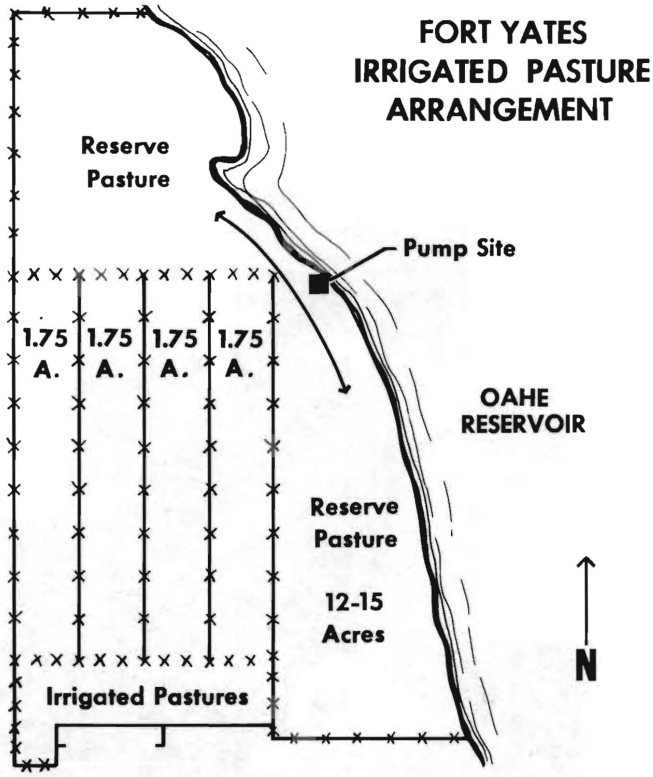

Fig. 1. Schematic drawing of irrigated rotation pastures, Ft. Yates, N. D.

PASTURE ESTABLISHMENT AND MANAGEMENT

The pastures were established during the spring of 1971. A grass and legume mixture consisting of Lincoln bromegrass, eight pounds; Sterling orchardgrass, six pounds; Garrison creeping foxtail, two pounds; and Vernal alfalfa, one pound, was planted. The mixture was double-seeded. Oats was seeded as a nurse crop at about 20 pounds per acre prior to seeding the grass-legume mixture. The plan was to irrigate the new seeding several times. However, only about one inch of water was applied due to equipment difficulties. The seeded oats and weed growth became very heavy by early July.

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We acknowledge the advice and counsel provided by members of the Extension Service Irrigation Task Force; Dr. Dwain Meyer, Department of Agronomy, for drying and weighing forage samples; Mike Sweeney, Department of Soils, for conducting a preliminary soil survey of the pasture area; assistance in setting up the pasture trial by staff members of the Standing Rock Sioux Tribe and Bureau of Indian Affairs, Fort Yates, North Dakota, and to Peter W. Breuer, Extension Irrigation Engineer (deceased), for work in organizing and establishing the grazing study.

Rotation pastures were clipped before and after grazing in each grazing cycle to obtain forage production and per cent of forage grazed.

Therefore, the growth was removed as hay. The established grass-legume stand based on observations made during the spring of 1972 was composed of approximately 80 per cent orchardgrass, 20 per cent alfalfa and a trace of bromegrass and Garrison creeping foxtail. The stand of forage was rated as only average for an irrigated pasture.

The irrigated pasture (Fig. 1) was fenced during early spring of 1972 into four equal-size rotation pastures (5, 15), each 1.75 acres, for a total of seven acres. Approximately 15 acres of dryland pasture surrounded the irrigated pasture which was used as a reserve pasture. The four-pasture rotation was established to allow seven days of grazing and 21 days of rest or regrowth for each pasture during the 28-day grazing cycle (17).

Fertilizer was applied on May 4, 1972 at rates of 75 pounds of nitrogen and 50 pounds of P_2O_5 per acre. Fertilizer should be applied in the fall or very early spring to obtain maximum benefit for early season growth. Approximately 95 pounds of additional nitrogen were applied on June 17, 1972 to provide enough nitrogen for forage growth during the remainder of the growing season (10). A soil test prior to fertilization in the spring indicated a very low phosphorus and a very high potassium level in the soil.

Forage production and utilization of irrigated pastures by yearling steers were determined by surface clipping seven one-square-yard samples per pasture at the beginning and end of each grazing period in each grazing cycle. Forage production during the grazing period on each rotation pasture was not measured using this clipping procedure. Therefore, each rotation pasture had 30 to 35 days of growth while being grazed not accounted for in the total production on each pasture. The samples were individually bagged, dried and weighed to obtain pounds of dry matter per acre.

SOIL AND IRRIGATION

The irrigated pasture site was soil surveyed to determine the types of soils and their ability to hold irrigation water. The soil is a loam texture and has the ability to hold an estimated five to seven inches of available water (16).

Sioux County Extension Agent Charles Soiseth moves tow-line irrigation system. In addition, Soiseth rotated steers and looked after other management details during the study.

The pastures were irrigated using a tow-line system. Water was pumped with a tractor PTO-driven centrifugal pump from the Oahe Reservoir which is immediately adjacent to the grazing trial. Water was applied following grazing of each pasture in each grazing cycle, and during part of the grazing season an additional water application was made two to three days immediately prior to grazing. The additional water was applied to maintain the soil water supply above 40 per cent of the available field capacity (10).

Based on an estimated available water-holding capacity of five to seven inches and an estimated forage water use of one-fourth inch per day, the pastures would require about 3.0 to 4.25 inches of water every 12 to 15 days to promote rapid regrowth and high forage yield. Based on these estimates, one irrigation during each 28-day grazing cycle allowed too long a time between irrigations to maintain soil water above 40 per cent of field capacity. Delays in water application during two grazing cycles, two and four, slowed grass growth and consequently reduced pasture carrying capacity during the following grazing cycle. Approximate irrigation water applied and April through September rainfall is shown in Table 1.

Table 1. Approximate inches of irrigation water applied by grazing cycles on each pasture and growing season rainfall.

	Inches of water applied/pasture				
Grazing cycle	1	2	3	4	Ave.
1	.90				.23
2	3.00	3.75	9.50	9.15	6.35
3	8.50	5.25	9.25	6.50	7.38
4	5.00	4.00	4.25	7.75	5.25
5	6.00	4.50	6.25	4.00	5.19
Water applied	23.40	17.50	29.25	27.40	24.38
Rainfall*					8.98
Total irrigation water plus rainfall					33.36

Fort Yates, North Dakota 1972.
*U.S. Weather Bureau records.

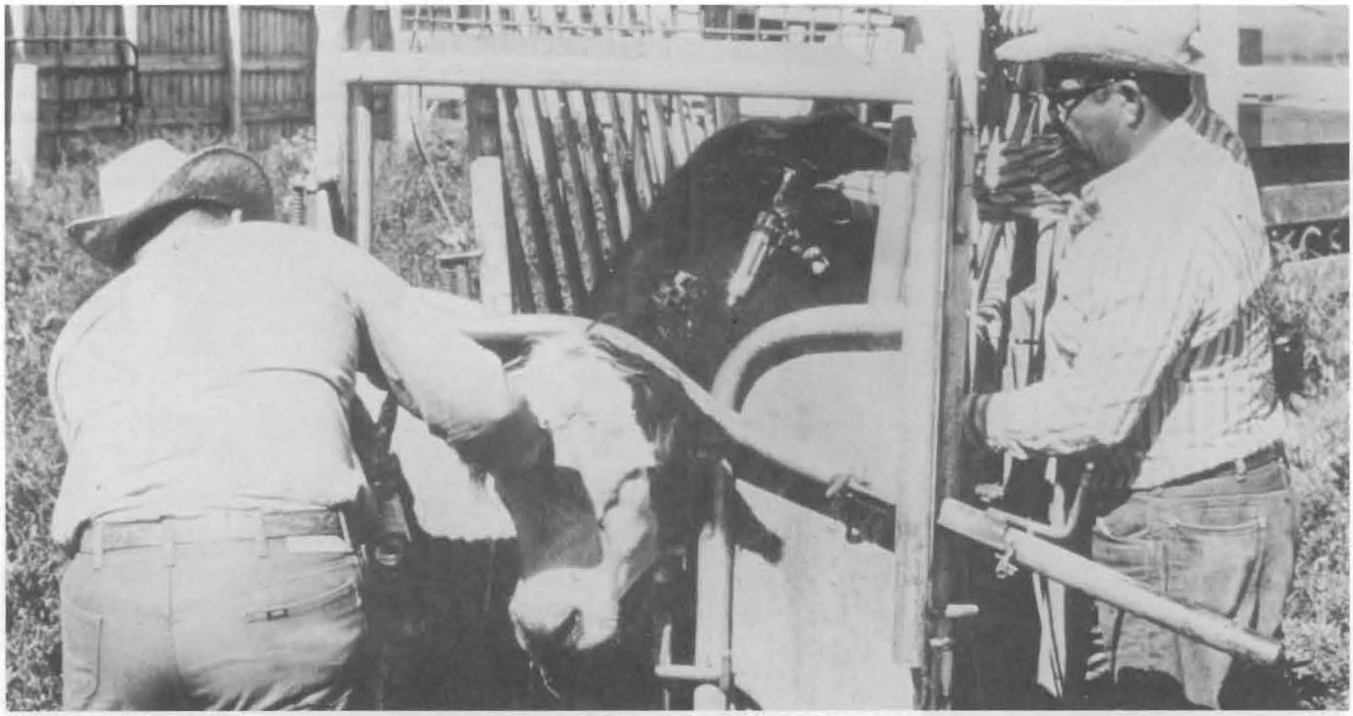
ANIMAL MANAGEMENT

Thirty head of mostly crossbred yearling steers were selected to represent a typical cross-section from a herd of about 400 head being wintered at the Standing Rock Tribal feedlot at Fort Yates, North Dakota. A breakdown of the kind of cattle used in the grazing study included 14 Hereford x Angus cross, two Hereford x Holstein cross, two Hereford (redneck), three Angus, two Angus x Holstein cross, four Charolais x Angus cross, two Charolais x Hereford cross and one Charolois x Hereford x Angus cross.

All cattle were grazed on the reserve tame grass pasture about one week prior to weighing and the start of the grazing trial. The cattle were taken off water each evening and weighed the following morning for three successive days at the start of the grazing study. The average initial weight of the 30 head was 626 pounds, based on the average of three weighings.

Twenty-one head of steers representing a cross-section of the 30 head weighing an average of 615 pounds were selected and designated as the primary irrigated pasture grazing steers. Thirteen animals from this group which grazed throughout the grazing season were designated as the tester animals. Average initial weight of the 13 tester animals was 621 pounds. All other steers were placed on the reserve pasture and placed on the irrigated pasture under a "put and take" system as needed to obtain proper utilization of the forage. Under the "put and take" system of grazing management cattle are added or removed from the pasture based on supply of available forage during the growing season.

The tester animals were weighed once at the close of each grazing cycle following an overnight shrink. All grazing data for the study were calcu-



Soiseth and William Sherwood, manager of the Standing Rock Sioux Tribe Irrigation Farm, weigh and treat steers for pinkeye, using a portable scale and headgate combination. Steers were weighed before and after each grazing cycle.

lated using the average of the 13 tester steers. Final steer weights at the close of the grazing season were determined by averaging three weighings on separate days, the same procedure as used to obtain the average initial weight.

The steers were all implanted with 24 mg. of stilbestrol during the initial weighing. Growth stimulants have increased daily gains 20 to 25 per cent in other grazing trials. (6, 8, 14).

Salt and minerals were fed free-choice throughout the grazing season. Poloxalene blocks (1, 2) were fed to the steers as a precautionary measure against bloat through the month of July. Bloat was not observed at any time during the grazing season.

Fly control was practiced using an automatic portable backrubber containing Korlan 24 per cent emulsifiable concentrate mixed with fuel oil.

Pinkeye was a problem during the first half of the grazing season. Animals were treated on June 30 with an injection of 10 c.c. of Carnation milk and a special aerosol preparation was applied to the eyes of infected animals as needed during each weighing.

Results and Discussion

The study was initiated on May 13 and ended on September 21, 1972 for a total of 132 days of grazing. The average initial weight of the 13 tester steers was 621 pounds and the average ending weight was 881 pounds (Table 2).

Table 2. Average beginning and ending weights of yearling steers grazing irrigated rotation pasture by grazing cycle.

Grazing cycle	Average yearling steer weight	
	Initial	Ending
	— Pounds —	
1	621	708
2	708	753
3	753	810
4	810	828
5	828	881

The steers grazed the four-pasture rotation through five grazing cycles. Each grazing cycle (Table 3) was 28 days in length with the exception of cycle one which was 20 days long. The shorter grazing cycle was due to starting grazing early with fewer steers per acre. Grass growth was five to six inches tall when steers were turned onto pasture. Growth was very rapid by the end of the first grazing cycle and the pastures were being grazed

Table 3. Days of grazing on irrigated rotation pasture by grazing cycles.

Grazing cycle	date on	date off	days grazed
1	5/13	6/2	20
2	6/2	6/30	28
3	6/30	7/28	28
4	7/28	8/25	28
5	8/25	9/21	28[1]
Total days grazed			132

[1]Steers grazed regrowth on pastures 1 and 2 one day each on September 20 and 21.

Table 4. Average number of steers, animal units, acres per steer and steerdays grazing per acre by rotation grazing cycles.

Item	1	2	3	4	5	Summary
Steers/acre	3.2	3.1	2.4	3.0	1.9	2.7
Animal units/A.	2.1	2.3	1.9	2.4	1.6	2.1
Acres/steer	.31	.32	.42	.33	.53	.37
Steerdays/acre	65	86	68	84	52	355

at a stocking rate of over three yearling steers per acre (Table 4) as compared to an initial stocking rate of two steers per acre. The pasture carrying capacity fluctuated during the grazing season. The highest carrying capacity in terms of number of steers and animal units per acre occurred in grazing cycles one, two and four. The lower carrying capacity during grazing cycles three and five is attributed to untimely irrigation water application following grazing of each pasture. Delays of 5 to 10 days occurred due to equipment problems and a fluctuating reservoir water level. The lower forage production following delays in water application increased the acreage required per steer from about 0.3 acres to 0.4 acres in cycle three and 0.5 acres during cycle five. As a result, the steerdays grazing per acre were reduced from a high of over 80 to 68 and 52 steerdays in cycles three and five, respectively.

During the grazing season, the number of steers grazed per acre should naturally decrease due to increase in body weight and the consequent higher animal forage requirement. If the growth of grasses and legumes could be maintained at early season levels, the animal units grazed per acre should remain nearly constant if proper stocking is achieved. However, growth of forages generally decreases as the season progresses resulting in reduced carrying capacity during late summer. The pasture system had an average carrying capacity of 2.1 animal units per acre per month or a potential of about 9.0 animal unit months of grazing per acre based on stocking rates in this study.

Weight gains by yearling steers are summarized in Table 5. The average daily gain of the 13 tester steers was 1.97 pounds per day. Daily gain was highly variable during the five rotation grazing cycles. The high daily gain of 4.4 pounds during the first 20 days of the study may be in part due to compensatory gain or gain in weight due to additional fill on lush pasture as compared to the dry feed period and the grazing of relatively short dryland pasture prior to the start of the irrigation grazing study.

Table 5. Average daily gain, gain per head and gain per acre of yearling steers grazing irrigated pasture.

Grazing cycle	Average daily gain	Average gain/head	Gain per acre
1	4.4	87	279
2	1.6	45	140
3	2.1	58	139
4	.6	17	51
5	1.9	53	101
Summary	1.97	260	710

Also, during the first weigh period the animals were taken off water early in the morning as compared to about 9:00 p.m. the evening prior to weighing during all other grazing cycles. The apparent lower gain of 1.6 pounds per day during the second grazing cycle is a reflection of an inadequate overnight shrink for the weighing following the first grazing cycle. Average daily gain for the first two grazing cycles was 2.75 pounds per day. Dryland grazing studies in North Dakota show May and June steer gains to be higher than those obtained later in the season, with a pattern of steadily declining gains as the season progresses.

Yearling steer gains based on a 24-year average at the Northern Great Plains Field Station, Mandan, North Dakota, show daily gains of 2.94 pounds per head during the month of May and 2.41 pounds daily in June (13). The lowest daily gain, 0.6 pounds daily, was obtained in grazing cycle four during the month of August. This may be due to high temperatures, averaging slightly over 84°F during August with temperatures being over 90°F during eight days of the 28-day grazing cycle. The average high daily temperature during July was about 79°F and animal gains were slightly over two pounds per day. In addition, fly control may have been inadequate during late summer.

The average seasonal gain per head was 260 pounds or 1.97 pounds per day for 132 days. This is similar to that obtained with yearling steers grazing dryland pastures (11, 12). Prior to the grazing study it was anticipated that gains per head would be lower on irrigated pasture due to the lower forage dry matter content as compared to dryland pasture. However, steers grazing the irrigated pasture did not appear as thrifty or carry the bloom throughout the study as compared to those grazing the dryland reserve pasture.

Total beef gain per acre in this study was 710 pounds. A high proportion of this gain was obtained during the first 48 days of the grazing period. The 419 pounds of gain per acre during grazing cycles one and two compares favorably with early season yearling steer gains on orchardgrass-alfalfa pasture in the state of Washington (7, 18).

Clipping data shows that the four irrigated pastures had an estimated average dry matter production of about 6,741 pounds or 3.4 tons per acre (Table 6). The difference between amount of forage present immediately prior to grazing and forage not consumed following the grazing was considered to represent forage consumed by the steers.

Table 6. Dry matter production and utilization percentage of irrigated rotation pasture.

Pasture no.	Lbs. dry matter/acre produced	Lbs. dry matter/acre consumed	Per cent Utilization
1	8379	7253	86.6
2	6034	5096	84.5
3	6558	6140	93.6
4	5992	4092	68.3
Average	6741	5645	83.7

A total of 5,645 pounds of dry matter was consumed for an average forage utilization of about 84 per cent. The per cent utilization may appear to be high. However, the method used to determine total forage production did not measure grass growth during the time the animals were grazing the rotation pastures. Therefore, 30 to 35 days of growth while cattle were grazing each pasture is not accounted for in the estimates of total forage production. This production, if known, would reduce the per cent utilization by several percentage points.

The pasture season was terminated on September 21, 1972 to permit the grass to regrow and build-up food reserves in roots and crowns prior to the first killing frost. Excessive forage utilization accompanied by limited fall regrowth can deplete stored food reserves causing a thinning of the grass stand and/or possible stand loss through winter injury. Orchardgrass is not completely winter hardy and should be in a healthy, vigorous growing condition going into the winter. This grass, although not winter hardy, has a better potential for regrowth during late summer than smooth bromegrass; therefore, it is desirable in irrigated pasture seed mixtures. It should not be seeded as the only grass for irrigated forage or pasture because of the possibility of complete stand loss due to winterkill.

Following the close of the irrigated pasture grazing season all steers were grazed for three days on very short dryland pasture and surrounding stubble fields. In addition, the steers had a one- to two-day stand at the auction market, after which the final average scale weight for the 30 head of steers was 864.5 pounds or approximately a two per cent shrink based on the 881 pound average grazing trial ending weight.

Analysis of the results of this study is based on estimated costs of operating a 138-acre center pivot irrigation system, cost of maintaining 2.7 yearling steers per acre on irrigated pasture and on the average selling price of steers sold by the Standing Rock Sioux Tribe. The estimated returns per acre and per head based on the results of this study are shown in the following budget.

ESTIMATED IRRIGATED PASTURE COSTS & RETURNS
(Center Pivot System)

I.	**Fixed investment cost**		
	Irrigation system:		
	Pivot System 1,285'	$19,000.00	
	Well 120' @ $25	3,000.00	
	Pump, Motor 1,200 gpm	4,500.00	
	Mainline to pivot	2,500.00	
		$29,000.00	$29,000.00
	Land 140 acres @ $100	14,000.00	14,000.00
	Fencing	1,500.00	1,500.00
	Field waterers, etc.	400.00	400.00
	Total fixed investment		$44,900.00
II.	**Fixed cost/acre**		
	Irrigation system:		
	Interest (average annual @ 8%	$8.29	
	Depreciation - 15 years	13.80	
	Insurance	.65	
	Return to land ($100 x 8%)	8.00	
	Fence and equip. interest and dep.	1.44	
	Land taxes	1.25	
	Total fixed cost/acre	$33.43	
III.	**Variable costs (2.7 steers/acre)**	**Per acre**	**Per head**
	1. Cost of steers 621 lbs. @ $41.40	$694.15	$257.09
	2. Interest on steers 8%, 5 months	23.20	8.59
	3. Vet and medicine $1.00/hd.	2.70	1.00
	4. Marketing costs	35.10	13.00
	5. Hired labor	3.00	1.11
	6. Pasture establishment	1.80	.67
	7. Clipping and mowing	1.50	.56
	8. Stilbestrol implants	.80	.30
	9. Irrigation costs (Rep., Power, etc.)	12.00	4.44
	10. Fertilizer cost (170 lbs. N, 50 lb. P_2O_5)	18.70	6.93
	11. Fence repair	.50	.19
	12. Interest on operating capital (8%, 3 months)	.80	.30
	Total variable costs	$794.25	$294.18
IV.	Income		
	Gross sales 2.7 steers/ac. x 864.5 lbs. final scale wt. x $37.91)	$884.88	$327.73
	Fixed plus variable costs	827.68	306.55
	Return to operator labor and management	$ 57.20	$ 21.18

Profitability of an irrigated pasture depends upon many factors, including the level of animal

Table 7. Irrigated rotation pasture grazing summary - one year results.

Item	season summary
Days grazed	132
Ave. no. steers/acre	2.69
Acres/steer	.37
Animal unit months/acre (AUM's)	9.0
Steerdays grazing/acre	355
Ave. daily gain lb.	1.97
Gain/head lb.	260
Gain/acre lb.	710

product, meat or milk, produced per acre. The pounds of yearling beef produced per acre, production costs and cattle prices will determine the position of irrigated pasture in relation to other potentially irrigable crops.

The purchase price of steers used in this study, based on the average selling price of 291 steers sold by the Standing Rock Sioux Tribe on April 27, 1972, was $41.40 per hundredweight. The average selling price of the 30 head of steers in the grazing study was $37.91 per hundredweight, based on sales receipts on September 26, 1972.

Based on the results obtained in this study, estimated costs of owning and operating a 138-acre center pivot irrigation system and costs of maintaining 2.7 yearling steers per acre, the irrigated pasture returned $57.20 to operator labor and management per acre, or about $21.00 per head grazed. Since the costs used in this analysis of the beef gains per acre may not be representative of any one farm, individual irrigators are encouraged to analyze their own irrigated pasture enterprise based on the budget approach used above.

The potential of irrigated pasture will depend largely upon the level of operator management. This study has shown that a four-pasture rotation can be managed to maintain a good growth of forage for grazing livestock provided water application is timely and based on the needs of the crop. Observations indicate that high soil fertility in addition to adequate and timely water application must be maintained to obtain highest forage production during each grazing cycle.

To obtain maximum use of irrigated pasture, the stocking rate must be at a level to utilize forage produced during the peak production period, which is usually during May, June and early July. Under this system, additional dryland pasture will be required to compensate for lower forage production in late season, and/or for increased forage requirements of yearling steers or calves as the season advances. Another management system which appears feasible is to use five equal-size rotation pastures. Stock the pastures based on the acreage in four pastures, graze only four pastures during the first two or three grazing cycles and harvest hay in the late boot or very early heading stage of growth on the fifth pasture. The pasture harvested early for hay can be grazed during mid-season in a five-pasture rotation when normal growth of forage is usually reduced and/or to compensate for increased forage requirements of the grazing animals.

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