Early Range Readiness with Nitrogen Fertilizer: An Economic Analysis

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Highlight: *Application of ammonium nitrate stimulated early spring growth initiation of Utah crested wheatgrass pastures. Application rates of 25 to 30 lb N per acre hastened spring range readiness by 11 to 13 days. During 1973, the initial year studied, ranchers could have profitably substituted crested wheatgrass fertilization for purchased hay.*

Crested wheatgrass (*Agropyron cristatum*) has long been considered the premier of early season grazing in the Intermountain area. Due to the shortness of the first two plant stem internodes, early abundant leafiness is produced. This early production of photosynthetic tissue allows restoration of carbohydrate reserves following the development of the third leaf stage (Trlica and Cook, 1972). The rapid accumulation of carbohydrate reserves following this morphological development provides the opportunity for early grazing with little damage to plant vigor.

At current forage and nitrogen prices, fertilization of crested wheatgrass solely for the purpose of increasing total forage production is not economically feasible (Workman and Quigley, 1974). However, fertilization of crested wheatgrass has also been found to stimulate early growth initiation, resulting in a greater amount of forage early in the growing season. Oregon research by Sneva (1973) has shown spring increases of up to 16 pounds of herbage per pound of nitrogen on new crested wheatgrass seedings and 8 pounds of herbage per pound of nitrogen on old stands.

In 1972, research was initiated in Utah to determine the magnitude and economic value of early range readiness of crested wheatgrass pastures fertilized with ammonium nitrate.

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Methods

Two western Utah crested wheatgrass pastures were selected to evaluate early growth responses of crested wheatgrass to nitrogen application. The Curlew plot is located at an elevation of 4,000 ft (1464 m) in the Curlew National Grassland 8 miles north of Snowville, Utah. The site receives an average of 11 inches (28 cm) of precipitation annually, occurring primarily as snow during the winter and as rain prior to the growing season.

The Benmore site is located at an elevation of 5,700 ft (1739 m) at the Benmore Experimental Range 4 miles south of Vernon, Utah. The site receives approximately 13 inches (33 cm) of precipitation annually, the bulk of which occurs as winter snow or as rain prior to the growing season. Two plots were established at the Benmore seeding. Both the North and South Benmore plots had been heavily invaded by sagebrush (*Artemisia tridentata*) and the North plot also contains a large percentage of bulbous bluegrass (*Poa bulbosa*), which blooms early but quickly shrivels.

Three replications of five or six levels of ammonium nitrate (34% nitrogen) were applied on each site during the fall, 1972, and spring, 1973. At Curlew 0, 12.5, 25, 50, 100, 200 pounds N per acre were applied and at Benmore the rates were 0, 15, 30, 90, 120 pounds N per acre.

To evaluate early growth response of crested wheatgrass to nitrogen application, weekly recordings of plant height were taken during the spring of 1973. Recordings began at growth initiation and range readiness was considered to have occurred when plants reached an average height of 6 inches (15.24 cm) (Sharp, 1970; Quigley, 1972; and Hyder and Sneva, 1961). Inverse prediction analysis of simple linear regression was then used to establish confidence intervals for early growth response (Ostle, 1966).

Results and Discussion

Early growth response of crested wheatgrass to nitrogen application appears graphically in Figures 1 to 4 inclusive.

Earlier spring growth and earlier range readiness (defined as an average plant height of 6 inches) resulted from each rate of nitrogen application tested on these four plots. For example, unfertilized plants on the Benmore South (spring) plot reached a height of 6 inches on May 17 while plants fertilized with 15 lb N per acre achieved a height of 6 inches 8 days earlier, on May 9.

The data in Figures 1 to 4 were subjected to regression analysis and the resulting linear regression equations and confidence intervals for the length of time required to achieve range readiness are shown in Table 1. The means of the confidence interval data were used to calculate the number of additional days of advanced range readiness gained through nitrogen fertilization (Table 2). On the Benmore South fall application, for example, the unfertilized plot reached range readiness 40 days after the initial measurement date while the plot receiving 15 lb N/acre achieved range readiness in 36 days, a gain of 4 days of advanced range readiness. The greatest response per pound of N applied occurred at 25 to 30 lb N/acre where 11 to 13 days of earlier grazing were achieved.

Early growth response of fertilized crested wheatgrass offers ranchers the opportunity to reduce feeding costs during the late spring by substituting early spring forage for hay. To evaluate this opportunity, hay costs must be compared to those of fertilization. All fertilization costs will be attributed to the advancement of early growth even though increased forage production resulting after range readiness is achieved also represents a significant grazing benefit.

The cost of fertilized forage per additional animal unit day (AUD) of early grazing was calculated as follows:

$$\text{Cost per AUD} = \frac{a + bN}{d}$$

where **a** is the cost per acre of fertilizer application, **b** is the price per pound of nitrogen, **N** is the number of pounds of nitrogen applied per acre, and **d** is the number of additional AUDs of early grazing produced per acre. Early spring forage in AUDs was calculated from the number of additional days of range readiness in Table 2. According to Hyder and Sneva (1961), crested wheatgrass in Oregon produced about 500 lb of air dry forage per acre during the initial 10 to 14 days of spring growth or 36 to 50 lb per acre per day. A 1000 pound cow, nursing a calf, has a nutrient requirement of 23.1 pounds (10.49 kg) of air dry forage per day (National Research Council, 1970). Due to sustained yield considerations, crested wheatgrass forage can be grazed at a utilization rate of only 70%. Thus $\frac{23.1}{.70}$ = 33 lb of air dry forage are required per AUD or slightly less than the daily per acre air dry forage production reported by Hyder and Sneva (1961). From this relationship the early spring carrying capacity of crested wheatgrass was conservatively set at one animal unit per acre per day or 14 AUDs per acre during the initial 2 weeks of spring growth. Costs per AUD of fertilized spring forage calculated by this method appear in Table 3. For example, 15 lb of N was applied to the Benmore South (fall) plot at a cost of \$.12/lb plus \$1.50/acre in application costs, producing 4 AUDs of additional spring grazing per acre. Cost per AUD equals

$$\frac{\$1.50 + \$.12(15)}{4} = \$.83.$$

In general, application rates of 25 to 30 lb N/acre yielded the most economical spring grazing increases.

Dividing the cost of fertilized forage per AUD by the amount of hay required per AUD (23.1 lb air dry forage ÷ 2000 lb = .0116 tons/AUD) yields a "break-even" hay price per ton. If the market price of hay exceeds this calculated

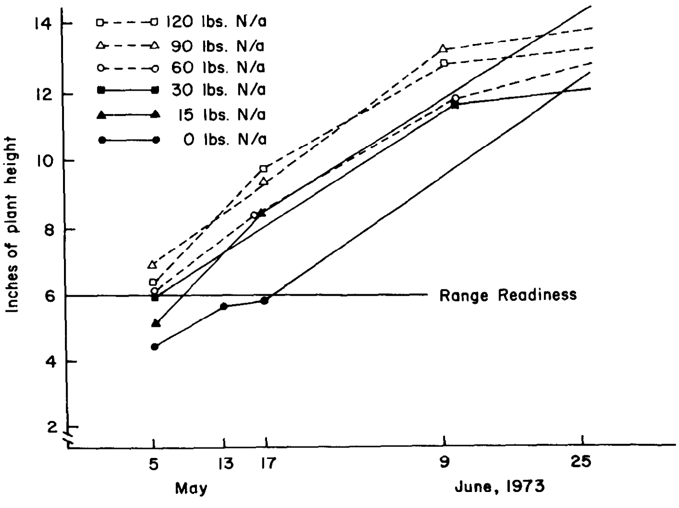

Fig. 1. *Early growth response, Benmore South, spring application.*

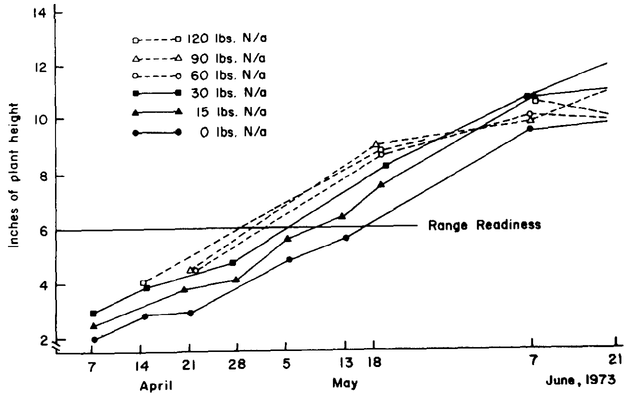

Fig. 2. *Early growth response, Benmore South, fall application.*

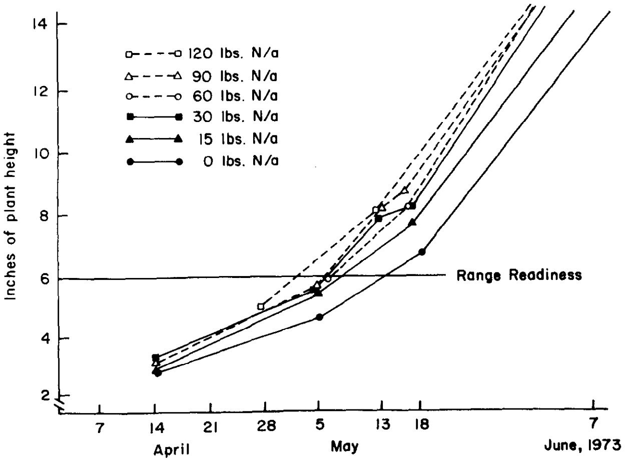

Fig. 3. *Early growth response, Benmore North, fall application.*

Table 1. Linear regression equations and 100% confidence limits for early growth response of crested wheatgrass to nitrogen fertilization. Tota plant height (Y) is set at 6 inches at range readiness; X = number of days from date of initial height measurement.

Plot	Initial date of measurement	N per acre (lb)	R^2	Regression equation	Confidence interval
Benmore South (fall)	April 7, 1973	0	.88	Y=1.78+.10X	40±10
		15	.83	2.16+.12X	36±13
		30	.88	2.50+.13X	27±10
		60	.85	2.40+.15X	24±12
		90	.93	2.64+.15X	23±8
		120	.87	2.25+.16X	24±11
Benmore South (spring)	May 5, 1973	0	.92	4.03+.17X	11±11
		15	.86	5.60+.18X	2±15
		30	.81	6.01+.15X	−1±17
		60	.82	6.13+.15X	−1±17
		90	.84	7.14+.15X	−8±16
		120	.68	6.89+.15X	−7±26
Benmore North (fall)	April 14, 1973	0	.81	2.42+.12X	29±12
		15	.86	2.50+.15X	23±10
		30	.87	2.80+.18X	18±9
		60	.86	2.60+.17X	20±10
		90	.83	2.60+.18X	18±11
		120	.85	2.60+.19X	18±10
Curlew (fall)	April 12, 1973	0	.68	3.30+.10X	27±13
		12.5	.65	3.50+.12X	20±14
		25	.76	3.50+.16X	16±11
		50	.80	3.30+.14X	19±10
		100	.75	3.70+.15X	15±12
		200	.84	3.60+.18X	11±9

break-even price, fertilized spring forage can be economically substituted for purchased hay (or for hay produced on the ranch which could be sold to another rancher). Again using the Benmore South (fall) plot, the break-even hay price for comparison with an application rate of 15 lb of N/acre is calculated as follows:

$$\frac{\$.83/\text{AUD}}{.0116\ \text{tons/AUD}} = \$71.55/\text{ton}.$$

Break-even hay prices for each application rate and each plot are shown in Table 4.

Spring fertilizer application on the Benmore South plot took place in early April as soon as snow and soil conditions permitted. By this time of year, most Intermountain ranchers can accurately predict whether or not they will find it necessary to purchase additional hay for spring feeding.

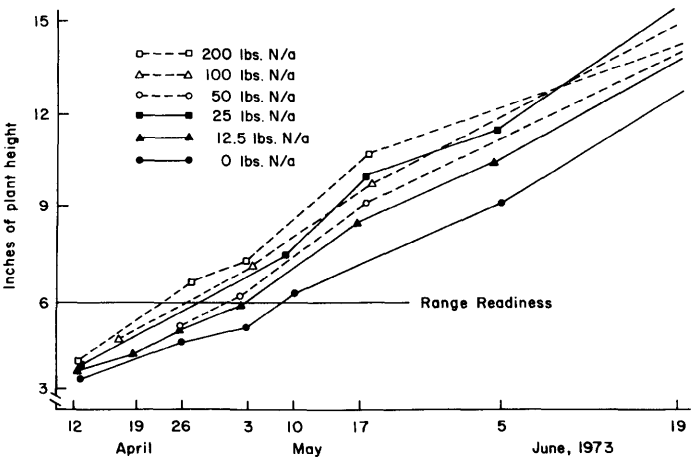

Fig. 4. *Early growth response, Curlew, fall application.*

Table 2. Number of days of advanced range readiness gained fron several rates (lb/acre) of nitrogen application on four crested wheat grass plots in Utah.

	N per acre applied									
Plot	12.5	15	25	30	50	60	90	100	120	20
Benmore South (fall)		4		13		16	17		16	
Benmore South (spring)		9		12		12	19		18	
Benmore North (fall)		6		11		9	11		11	
Curlew (fall)	7		11		8			12		1

Table 3. Cost of fertilized spring forage per additional AUD (dollars).

	N per acre applied (lb)									
Plot	12.5	15	25	30	50	60	90	100	120	20
Benmore South (fall)		.83		.39		.54	.72		.99	
Benmore South (spring)		.37		.43		.73	.65		.88	
Benmore North (fall)		.55		.46		.97	1.12		1.45	
Curlew (fall)	.43		.40		.93			1.00		1.5

[1] AUD = Animal Unit Day.

Table 4. Break-even hay prices per ton for several rates of nitrogen application on four crested wheatgrass plots in Utah (dollars).

	N per acre applied (lb)									
Plot	12.5	15	25	30	50	60	90	100	120	200
Benmore South (fall)		71.55		33.62		46.55	62.07		85.34	
Benmore South (spring)		31.90		37.07		62.93	56.03		75.86	
Benmore North (fall		47.41		39.66		83.62	96.55		125.00	
Curlew (fall)	37.07		34.48		80.17			86.21		129.31

Comparison of the average Utah hay price of $45/ton for April 1973 with the break-even prices in Table 4 indicates that a rancher anticipating a hay shortage during the latter portion of April could have decreased operating expenses by applying nitrogen to stimulate early spring forage instead of buying hay. For example, the application of 30 lb N to the Benmore South (spring) plot yielded 12 additional AUDs/acre (Table 1) at a cost of $.43/AUD or a total cost per AU for the 12-day period of $5.16. Hay at $45/ton for one AU for the same 12 days would have cost $6.26 (.0116 tons/day for 12 days at $45/ton). If applied to a breeding herd of several hundred head, the $1.10 saved per AU is substantial.

A word of caution concerning the effects of fertilization and early spring grazing on stand life and sustained yield of crested wheatgrass seedings is appropriate at this point. Nitrogen stimulation of early growth is usually accompanied by more rapid depletion of soil moisture (Sneva and Hyder, 1965; and Wight and Black, 1972) and greater mobilization of plant carbohydrates (Hyder and Sneva, 1961). Grazing of early spring growth initiated through nitrogen application subjects crested wheatgrass to the danger of stand depletion (Hyder and Sneva, 1961; and Sneva, 1973). However, depending upon the value of hay saved over a period of several years and the costs of re-establishing crested wheatgrass, it may be more economical to deplete crested wheatgrass pastures (provided that re-establishment takes place prior to soil loss) than to defer grazing until after the critical carbohydrate replenishment period. It should also be emphasized that the results reported are based on data for only one year and that range fertilization results can be expected to vary widely with changes in amount and distribution of annual precipitation. Potential advanced range readiness carry-over response during the second and third seasons following nitrogen application will be the subject of further study. Such carry-over response would make fertilization of spring range an even more attractive substitute for purchased hay.

Summary and Conclusions

Several rates of ammonium nitrate were applied to two Western Utah crested wheatgrass pastures to determine the effect of nitrogen on spring forage growth initiation. During the initial year studied, fertilization resulted in from 4 to 19 days of advanced range readiness. Of the various application rates tested, 25 to 30 lb N/acre provided early spring forage at the lowest costs per AUD. Hay feeding costs saved as a result of advanced range readiness outweighed fertilization costs by over $1 per AU during the initial 12 days of the spring grazing season. In the Intermountain area the decision to substitute nitrogen fertilization of crested wheatgrass for purchased hay could usually be made as late as April 1. The growth stimulation effects of fertilization offers increased flexibility to the rancher in his selection of a least cost grazing and feeding program.

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