Fertilization of Cheatgrass Ranges in California

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Highlight

Nitrogen plus sulfur increased production of cheatgrass in 9 of 11 years studied. However, fertilization was not a dependable means of producing additional forage in dry years.

Many acres of rangeland in northeastern California are predominantly cheatgrass (*Bromus tectorum* L.), with some tansy mustard (*Descurainia pinnata* (Walt.) Britton) and tumblemustard (*Sisymbrium altissimum* L.). Most of these ranges formerly grew big sagebrush (*Artemisia tridentata* Nutt.). The sagebrush has been removed by fire or mechanical clearing and often is slow to re-invade the area. Forage production from cheatgrass is highly variable from year to year, and of good quality for only a short period. One possible method of increasing forage production and quality, and lengthening the green feed period (both earlier and later feed), is to apply nitrogen fertilizer.

Nitrogen fertilization of resident annuals is a popular range improvement practice in the Mediterranean climate of California (100,000 to 200,000 acres are fertilized annually with 50 to 100 lb of nitrogen). Modoc County ranchers wanted to know if and how such a program could be used on cheatgrass ranges.

Although voluminous literature has appeared on range fertilization in the last two decades, very little is reported on the fertilization of cheatgrass. Kay and Evans (1965) reported nitrogen and nitrogen-sulfur fertilizers increased cheatgrass yields when the cheatgrass was growing in association with intermediate wheatgrass (*Agropyron intermedium* (Host) Beauv.). Eckert and Evans (1963) compared responses of cheatgrass and crested or desert wheatgrass (*A. desertorum* (Fisch. ex Link) Schult.) in greenhouse studies. However, nothing has been written about cheatgrass fertilization per se.

Procedures

The cheatgrass site for this study is 18 miles south of Alturas, and is representative of cheatgrass ranges at this elevation in northeastern California.[1] The site was burned 20 years ago and has remained clear of brush. The area is formed on a basalt flow and is commonly referred to as tableland. The soil is gravelly loam over clay on a cemented layer on basaltic bedrock (Yancy series). Soil depth averages 10 to 20 inches.

Big sagebrush, cheatgrass, squirrel tail (*Sitanion hystrix* (Nutt.) J. G. Smith), Sandberg bluegrass (*Poa secunda* Presl), and red-stem filaree (*Erodium cicutarium* (L.) L'Her.) were the dominant species before the fire. Annual precipitation averages 10 inches, with seasonal totals varying widely. The elevation is 4,500 feet, and the growing season is short and variable. Cheatgrass may germinate as early as October or as late as April, but seldom is tall enough to graze before May. Winter temperatures commonly fall below zero; summer temperatures may exceed 100 F. Use of the range by livestock generally is from April 15 to June 15.

The soil was tested in the greenhouse, using barley and lettuce, and determined to be deficient in both nitrogen and sulfur. In April, 1955, at the beginning of the growing season, nitrogen (N) was applied to field plots at rates of 0, 30, 60, or 120 lb/acre in ammonium nitrate both with and without sulfur (S) at 40 lb/acre applied as gypsum. Each

[1] *The cooperation of rancher Warren Flournoy on whose land this study was conducted is gratefully acknowledged.*

plot was 15 x 15 feet. A randomized block design of four applications was used.

After the first year, nitrogen was reapplied annually in the fall to one replication; the other three were not further treated so that plant responses to the single application of fertilizer could be measured. Sulfur was not reapplied to any plot. The second study was located about a mile away prior to the 1960 growing season. Four replications of each the single application and the annual reapplication were included at the new location. All fertilizers were applied in October. Sulfur was applied only in the first year.

Yield measurements were made about the first week of June each year by clipping the grass to ground level. The size of plot clipped was varied from 4 ft^2 on "good" years to 35 ft^2 on "poor" years in an attempt to achieve similar sampling accuracy for all years. Old plant material was mowed and raked from the study area each fall.

Botanical composition was measured by the step-point method (Evans and Love, 1957) on the same date yield measurements were made. Botanical composition was measured in the second study only. Crude protein and sulfur content of the forage were measured near the end of the 1957 growing season only.

Results and Discussion

Of particular interest was the yearly variation in the yield of the non fertilized plots. Production varied from none to 1100 lb/acre in the 11-year period (Tables 1 and 2). Average production was 450 lb/acre, while median production was 320 lb/

Table 1. Effects of a single fertilizer application on forage yields, and cost of additional feed produced.

Treatment[1]	FIRST EXPERIMENT Yield deviations from check lb/acre, ovendry						FIRST EXPERIMENT Cost/ton of forage increase[3]	SECOND EXPERIMENT Yield deviations from check lb/acre, ovendry						SECOND EXPERIMENT Cost/ton of forage increase[3]
	1955	1956	1957	1958	1959	1960		1960	1961	1962	1963	1964	1965	
Check	210	200	1090	110	0	390		330	40	980	760	610	290	
S_{40}		90	−80	−50	0	80		70		160	320	140	60	
N_{30}		200	340	50	0	10	$14.40	480**		350	300	130	170	$ 5.03
N_{60}		420**	490	20	0	10	15.31	740**		380**	670**	320	240	6.13
N_{120}		510**	1130**	30	0	0	17.24	840**		680**	790**	70	240	10.99
$N_{30}S_{40}$		230*	50	−30	0	120	19.46	420**		60	550**	250	160	5.00
$N_{60}S_{40}$		420**	520	60	0	70	13.46	890**		320	480*	330	120	6.73
$N_{120}S_{40}$		480**	510	90	0	150	23.41	1100**	−30	880**	1040**	250	70	8.89
Precipitation (in.)[2]	8.73	14.54	15.48	17.40	4.92	7.28		7.28	5.37	9.75	14.36	12.44	15.13	

[1] Rates of nitrogen (N) and sulfur (S) are given in lb/A.
[2] Data 1955-1958 are USFS—Alturas. 1959-1965 data measured on experimental area.
[3] Calculated at $0.12/lb of N. Fertilizer application costs not included.
* Significant at .05 level.
** Significant at .01 level.

Table 2. Effects of repeated fertilizer applications on forage yields, and cost of additional feed produced.

Treatment[1]	FIRST EXPERIMENT Yield deviations from check lb/acre, ovendry					FIRST EXPERIMENT Cost/ton of forage increase[2]	SECOND EXPERIMENT Yield deviations from check lb/acre, ovendry						SECOND EXPERIMENT Cost/ton of forage increase[2]
	1955	1956	1957	1958	1959		1960	1961	1962	1963	1964	1965	
Check	210	250	1100	20	0		330	120	920	970	940	320	
S_{40}		−80	−490	0			70		−220	160	−190	−60	
N_{30}		300	1220	440		$18.37	480**		940**	3030**	500	400	$ 8.07
N_{60}		490	2270	1150		18.41	740**		1020**	2650**	−340	1020**	16.97
N_{120}		530	1810	410	100	50.52	840**		1140**	3340**	−190	660*	29.84
$N_{30}S_{40}$		360	2010	440	420	11.18	420**		1050**	2670**	390	610*	8.40
$N_{60}S_{40}$		600	4590	2030	880	8.89	890**		1440**	4130**	900**	1240**	10.05
$N_{120}S_{40}$		540	5100	3280	810	14.80	1100**	−80**	1790**	6050**	2130**	2000**	13.30
Precipitation (in.)	8.73	14.54	15.48	4.92	7.28		7.28	5.37	9.75	14.36	12.44	15.13	

[1] Rates of nitrogen (N) and sulfur (S) are given in lb/A.
[2] Calculated at $0.12/lb of N. Fertilizer application costs not included.
* Significant at .05 level.
** Significant at .01 level.

acre. Precipitation averaged 11.40 inches and varied from 4.92 to 17.40 inches (July 1-June 30).[2]

Single application. — Significant forage increases were measured in the second and third years of the first experiment (Table 1) and in the first, third, and fourth years of the second experiment. A significant decrease was measured in the second year of the second experiment, the result of a very dry spring. There was no additional feed produced on the dry years (1955 and 1961), but yield was at least doubled in the good feed years (1957, 1962, and 1963). Additional feed was also produced in the "average" years of 1956 and 1960. Applied nitrogen was apparently gone by the end of the third and fourth years, respectively, in both experiments. No sulfur response was noted in either experiment.

Repeated applications.—Yields were increased in all but the low rainfall years (Table 2). Thirty pounds of nitrogen plus sulfur at least doubled yields in 8 of 11 years. $N_{60}S_{40}$ was better than $N_{30}S_{40}$ in 7 of 11 years. $N_{120}S_{40}$ was better than $N_{30}S_{40}$ in 8 of 11 years. $N_{120}S_{40}$ was better than $N_{60}S_{40}$ in 4 of 11 years.

Application of sulfur in addition to nitrogen resulted in increased yields over nitrogen alone in 7 of 11 years. This additional response was noted in the latter years of both experiments, indicating that the growth responses to nitrogen alone had depleted the available sulfur inherent in the sites during the first years of the experiments.

Botanical composition was predominantly cheatgrass (90 to 100%), regardless of fertilization, except in 1962. In 1962 tansy mustard made up 25% and 87% of the check and $N_{120}S_{40}$ plots, respectively, while cheatgrass was 45% and 13%.

In 1959, the driest year, the last effective rainfall was on February 19. Even so, increased yields were recorded at harvest on March 17. These increases consisted entirely of tansy mustard. Tansy mustard is palatable to stock in early vegetative stages, but was dried and shattered in the plots before cattle came onto this range in 1959. Tansy mustard is the only species at this site which has been observed to produce earlier feed due to fertilization. Cheatgrass may change in color, and increase in ground cover, but has not produced additional grazeable growth as the result of fertilization. Production of early feed by fertilization of tansy mustard was not observed in the second experiment (1960 to 1965), even though 1962 was a "mustard year."

Analysis of tansy mustard from the $N_{120}S_{40}$ treatments in 1958 and 1959 revealed a crude protein content of 30.8% and 31.6%, respectively. Also nitrate nitrogen was 2750 ppm in 1958, making nitrate poisoning a potential hazard (Tucker et al., 1961).

The chemical composition of forage was improved by fertilization in other than mustard years (Table 3). The crude protein percentage was doubled and tripled, respectively, by the N_{120} and $N_{120}S_{80}$ treatments where nitrogen had been applied annually. Sulfur content was increased by all sulfur treatments.

Table 3. Effects of fertilization on chemical composition of forage.[1]

Treatment	% Protein Application Sing.[2]	% Protein Application Rept.[3]	% Sulfur Application Sing.[2]	% Sulfur Application Rept.[3]
Check	5.56	5.25	0.049	0.053
S_{80}	5.68	5.50	0.093	0.151
N_{120}	6.58	11.27	0.050	0.035
$N_{120}S_{80}$	6.26	17.12	0.081	0.183

[1] Samples collected at late flowering or ½ purple stage.

[2] Third growing season since the single application.

[3] Nitrogen applied at beginning of each growing season for 3 years—sulfur applied only first year.

Total ground cover was increased by fertilization in all years 1960 to 1965 except the driest year (1961). Ground cover varied from 3% to 45% on the check and 1% to 100% on the $N_{120}S_{40}$ treatment repeated annually. Thus fertilization frequently provided the added benefit of extra ground cover, thereby lessening the probability of soil erosion.

Nitrogen fertilization is expensive, and the anticipated benefits should be examined closely. Even at the lowest rates tested, the practice would cost about \$3.60/acre/year, plus costs of application. The increased forage production at 30 lb N/acre, (with sulfur), cost \$11.18/ton in the first experiment and \$8.40/ton in the second (Table 2). However, an average figure is of little value as no extra forage was produced on the years when it was most needed. Actually less forage was produced on the fertilized than on the non-fertilized plots in 1959 when extra feed would have been very valuable. In the best feed year the additional growth cost only \$2.70/ton. However, there was no demand for extra feed as the non-fertilized plots produced 3 times the 11-year median.

Summary

Fertilization of cheatgrass may frequently increase forage yield and ground cover of forage. However, fertilization is not a dependable means of increasing cheatgrass and associated species every year. In the three poorest feed years of the 11-year study, fertilization either did not increase yields or produced all mustard, which shattered before the normal grazing season. The impressive yields obtained with fertilization on a "good year"

[2] *Precipitation data appear at the bottom of Table 1 and Table 2.*

probably represent wasted feed, as only rarely would it be possible to utilize this feed.

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