Fertilization of Mixed Cheatgrass-Bluebunch Wheatgrass Stands[1]

A. M. WILSON, G. A. HARRIS, AND D. H. GATES[2]

Plant Physiologist, Crops Research Division, Agricultural Research Service, U.S.D.A.; Associate Professor of Range Management, Department of Forestry and Range Management, Washington State University, Pullman, and Range Management Specialist, Oregon State University, Corvallis.

Highlight

On both dense and sparse bluebunch wheatgrass stands, cheatgrass became dominant with increasing applications of ammonium sulfate. High and repeated fertilizer applications (80 lb N/A in 4 successive years) depressed bluebunch wheatgrass yield 50%.

Annual and perennial grasses growing in competition often respond differently to nitrogen fertilization. In Colorado, ammonium nitrate at 40 lb N/A increased sixweeks fescue *(Festuca octoflora* Walt.) yield 146%, but increased blue grama *(Bouteloua gracilis* (H.B.K.) Lag. ex Steud.) yield only 18% (Hyder and Bement, 1964). In California, ammonium sulfate at 60 lb N/A increased yield of annual grasses 91%, but did not increase yield of hardinggrass *(Phalaris tuberosa* (Hack.) Hitchc.) (Martin et al., 1964). Only at high nitrogen rates (240 lb N/A) was growth of hardinggrass appreciably stimulated. In northeastern California, ammonium sulfate at 60 lb N/A increased percent ground cover of cheatgrass *(Bromus tectorum* L.) but decreased ground cover of intermediate wheatgrass *(Agropyron intermedium* (Host) Beauv.) (Kay and Evans, 1965). In southeastern Washington, nitrogen fertilizer greatly increased the yield of cheatgrass (Patterson and Youngman, 1960). Although nitrogen at 20 or 40 lb/A applied for 3 and 4 years had little effect on bluebunch wheatgrass *(Agropyron spicatum* (Pursh) Scribn. and Smith), 60 or 80 lb N/A applied for the same period reduced bluebunch wheatgrass yield.

In southeastern Washington, cheatgrass is palatable and nutritious during 6 to 8 weeks in the spring, but is less desirable as forage than bluebunch wheatgrass throughout the remainder of the year. Consequently, fer-

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[1] *Cooperative study of Crops Research Division, Agricultural Research Service, U.S.D.A., and College of Agriculture, Washington State Univ. Scientific paper 2635, Coll. of Agric., W.S.U. Michael Maynard and Richard Page assisted with 1961 and 1962 measurements.*

[2] *Formerly Range Conservationist, Crops Research Division, Agricultural Research Service, U.S.D.A.*

tilization resulting in dominance of cheatgrass and suppression of bluebunch wheatgrass is contrary to management objectives on most of these ranges.

This paper reports changes in mixed cheatgrass-bluebunch wheatgrass stands induced by nitrogen-containing fertilizers.

Procedure

Two experiments, separated by about 20 miles, were located within the *Agropyron spicatum-Poa secunda* habitat type described by Daubenmire (1942). The first site was located 8 miles southwest of Lacrosse, Washington, on a moderately deep (20 to 36 inches) Benge silt loam soil. The second site was located 8 miles northwest of Dodge, Washington, on a deep (more than 60 inches) Ritzville silt loam soil. Both sites had an elevation of 1,400 feet and a slope of approximately 10% in a northeasterly direction. During the study, 1961-1964, average October to June precipitation reported by the Lacrosse and Pomeroy stations was 13.8, 11.2, 10.1 and 10.4 inches. This was slightly lower than the 13.2-inch average during the preceding 10 years.

At each location, studies were conducted on adjacent good and poor condition sites (dense and sparse bluebunch wheatgrass stands) which were the result of past management on different sides of an old fenceline (Fig. 1). Five replications were established at each site with a randomized complete block design. Ammonium sulfate was applied every year or every second year in October or March at rates of 0, 20, 40, and 80 lb N/A. In the fall of 1960 the sites were fenced to exclude cattle. Little evidence of grazing by game animals or rodents was observed.

Yields were measured in subplots (0.5 x 2.0 meters) within each major plot. Subplots were clipped in a new location each year. Time of clipping was determined by the phenological development of bluebunch wheatgrass. When this species reached the soft-dough stage, plants were clipped to the ground level, separated by species, oven-dried, and weighed. In August each year, after all species were dormant, the entire area was clipped at 4 inches above ground level and the herbage removed from the plots.

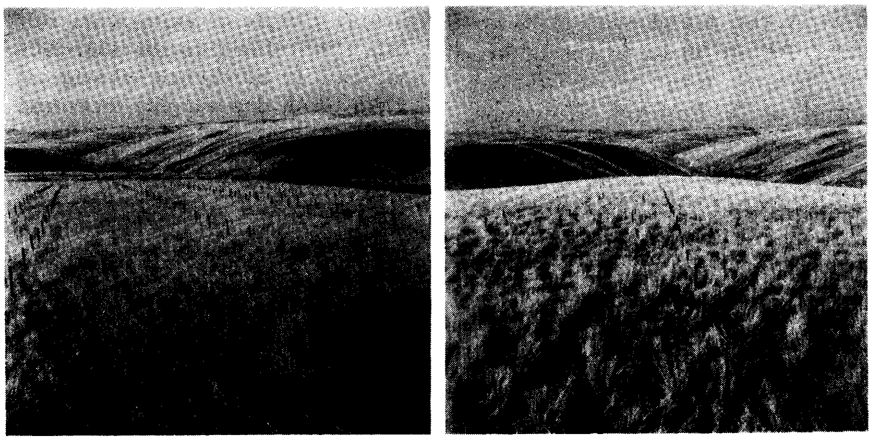

FIGURE 1. Experimental sites near Lacrosse, Washington in fall of 1960: dense cheatgrass and sparse bluebunch wheatgrass (left), dense bluebunch wheatgrass and sparse cheatgrass (right).

Results

Yields of cheatgrass and bluebunch wheatgrass were measured in 1961 and 1962. Because response at the two locations (Lacrosse and Dodge) and for the two application dates (October and March) was not significantly different, yield data were combined.

Average yields of unfertilized bluebunch wheatgrass were about 2.5 times higher on good than on poor condition sites (Fig. 2). The reverse was true of unfertilized cheatgrass yields; poor condition sites yielded slightly more than twice as much cheatgrass as good condition sites. This was expected because good sites were selected to have more bluebunch wheatgrass and less cheatgrass.

In the growing season immediately following either fall or spring application, cheatgrass yields increased with increasing rates of ammonium sulfate. At 80

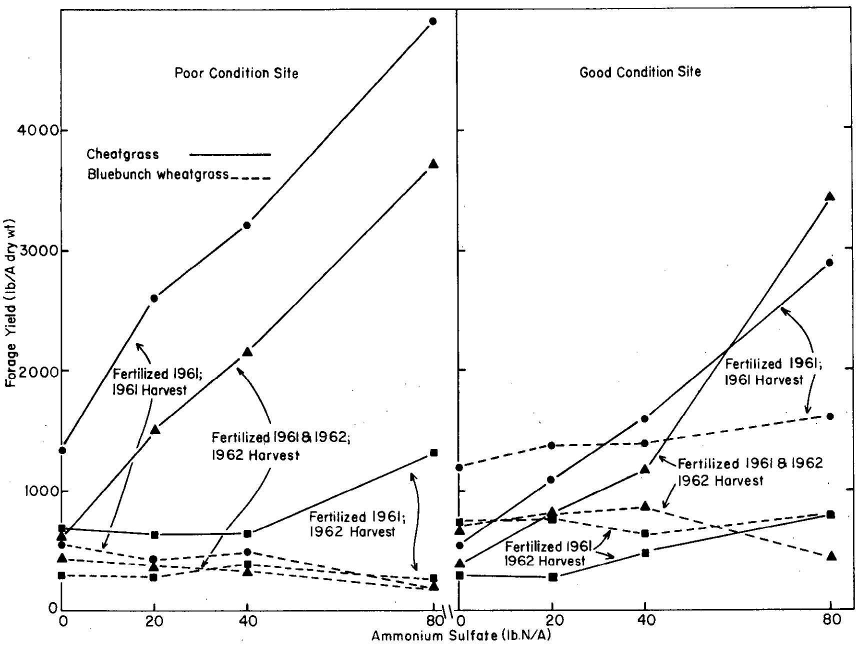

FIGURE 2. On poor and good condition sites, cheatgrass became dominant when increasing amounts of ammonium sulfate were applied.

lb N/A the trend was still upward. About 30 to 40 lbs of air-dry forage was produced per pound of N applied. However, 1962 yields from plots fertilized in 1961 but not in 1962, and 1962 yields from plots fertilized in both 1961 and 1962 showed little carry-over of fertilizer.

Bluebunch wheatgrass yields failed to increase significantly with increasing rates of ammonium sulfate, except in one instance. This was during the first year of fertilization on good condition sites where cheatgrass competition was at a minimum. Bluebunch wheatgrass yields were increased one-third above similar unfertilized plots by the application of 80 lb N/A.

The high rate of ammonium sulfate applied to poor condition sites in the first year or applied to both good and poor condition sites in two successive years slightly decreased bluebunch wheatgrass yields. Fertilizer treatments were, therefore, continued in 1963 and 1964 to determine the long-term effects of fertilization on yield of bluebunch wheatgrass.

Eighty lb N/A applied to the same plots in 4 consecutive years depressed bluebunch wheatgrass yields approximately 50% on both good and poor condition sites (Table 1). The lower rates of ammonium sulfate had no obvious effect on the bluebunch wheatgrass stand.

Annual application of 80 lb N/A to the same plot for 4 consecutive years quadrupled the number of cheatgrass plants (Table 2). In fertilized plots, cheatgrass was often growing in bluebunch wheatgrass clumps.

In 1963, new plots were treated to separate the influence of cheatgrass competition from the influence of fertilizer application on the yields of bluebunch wheatgrass. Competing species were removed from selected plots on the good condition site at Lacrosse by hand-hoeing. Treatments were continued on the same plots for two consecutive years.

In 1963 and 1964, removing competing vegetation doubled bluebunch wheatgrass yield (Table 3). Applying 80 lb N/A to plots without competing vegetation increased yields an additional 30%. Fertilizer applied to plots having competing species increased bluebunch wheatgrass yields about 70% the first year, but only 35% the second year. This indicates the intensified competition with other species resulting from consecutive years of fertilizer application.

In a 1963 experiment at Lacrosse, ammonium nitrate and calcium sulfate were applied, separately and in combination, to determine whether the stimulated growth of cheatgrass was due to nitrogen, sulfur, or a combination. When applied separately, neither ammonium nitrate nor calcium sulfate greatly influenced cheatgrass yield (Table 4). However, when they were applied in a combination that was equivalent to 80 lb N/A using ammonium sulfate, cheatgrass yield increased sixfold.

Table 1. Effects of ammonium sulfate applications, in the 1961-1964 seasons, on bluebunch wheatgrass yield (lb/A dry weight) measured in June 1964.

Ammonium sulfate (lb N/A)	Yield[1] Good site	Poor site
0	520	370
80	270	160

[1] LSD at 5% level for differences between yields is 100 lb/A on both good and poor condition sites.

Table 2. Effects of ammonium sulfate, applied in fall or spring, on number of cheatgrass plants per square foot in June 1964.

Ammonium sulfate (lb N/A)	Cheatgrass plants[1] Fall	Spring
0	150[a]	120[a]
80[2]	320[b]	310[b]
80[3]	580[c]	620[c]

[1] Values having the same letter in the superscript do not differ significantly at the 5% level (Duncan, 1955).

[2] Applied in 1961 and 1964.

[3] Applied in 1961, 1962, 1963, and 1964.

Discussion

In southeastern Washington, ammonium sulfate fertilizer applied to mixed cheatgrass-bluebunch wheatgrass stands resulted in ecological regression rather than improvement of condition. This was especially true where applications were made in 2 or

Table 3. Effects of ammonium sulfate applications, in two consecutive years, on yield of bluebunch wheatgrass (lb/A dry weight) in plots with and without competing species.

Ammonium sulfate	Yield[1] With competition	Without competition
0 lb N/A		
1963	560	1260
1964	450	890
Average	510[a]	1080[c]
80 lb N/A		
1963	970	1620
1964	580	1250
Average	780[b]	1440[d]

[1] Yield averages having the same letter in the superscript do not differ significantly at 5% level (Duncan, 1955).

Table 4. Cheatgrass yield (lb/A dry weight) in response to nitrogen, sulfur, or nitrogen and sulfur.

Fertilizer treatment[1]	Cheatgrass yield[2]
Unfertilized	290[a]
90 lb S/A	210[a]
80 lb N/A	440[a]
90 lb S & 80 lb N/A	1900[b]

[1] Fertilizer applied in March 1963. Yield measured in June 1963.

[2] Values having the same letter in the superscript do not differ significantly at the 5% level (Duncan, 1955).

more consecutive years at the highest level tested. In the first year of application and on good condition sites where wheatgrass yields exceeded cheatgrass yields more than 2:1, the application of 80 lb N/A reversed the yield to favor cheatgrass 2:1.

Wheatgrass bunches were invaded by cheatgrass on plots receiving heavy and repeated annual fertilization. Cheatgrass seedlings crowded wheatgrass plants by growing closely around and within established bunches. These bunches became progressively smaller under the pressure of competition.

Important in this competitive relationship is the ability of cheatgrass to grow and reproduce under the extreme habitat variations found in eastern Washington. When moisture and nutrients are limiting, cheatgrass may mature as a single stem 3 to 4 inches tall and produce only one spikelet containing one or two viable seeds. On the other hand, when growing conditions are favorable, cheatgrass plants may develop 10 to 15 tillers 2 to 3 feet tall, each producing 50 or more viable seeds.

When fertilizer was applied in successive years, the density of cheatgrass increased. New bluebunch wheatgrass seedlings were not observed in either fertilized or unfertilized plots. Therefore, scattered wheatgrass bunches would not be as effective as dense cheatgrass in utilizing surface-applied fertilizer.

Periodicity in growth also favors cheatgrass in its competition with bluebunch wheatgrass. Because it reaches maximum growth earlier than bluebunch wheatgrass (Hull, 1949), cheatgrass often completes its life cycle before soil moisture is depleted. But bluebunch wheatgrass, normally green until mid-July, is damaged when heavily fertilized cheatgrass depletes moisture by early June.

Removal of cheatgrass competition is much more effective than fertilization in stimulating bluebunch wheatgrass growth. Preliminary trials, using selective herbicides which remove cheatgrass without obvious harm to wheatgrass, show promise in providing a practical means of increasing vigor of established bluebunch wheatgrass plants.

Under normal conditions, during the short period when cheatgrass is green and grazable, a surplus of forage exists. Fertilizing to provide more forage at this time may be wasteful, except in special cases. Examples where the use of fertilizers on cheatgrass may be economically feasible include: (1) fertilization of drop range near lambing sheds or (2) fertilization of a small area of annual spring range to shorten the winter livestock feeding period and allow later turn-out on perennial grass range. Grazable cheatgrass was produced 2 to 3 weeks earlier on fall fertilized plots than on unfertilized plots. In considering fertilizer applications, however, the cost and returns of fertilizing must be weighed against the cost of alternative sources of forage. Any plan for fertilizing in this region should include preliminary trials to determine whether sulfur is required in addition to nitrogen.

In general, fertilization of semi-arid ranges in southeastern Washington appears undesirable. Even excellent condition sites have a small population of cheatgrass plants which have the potential to increase and take over a site as a result of fertilization. In most situations, there are adequate amounts of cheatgrass to fill the needs for forage of this species without fertilization. Generally, management objectives on these ranges should include increasing the amount and vigor of bluebunch wheatgrass.

Summary

Range sites having dense bluebunch wheatgrass and sparse cheatgrass or sparse bluebunch wheatgrass and dense cheatgrass were fertilized with increasing amounts of ammonium sulfate. Rather than improving range, heavy fertilization (80 lb N/A in 4 consecutive years) produced a retrogression in range condition: bluebunch wheatgrass yields decreased 50%, cheatgrass yields increased 400 to 600%. This retrogression occurred regardless of the initial density of bluebunch wheatgrass.

In the absence of competing vegetation, bluebunch wheatgrass was not responsive to fertilization. On plots with competing vegetation removed and fertilized with 80 lb N/A, bluebunch wheatgrass yielded only 30% more than on similar unfertilized plots.

Neither ammonium nitrate nor calcium sulfate greatly influenced cheatgrass yield; but in a combination, equivalent to 80 lb N/A using ammonium sulfate, they increased cheatgrass yield sixfold.

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