Department of Agronomy and Range Science
UNIVERSITY OF CALIFORNIA, DAVIS

# RANGE SCIENCE REPORT

Agricultural Experiment Station

Cooperative Extension

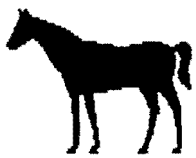
No. 18 September 1988

## WHEATGRASS FERTILIZATION AND WEED CONTROL 1/

Burgess L. Kay 2/

### Abstract

Greenar intermediate wheatgrass, seeded on the Likely Table in the spring of 1958, was fertilized each year 1964 to 1976 with nitrogen and sulfur. Because cheatgrass growth was also increased by fertilizers, atrazine was applied for weed control on half of each treatment annually from the fall of 1965 to 1976. Total forage yields were increased as the result of fertilizer applications, and wheatgrass yields further increased by the weed control. Atrazine increased the nitrate content of wheatgrass, but not to levels considered dangerous to livestock. Mortality of grazed wheatgrass increased as fertilizer rates increased. Mortality caused by atrazine was least severe if fertilized, and was increased by grazing. Observations in 1988 show the atrazine treated areas to be populated with big sagebrush, and the untreated areas to be vigorous wheatgrass, especially if never fertilized



1/ This research was cooperative with the local Farm Advisor and rancher Warren Flournoy of Likely, California.

2/ Wildland Seeding Specialist, Department of Agronomy and Range Science, University of California, Davis 95616.

### Introduction

The planting of wheatgrass (Agropyron sp.) following the removal of big sagebrush (Artemisia tridentata) is an established range improvement practice in the west, including northeastern California. Range fertilization is also successfully used in some areas. However, fertilization of wheatgrass has not become widespread, being practiced only in the higher rainfall areas on rangeland with the deepest soils.

Reasons why fertilization is not more widely used include the variation in forage response caused by the differences in year-to-year rainfall amounts and distribution, the increased growth of weeds such as cheatgrass (Bromus tectorum) on fertilized areas, and the possibility that fertilizing may shorten the life of the wheatgrass stand (Kay et.al, 1965). Fertilization was also shown to increase the nitrate content of wheatgrass (Kay, 1971).

The following long-term study measures the annual forage response to three fertilizer rates, the effect of using an herbicide to limit weedy fertilizer response, and the effects of these treatments on wheatgrass stand longevity under both grazed and fenced conditions.

### Methods

The study was conducted on the "Likely Table", 2 miles NE of the town of Likely, California. This relatively flat basaltic area was growing big sagebrush with an understory of cheatgrass, red-stem filaree (Erodium cicutarium), and Sandberg bluegrass (Poa secunda). The area was cleared of sagebrush by burning in 1957, and disked and drill seeded to Greenar intermediate wheatgrass (Agropyron intermedium)in the spring of 1958.

Total soil depth averages 10 to 20 inches, and is gravelly loam over clay, superimposed on a cemented layer on basalt bedrock. The soil has been determined by greenhouse studies to be deficient in nitrogen and sulfur (Kay, 1966),

Annual precipitation averages 10 inches, with seasonal totals varying widely. The elevation is 4,500 feet, and the growing season short and variable. Livestock use is generally is from April 15 to June 15. Deer and antelope may use the area all year, but are particularly important because they use the wheatgrass in winter and early spring.

Cheatgrass may germinate as early as October or as late as March, but is seldom tall enough to graze before May. In a warm-wet season, growth may start as early as February. The annual grass matures about the first week of June and is dry by the end of June. Fertilizing the resident cheatgrass gives excellent responses in years with high spring rainfall amounts, but is not a dependable means of producing additional forage in dry years (Kay, 1966). Wheatgrass is considered a much more dependable spring feed for these dry years.

Two adjacent fertilizer trials were established in the fall of 1964 on the 7-year-old stand of wheatgrass. One trial was fenced to exclude cattle, deer, antelope, and rabbits, and the small rodents were poisoned. The second trial was left exposed to grazing by all animals. Four fertilizer treatments were replicated four times in each trial in a randomized block design. Nitrogen was applied each fall (1964-1976) as ammonium sulfate at rates of 20, 40, and 80 lb actual nitrogen per acre, (which also gave rates of 24, 48, and 96 lb/acre sulfur), and compared to an unfertilized check plot. The same one-half of each 15 x 15 ft plot was sprayed each fall 1964 through 1976 with atrazine at (1 lb/acre active ingredient) to control cheatgrass.

Yield data were taken on fenced plots only, and usually in early July. Wheatgrass had just flowered, and the cheatgrass was dry. Samples were cut to a 2-inch height on the wheatgrass, and to ground level for the other species. Samples from an area 3 x 6 ft were separated into cheatgrass and wheatgrass components before oven drying and weighing. The entire plot area was mowed to a 2-inch stubble height and the plant material removed each fall before reapplying fertilizer and atrazine.

Measurements of plant presence and survival was by percent stocking (percent of the square feet in the plot which contained one or more live wheatgrass plants).

## Results and Discussion

Total herbaceous yield (wheatgrass plus all other species) was increased by fertilizing in all years by all rates of fertilizer, except in the driest year, 1966 (Table 1). The use of atrazine did not affect the average total forage yield for the period 1966 thru 1977. Total herbaceous yield increased in some years and decreased in others as a result of the atrazine application. The decreased yields may have been due to the herbicidal effect and the accumulation of herbicide which may not have been completely broken down or leached in some years. The increased yields may have been due to fallowed moisture resulting from weed control in wet years (Kay, 1971).

Wheatgrass yields were increased by fertilizing in all but the driest years. The addition of atrazine further increased wheatgrass yield in most years, sometimes several fold (Table 2).

Cheatgrass showed dramatic yield increases in all but the driest years (Table 3). There was no cheatgrass or other species (other than wheatgrass) in any of the treatments in 1966 or 1968. Atrazine resulted in complete weed control in all years except 1967, when species other than cheatgrass predominated. The other species were mostly mustards (Descurainia pinnata and Sisymbrium altissimum), and were a significant part of the yield in 1967 only.

Fertilizer rate responses suggest that the maximum amount ammonium sulfate that could be used and still result in higher yields may not have been reached. Plant growth with 80N>40N>20N>check. There was no suggestion of a leveling off of yields at 80N.

Table 1. Effects of fertilizer and atrazine treatments on total herbage yield (wheatgrass, cheatgrass, and all other species).

| Treatment | 1965 | 66 | 67 | 68 | 69 | 70 | 72 | 73 | 74 | 75 | 76 | 77 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Pounds per acre (oven dry) | | | | | | | |
| Check | 460 | 220 | 920 | 350 | 630 | 480 | 270 | 260 | 190 | 280 | 200 | 340 | 376 |
| Check + A | | 160 | 630 | 470 | 830 | 200 | 440 | 380 | 340 | 360 | 240 | 350 | 400 |
| N20 | 890 | 240 | 1500 | 330 | 1040 | 710 | 460 | 370 | 230 | 360 | 230 | 520 | 545 |
| N20 + A | | 180 | 1230 | 480 | 1390 | 840 | 400 | 700 | 640 | 730 | 330 | 620 | 685 |
| N40 | 1280 | 270 | 2040 | 370 | 1240 | 1340 | 820 | 750 | 360 | 780 | 370 | 740 | 825 |
| N40 + A | | 290 | 2080 | 580 | 1810 | 1330 | 460 | 900 | 630 | 1190 | 370 | 1020 | 969 |
| N80 | 1610 | 360 | 2920 | 720 | 2190 | 1980 | 1490 | 1470 | 720 | 1040 | 300 | 1460 | 1332 |
| N80 + A | | 260 | 2490 | 670 | 2690 | 1940 | 780 | 1140 | 740 | 1330 | 440 | 1060 | 1231 |

Table 2. Effects of fertilizer and atrazine treatments on the yield of intermediate wheatgrass.

| Treatment | 1965 | 66 | 67 | 68 | 69 | 70 | 72 | 73 | 74 | 75 | 76 | 77 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Pounds per acre (oven dry) | | | | | | | |
| Check | 440 | 220 | 870 | 350 | 600 | 430 | 230 | 230 | 160 | 260 | 190 | 340 | 350 |
| Check + A | | 160 | 620 | 470 | 830 | 200 | 440 | 380 | 340 | 360 | 240 | 350 | 400 |
| N20 | 800 | 240 | 850 | 330 | 750 | 360 | 90 | 110 | 100 | 140 | 100 | 460 | 320 |
| N20 + A | | 180 | 1220 | 480 | 1390 | 840 | 400 | 700 | 640 | 730 | 330 | 620 | 680 |
| N40 | 940 | 270 | 910 | 370 | 820 | 280 | 50 | 80 | 60 | 140 | 60 | 580 | 330 |
| N40 + A | | 290 | 2010 | 580 | 1810 | 1330 | 460 | 900 | 630 | 1190 | 370 | 1020 | 960 |
| N80 | 1160 | 360 | 1200 | 720 | 1310 | 660 | 80 | 80 | 120 | 260 | 60 | 1370 | 570 |
| N80 + A | | 260 | 2450 | 670 | 2690 | 1940 | 780 | 1140 | 740 | 1330 | 440 | 1060 | 1230 |
| Atrazine | | * | | ** | ** | ** | ** | ** | ** | ** | ** | * | ** |
| Fertilizer | ** | * | ** | ** | ** | ** | ** | * | | ** | | ** | ** |
| Atr X Fert | | | ** | * | ** | ** | ** | ** | | ** | ** | | ** |

(* indicates significant difference at .05 level; ** at .01 level.)

Table 3. Effects of fertilizer and atrazine treatments on the yield of cheatgrass and all species other than wheatgrass.

| Treatment | 1965 | 66 | 67 | 68 | 69 | 70 | 72 | 73 | 74 | 75 | 76 | 77 | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Pounds per acre (oven dry) | | | | | | | |
| Check | 20 | 0 | 50 | 0 | 30 | 50 | 40 | 30 | 30 | 20 | 10 | 0 | 24 |
| Check + A | | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| N20 | 90 | 0 | 650 | 0 | 290 | 350 | 370 | 260 | 130 | 220 | 130 | 60 | 224 |
| N20 + A | | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| N40 | 340 | 0 | 1130 | 0 | 420 | 1060 | 770 | 670 | 300 | 640 | 310 | 160 | 496 |
| N40 + A | | 0 | 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| N80 | 450 | 0 | 1720 | 0 | 880 | 1320 | 1410 | 1390 | 600 | 780 | 240 | 90 | 766 |
| N80 + A | | 0 | 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |

Table 4. Effects of fertilizer and atrazine treatments on the percent protein in wheatgrass.

| | Protein-percent | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 68 | 69 | 70 | 72 | 73 | 74 | 75 | 76 | 77 | Mean |
| Check | 9.6 | 14.72 | 13.59 | 18.29 | 14.91 | 13.8 | 12.76 | 14.92 | 18.71 | 13.54 | 15.03 |
| Check + A | 9.6 | 16.89 | 12.15 | 17.26 | 18.96 | 15.86 | 13.92 | 15.49 | 19.97 | 15.78 | 16.25 |
| N20 | | 10.52 | 9.15 | 13.13 | 10.51 | 10.02 | 9.34 | 9.76 | 12.19 | 9.48 | 10.46 |
| N20 + A | | 14.16 | 10.46 | 15.01 | 13.44 | 12.99 | 11.2 | 13.11 | 16.09 | 13.48 | 13.33 |
| N40 | | 10.47 | 8.06 | 11.4 | 9.65 | 8.95 | 8.78 | 9.46 | 10.57 | 9.12 | 9.61 |
| N40 + A | | 12.9 | 11.16 | 16.31 | 12.69 | 11.93 | 10.76 | 13.47 | 14.11 | 12.56 | 12.88 |
| N80 | 4.61 | 8.16 | 6.6 | 9.89 | 8.93 | 7.55 | 8.33 | 8.93 | 8.75 | 7.84 | 8.33 |
| N80 + A | 5.82 | 12.93 | 10.09 | 19.04 | 12.34 | 12.28 | 10.41 | 12.56 | 11.32 | 13.83 | 12.76 |

Table 5. Effects of fertilizer and atrazine treatments on the protein per acre from wheatgrass.

| | Pounds potein per acre | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatment | 1967 | 68 | 69 | 70 | 72 | 73 | 74 | 75 | 76 | 77 | Mean |
| Check | 84 | 52 | 82 | 79 | 34 | 32 | 20 | 39 | 36 | 46 | 47 |
| Check + A | 60 | 79 | 101 | 35 | 83 | 60 | 47 | 56 | 48 | 55 | 63 |
| N20 | - | 35 | 69 | 47 | 9 | 11 | 9 | 14 | 12 | 44 | 28 |
| N20 + A | - | 68 | 145 | 126 | 54 | 91 | 72 | 96 | 53 | 84 | 88 |
| N40 | - | 39 | 66 | 32 | 5 | 7 | 5 | 19 | 6 | 53 | 26 |
| N40 + A | - | 75 | 202 | 217 | 58 | 107 | 68 | 160 | 52 | 128 | 119 |
| N80 | 55 | 59 | 86 | 65 | 7 | 6 | 10 | 23 | 5 | 107 | 41 |
| N80 + A | 142 | 87 | 271 | 369 | 96 | 140 | 77 | 167 | 50 | 147 | 156 |

Table 6. Effects of fertilizer and atrazine treatments on the nitrate content of wheatgrass.

| | Nitrate-ppm | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1967 | 68 | 69 | 70 | 72 | 73 | 74 | 75 | 76 | 77 | Mean |
| Check | 471 | 575 | 321 | 1168 | 128 | 145 | 222 | 222 | 193 | 531 | 389 |
| Check + A | 796 | 1132 | 828 | 718 | 682 | 1130 | 708 | 644 | 861 | 1576 | 920 |
| N20 | | 118 | 51 | 322 | 81 | 48 | 129 | 241 | 80 | 563 | 181 |
| N20 + A | | 271 | 383 | 306 | 195 | 193 | 209 | 522 | 32 | 724 | 315 |
| N40 | | 68 | 17 | 245 | 405 | 48 | 113 | 233 | 0 | 418 | 172 |
| N40 + A | | 133 | 372 | 607 | 143 | 65 | 258 | 354 | 0 | 644 | 286 |
| N80 | 97 | 0 | 102 | 272 | 205 | 185 | 161 | 96 | 0 | 322 | 149 |
| N80 + A | 81 | 65 | 270 | 1561 | 193 | 338 | 64 | 338 | 0 | 1046 | 431 |

Figure 1. Big sagebrush invading the wheatgrass is a dramatic result of the decline of vigor and numbers of grass plants. Establishment of sagebrush is almost nil except in the strips sprayed with Atrazine.

Protein content of the wheatgrass plants was generally decreased by increasing rates of fertilizer applications. Atrazine, on the other hand, seems generally to have increased protein, especially if combined with a fertilizer treatment (Table 4).

The total amount of protein produced per acre (a function of yield as well as percent protein in the forage) was generally increased by atrazine applications (Table 5). The highest production of protein per acre was from the highest fertilizer rates, and lowest from the intermediate fertilizer rates used without atrazine. The unfertilized treatment had the highest protein production of the non-atrazine treatments. The possible earlier maturity of the fertilized treatment, combined with relatively unchanged wheatgrass production, resulted in less total protein per acre in the non-atrazine treatments.

The nitrate content of the wheatgrass is important because high levels of nitrate (above 2078 ppm) are possibly toxic to livestock. None of the values in this study approached this value. However, nitrate levels were considerably elevated at all levels of fertility (including the check), if atrazine was applied.

An earlier study on an adjacent site showed the stand of wheatgrass to deteriorate as the result of fertilizing, both if grazed or protected (Kay et. al 1965). The present study shows similar results as indicated by stand measurements at the conclusion of the study (Table 7). The stand of wheatgrass generally declined as the result of atrazine or fertilizer treatments. Mortality due to atrazine applications was reduced by fertilizer applications up to 40N. Mortality was greater in grazed than fenced stands.

Table 7. Wheatgrass survival following 12 annual applications of Atrazine and fertilizer.

| | Percent stocked, one-foot squares. | | | |
|---|---|---|---|---|
| | Grazed | | Fenced | |
| Check | 92 | | 98 | |
| Check + A | | 0 | | 46 |
| N20 | 73 | | 92 | |
| N20 + A | | 15 | | 75 |
| N40 | 62 | | 92 | |
| N40 + A | | 33 | | 83 |
| N80 | 37 | | 85 | |
| N80 + A | | 27 | | 75 |
| LSD .05 | 19 | 21 | -- | 23 |
| .01 | 25 | 29 | -- | -- |

The interaction between Atrazine and fertilizer treatments is also significant (**), both in the grazed and the fenced treatments.

Table 8. Inches precipitation (US Forest Service, about 20 miles NNW of experiment site).

| Year | J | A | S | O | N | D | J | F | M | A | M | J | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964-65 | .22 | .14 | .24 | .45 | 1.61 | 4.15 | 2.95 | .16 | .23 | 1.76 | 1.63 | 2.34 | 15.88 |
| 65-66 | .38 | 3.00 | .01 | .17 | 1.91 | 1.47 | 1.15 | .61 | .57 | .67 | .79 | .47 | 11.20 |
| 66-67 | .63 | -- | .59 | .15 | 2.78 | 1.48 | 3.05 | .15 | .94 | 1.58 | 1.05 | .87 | 13.27 |
| 67-68 | .25 | .10 | .11 | .26 | .88 | 1.53 | 1.88 | 1.39 | .61 | .20 | 1.46 | .47 | 9.14 |
| 68-69 | -- | 1.97 | -- | .42 | 2.17 | .98 | 4.24 | .93 | .53 | 1.11 | .29 | 3.35 | 15.99 |
| 69-70 | .09 | -- | -- | 1.77 | .70 | 2.85 | 3.65 | .59 | 1.46 | .84 | .64 | 2.61 | 15.20 |
| 70-71 | -- | -- | .17 | .65 | 3.18 | 3.33 | .27 | .20 | 3.34 | .92 | 2.99 | 1.56 | 16.61 |
| 71-72 | .42 | .03 | 1.70 | .73 | 1.36 | .90 | 1.53 | 2.48 | .91 | .99 | .64 | .24 | 11.93 |
| 72-73 | .04 | .19 | 1.42 | .87 | 1.71 | 1.03 | 1.49 | .56 | .57 | 1.61 | .68 | -- | 10.17 |
| 73-74 | .01 | -- | .65 | .62 | 1.91 | 1.23 | 1.72 | .86 | 1.71 | .50 | .03 | -- | 9.24 |
| 74-75 | .73 | -- | -- | .63 | .66 | 1.54 | .59 | 2.47 | 1.24 | 1.45 | .15 | .80 | 10.26 |
| 75-76 | .19 | .54 | .04 | .39 | .61 | .42 | .39 | 1.38 | 1.12 | .16 | .21 | .50 | 5.95 |
| 76-77 | .46 | .99 | 1.14 | -- | .17 | .02 | 1.06 | .48 | .49 | .11 | 2.59 | 1.36 | 8.87 |
| Mean | .26 | .54 | .47 | .55 | 1.51 | 1.61 | 1.84 | .94 | 1.06 | .92 | 1.01 | 1.12 | 11.82 |

It must be noted that the grazing pressure was fairly intense, from cows from about April 15 to June 15, and possibly deer and antelope all year. The improved palatability of fertilized forage is well known, and was probably a significant factor in encouraging heavy grazing use. The best remaining stands were in the fenced treatments which did not receive atrazine and the grazed check which never received fertilizer or atrazine.

A dramatic result of this decline in wheatgrass numbers and vigor, is the invasion by big sagebrush. The establishment of sagebrush in this 1958 wheatgrass seeding has been minimal, probably because of the thrift of the wheatgrass plants which generally excludes even cheatgrass. Observations in 1988 show sagebrush well established in all of the atrazine treatments of both the grazed and formerly fenced experiments (Figure 1).

## Literature Cited


1. Kay, Burgess L., and Raymond A. Evans. 1965. Effects of fertilization on a mixed stand of cheatgrass and intermediate wheatgrass. J. of Range Management 18:7-11.

2. Kay, Burgess L. 1966. Fertilization of cheatgrass ranges in California. J. of Range Management 19:217-220.

3. Kay, Burgess L. 1971. Atrazine and simazine increase yield and quality of range forage. Weed Science 19:370-372.