A Comparison of Methods of Renovating Old Stands of Crested Wheatgrass

RUSSELL J. LORENZ AND GEORGE A. ROGLER

Research Agronomists, Crops Research Division, Agricultural Research Service, U.S. Department of Agriculture, U.S. Northern Great Plains Field Station, Mandan, North Dakota.

A method of economically increasing production from many acres of old, low-producing crested wheatgrass would be of great benefit to livestock producers throughout the West. Various renovation methods have been tried and reported in the literature; however, little has been reported on comparison of methods involving partial or complete destruction of the old stand with methods which retain a degree of soil protection by not removing the existing stand. Results of a study comparing various renovation methods are presented here.

Review of Literature

After studying the effects of various tillage implements including the disk, one-way, heavy-duty cultivator, and Noble blade, Knowles (1956) recommended plowing unproductive crested wheatgrass stands, cropping for a few years, and and then reseeding to a grass-alfalfa mixture. Double one-waying was the best tillage treatment. It resulted in ⅓ of a ton per acre increase in hay yield, which would not pay for the cost of the treatment. Furthermore, all tillage implements left the fields rough and difficult to mow.

Houston (1957) reported an increase in forage production from 50 pounds of N in the year of application, but residual response was small and 2 years after application little or no increase in yield was obtained. Moderate disturbance of the stand by springtooth harrowing had little effect on forage production although seed production was reduced the year of treatment. Double disking or plowing and reseeding decreased forage and seed production and increased weed growth in the first year. Two years after plowing and reseeding, the stand was near optimum density and production was increased slightly.

Lodge (1960) reported a reduction in first year forage yield from mowing, burning and double disking, but forage harvested from burned treatments contained no previous season's growth; thus the total material suitable for grazing was greater on the fall-burned than on the check treatment.

Seamards and Lang (1960) concluded that addition of N to old stands of crested wheatgrass would increase production if soil moisture was available during the season of growth of crested wheatgrass.

The use of N to increase crested wheatgrass production appeared

practical on the Oregon high desert as reported by Sneva et al. (1958). By June 1 of each year herbage yields were doubled when 30 pounds of N was added. Limited soil moisture in any one year increased the residual response the following year.

Eckert et al. (1961) reported a response to N but they concluded that fertilization at the rates and with materials used would not be practical in the 8- to 12-inch precipitation sites studied in Nevada.

Procedure

A renovation study was initiated at Mandan, North Dakota, in 1949 to evaluate various methods of increasing production from an old stand of crested wheatgrass *(Agropyron desertorum* (Fisch.) Schult.). The area selected for study was seeded to crested wheatgrass in 1932 and was grazed each spring beginning in 1933. The vigor of the grass decreased with increasing age, and as fringed sage *(Artemisia frigida* Willd.) invaded the stand. This resulted in very low forage production and reduced livestock carrying capacity.

Each of the following treatments was replicated 3 times in 12- by 30-foot plots: (1) no treatment (check), (2) tearing up sod to a depth of 3 inches with a heavy field cultivator with shanks 9 inches apart and shovels 3 inches wide to kill about ⅓ of the existing plants on April 13, 1949 (scarification), (3) scarification followed by seeding Ladak alfalfa at 8 pounds per acre, (4) scarification followed by seeding common yellow sweet clover at 8 pounds per acre, (5) scarification plus application of 60 pounds of P_2O_5 per acre each fall, (6) scarification plus application of 30 pounds of nitrogen per acre (30-N) each fall, (7) 30 pounds of nitrogen per acre (30-N) each fall, (8) 60 pounds of nitrogen per acre (60-N) each fall, (9) spring plowing followed by a corn crop and reseeding crested wheatgrass in the fall of 1949, and (10) spring plowing followed by summer fallow and reseeding crested wheatgrass in the fall of 1949.

A sickle-bar mower which left 1.5 inches of stubble was used to harvest the forage for hay each year when the crested wheatgrass was in flower. The samples were separated to determine the percentage grass and sage (and legume when included in the treatment). When the air-dried hay samples were weighed, subsamples were oven-dried at 72 degrees C. for about 48 hours and forage yields in pounds of hay (grass or grass plus legume) per acre were calculated at 12-percent moisture.

To determine the effect of weed competition on forage production, half of each plot was sprayed with 2.5 pounds acid equivalent of 2,4-D per acre as low-volatile ester on June 18, 1958. A 4- by 12-foot sheet of pressboard was used to reduce drift to the unsprayed half of the plot. On the same date, a 75-foot strip of the 1932 crested wheatgrass pasture was sprayed with 2.7 pounds acid equivalent of 2,4-D ester in 12 gallons of water per acre . To measure the effect of removal of fringed sage on forage production, 6 paired areas were caged on the sprayed and nonsprayed portions of the pasture during the grazing periods of 1959, 1960, and 1961.

The soil type in the experimental area is Eakin silt loam. The 45-year (1915-60) annual precipitation averaged 15.81 inches with a seasonal (April-August) average of 11.04 inches. April through September evaporation from a free-water surface averaged 32.65 inches with a 136-day average frost-free period.

Results And Discussion

First Year

When comparing methods of renovation involving various degrees of destruction of the old sod, the first consideration should be the immediate effects of the treatment. Plowing plus preparation of a seedbed for reseeding grass resulted in complete removal of the grass cover. Erosion of topsoil by wind or water is possible and in many instances very probable. Loss of 2 years' production is usually involved in plowing and reseeding; however a portion of this loss can be eliminated by growing an annual crop and reseeding the grass in the fall after the crop has been removed. Corn used in treatment 9 of this study produced 5241 pounds of stover per acre the year the sod was plowed.

Tearing up the sod in early spring to reduce the plant population (scarification) reduced yields the year

Table 1. Average yields of crested wheatgrass from a 17-year-old renovated stand for 1949-1953.[1]

Treatment	1949	1950	1951	1952	1953	5-yr. av.
	(Pounds per acre at 12-percent moisture)					
Check	356 b[2]	867 a	363 a	116 a	1447 a	630 a
Scarification	257 ab	1074 b	587 ab	255 a	1473 a	729 ab
Scarification + alfalfa	183 a	1074 b	789 bc	566 a	1793 a	881 bc
Scarification + sweet clover	250 ab	1090 b	758 bc	247 a	1720 a	813 ab
Scarification + 60-P_2O_5	157 a	1074 b	704 abc	284 a	1680 a	780 ab
Scarification + 30-N	380 b	1911 d	1001 c	460 a	3300 b	1410 d
30-N	641 c	1665 c	784 bc	336 a	3360 b	1357 d
60--N	907 d	2195 e	1795 d	503 a	4013 c	1883 e
Plowed + corn	.....[3]	.....	1935 d	448 a	1733 a	823 b
Plowed + fallow	.....	.....	2882 e	376 a	1860 a	1024 c
Average	313	1095	1160	359	2238	1033

[1] Each value is the mean of 3 replications.

[2] Within each column, means followed by the same letter do not differ significantly (5%) (Duncan 1955).

[3] 5241 pound per acre corn stover yield not included in averages or statistical analysis.

Table 2. Average yields of crested wheatgrass from a 17-year-old renovated stand for 1954-1960.[1]

Treatment[2]	1954	1955	1956	1957	1958	1959	1960	12-year av.[4]
	(Pounds per acre at 12-percent moisture)							
Check	560 a[3]	573 a	807 a	561 a	320 a	398 a	896 a	605 a
Scarification	627 a	747 a	873 a	654 a	479 a	479 ab	999 a	709 a
Scarification + alfalfa	1333 b	2520 c	2453 b	2051 b	1213 b	1048 c	2238 b	1438 c
Scarification + 60-P_2O_5	613 a	693 a	747 a	638 a	447 a	505 ab	1030 a	714 a
Scarification + 30-N	1493 bc	1880 b	2193 b	1731 b	1218 b	981 c	2066 b	1551 c
30-N	1633 c	1640 b	1993 b	1792 b	1248 b	997 c	1949 b	1503 c
60-N	2413 d	2840 d	3953 c	2388 c	1826 c	1277 d	3075 c	2265 d
Plowed + corn	700 a	833 a	733 a	743 a	400 a	520 ab	1068 a	759 ab
Plowed + fallow	753 a	887 a	780 a	812 a	432 a	641 b	1304 a	894 b
Average	1125	1401	1615	1263	843	761	1625	1160

[1] Each value is the mean of 3 replications.
[2] Scarification + sweet clover discontinued after 1953.
[3] Within each column, means followed by the same letter do not differ significantly (5%) (Duncan 1955).
[4] Includes 1949-1953 data from table 1.

of treatment, 1949 (Table 1). Two of the 5 scarification treatment means were significantly lower than the mean of the check, and difference between mean yields of each of the remaining 3 scarification treatments and the check were not significant.

Application of N to undisturbed sod was the most effective means of increasing yields in the first year of treatment. Each increment of N produced a significant yield increase. Aplication of 30-N to undisturbed sod increased the yield by 9.5 pounds per pound of N applied or 285 pounds per acre; however, 30-N applied to scarified sod did not increase the yield significantly over that of the check in the first year. On undisturbed sod, the 60-N treatment was almost as efficient as the 30-pound rate. It produced 9.2 pounds of forage per pound of N, or 551 pounds more than the 356-pound average for the check.

Second Year

In 1950, the second harvest year all plots scarified in 1949 produced significantly more than the check; however, the addition of a legume to scarified sod did not produce the expected increase in yield. The alfalfa plants were small and lacked vigor. The sweet clover flowered, but it also lacked vigor. Only 5 percent of the stand of each plot containing alfalfa or sweet clover was estimated to be legume on June 30, 1950.

Application of phosphorus following scarification had no effect on yield but 30-N increased the yield and it produced significantly more when applied to scarified rather than to undisturbed sod. As in the first year, the plots receiving 60 pounds of N were most productive, yielding 1328 pounds more than the check, an increase of over 22 pounds of forage per pound of N applied.

Yields were not taken from the plowed and reseeded plots in 1950; however, it was evident that the grass seeded in the fall of 1949 was more vigorous and grew more rapidly on the fallowed plots than on those cropped with corn in 1949.

Third Year

In 1951, the third year of study, the plowed-fallowed-and-reseeded plots produced 2882 pounds of herbage per acre, significantly more than any other treatment. Comparison of the 2 treatments plowed in 1949 shows a 947-pound yield advantage for the fallow over the corn system. The value of fallow was evident during establishment of the seedlings and in the herbage yields the harvest year. The annual precipitation in 1949, 1950, and 1951 was 16.29, 19.30, and 20.31 inches, respectively, all above the long-time average. The moisture advantage of fallow would be of even greater value in establishing grass during years of below-normal precipitation.

Response to scarification was less in 1951 than in 1950. Scarification alone and with phosphorus was no better than no treatment; however, scarification plus legume or plus 30-N produced significantly more than the check. About 8 percent of the stand was alfalfa, but it contributed little to the forage production. No sweet clover was found in 1951.

Fourth and Fifth Years

The 2 years with extremes in precipitation and herbage production during the 12-year period occurred in succession. Precipitation was far below normal in 1952, with only 10.25 inches, and far above normal in 1953, with 21.76 inches. Lack of moisture in 1952 resulted in an average yield of only 359 pounds per acre with no significant difference between means (Table 1). In contrast, yields were unusually high in 1953, averaging 2238 pounds per acre. As would be expected with an abundance of moisture, the N plots produced the most. Yields from the 30-N plots were significantly higher than those of any of the plots not receiving N; and 60-N produced significantly more than either of the 30-N treatments. Thirty pounds of N produced an increase of over 60 pounds of herbage per pound of N applied on both the scarified and undisturbed sod. Sixty pounds of N on undisturbed sod produced only 43 pounds of additional herbage per pound of N.

Difference between mean yields of treatments not receiving N and the check were not significant. The importance of adequate moisture for production was illustrated by the 1447-pound yield of the check in

Table 3. Average yields for sprayed[1] and nonsprayed plots of 8 treatments of a 12-year crested wheatgrass renovation study.[2]

Treatment[3]	1959		1960		2-year av.	
	Sprayed	Nonsprayed	Sprayed	Nonsprayed	Sprayed	Nonsprayed
	(Pounds per acre at 12-percent moisture)					
Check	701 a[4]	398 a	1132 a	896 a	917 a	647 a
Scarification	950 ab	479 ab	1356 b	999 ab	1153 ab	739 a
Scarification + 60-P_2O_5	1091 ab	505 ab	1242 ab	1030 ab	1167 b	768 ab
Scarification + 30-N	1718 c	981 c	2128 c	2066 c	1923 c	1524 c
30-N	1349 bc	997 c	2186 c	1949 c	1768 c	1473 c
60-N	1681 c	1277 d	2986 d	3075 d	2333 d	2176 d
Plowed + corn	1182 ab	520 ab	1400 b	1068 ab	1291 b	794 ab
Plowed + fallow	1007 ab	641 b	1256 ab	1304 b	1132 ab	973 b
Average	1210	725	1711	1548	1461	1137

[1] Sprayed with 2.5 lbs. acid equivalent of 2,4-D ester on June 18, 1958.
[2] Each value is the mean of 3 replications.
[3] Treatments containing legume omitted from this part of the study.
[4] Within each column, means followed by the same letter do not differ significantly (5%) (Duncan 1955).

1953, which was larger than the majority of the renovation treatment means during the previous 4 years.

Five-year Average

Several factors influenced the average yield for the first 5 years of this study. Normally the first increase in yield through effective rejuvenation of an old stand of grass would be expected to be the largest if climatic conditions are conducive to normal plant growth. Annual precipitation in 1949 and 1950 was 16.29 and 19.30 inches. Increases in yield from 1949 to 1950 were 144 percent for the check and ranged from 318 to 584 percent for the scarification treatments without N. Scarification was effective in increasing yields significantly above those of the check in the year after treatment although yields of scarified plots had been no better than or less than those of the check in the first year. Application of N had a different initial effect on yield. A 155-percent increase in yield was obtained in the year of initial application of 60-N, and another 153-percent increase was obtained the second year of application. This resulted in a 142-percent increase in yield for the 60-N treatment from 1949 to 1950 compared with 144 percent for the check. Thus, other growth factors being the same for both treatments, the application of 60 pounds of N in 1950 was as efficient in increasing yields as was the 60-pound rate applied to the same plots in the previous year.

Plowing and reseeding produced still another initial response to treatment. Yields the first harvest year were very high, the mean yield of the plowed plus fallow treatment significantly exceeded the mean of the 60-N treatment. However, the following year (1952) was the driest of the 12 years, with only 10.25 inches of precipitation, and yields of all treatments were exceptionally low. In the first harvest year the fallow plots had produced significantly more than those cropped in 1949, but fallow showed no advantage in 1952 or in 1953, the year of highest precipitation (21.76 inches) during the study.

Drought, above-normal precipitation, and variation in initial response to various treatments are all reflected in the 5-year average. Scarification alone, with sweet clover, and with phosphorus produced no more than the check. The addition of alfalfa, sweet clover, or phosphorus to scarified sod produced no more hay than scarification alone. Application of 30 pounds of N on scarified sod produced significantly more than any of the other scarification treatments, but it was no better than 30-N on undisturbed sod for the 5-year period. The loss of 2 years' production by plowing and reseeding reduced the average yields for these treatments and their 5-year production was no better than that of the scarification treatments. By far the best yields of the 5-year period were obtained by application of N. The 60-N treatment produced significantly more than the 30-N treatment.

Years Six Through Twelve

During the last 7 years of the study the year-to-year yield pattern for the various treatments was very similar. The scarification plus sweet clover treatment was discontinued after 1953 because there had been no sweet clover in the plots since 1950 and the legume had no effect on the yield. Mean yields of the scarified, scarified plus phosphorus, and plowed plus corn treatments did not differ significantly from those of the check during this period, and the plowed plus fallow mean yield significantly exceeded that of the check in 1959 only (Table 2). The few alfalfa plants established in the

Table 4. Average yields from sprayed[1] and nonsprayed portions of an old crested wheatgrass pasture.[2]

Year	Sprayed	Nonsprayed	Increase	
	(Pounds per acre at 12 percent moisture)			Percent
1959	1604	1004	600	60
1960	2502	1554	948	61
1961	1482	1002	480	48

[1] Sprayed with 2.6 lbs. acid equivalent of 2,4-D ester on June 18, 1958.
[2] Each value is the mean of 6 caged areas in 1959 and 1960 and 5 caged areas in 1961 clipped at the soil surface.

scarification plus alfalfa plots became very large. Their contribution to the total yield was out of proportion to their population, thus this treatment often yielded as much as the 30-N treatments.

As in the first 5 years of the study, the application of N was the most effective method of increasing yield. Each year 60-N produced significantly more than either of the 30-N treatments.

Fringed sage re-invaded the plowed and reseeded plots rapidly after 1953. In 1956 over half of the material harvested from the plowed, scarified, and check plots was fringed sage. The weight of fringed sage from the plots receiving N actually exceeded the amount from the plots of the other treatments, but the increase in forage production due to the application of N resulted in a relatively lower percentage sage from the N plots.

Twelve-year average

Application of 60 pounds of N annually was the most effective means of increasing production over the 12-year period. The average yield of 2265 pounds per acre for the 60-N treatment exceeded the 30-N yield by an average of 762 pounds and furnished a return of 25 pounds of additional herbage per pound of N applied in the second 30-pound increment. The average yield of the 60-N treatment exceeded the check yield by 1660 pounds per acre, or an additional 28 pounds per pound of N applied.

Scarification plus alfalfa was the only treatment not receiving N to have a 12-year average yield of over 900 pounds per acre.

Fringed sage control

Perfect control of fringed sage was obtained by spraying with 2,4-D June 18, 1958. Yields of sprayed and nonsprayed halves of plots of each treatment harvested for 2 years are shown in Table 3. Differences between sprayed and nonsprayed means were highly significant for each year and for the 2-year average. The interaction of treatments with spraying was not significant for the 1959 data or for the 2-year average, but it was significant for the 1960 data. In 1959 and 1960, spraying increased yields by an average of 67 and 10 percent, respectively. Removal of the competition for moisture offered by the fringed sage may have been more beneficial in 1959, a year of below-normal precipitation (11.97 inches), than it was in 1960, when precipitation was near normal (14.98 inches). Yields of the nonsprayed areas in 1960 averaged more than twice those in 1959.

Three years' data from paired cages in the 1932 crested wheatgrass pasture showed a marked yield response to removal of the fringed sage (Table 4). The yields were all higher than those of the plot study presented in table 3 because the paired cages were clipped by hand at the soil surface. Removal of the fringed sage increased the herbage production by 2028 pounds over a 3-year period. The percentage increase in yield was less in 1961 than it was in the 2 previous years. A natural decrease in fringed sage occurred in 1961; thus competition in the nonsprayed area was less. The percentage sage in the nonsprayed areas averaged 19, 21, and 8 percent in 1959, 1960, and 1961, respectively.

Summary

Ten renovation treatments involving complete, partial, and no destruction of the old sod were compared on a 17-year-old crested wheatgrass pasture for 12 years.

Killing ⅓ of the grass plants by scarification with a field cultivator resulted in a decrease in production the year of treatment and an increase in production 1 year after treatment. Yield increases from scarification were not significant for the remainder of the 12-year period.

Application of phosphorus or seeding sweet clover on scarified sod showed no advantage over scarification alone. Alfalfa seeded on scarified sod was very slow to become established, but after the fifth year following seeding the alfalfa, this treatment produced more forage than scarification alone.

Killing all the old plants by plowing and reseeding resulted in very high yields the second year after reseeding the grass; however, two years of production were lost in establishing the new stand and the new stand rapidly declined in productivity. This method had very little long-time advantage over scarification. Growing corn rather than fallowing the plowed sod supplied a crop for one of the two production years lost during reseeding, but the first hay crop and the total production for the first 3 harvest years were significantly decreased when the corn crop was grown.

The outstanding renovation treatment was application of N to undisturbed sod. Yields were significantly increased by each of the two 30-pound increments of N in each year, including the first year of application, except in the drought year of 1952. Yields of the 30- and 60-N treatments averaged 2.5 and 3.7 times those of the check for the 12-year period. Scarification before application of 30-N produced no more herbage during the 12-year period than 30-N applied to undisturbed sod.

Removal of the fringed sage by spraying significantly increased yields from all treatments.

The results of this study indicate that a combination of weed control and nitrogen fertilization should be an effective means of renovating low-producing crested wheatgrass stands containing a fair to good stand of low-vigor plants in areas having enough soil moisture during the spring to promote active growth of the grass.

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