Native Grass and Crested Wheatgrass Production as Influenced by Fertilizer Placement and Weed Control[1]

D. E. SMIKA, H. J. HAAS, AND G. A. ROGLER

Soil Scientists, Soil and Water Conservation Research Division; and Research Agronomist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Mandan, North Dakota. The senior author is presently located at North Platte, Nebraska

In foreign countries and in most areas of the United States, fertilization of grassland is being practiced more extensively than ever before. The most convenient and most widely used method of fertilizer application is surface broadcasting. Another method — subsurface placement —has gained popularity in recent years, largely because of the manufacture of machines specifically designed for this purpose. But does subsurface-placed fertilizer produce greater yield increases than fertilizer broadcast on the surface?

Karlorisky (1957) found over a 2-year period that subsurface placement of phosphorus fertilizer resulted in lower grass yields than surface broadcasting. The National Joint Committee on Fertilizer Application (1948) reported that there is no need for incorporating any fertilizer material into the soil for grass unless liquid or gaseous forms of nitrogen are used. Neller and Hutton (1957) working in Florida found that depth of fertilizer placement did not significantly affect growth of grass.

In the Northern Great Plains cool-season grass species such as western wheatgrass *(Agropyron smithii)*, needle-and-thread grass *(Stipa comata)*, and crested wheatgrass *(Agropyron desertorum)* respond to nitrogen fertilization with very vigorous growth in early spring (Rogler & Lorenz, 1957). However, weeds and various sage species present in much of the grassland will also respond to nitrogen and make heavy growth, particularly during the first growing season after fertilization.

Vigorous cool-season grass growth and perennial weed growth may suppress warm-season annual weed growth. In a review on pasture weed control in the North Central Region, Klingman (1956) reported that fertilizer helped control some weeds, particularly annuals, by developing competition from grasses. Hay and Quellettee (1959) obtained some weed control with fertilizer alone, but best results from the standpoint of both yield of grass and absence of weeds in pastures were obtained when fertilizer treatment was supplemented by 2,4-D applications.

The study reported herein was conducted at the Northern Great Plains Field Station, Mandan, North Dakota. The objectives were to (1) determine the effect of one application each of surface broadcast and subsurface placed nitrogen and phosphorus fertilizer on the yield of native grass and crested wheatgrass, and (2) determine the effects of chemical weed spray and fertilizer and the interaction of these treatments on the control of fringed sage and other weeds and the subsequent effect on the yield of grass in the two pastures.

Methods and Materials

This experiment was conducted on two sites. One was isolated from grazing in a native pasture that had been heavily grazed for 42 years. The second site was isolated from grazing in a crested wheatgrass pasture which had been seeded in 1932 and grazed annually from that time on. The native grass area at the beginning of the study was a mixed-prairie type, about 80 percent blue grama *(Bouteloua gracilis)*. Other grass species were western wheatgrass, needle-and-thread, and thread-

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Table 1. Seasonal, April through July, climatic data during period of study and long time average. Northern Great Plains Field Station, Mandan, North Dakota.

	1958	1959	1960	45 year average
Precipitation (inches	8.74	5.28	10.94	9.34
Evaporation (inches)	21.91	23.40	22.53	21.80
Mean seasonal temperature				
Maximum (°F)	70	72	71	68
Minimum (°F)	46	46	45	46

leaf-sedge *(Carex filifolia)*. The crested wheatgrass pasture contained only a sparse stand of the original grass. Both areas had a very high infestation of fringed sage *(Artemisia frigida)*. Other weeds of importance growing on the plots of both areas were marestail *(Erigeron canadensis* L.), dandelion *(Taraxacum officinale)*, and tansy mustard *(Descurainia pinnata)*.

The soil at both experimental sites is Eakin silt loam, which consists of a loess layer of about 24 inches over glacial till. At both sites the 0-to- 6-and 6- 12-inch depths had a saturated paste pH of 6.5 and 6.6, respectively. The average total nitrogen content of the 0-to 6-and 6-to 12-inch depths was .274 and .160 percent, respectively, at the native grass plot site and .239 and .126 percent, respectively, at the crested wheatgrass plot site. Sodium bicarbonate soluble phosphorus content of the 0-to 6-and 6-to 12-inch depths was 25 and 13 pounds of P_2O_5 per acre, respectively, in both plot areas. At this phosphorus level, yield response to phosphorus fertilizer was considered probable.

Climatic data during the 3 years of the study and 45-year averages are presented in Table 1.

A split-split plot design with three replications was used in both study areas. Main plots were fertility treatments—0-0, 40-0, 80-0, 160-0, 0-40, 80-40, and 80-80 pounds of nitrogen (ammonium nitrate) and P_2O_5 (triple super phosphate) per acre, respectively. Subplots (11.8 by 24 feet) were fertilizer application methods—surface broadcast and subsurface placement at a 4-inch depth. One-half of each non-fertilized plot was treated with the drill without fertilizer to determine the effect of the drill alone. Fertilizer was applied only once, on October 28 or 29, 1957, by means of a John Deere Grassland Drill.[2] This implement had 2-inch shoes spaced ten inches apart. One-half of each subplot was sprayed on June 9, 1958 at the rate of approximately 2.5 pounds of acid equivalent 2,4-D ester per acre.

The crested wheatgrass and native grass plots were harvested each year in late June and late July, respectively. The grass on both sites was harvested at approximately one-inch above the ground. Sage and other weeds were hand-separated from the grass and the amount of each determined on a dry weight basis.

Table 2. 1958-60 average ovendry yields of native grass by fertilizer treatments and method of application.

Fertilizer treatments $N\text{-}P_2O_5$	Grass Yields: Fertilizer surface broadcast	Fertilizer subsurface placed: drill effect included	Fertilizer subsurface placed: drill effect deducted
	(Pounds/Acre)		
0-0	340	490*	340
40-0	490	600	450
80-0	800	940	790
160-0	1100	1190	1040
0-40	290	480*	330
80-40	710	920*	770
80-80	770	910	760

* Significantly greater than surface broadcast yield (P .05 or greater).

Results and Discussion

Native Grass Study

Fertilizer placement — Grass yields were greater from the subsurface-placed than from the surface broadcast treatment (Table 2). The difference, however, was due to the cultivating effect of the drill rather than to placement of fertilizer. That is, when the increase due to the drill alone on the non-fertilized treatment was deducted from the yield of each of the other subsurface-placed fertilizer treatments, there was no difference in yield due to placement of fertilizer. Grass height on plots in which fertilizer was subsurface placed averaged over two inches taller than on plots which received the surface application of fertilizer for the three years of study. The cultivating action of the drill on the subsurface-placed plots thinned the stand of grass but did not increase weed production. Thus, there were fewer plants to compete for moisture and nutrients, which resulted in greater grass growth.

The response to fertilizer was due entirely to nitrogen. No yield increase was obtained from phosphorus irrespective of rate, method of application, or the addition of nitrogen even though a soil test indicated a response

[2] *The mention of the specific name of this implement does not constitute endorsement by the United States Government. It is used only to identify the type of implement used.*

Table 3. Fringed sage and other weeds in native grass yields during 3 years[1] by fertilizer and spray treatments.

Fertilizer treatments N-P_2O_5	Non-Sprayed Treatment 1958	1959	1960	Sprayed Treatment 1958	1959	1960
(Lbs./Ac)	(Percent)					
0-0	53.5	10.8	21.5	6.2	1.3	3.5
40-0	58.5	8.8	31.8	28.6	0.4	1.6
80-0	70.9	15.8	18.8	22.2	0.8	2.9
160-0	72.3	17.0	24.0	22.8	3.4	0.3
0-40	60.6	9.5	29.5	23.3	0.0	4.6
80-40	75.0	15.3	17.0	31.1	0.0	1.3
80-80	75.8	10.5	16.2	27.5	0.1	5.1

[1] Average of subsurface placed and surface broadcast plots.

to phosphorus could be expected.

Spraying effects — Percent of fringed sage and other weeds in native grass (Table 3) was largely reduced by spraying alone. Some additional decrease occurred, however, in the second year after spraying where 160 pounds of nitrogen fertilizer had been applied in conjunction with spraying. Fertilization alone had little effect on reducing the weed content.

Table 4. Ovendry yields of native grass for the 1958-1960 period by fertilizer and spray treatments.

Fertilizer treatments N-P_2O_5	Non-Sprayed Treatment	Sprayed Treatment	Increase due to spray
(Pounds/Acre)			
0-0	370	450	80**
40-0	480	610	130**
80-0	770	970	200**
160-0	1020	1260	240**
0-40	360	410	50**
80-40	740	890	150**
80-80	770	910	140**

** Significant increase P .01.

Much of the high sage and other weed content in the sprayed plots consisted of dead plants. Spraying killed the plants but they were still present and made up a considerable portion of the 1958 harvest yields.

Weed production on the non-sprayed plots was much less in 1959 than in 1958, possibly due to less precipitation in 1959. In those plots which had been sprayed there was very little weed growth.

In general, fringed sage and other weed production increased in 1960 on both the sprayed and non-sprayed plots, compared to 1959. More precipitation in 1960 may have accounted for this. The percentage present in the sprayed plot yields, however, was still very small.

The number of years that a single spraying will be effective has not been determined. In the present study it has been effective for three years and it appears that there may be some carryover into the fourth year.

Yields of native grass from all fertilizer treatments (Table 4) were higher with spraying than without. The difference between native grass yields from sprayed and non-sprayed treatments increased as the rate of nitrogen increased. By controlling the weed growth with spray, more nitrogen and moisture were available to increase grass growth rather than weed growth.

Crested Wheatgrass Study

Fertilizer placement — Yields of crested wheatgrass were greater when the fertilizer was subsurface placed than when broadcast (Table 5). As with the native grass the increase from subsurface placement of fertilizer was due to the cultivating effect of the drill alone and not the placement of the fertilizer.

Crested wheatgrass responded to phosphorus only when nitrogen was applied with phosphorus. Method of application had no effect on response.

Spraying effects — Percentage of fringed sage and other weeds was reduced considerably in 1958 and practically eliminated in 1959 and 1960 by the single spray application in 1958 (Table 6).

In 1958, dead weeds, consisting

Table 5. Average ovendry crested wheatgrass yield, 1958 to 1960,[1] by fertilizer treatments and methods of application.

Fertilizer treatments N-P_2O_5	Fertilizer surface broadcast	Fertilizer subsurface placed: Drill effect included	Drill effect deducted
(Pounds/Acre)			
0-0	370	710**	370
40-0	600	980**	640
80-0	790	1090*	750
160-0	940	1190*	850
0-40	340	690*	350
80-40	840	1210*	870
80-80	960	1270*	930

[1] Average of sprayed and non-sprayed plots.
* Significantly greater than surface broadcast yield P .05.
** Significantly greater than surface broadcast yield P .01.

Table 6. Fringed sage and other weeds in crested wheatgrass during 3 years[1] by fertilizer and spray treatments.

Fertilizer treatments $N-P_2O_5$	Non-Sprayed Treatment			Sprayed Treatment		
	1958	1959	1960	1958	1959	1960
(Lbs./Ac)	(Percent)					
0-0	25.9	4.4	11.3	7.9	0.5	0.0
40-0	29.6	2.3	1.2	11.7	0.0	0.0
80-0	32.6	3.1	1.6	10.2	0.0	0.0
160-0	32.9	1.3	0.9	13.2	0.0	0.0
0-40	29.3	2.5	7.4	10.4	0.4	0.0
80-40	30.3	1.6	0.8	15.8	0.0	0.0
80-80	27.9	0.3	0.6	12.7	0.1	0.0

[1] Average of subsurface placed and surface broadcast plots.

Fringed sage and other weeds were primarily controlled in both pastures by spraying alone. The nitrogen fertilization, however, was moderately successful in reducing the weed percentage in crested wheatgrass the second and third year after application by encouraging the growth of grass, which in turn offered greater competiton to weeds. Where weed growth was eliminated by spraying, grass yields were increased.

primarily of fringed sage, were still present at harvest time in the sprayed plots. If spraying had been done earlier, weed growth would probably have been less. Fertilization tended to increase the percentage of weeds in both the sprayed and non-sprayed yields in 1958.

By 1959, no weeds or sage were present where nitrogen was applied in conjunction with the spray. All non-sprayed plots also showed a sharp reduction in weed percentage in 1959, with plots which had received nitrogen showing the greatest reduction.

Weeds were not present in 1960 in plots which had been sprayed in 1958 and were less prevalent in the non-sprayed, nitrogen-fertilized plots than in 1958 and 1959. On the non-sprayed, no nitrogen plots, percentage of weeds increased in 1960 compared to 1959.

A single spray application and nitrogen fertilizer were successful in eliminating sage and other weeds from the crested wheatgrass yields.

Yields of crested wheatgrass were slightly higher from sprayed than from non-sprayed areas (Table 7). However, the differences were significant for only the 0-0 and 0-40 treatments.

Table 7. Ovendry crested wheatgrass yields from sprayed and non-sprayed plots by fertilizer treatments.[1]

Fertilizer treatments $N-P_2O_5$	Non-Sprayed Treatment	Sprayed Treatment	Increase due to spray
	(Pounds/Acre)		
0-0	470	610	140**
40-0	780	790	10
80-0	930	950	20
160-0	1010	1030	20
0-40	470	560	90**
80-40	1000	1060	60
80-80	1110	1120	10

[1] Average of subsurface placed and surface broadcast plots for the period 1958-1960.

** Significant increase P .01

Summary

Effects of surface and subsurface placement of fertilizer on the yield of native grass and crested wheatgrass were determined, as well as the effects on yield of 2,4-D spraying to control fringed sage and other weeds.

Yields of both native and crested wheatgrass were higher when fertilizer was subsurface placed, but the increase was due to the cultivating effect of the drill and not to the placement of the fertilizer. Native grass showed no yield response to phosphorus with or without nitrogen, but crested wheatgrass showed a small response to phosphorus when applied in conjunction with nitrogen.

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