Fertilizer Effects on Hay Production of Three Cultivated Grasses in Southern Saskatchewan[1]

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The importance of cultivated forage crops in the Northern Great Plains continues to increase. Each year more stockmen are turning to, or extending, established cultivated forage crops for their winter feed requirements. Unfortunately, many of the dryland hay fields are composed of grasses only, notwithstanding recommendations to seed grass-legume mixtures. Grass alone becomes sod-bound quickly and resultant hay yields are low. This is attributable to an insufficient supply of available nitrogen in an area where the climate is usually the main uncontrollable limiting factor. Thus, it seems important to learn as much as possible about the factors which can be controlled.

Although fertilizer trials on cultivated grasses for hay in dry climates have been, and are being conducted, few results have been published. Most reports deal with fertilizer trials on grass-legume mixtures, or those which are grown on irrigated lands, or those which are grown outside the Northern Great Plains region. Rogler and Lorenz (1956) reported that nitrogenous fertilizer applications on native grassland in North Dakota increased yields and speeded the recovery of overgrazed fields. Stitt, *et al.* (1955) observed the benefits of fertilizer application to crested wheatgrass in Montana and found that 25 to 30 pounds of nitrogen per acre increased the hay yield of crested wheatgrass from 300 to 600 pounds per acre; however, a good deal of their work dealt with the response and influence of the volunteer sweet clover which was present in the stand.

The experiment being discussed in this paper was undertaken to measure the response of pure stands of crested wheatgrass (*Agropyron cristatum*), intermediate wheatgrass (*Agropyron intermedium*) and Russian wildrye (*Elymus junceus*) to fertilizer applications. It was conducted at Swift Current, Saskatchewan, which is near the center of the Northern Great Plains region. The climate at this point is classified as semi-arid with an average annual precipitation of 13.97 inches and a precipitation/evaporation index of 0.45. The soil is classified as a light loam, low in organic matter and available nitrogen, and a member of the chestnut or brown soil zone.

Experimental Methods

Blocks of crested wheatgrass, intermediate wheatgrass and Russian wildrye were seeded in 12-inch spaced rows during May, 1952. Each block was 3x85 rods.

In October 1953, a fertilizer test was established on these three adjacent strips of grass. The experiment was designed as a random block with 6 fertilizer treatments plus a check. Five replications were used. Individual fertilizer plots were 40 feet wide by 9 rods long—the total width of the three grass strips.

One hundred and two hundred pounds of ammonium phosphate (11-48-0), ammonium phosphate-sulphate (16-20-0), and ammonium nitrate (33.5-0-0) comprised the 6 fertilizer treatments. The fertilizers were applied by drilling into the sod during October of each year from 1953 to 1956 inclusive.

Results and Discussion

Dry matter yields from the three grasses according to fertilizer applications are presented in Table 1. The 4-year average

[1]*Contribution from Experimental Farms Service, Canada Department of Agriculture, Ottawa.*

Table 1. Four-year average dry matter yields of grasses in relation to fertilizers applied.

Fertilizer and Formulation	Application Rate in Pounds per Acre	Pounds of Element Per Acre		Tons Per Acre			Fertilizer Mean
		N	P_2O_5	Crested Wheat	Russian Wildrye	Intermediate Wheat	
Ammonium phosphate	100	11	48	.48	.31	.56	.45
(11-48-0)	200	22	96	.56	.42	.69	.56
Ammonium phosphate-sulphate	100	16	20	.59	.40	.59	.53
(16-20-0)	200	32	40	.82	.44	.67	.64
Ammonium nitrate	100	34	—	.74	.42	.67	.60
(33.5-0-0)	200	67	—	1.16	.62	.81	.86
Check—no fertilizer	—	—	—	.35	.24	.54	.38
L.S.D. (P= .05)				.14	.11	.21	

yield increased with increasing levels of nitrogen, irrespective of the source of nitrogen. As the phosphorus in the mixed fertilizers did not increase yield, the discussion following will be confined to the effects of nitrogen—irrespective of its source. Likewise, earliness of spring growth and darkness of foliage color were related to the increasing amounts of nitrogen applied.

The unfertilized check showed that intermediate wheatgrass outyielded crested wheatgrass and Russian wildrye. However, the response of crested wheatgrass to the higher levels of nitrogen was such that its dry matter yields were greater than yields of intermediate wheatgrass at the same levels of nitrogen. Russian wildrye did not yield as much as either of the wheatgrasses following any of the treatments, although its proportionate yield increases were greater than those of intermediate wheatgrass.

The highest yields were obtained in 1954 (Table 2) when the precipitation, particularly during the month of May, was high. The increases attributable to nitrogen applications were good for all species. Crested wheatgrass produced a maximum increased yield which was 3.7 times greater than that of the check, while Russian wildrye was 2.9 times greater, and intermediate wheatgrass 1.5 times greater. Although overall yields were less in 1955, the percentage increase of crested wheatgrass and Russian wildrye to nitrogen was as marked as in 1954. During 1956 and 1957, when the spring seasons were dry, the responses to nitrogen were quite small, with crested wheatgrass responding better than the other two grasses.

Yield responses of the different grasses in each year at the various levels of nitrogen fertilizer are illustrated by the graphs in Figure 1. It will be noted that the yield response lines for crested wheatgrass are steeper than those for the other two grasses indicating that more dry matter was produced per unit of nitrogen applied. In every year 30 pounds of nitrogen doubled the yield of crested wheatgrass, while 65 pounds tripled or quadrupled it. Russian wildrye yield increments were moderately good in 1954 and 1955, but very small in 1956 and 1957. Intermediate wheatgrass gave a response to fertilizer only in 1954.

For clearer yield response comparisons between species the 4-year mean yields at varying levels of nitrogen are shown in Figure 2. The crested wheatgrass line is the steepest, indicating that it responds better to increased amounts of nitrogen.

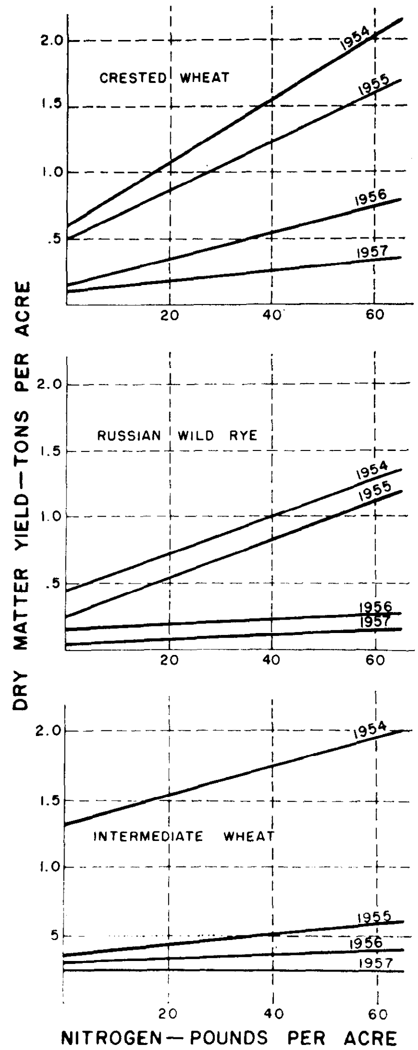

FIGURE 1. Yield response of each grass each year to various levels of nitrogen application.

Russian wildrye was somewhat better than intermediate wheatgrass in this respect. At the high level of nitrogen application the yield of crested wheatgrass was 3 times greater than that of its check, Russian wildrye was twice as much, and intermediate wheatgrass only half again as much.

The importance of yield increases by themselves cannot be properly assessed without subjecting them to cost analysis studies to determine whether it pays to apply fertilizer. Nitrogen fertilizer, even in its least expensive form as ammonium nitrate, costs about 15 cents per pound of elemental nitrogen. On the pre-

Table 2. Average dry matter yields of the three grasses in relation to fertilizers, years, and precipitation.

Fertilizer	Application Rate in Pounds per Acre	Pounds of Nitrogen	Tons Per Acre 1954	1955	1956	1957
11-48-0	100	11	.97	.42	.24	.15
	200	22	1.15	.55	.32	.19
16-20-0	100	16	1.02	.55	.33	.20
	200	32	1.33	.69	.34	.22
33.5-0-0	100	34	1.21	.63	.37	.21
	200	67	1.76	1.11	.34	.24
Check			.79	.35	.22	.15
Year Mean			1.18	.61	.31	.20
Annual precipitation in inches			19.71	17.31	13.15	11.80
May precipitation in inches			3.37	2.58	1.24	.13

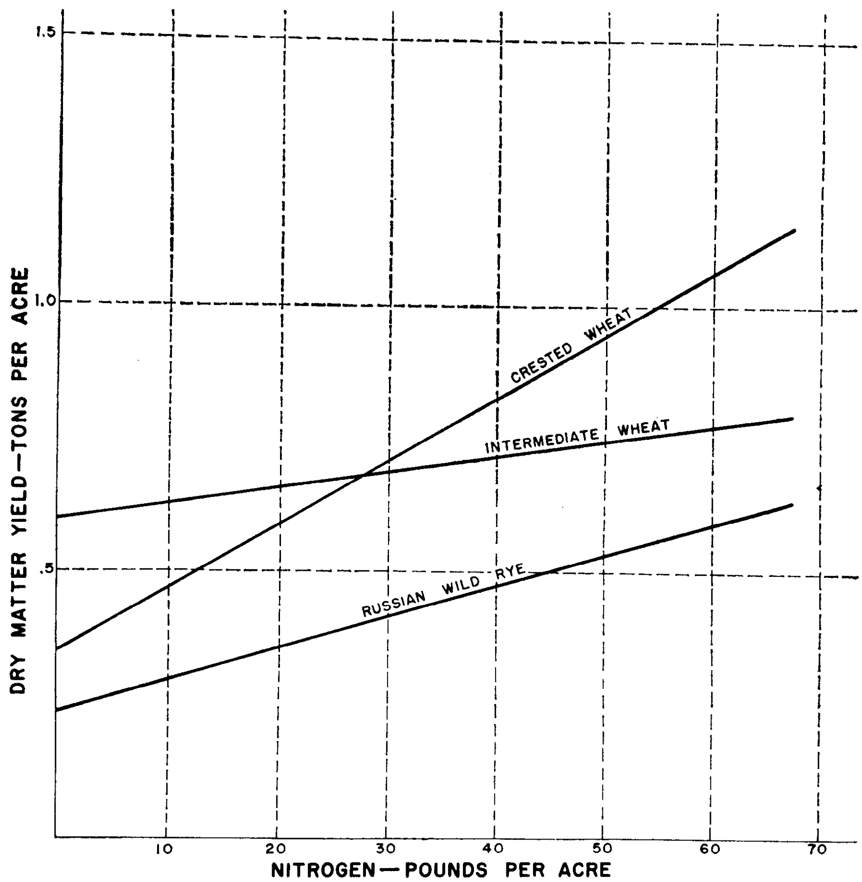

FIGURE 2. Four-year average yield response of each grass to levels of nitrogen application.

mise that hay is worth 15 dollars per ton then each pound of elemental nitrogen applied must produce 20 pounds of hay to pay for itself. Any yield increase short of 20 pounds per pound of nitrogen increases the cost of the extra hay. The pounds of hay return per pound of nitrogen applied obtained in this experiment are shown in Table 3. Many of the values shown are less than the required 20-pound level for economic returns. The influence of the latter two dry years will be noted. Crested wheatgrass yields were adequate for nearly three years out of four, Russian wildrye yields two years out of four, while intermediate wheatgrass yields were adequate only in the first year, when 20 or more pounds of nitrogen were applied.

The 4-year average cost of each additional ton of hay obtained from various levels of nitrogen fertilizer was computed and is illustrated graphically in Figure 3. Only crested wheatgrass produced additional hay at all levels of nitrogen at a cost of less than 15 dollars per ton. Additional hay of Russian wildrye cost an average of 24 dollars per ton, while additional intermediate wheatgrass hay cost anywhere from 30 to 90 dollars per ton.

The results from this 4-year fertilizer trial should not be construed as a recommendation for, or a condemnation of the use of fertilizers on grasses for dryland hay production in the Northern Great Plains region. Certainly there were early growth and yield increases due to fertilizer, but just as certainly the results point to the borderline nature of the economical returns. It does not appear that the use of fertilizers on grass for hay production in such an arid region will approach the steady performance obtainable from a mixture of grass and alfalfa. On the other hand there are instances where fertilizing grass for added hay production might play an important role. In his management program a stockman may, for a reason other than drought, be forced to face a short feed year. Rather than buy additional feed at high prices with long hauling distances, he may be wiser to grow it himself by applying fertilizer.

Another very important consideration in any fertilizer venture is the formulation of the fertilizer. If response is due sole-

Table 3. Pounds of hay increase for each pound of nitrogen applied.

Year	Pounds of Nitrogen Per Acre				
	11	16	22	33	67
			Crested Wheatgrass		
1954	52	49	32	47	47
1955	24	31	32	31	36
1956	15	25	15	20	9
1957	-2	15	7	6	4
			Russian Wildrye		
1954	33	26	35	20	17
1955	20	39	25	20	23
1956	-2	10	4	3	2
1957	2	4	1	5	3
			Intermediate Wheatgrass		
1954	16	14	33	20	24
1955	-2	5	7	5	8
1956	0	6	9	4	-2
1957	2	-2	8	2	1

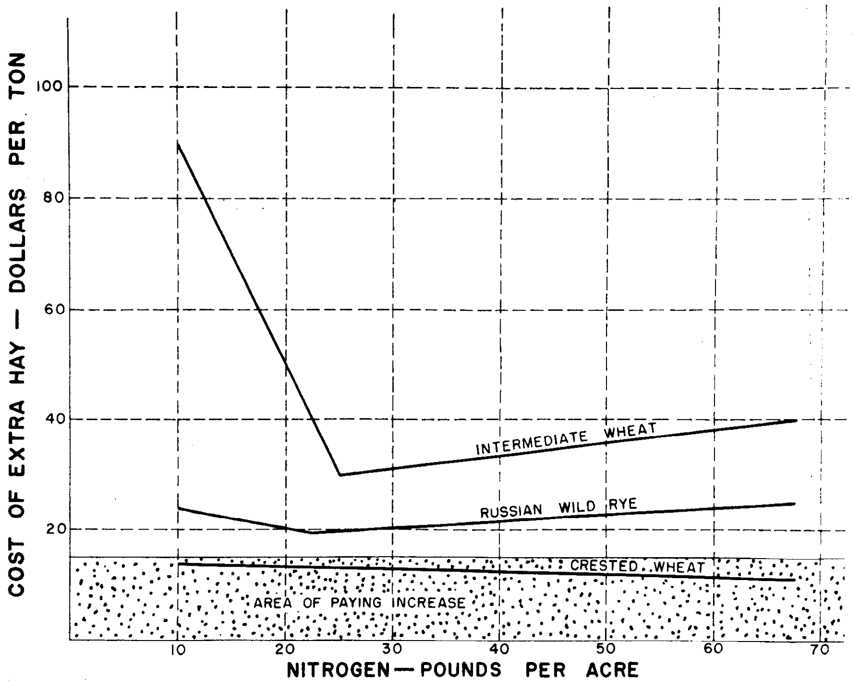

FIGURE 3. Cost of each additional ton of hay resulting from various levels of nitrogen application.

ly or mainly to nitrogen, then it is advisable to avoid the use of mixed fertilizers. The fertilizer to use in this case would be the one containing only nitrogen.

More than anything else these preliminary fertilizer trials emphasize the need for more detailed experimentation over a longer period of time with a greater number of plant species and varieties.

Summary

Pure stands of crested wheatgrass (*Agropyron cristatum*), intermediate wheatgrass (*Agropyron intermedium*), and Russian wildrye (*Elymus junceus*) were fertilized for four years at Swift Current, Saskatchewan, Canada. Commercial fertilizers, including ammonium phosphate (11-48-0), ammonium phosphate-sulphate (16-20-0), and ammonium nitrate (33.5-0-0) each at 100 and 200 pounds per acre were applied for dryland hay production studies.

None of the grass stands responded to phosphorus, but there was a general yield response to increasing amounts of nitrogen. Paying hay yield increases from applications of nitrogenous fertilizers on crested wheatgrass were obtained in most years. Increases in yield of Russian wildrye from nitrogenous fertilizers were economical during the first 2 moist years. Intermediate wheatgrass increases were economical only at higher levels of nitrogen in the first wet year.

Favorable precipitation, especially in May, is an important requirement for the successful and economical use of fertilizers on pure stands of cultivated grass hay in this part of the Northern Great Plains region.

LITERATURE CITED

ROGLER, G. A. AND R. J. LORENZ. 1956. Nitrogen fertilization of Northern Great Plains rangelands. Jour. Range Mangt. 10: 156-160.

STITT, R. E., J. C. HIDE AND ELMER FRAHM. 1955. The response of crested wheatgrass and volunteer sweetclover to nitrogen and phosphorous under dryland conditions. Agron. Jour. 47: 568-572.

Research Grants Received at University of Arizona

The Range Management Department of the University of Arizona, now included as part of the University's newly organized Department of Watershed Management, has received two research grants. The National Science Foundation has provided $36,000 for the study of annual rings of desert shrubs. It is hoped that by determining the age of these shrubs through ring studies, new information on causes of brush invasion of range lands may be discovered.

The Charles Lathrop Pack Foundation has awarded a grant of $5,300 plus operating expenses, to be made available annually for a three year period. Research carried on under this grant will be in basic transpiration studies of range plants.