Effect of Snowtrapping and Fertilization on Production of Crested Wheatgrass and Native Pastures in Southwest Saskatchewan

M P. Schellenberg
Agriculture and AgriFood Canada

J Waddington
Kelowna, British Columbia

EFFECT OF SNOWTRAPPING AND FERTILIZATION ON PRODUCTION OF CRESTED WHEATGRASS AND NATIVE PASTURES IN SOUTHWEST SASKATCHEWAN

M.P. Schellenberg[1] and J. Waddington [2]

[1] Semiarid Prairie Agricultural Research Centre, Agriculture and Agri-Food Canada, Box 1030, Swift Current, Saskatchewan, S9H 3X2, Canada

[2] Retired scientist, 3278 Boucherie Road, Kelowna, British Columbia, V1Z 2H2

ABSTRACT

The benefits of increasing soil water with snow management and fertilizer for annual and perennial crops have been demonstrated for semiarid environments. We examined the combined effect of snow management and fertilizer on forage production. In 1985, vertical wood slat or slotted plastic snow fencing (0.7m high) were erected on crested wheatgrass (*Agropyron cristatum*) pasture. In 1986, five rates of fertilizer: 400, 200, 100, 50, 0 kg ha^{-1} nitrogen each with 50 kg ha^{-1} phosphorous and a sixth treatment with no fertilizer were applied to each side and type of the snowfence. A second site was selected on native range in fall 1986 with fertilizer applied in spring 1987. Samples were harvested from subplots every 1.5m perpindicular to the fence in the subsequent springs until 1991. Production of crested wheatgrass and native range was influenced by the fertility level, type of snowfence, distance and direction from the snowfence.

KEYWORDS

Snow management, fertilizer, native range, Crested wheatgrass, *Agropyron cristatum*, forage production

INTRODUCTION

Snow management in the northern Great Plains will increase stored soil water and yields of annual crops (Black and Siddoway, 1971, 1976; Greb and Black, 1971; Steppuhn, 1980), and perennial forages (Haas and Willis, 1971; Greb, 1980; Ries and Power, 1981 and Waddington and Steppuhn, 1995). After soil moisture, low fertility, particularly nitrogen, is generally considered to be limiting forage productivity in semiarid southwestern Saskatchewan (Leyshon 1978). Forage production has shown no response to phosphorus fertilization although it is considered that some P is required to obtain the maximum response from N (Leyshon 1978). We conducted two experiments to determine the combined effect of snow management and fertility on forage. Two types of snow fence were compared in each experiment.

METHODS AND MATERIALS

Starting in fall 1985 and each fall through 1990, two types of snow fencing, vertical wood slat and slotted plastic, 0.7m high were erected in a single line in an East-West direction in an established field of crested wheatgrass (*Agropyron cristatum* (L.) Gaertn.). The land had a slight downward slope to the Northwest. Each fence type was 14 m long with the plastic to the west of the wood. Each spring after the snow had melted, the fences were removed. On 7 April 1986, fertilizer was broadcast in strips 2m wide by 35m long, perpendicular to the snowfence, on both sides. There were five rates of fertilizer: 400, 200, 100, 50, 0 kg ha^{-1} nitrogen (46-0-0) each with 50 kg ha^{-1} phosphorus (0-45-0), and a sixth treatment with no added fertilizer. The treatments were randomized separately for each side of the snowfence and each snowfence type. In late June or early July in 1986, 1987, 1989, and 1991, starting at the line of the snowfence and continuing at 1.5m intervals perpendicular to the snowfence, forage was harvested from 20 areas each 1.3m x 0.64m in each treatment using a flail harvester (Thompson 1972). The forage was cut to leave a 5cm stubble, dried, and weighed. In fall 1986, a similar experiment was started on an area of native range 1 km north of the crested wheatgrass site. The snowfences were erected in a north-south direction, the fertilizers were applied in 1987, and harvests made in 1987, 1989, and 1991. Each year, yield data from each experiment were analysed in three ways using a one-replicate, two-factor factorial design. The factors were: type of snowfence, and side of snowfence. In the first analysis, distance from the snowfences was a subplot factor. In the second analysis, distance and squared distance from the snowfence were covariates. In both, yield data were converted to logarithms prior to analysis to normalise the variances. To isolate any interaction between distance from the snowfence and fertilizer effects, the ratio: yield from fertilized plots/average yield from non-fertilized plots at each distance from the fence, was calculated. In the third analysis, these ratios were subjected to analyses of covariance using the same design and covariates as before, but with one less treatment.

RESULTS

The kind of snowfence used did not affect crested wheatgrass production. On the native grass area, significantly more forage was produced on the east side of the fences, and areas influenced by the plastic fence produced more forage (Table 1).

Application of N fertilizer increased crested wheatgrass forage production significantly in 1986 and in 1989 (Table 1). Increasing the amount applied significantly increased production in 1989 and 1991, particularly at the 400 kg ha^{-1} rate. Fertilizer application to the native area in 1987 increased forage production significantly in 1989 and 1991. Applying 50 kg ha^{-1} of phosphorus increased production significantly only from crested wheatgrass in 1991.The limited rainfall in 1987 appeared to prevent the native grasses from responding to the applied fertilizer until later years.

In general, forage yield was significantly affected by distance from the snowfence. Also, yields of crested wheatgrass showed significant interaction between combinations of distance from the snowfences with: type of snowfence, direction from the snowfence, and amount of fertilizer applied. In the native area, interactions of distance from the fences were with fence type and fertilizer rate in 1987, and with direction from the snowfences and fertilizer rate in 1989 and 1991. On an individual plot basis, the proportion of variance explained by distance from the snowfence ranged from 82% to less than 1%. When averaged across factors the proportion of variance explained by distance from the snowfences was generally less than 30%. The effect of distance from the snowfences averaged across all factors in each experiment in each year explained less than 15% of the variability in the data. When the ratio: yield with/yield without fertilizer was regressed with distance and squared distance of the sample from the snowfence in crested wheatgrass, both regression parameters were significantly different from zero in 1986 for all nitrogen application rates on the north side of the snowfences, and for rates of 100 kg ha^{-1} or above on the south side of the snowfences, but did not differ between fertilizer rates (Table 2). In 1987, only the 400 kg ha^{-1} rates were significant, and in 1989 and 1991, only the zero nitrogen rates on the north side of the snowfences were significant. In the native area, the effect of distance from the snowfences interacting with location relative to the fences on the ratio: yield with/yield without fertilizer, was significant in 1989 and 1991, and there was a trend towards larger parameter values as fertilizer amount increased. The trend was most clearly present in 1991 on the east side of the snowfences (Table 2).

DISCUSSION

The predominant winter wind direction at Swift Current is from the northwest, so snowdrifts are usually deeper and more extensive south and east of obstructions. In these experiments, the snowfence increased native forage consistently on the east side, but the snowfence area had much less effect on crested wheatgrass forage. According to Tabler

(1980), the vertical-slat wood fence used in the present experiments stores about 26% less snow than the horizontal-slat "Wyoming" fence having approximately the same porosity. The plastic fence used in the experiments should be considered to be a design between the horizontal- and vertical-slatted fence types consisted of both vertical and horizontal slats. Our results suggest that the plastic fence is slightly superior to the wood fence, although forage yields were not consistently increased adjacent to it. The variability in R^2 values of the regression of yield on distance from the snowfences indicates that other influences had a greater impact. One possible influence is spring precipitation, with a possible relationship between forage yield and spring precipitation. A second possible factor was the effect of wind blowing around the edges of the snowfences reducing snow accumulation. The fences were not extended beyond the experimental areas far enough to avoid this problem.

The interaction between water and fertility level occurred with crested wheatgrass in 1986 and native range in 1989 and 1991, the distance parameters were significantly different from zero. They indicated a maximum positive interaction between distance from the fence and fertilizer application between 10 and 13m from the fences. This distance from the fence does not agree with Tabler's (1980) experiments suggestion that maximum drift depth will occur at 4-5m from the fences used in the present experiments. A possible reason for the difference was water flow away from the fence. Greb (1980) who used a snowfence to increase available soil water, and Smika *et al.* (1965) who added water both found no positive interaction between additional water and additional fertilizer. The ratio: yield with fertilizer/yield without fertilizer was similar with and without extra water. The positive interaction found in the experiments reported here appeared only in years with significant benefits from added fertilizer, and assumes that extra water was present from snowmelt. Under the highest nitrogen rate, the native vegetation changed over the four-year period from a mixed midgrass type to one dominated by northern wheatgrass (*Agropyron dasystachyum* (Hook.) Scribn.), similar to the change reported by Smika *et al.* (1965) in North Dakota. This grass still dominated in 1994. There is no evidence of ecological change to the crested wheatgrass area.

The results indicate that fertility level of the pasture, the type of snowfence, the location relative to distance and direction from the snowfence, all influence production and the success of species present relative to each other. If sustainable snow management practices can be developed for rangeland, forage production can be optimized with increased N availability.

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Table 1

Effect of type of snowfence, location relative to snowfence and application of fertilizer on crested wheatgrass and native pasture yield.

Native

Fertilizer Rate (kg ha^{-1})

N	P				
0	0	-	165	330	280
0	50	-	190	370	340
50	50	-	200	690	380
100	50	-	185	1385	700
200	50	-	185	1015	1310
400	50	-	185	1740	3050
C.V. (%) (Log transform)			12.4	8.6	9.1
Orthogonal comparisons: probabilities					
Nitrogen vs none			ns	0.01	0.01
Nitrogen rate, linear			ns	0.05	0.01
Phosphorus vs none			ns	ns	ns

Table 2

Relationship between the ratio: yield with fertilizer/yield without fertilizer and distance from the snowfences.

Fertilizer Applied N	P	Yield ratio as function of distance from snowfence
Crested wheatgrass north of snowfences, 1986		
0	50	Yield ratio = 0.42** + 0.09** distance - 0.004* distance^2
50	50	Yield ratio = 2.02** + 0.20** distance - 0.008* distance^2
100	50	Yield ratio = 1.90** + 0.26* distance - 0.010* distance^2
200	50	Yield ratio = 2.05** + 0.20** distance - 0.008* distance^2
400	50	Yield ratio = 1.69 + 0.24 distance - 0.009 distance^2
Native range east of snowfences, 1991		
0	50	Yield ratio = 1.07* + 0.14 distance - 0.002 distance^2
50	50	Yield ratio = 1.72 + 0.11* distance - 0.005* distance^2
100	50	Yield ratio = 0.13 + 0.91** distance - 0.036* distance^2
200	50	Yield ratio = 0.52 + 1.76** distance - 0.070* distance^2
400	50	Yield ratio = 0.19 + 3.34 distance - 0.149 distance^2

**: $P<0.01$, *: $P<0.05$, that value is significantly different from zero