Long-Term Effects of Annual Applications of N and S Fertilizers to Grassland on Forage Yield, Rootmass, and Soil pH, Organic C and N on a Dark Gray Chernozem in North-Central Saskatchewan

S. S. Malhi
Agriculture and Agri-Food Canada, Canada

M. Nyborg
University of Alberta, Canada

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S . S . Malhi[1] *and M . Nyborg*[2]
[1] *Agriculture and Agri-Food Canada , P .O . Box* 1240 *, Melfort , Saskatchewan , Canada S0E* 1A0 *(Phone :* 306 -752 -2776 *Ext* 230 *; Fax :* 306 -752 -4911 *; E-mail ;malhis@ agr .gc .ca) ; and* [2] *Department of Renewable Resources , University of Alberta , Edmonton , Alberta , Canada*

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Introduction Many soils in the Parkland region of Prairie Provinces of Canada contain insufficient amounts of both plant-available N and S for high crop yields . Application of N and/or S fertilizers on grasslands can acidify soil or alter some other soil properties , but also improve soil quality (Malhi et al . 1991) . The objective of this study was to determine the effects of long-term N , S and/or K fertilization on forage dry matter yield (DMY) , root mass , plant species composition , and soil pH , total organic C (TOC) and N (TON) , and light fraction organic C (LFOC) and N (LFON) .

Materials and methods A field experiment on a perennial grass stand was conducted from 1980 to 2005 on a Dark Gray Chernozem (Boralfic Boroll) loam soil at Canwood in north-central Saskatchewan , Canada (mean annual precipitation 425 mm) . The site had been under annual crops for several years in 1920's or early 1930's , and then allowed to revert to grassland . The dominant grasses at the start of experiment were bromegrass (*Bromus inermis* Leyss) , Kentucky bluegrass (*Poa pratensis* L .) and rough hair grass (*Agrostic scabra* Wild) . There were five annual fertilizer treatments : 1 . no fertilizer (Nil) , 2 . 112 kg N ha^{-1} (N) , 3 . 11 kg S ha^{-1} (S) , 4 . 112 kg N+11 kg S ha^{-1} (NS) , and 5 . 112 kg N+11 kg S+40 kg K ha^{-1} (NSK) . Forage was usually harvested once in each growing season for determination of DMY . Plant species composition in 1994 was estimated using ground cover method . Soil samples in Nil , N , S , NS or NSK treatments were obtained at 5 or 7 .5 cm intervals from the 0-15 and 15-30 cm depths in different years for pH , bulk density , and total and light fraction organic C and N . Root mass was estimated by digging out soil from the 0-15 cm depth .

Results and discussion

Dry Matter Yield (DMY) and Root Mass Except in some years , application of N fertilizer increased DMY only slightly over the Nil treatment . The DMY was increased considerably with combination of N and S fertilizers (i .e . , NS treatment) . This indicated that the response of hay yield to N was impeded by S deficiency in soil , and application of N together with S was an effective way for increasing DMY . However , application of K in addition to N and S fertilizers only had moderate effect on increasing DMY . Like DMY , root mass was greatest in treatments receiving both N and S fertilizers .

Plant Species Composition The composition of plant species changed markedly in various fertilizer treatments after long-term fertilization . In the Nil treatments , land was covered with bromegrass , fine grasses and herbs (dogwood) . The S only treatment had vegetation generally similar to Nil , with slightly more vetches . In the N only treatment , the vegetation changed dramatically and there was virtually no bromegrass in the stands . The grass stand changed towards increasing predominantly bromegrass with combined applications of NS or NSK . Bromegrass is a higher yielding species than other grasses , which may have contributed to increased forage DMY due to combined N and S fertilization compared to other species .

Soil pH Soil pH in the surface soil layer was substantially decreased with annual applications of N and S fertilizers . The decrease in soil pH was more when only N fertilizer was applied compared to both N and S fertilizers together . In the 5-10 cm layer , there was some depression in soil pH in the N alone treatment . In the deeper soil layers , soil pH tended to increase with N or NS fertilization in most cases , probably due to downward movement of Ca or other bases to these soil layers .

Organic C and N Storage in Soil Total organic C and total N in soil increased with annual applications of N and S fertilizers together (NS treatment) . Annual applications of NS fertilizer treatments increased both LFOC and LFN considerably in the surface soil layer . The NS treatment also increased LFOC and LFN in deeper layers . The increase due to NS application for LFOC as a percentage of TOC and for LFN as a percentage of TN indicated that application of N and S fertilizer could markedly increase light fraction of C and N sequestrated in soil , most likely due to increase in root mass from balanced fertilization (Malhi and Gill 2002) .

Conclusions Forage DMY increased considerably with combined application of N and S fertilizers and further improved when K fertilizer was also applied (NSK) , while N or S alone had limited effect on the DMY on this soil deficient in both available N and S . Annual applications of N and S fertilizers reduced soil pH in the top 10 cm soil , mainly in the 0-5 cm layer , while there was a tendency for increase in soil pH in some deeper soil layers . Mass of TOC , TN , LFOC and LFN in the 0-15 cm soil increased with NS application . There was a close relationship between DMY improvement and increase in C storage in soil from proper fertilization . The findings suggest that application of balanced fertilization by alleviating all nutrient deficiencies is an appropriate strategy for sustaining high forage yield and increasing C and N sequestration in soil .