PLANT WATER RELATIONS AND GAS EXCHANGE IN A GRASSLAND WITH CATTLE GRAZING IN THE MISSOURI COTEAU OF NORTH DAKOTA

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OBJECTIVES:

(1) Compare leaf water potentials and gas exchange rates with different grazing intensities between Kentucky bluegrass and western wheatgrass, 2 of the dominant grasses growing in the Missouri Coteau of North Dakota.
(2) Evaluate the severity of seasonal drought stress experienced by the two grasses under different grazing intensities using information of leaf water potential components obtained from the pressure-volume analysis, as well as that of the field measured leaf water potentials.

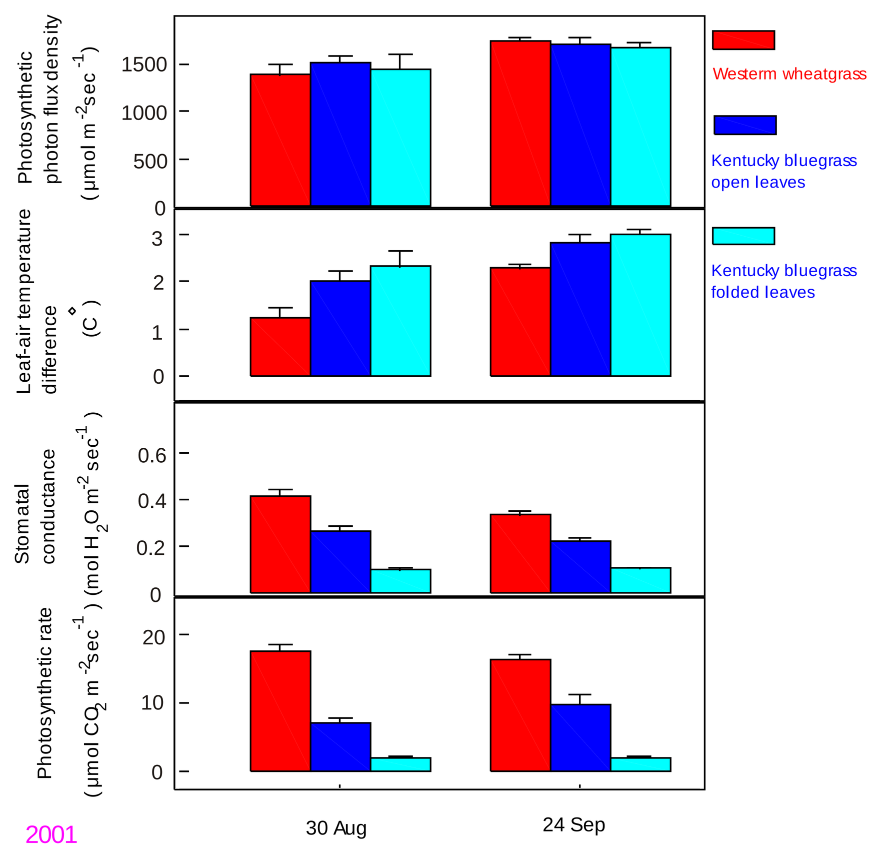

Fig.1 Under drought stress, portion of Kentucky bluegrass leaves began to fold with a partial stomatal closure.

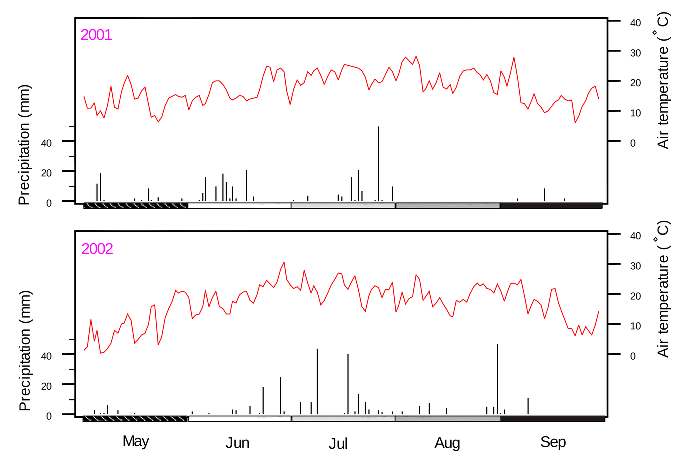

Fig.2 Daily precipitation and temperature in the growing season of 2001 and 2002. Note that 2001 had a dry late summer and 2002 had a dry spring.

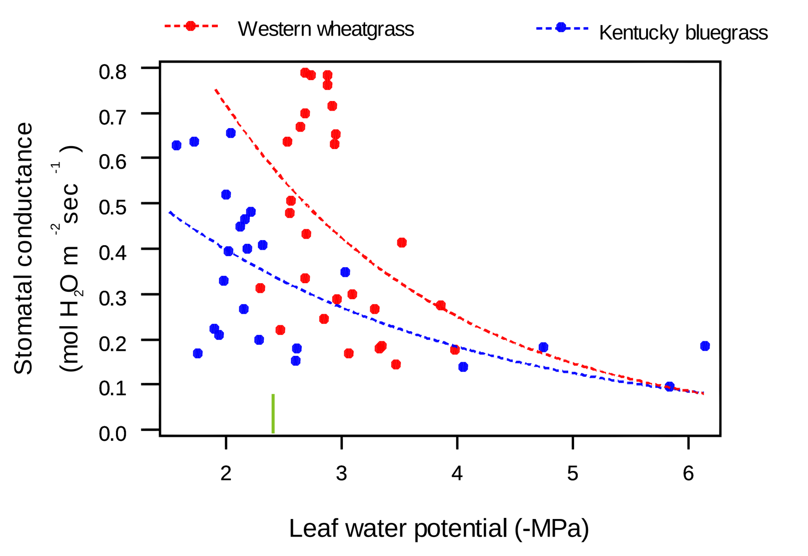

Fig.3 Western wheatgrass attained the same stomatal conductance level at a more negative leaf water potential, compared with Kentucky bluegrass. The green bar indicates the observed average water potential at which Kentucky bluegrass leaves began to fold.

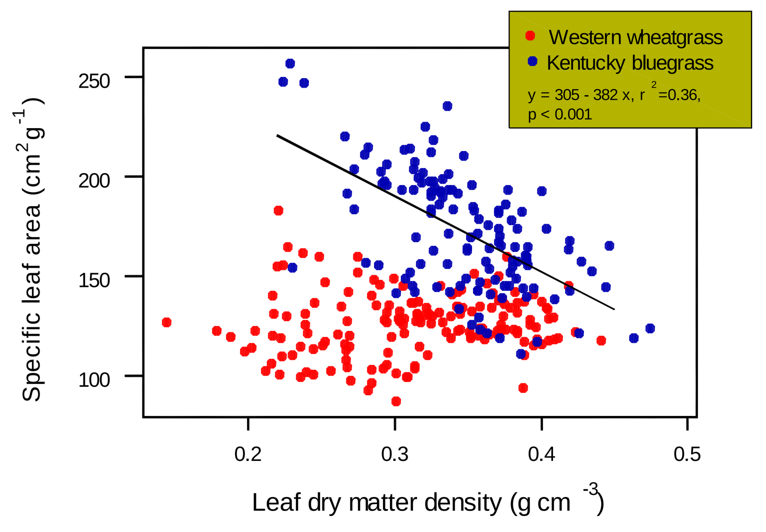

Fig.4 Kentucky bluegrass leaves increased specific area (and hence leaf volume) with the increase of leaf water content (inversely proportional to leaf dry matter density).

METHODS:

The study was conducted at the Central Grasslands Research Extension Center, Streeter, North Dakota. The field measurements were imposed on a grazing intensity study site which has been in progress for 15 years. The data was collected from 2001-2003. Leaf gas exchange rates were measured using the LI-6200 and LI-6400 photosynthesis systems. Leaf water potentials and their components were measured with a pressure chamber (PMS-model 1000). Soil water content was measured using a neutron probe (Troxler 4300). Leaf specific area was measured using contact paper and an image analysis system. With moderate grazing, about 50% of the average year's forage growth was left standing at the end of grazing season. The percent standing forage for heavy grazing treatment was 20%.

RESULTS

(1) Western wheatgrass employed a drought resistant leaf physiology (Fig.1 and Fig.3). The plasticity of wetness related area (volume) change in Kentucky bluegrass indicates a greater capacity of water use under ample water supply (Fig.4)

(2) The less unfavorable leaf water potentials were measured for plants growing in the non-grazing exclosure (Fig.9 and Fig.10). With an almost pure Kentucky bluegrass community of leaf area index of near 2.3, the water conservation due to stomatal closure accompanied with leaf folding in Kentucky bluegrass (Fig.1) may be the primary mechanism of the phenomena observed.

(3) Under heavy grazing, the drought survival of plants may be aided by osmotic adjustment (Fig.7 and Fig.8), but plants were faced with other problems, reflecting the disadvantage of limited root growth with heavy grazing. Heavy grazing may also encourage surface run-off and evaporation resulting in unfavorable soil water storage at top layers (Fig.6).

(4) Under moderate grazing, the exploitative water use (with the depletion of water to greater depth, Fig. 5, Fig. 9 and Fig.10) reflects the benefits of healthier root development associated with moderate grazing. However, at the mean time, the depletion of soil water would eventually bring about drought stress to plants, especially for the shallow-rooted Kentucky bluegrass under a spring drought (Fig.9).

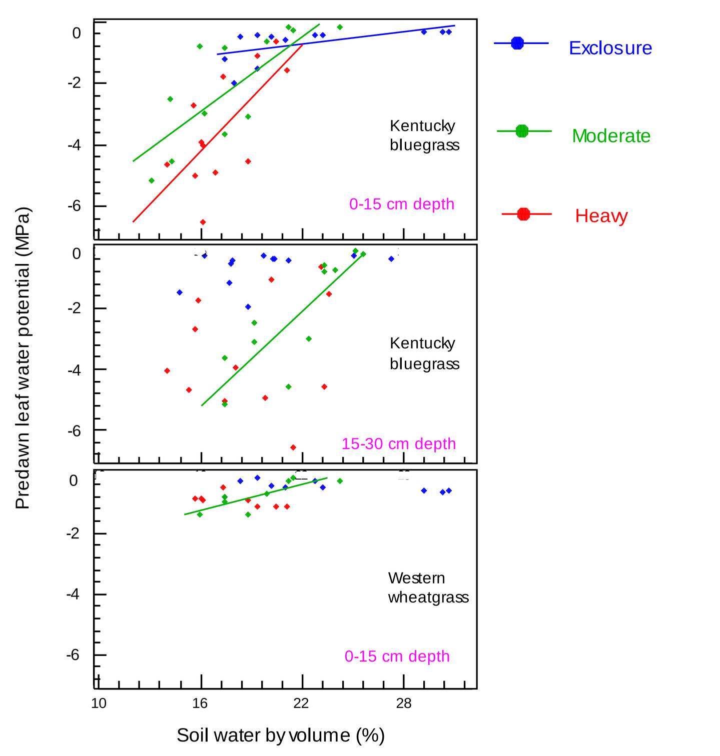

Fig.5 In moderate grazing treatment, predawn leaf water potentials of both species showed significant (p<0.05) linear relationship with soil water content at the 0-15 cm depth, and in Kentucky bluegrass the relationship also existed for the 15-30 cm soil depth. But in the exclosure or the heavy grazing treatment, the linear relation only existed in Kentucky bluegrass at the 0-15 cm soil layer.

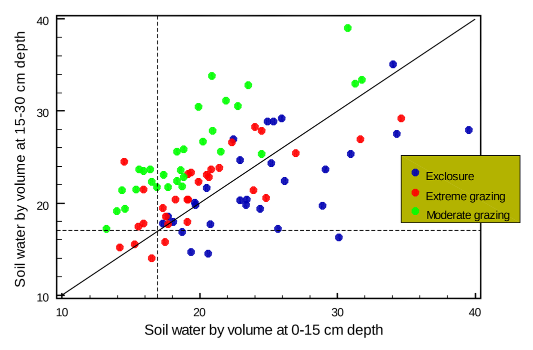

Fig.6 Soil water tended to be higher for the 0-15 cm depth in the exclosure and for the 15-30 cm depth with moderate grazing than for comparable depths with heavy grazing. This is especially so for the low water content range (measured in the dry period of May-June, 2002).

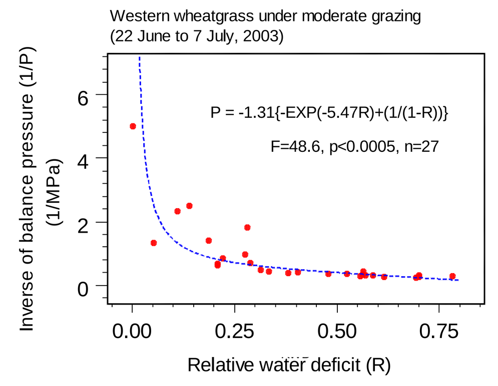

Fig. 7 A sample pressure-volume curve for plant leaf.

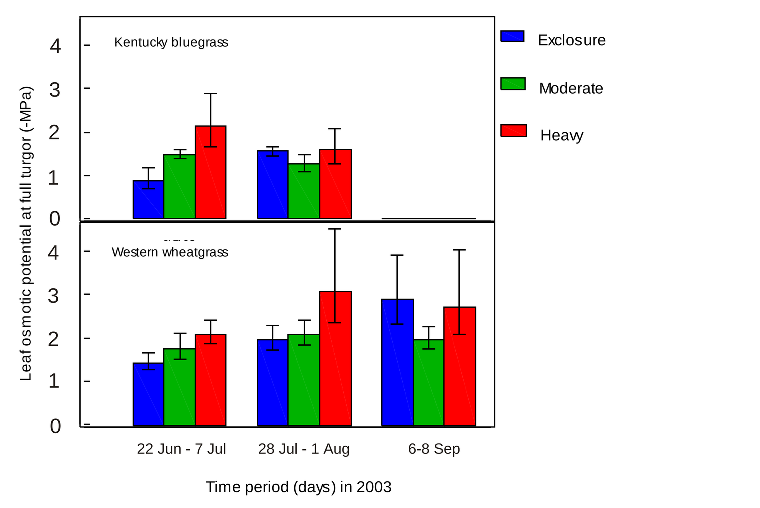

Fig.8 Maximum leaf osmotic potential (based on pressure-volume analysis) in Kentucky bluegrass and western wheatgrass with 95% confidence intervals. The data tended to decrease with the increase of grazing intensity for Kentucky bluegrass during 22 June- 7 July, and for western wheatgrass during periods of 22 June - 7 July and 28 July - 1 August in 2003. However, for the last measurements (28 Jul - 1 August, Kentucky bluegrass, 6-8 September for western wheatgrass), data from the moderate grazing treatment tended higher (less negative).

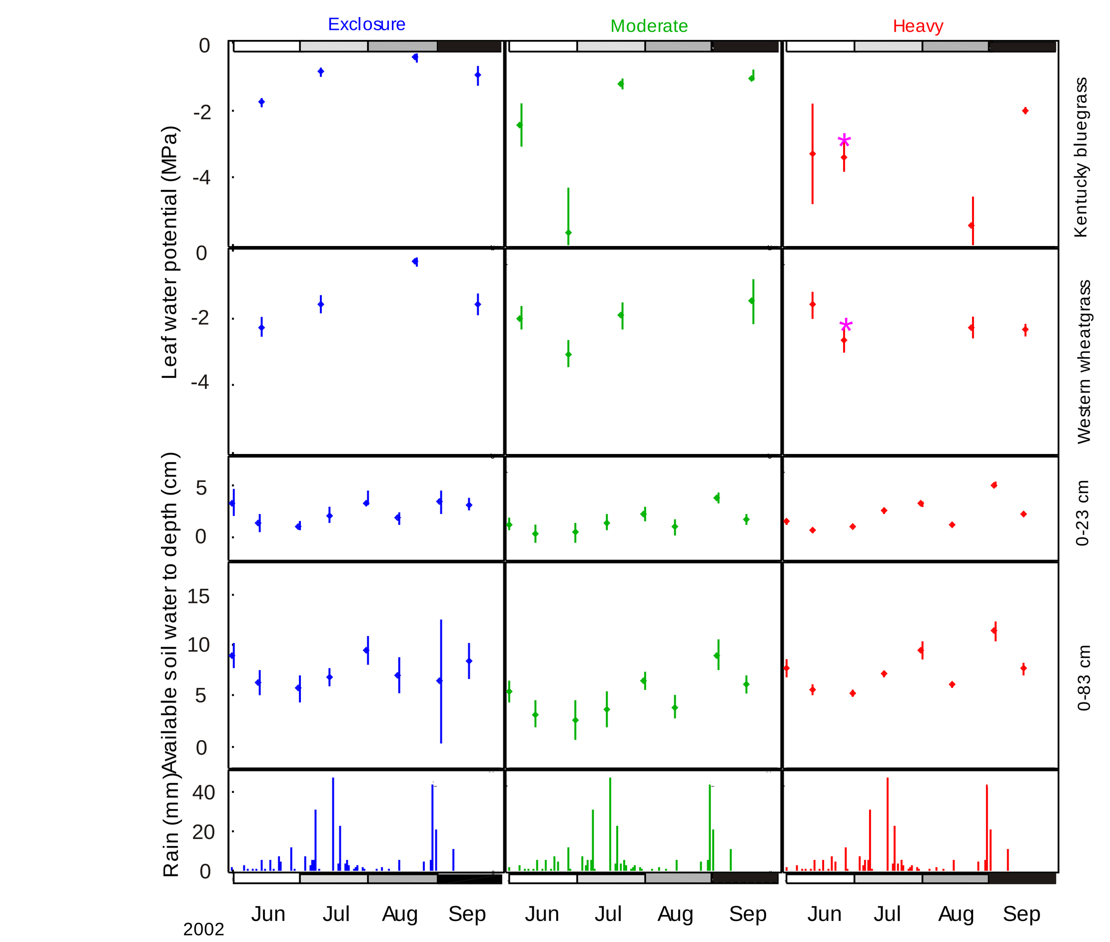

Fig.9 Soil and plant water status were not affected by the 2002 spring drought in the exclosure, however, soil and plant water status in grazed pastures were more severely affected in the spring drought. Available soil water was the lowest with the moderate grazing. A foggy morning made leaf water potentials for both grasses less negative than they should be (pink stars). Kentucky bluegrass with heavy grazing experienced severe water stress at late August. Following late August's heavy rain, leaf water status in both grasses improved more with moderate grazing than heavy grazing.

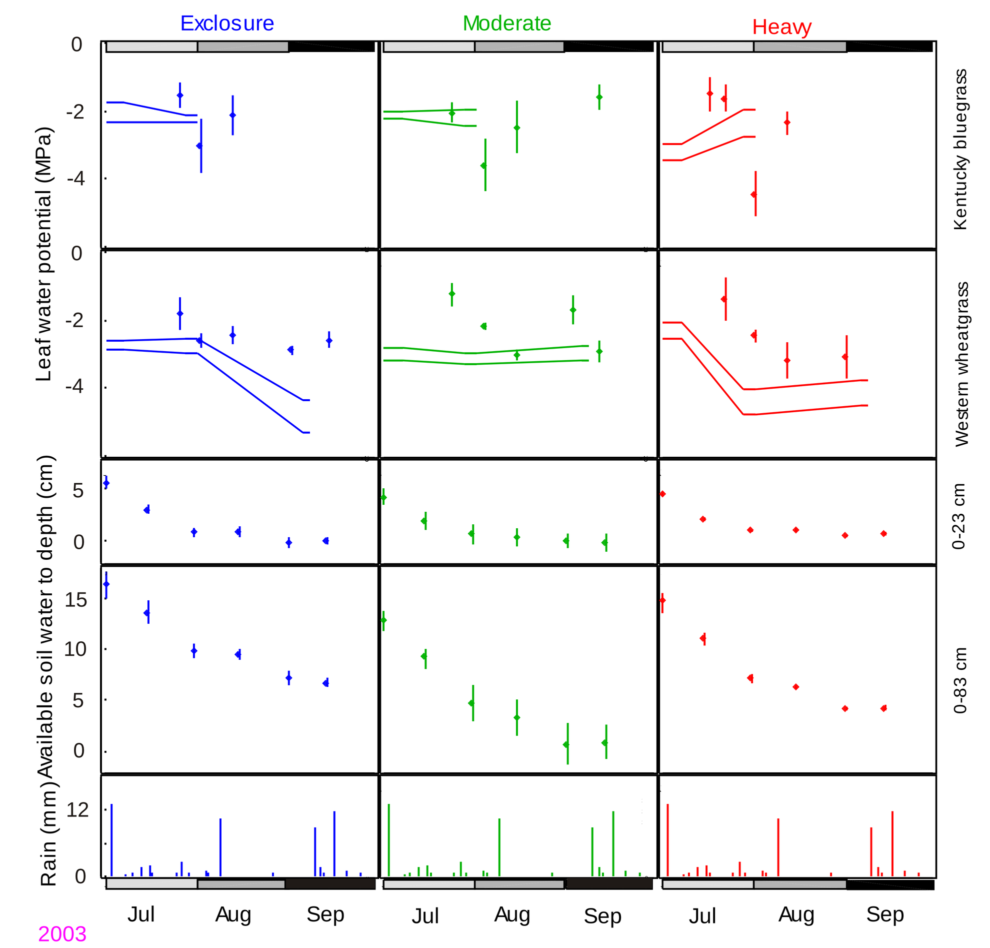

Fig.10 In the 2003 summer drought, plants from all grazing treatments experienced severe drought stress. The severity of drought stress increased with the increase of grazing pressure. Although available soil water was higher in the heavy grazing treatment, compared with moderate grazing treatment, plants experienced more severe drought stress with heavy grazing. Also shown are 95% confidence intervals for the turgor loss water potentials, as estimated from the pressure-volume analysis.