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Plant Responses to Different Grazing Intensities in the Missouri Coteau of North Dakota

Materials and Methods

This study was conducted at the Central Grasslands Research Extension Center in south central North Dakota. All samples mentioned below were from three grazing intensities, ungrazed (0% utilization), moderately grazed (50% utilization), and heavily grazed (65% utilization) areas. Each grazing intensity is replicated three times. Criteria for selecting the species investigated were: high abundance and/or major contribution to stand biomass on overflow range sites. Overflow range sites receive additional moisture from runoff of nearby slopes or stream flooding. According to these criteria, five perennial species were selected: western wheatgrass, smooth brome, stiff sunflower, stiff goldenrod and green needlegrass. These species were monitored regularly from 1989 until the present time (2005) (see article on page 21). This study investigated frequency of plant occurrence, leaf nitrogen content, specific leaf area and photosynthetic rate for response to the three grazing intensities (ungrazed, moderately grazed, and heavily grazed).

The leaf area and nitrogen content of the forage was sampled between 15 August and 20 August 2005. After collection, some of the leaves were used to measure SLA. Measurements of SLA for each species were taken from a sample of 24 fully expanded, but not senescing, healthy leaves from at least eight reproductively mature individuals. Leaf area (cm^2) was estimated from the fresh leaves by scanning their area with a scanner and using the software SigmaScan Pro Image Analysis Version 5.00 (1987-1999 SPSS Inc., USA). The dry mass (g) was estimated by oven drying to a constant weight (60°C) for 48 hours. After determining estimated leaf area and dry mass, SLA (cm^2g^{-1}) was calculated

using the leaf area divided by the dry mass. The remaining leaves were oven dried at 60 °C for two days and then ground to pass through a mesh screen (0.5 mm). These samples were submitted to the NDSU nutrition lab (Animal and Range Sciences, NDSU, Fargo, North Dakota, USA) for analysis of leaf nitrogen content. Tissues used in nitrogen analyses were digested in a block digester using concentrated (98%) sulphuric acid.

All five plant species chosen for this study are cool season (C₃) plants and have the same photosynthetic pathway. Photosynthesis-intercellular CO₂ response curves (A/Ci response curves) were measured on fully expanded young leaves of current-year foliage from the five species using a Li-Cor 6400 portable photosynthesis system (Li-6400; LiCor, Lincoln, Nebraska, 2003, USA) within a 12-day period in August 2005 (from 10:00 to 16:00).

Methods to Estimate the Vcmax and Jmax

The microenvironment of the Li-Cor 6400 system was controlled to mimic the field conditions. During the daylight hours of the measurement days, the Li-Cor 6400 was set to a leaf temperature of 26-31°C, atmospheric relative humidity of 30-60%, and photosynthetic active radiation of 1500 μmol m⁻² s⁻¹. The CO₂ partial pressure in the cuvette was manipulated to undergo 8-step changes from 10 Pa to 120 Pa (Pa is a unit of atmospheric pressure equal to one newton per square meter), so that non-linear curves were obtained relating photosynthesis to internal CO₂ partial pressure. These photosynthetic internal CO₂ response curves (A/Ci response curves) were analyzed to show which part of the photosynthetic biochemical machinery (Vcmax or Jmax) is predominately limiting the plants' ability to acquire carbon.

Statistical analysis

This experiment utilized a completely randomized design with three replications for each grazing intensity treatment. The joint effects of intensity and species on each variable (leaf nitrogen content, specific leaf area, photosynthetic rate, Vcmax, Jmax, and frequency of occurrence) were analyzed using Analysis of Variance (SAS General Linear Models). Grazing intensity and plant species were considered two factors, and when the interaction between these two factors was not significant, the species effect and grazing intensity were tested. Population (frequency of occurrence), morphological (specific leaf area) and physiological (Vcmax, Jmax, photosynthetic rate, and leaf nitrogen content) traits were

compared between the five species and between the different grazing intensities. A significant interaction is a red flag signaling that tests of individual factors provide only a partial and often misleading picture of what has happened in an experiment (Kirk, 1982).

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