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BRIEF COMMUNICATION

Leaf area expansion and net photosynthetic rate of three bromegrass (*Bromus*) species

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Abstract

This study measured individual leaf area expansion rate and leaf net photosynthetic rate (P_N) of meadow bromegrass (*Bromus riparius* Rehm.), smooth bromegrass (*Bromus inermis* Leyss.) and hybrid bromegrass (*B. riparius* × *B. inermis*). Smooth bromegrass expanded individual leaf area 1.5 times faster than meadow bromegrass and hybrid bromegrass. P_N was highest in smooth bromegrass, intermediate in hybrid bromegrass, and lowest in meadow bromegrass. Rapid growth of meadow bromegrass following defoliation compared to smooth bromegrass and hybrid bromegrass could not be explained by higher rates of these measured characteristics.

Additional key words: bromegrass; forage; regrowth.

Bromegrass (*Bromus*) species are important forage grasses cultivated in temperate regions of world. Meadow bromegrass (*Bromus riparius* Rehm.) is mainly used for pasture, while smooth bromegrass (*Bromus inermis* Leyss.) is generally used for hay production (Knowles *et al.* 1993). The hybrid bromegrass (*B. riparius* × *B. inermis*) cultivar ‘Knowles’ has potential for both hay and pasture (Coulman 2004). Regrowth following defoliation was most rapid in meadow bromegrass, intermediate in hybrid bromegrass, and slowest in smooth bromegrass (Knowles *et al.* 1993, Biligetu and Coulman 2010). Biligetu and Coulman (2010) compared tiller density, sward leaf area development, and below-ground biomass of the three bromegrass species following defoliation at different growth stages. Meadow bromegrass had a higher density of tillers, a faster leaf area establishment, and maintained a larger below-ground biomass than the other two species following defoliation. Meadow bromegrass has narrow, pubescent leaves (Knowles *et al*. 1993) whereas smooth bromegrass has broader, glabrous leaves (Vogel *et al.* 1996). The leaf pubescence of hybrid bromegrass more closely resembles that of meadow bromegrass (Ferdinandez and Coulman 2000). Leaves of meadow bromegrass have less protein than the other two bromegrasses (Ferdinandez and Coulman 2001). The morphological and physiological differences in the leaves may cause differences in P_N among the bromegrass species, which may be another factor affecting the regrowth potential of these three bromegrass species. The objective of this study was to compare P_N and individual leaf area expansion of the three bromegrass species in a greenhouse environment.

Sods of the three bromegrasses were transferred from the field to the greenhouse in May 2007. Sods were planted in 20 cm diameter pots. The three bromegrass species were arranged in a randomized complete block design (RCBD) with four replications. Sods were watered periodically when the soil surface became dry. Light was provided by high-intensity sodium lamps with a day length of 16 h at 21°C and night period of 8 h at 16°C.

At the 2−3 leaf stage, 20 individual tillers from each of the three species were randomly selected and marked with rings near the centre of pots. Newly emerging leaves (4th and 5th leaves) of the selected tillers were marked

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Abbreviations: g_s – stomatal conductance; N – nitrogen; P_N – net photosynthetic rate; PAR – photosynthetically active radiation; WUE – water-use efficiency.
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using a permanent marker on the first day, and again 5 days later, and expanded leaf area day^{-1} [cm^2 day^{-1}] was calculated. Measurements of P_N and stomatal conductance (g_s) were performed on two tillers $replication^{-1}$ from each of the three bromegrass species. Leaf gas-exchange measurements were taken on the uppermost fully expanded leaf on each tiller. Six gas-exchange measurements were taken on the same leaf blade every other day for 6 days using a *LI−6200 Portable Photosynthesis System* (*LI−COR Inc*., Lincoln, NE, USA). A leaf blade was held horizontally in the leaf chamber during the 30-s measurement period. The area of the leaf blade enclosed in the chamber was determined at the end of the experiment, and P_N was calculated. Leaf chamber CO_2 concentration was near 335 ppm, and leaf temperatures were 23−25°C during the measurements. Relative humidity in the air ranged from 35 to 40%. The K test is an assurance test to verify that the *LI−6200* system is working properly; if so, the K value will range between 1−1.5. The K test was conducted before each measurement, and values ranged from 1.19 to 1.35. Photosynthetically active radiation (PAR) on each successive measurement day was 895, 510, 128, 107, 572, and 927 [μmol(photon) m^{-2} s^{-1}], respectively.

Analysis of variance (*ANOVA*) of expanded areas of fourth and fifth leaves of the three bromegrass species was conducted using *SAS 9.1.3 Proc Mixed Model*. When *ANOVA* indicated significant differences ($P \leq 0.05$), the means were separated using least square means comparisons. P_N and g_s data were analyzed as repeated measurements in a randomized complete block design using *SAS 9.1.3 Proc Mixed Model*.

For the three bromegrass species, species and day of measurement had significant effects on P_N ($P<0.0001$, 0.0003, respectively) and g_s ($P=0.0309$, <0.001, respectively), but there was no species × day interaction effect on P_N and g_s ($P=0.85$, 0.92) (Fig. 1). Smooth bromegrass exhibited the highest P_N, and meadow bromegrass had the lowest one over all measurement days. Smooth bromegrass also had higher g_s than meadow bromegrass, but it was similar to hybrid bromegrass. This indicated that P_N is not related to the rapid regrowth of meadow bromegrass compared to smooth bromegrass. In a previous study, two wheatgrass (*Agropyron*) species with variable regrowth capacities showed similar P_N; however, photosynthetic nitrogen (N) and water-use efficiency (WUE) were higher in the species with more rapid regrowth (Caldwell *et al.* 1981).

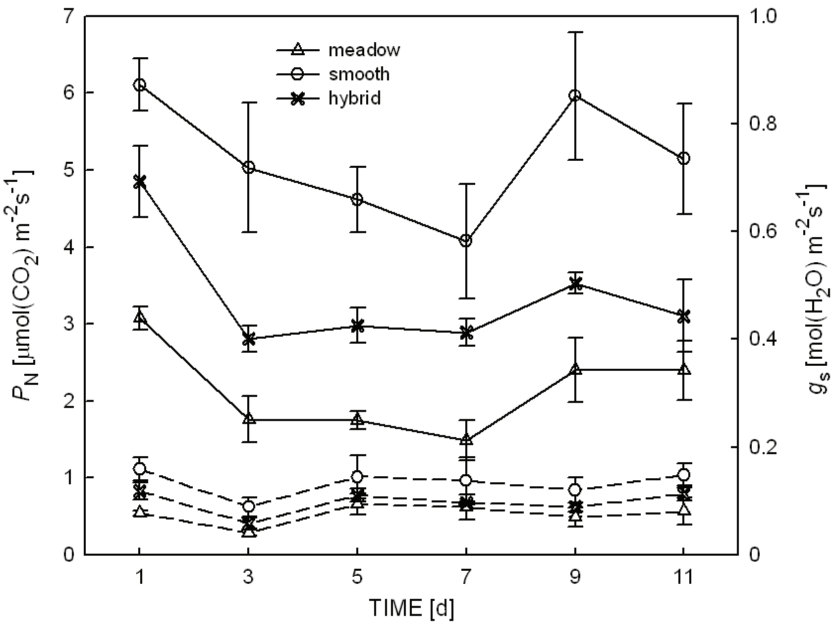

Fig. 1. Trends of net photosynthetic rate (P_N) (*solid lines*) and stomatal conductance (g_s) (*dash lines*) of three bromegrass (*Bromus*) species at the vegetative growth stage over 11 days in a greenhouse. Bars are means ± SE ($n = 4$).

Table 1. Leaf area expansion of fourth and fifth leaves of three bromegrass (*Bromus*) species at the vegetative stage. * Means within a column with the same letter are not significantly different ($P>0.05$). SEM – standard error of the means.

Bromegrass species	4th leaf lamina [cm^2 d^{-1}]	5th leaf lamina [cm^2 d^{-1}]
Meadow	0.90^{b*}	0.87^{b}
Smooth	1.26^{a}	1.42^{a}
Hybrid	0.97^{b}	0.95^{b}
P	<0.01	<0.01
SEM	0.18	0.11

Leaf area expansion of the fourth and fifth leaves of individual tillers were significantly different among species (both $P<0.01$) (Table 1). Smooth bromegrass increased the surface area of leaves 1.5 times faster than meadow or hybrid bromegrass, but there was no difference between the latter two species. Thus, the more rapid reestablishment of leaf area in meadow bromegrass relative to the other two bromegrasses found in previous studies did not arise from the faster expansion of individual leaves. In a previous study, smooth bromegrass and an experimental hybrid bromegrass population also had greater leaf area per tiller and number of leaves per tiller than meadow bromegrass during regrowth (Van Esbroeck *et al.* 1995). Tiller density following defoliation, however, was greater in meadow bromegrass (Biligetu and Coulman 2010), and this high tiller density compensated for lower individual leaf area.

In conclusion, our work demonstrates that P_N and leaf area expansion were not related to the rapid regrowth following defoliation of meadow bromegrass. Further studies of P_N and related traits in the field are needed to verify the initial findings of the present study under natural growing conditions.

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