Nitrogen Fixation and Isotope Composition of Native and Tame Forage Plants

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Abstract

A plant mixture of alfalfa, purple prairie clover and 7 natives grass species: western wheatgrass, northern wheatgrass, awned wheatgrass, Canada wildrye, green needle grass, little bluestem and blue grama was established at the south farm (SPARC) in Saskatchewan in 2006. Legumes were included in forage stands to sustain pasture production. The fixation of atmospheric derived nitrogen for forage plants was estimated by the method natural abundance of ^{15}N. This method showed that The N_2 fixation activity of both alfalfa and purple prairie clover was very important in 2008. They fixed about 90 % of their nitrogen needs. Alfalfa was the good candidate to sustain the production of high quality of forage because it increased the yield of native grass stand by 33 % and increased herbage stand protein by 45 % but this method is failed to detect fixed N in grasses.

Introduction

Native plants are well adapted to the soil and climate in Southwest of Saskatchewan. Typically, in the native prairie, cool season species are followed by warm season species. Some of these could be interesting source of good quality forage in early, but also in late season when tame species become dormant. Native plants are a natural component of the ecosystem and, as such, should use optimally natural soil biotic and abiotic resources. They should use soil water and nutrients very efficienty, be resistant to pest, lenghty drought periods, and maintain soil quality. Pastures composed of native species could be self-sustaining and permanent, and if N_2-fixing legumes are present, they could have relatively high productivity. Legumes have traditionally been used to provide forage stands with nitrogen from biological N_2-fixation and improve the protein content of herbage. The utilisation of legumes in pastures seeded with native grasses may increase and sustain the productivity of native plant pastures in Southwest Saskatchewan. Grasses are very competitive plants especially in presence of abundant soil nitrogen.

In this work, we are interested to improve herbage yield and protein content through the inclusion of legumes in plant stands and to measure the contribution of legumes' N_2 fixation to the N nutrition of companion grasses.

Methods:

There were four plant mixtures established at semiarid prairie agricultural research centre in Swift current.

*1: 7 grass.

*2: Meadow brome and alfalfa.

*3: 7 grass and alfalfa.

*4: 7 grass and purple prairie clover. Treatments were randomized in four blocks.

The native plant mixtures included cool season and warm season grasses. Cool season grasses were northern wheatgrass, western wheatgrass, awned wheatgrass, Canada wildrye and green needlegrass. Warm season grasses were little bluestem and blue grama grasses. These warm season grasses were expected to increase the feeding value of the mixture during the warm and dry period of late summer at the end of the growing season, plant biomass in the stand was estimated from one 0.25 m^2 quadrate randomly placed in each plot. Plants were cut at ground level, dried at 45°C, weighed and analysed for N and $\delta^{15}N$ using mass spectrometry.

We used the natural abundance of ^{15}N (Shearer and Kohl 1987) to measure N_2 fixation in Alfalfa, purple prairie clover and the various grass species, as the amount of fixed N in plant is negatively related with ^{15}N abundance in plant tissue.

The data was analyzed by ANOVA, and Student-t tests were used to assess the significance of differences (α=0.05) between treatments. Analyses were conducted using JMP 7.0.1.

Results:

Plant Biomass Production:

Plant biomass varied with plant community. It was larger in the seven-grass native mix when they were grown with alfalfa, as well as the meadow brome – alfalfa communities (Fig. 1). Biomass of the grass component of the plant mixture varied with different plant community. It was larger in the seven native mixtures and in meadow brome – alfalfa communities (Fig 2). Plant biomass was larger in 2009 than in 2008 (P<0.0001) (Fig. 3).

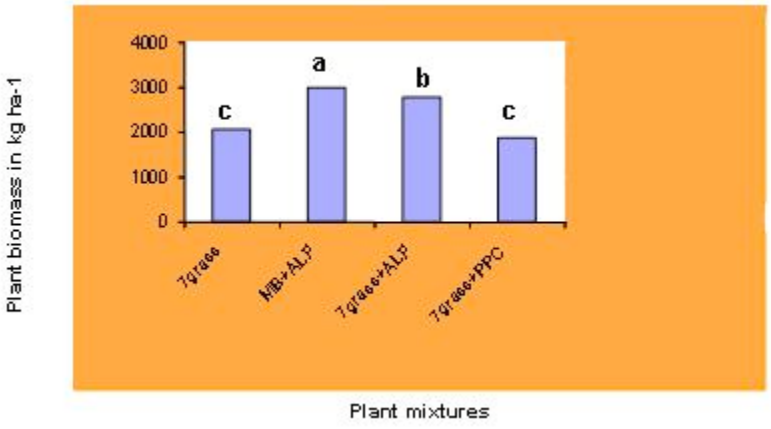

Figure 1. Plant biomass (kg ha^{-1}) influenced by different plant community. Bars represents the average of 24 replicates (P<0.0001) during two years.

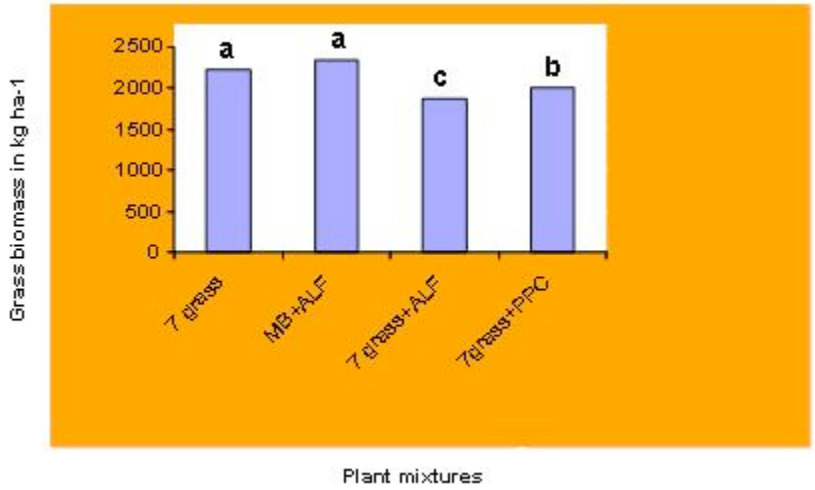

Figure 2. Biomass (kg ha^{-1}) of the grass component of the plant mixture as influenced by different plant community of plant in 2009 (P=0.0468).

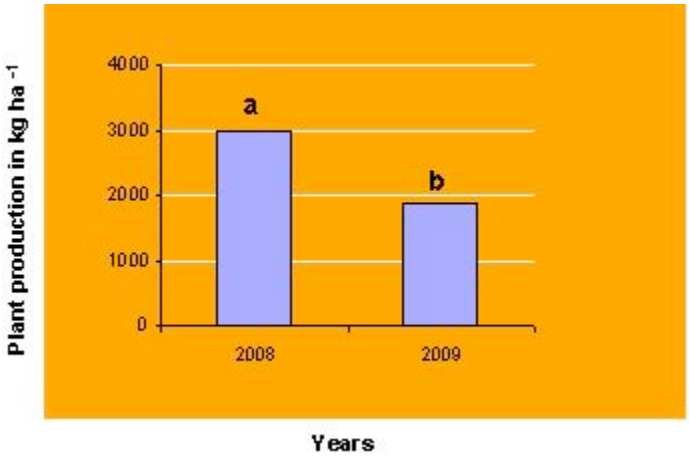

Figure 3. Total herbage biomass (kg ha^{-1}) in 2008 and 2009. Bars represents the average of 96 replicates (P<0.0001).

Nitrogen fixation in legumes:

The amount of N_2 derived from fixation in alfalfa exceeded that measured in purple prairie clover (Fig. 4). The amount of N_2 derived from fixation in alfalfa in 2008 was higher when grown with meadow brome than with the seven native grasses (Fig. 5) (P=0.0049); the 2009 determinations are not completed yet.

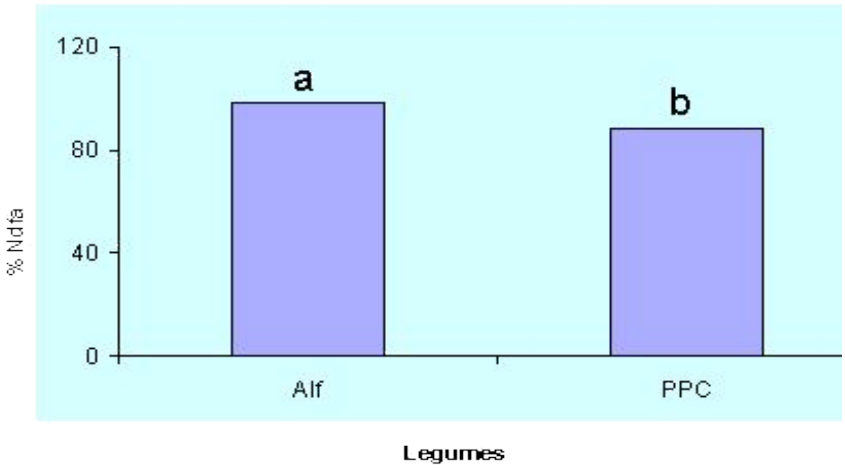

Figure 4. Percentage of nitrogen derived from air (Ndfa) in Alfalfa and purple prairie clover in 2008. Bars represents the average of 12 replicates (P=0.0002).

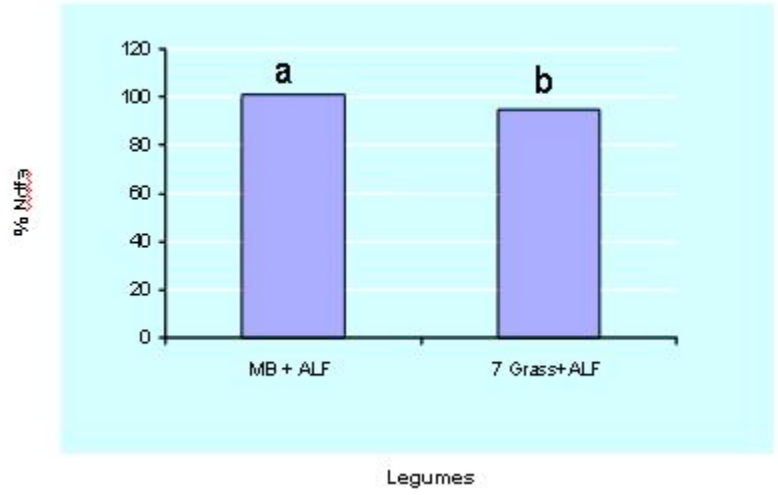

Figure 5. Percentage of nitrogen derived from air (Ndfa) in Alfalfa tissues as influenced by plant mixture in 2008. Bars represents the average of 12 replicates (P=0.0049).

The $\delta^{15}N$ value of grass was very high in all plant communities and was not influenced by the presence of any legume component

Protein content of forage plants

The quantity of protein is influenced by different plant community. It was higher in the seven-grass native with alfalfa, as well as the meadow brome – alfalfa communities (P= 0.0011).

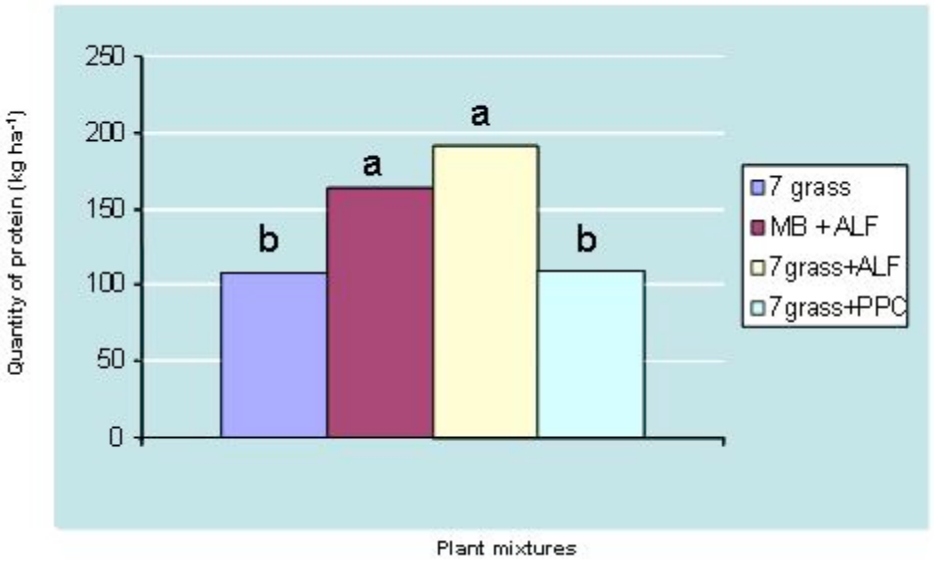

Figure 6. Quantity of protein (kg ha^{-1}) in plants tissues as influenced by different plant community in 2008. Bars represents the average of 12 replicates (P= 0.0011).

Figure 7. Alfalfa (a) is a vigorous tame N2-fixing species relatively well adapted to southwestern Saskatchewan. Purple prairie clover (b) is a native legume of this area.

Discussion:

Plant biomass production:

Yield varied with community (Fig 1). Alfalfa increased total herbage production in the seven grass native mix, which then yielded as well as the meadow brome-alfalfa communities, although it reduced grass production through competition (Fig 2). The competition created by legumes reduces available source for grasses (Casper, 1997). Plant biomass was larger in 2008 (2980 kg ha^{-1}) than in 2009 (1886 kg ha^{-1}) ($P<0.0001$) (Fig 3), the lower yields in 2009 could be explained by dry weather in early season.

Nitrogen fixation in legumes:

The N_2 fixation activity of both alfalfa and purple prairie clover was very important in 2008. They fixed about 90 % of their nitrogen needs. Alfalfa fixed more nitrogen than purple prairie clover (Fig 4) because of its large productivity. N_2 fixation by alfalfa was more active when this legume was associated with meadow brome than with the 7 native grass species (Fig 5). Higher N_2 fixation with meadow brome was associated with large productivity of this plant community, and reflects the larger demand for nitrogen by productive meadow brome than by the less productive native mix.

The $\delta^{15}N$ value of grass was very high in all plant community with or without legumes, this results suggesting that the N_2 fixed by legumes is not transferred to companion grasses. This conclusion needs further confirmation.

Protein content of forage plants:

The quantity of protein in forage differed with plant community in 2008 ($P= 0.0011$) (Fig 6). It was very important when grasses were growing with alfalfa (190 kg ha^{-1}), as well as the meadow brome-alfalfa plant mixture. Better yield were always found in presence of alfalfa suggesting that the availability of N_2 fixation was involved in better plant productivity.

Conclusions:

1. Alfalfa increased the yield of native grass stand by 33 %.

2. Alfalfa increased herbage stand protein by 45 %.

3. The ^{15}N natural abundance method failed to detect fixed N in grasses but indicated that about 90% of the N in legumes tissues was from fixation.

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