Diverse Annual Plantings and their Contribution to Forage Yield and Soil Improvement

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Abstract

Multi-species plantings, also known as polycultures, are expected to have several ecosystem benefits based on the varying contributions from different plants. Potential benefits include increased nutrient cycling, increased soil moisture retention, increased forage yield, decreased soil compaction, and decreased weed communities. Local Saskatchewan producers and groups have implemented multi-species plantings with great success, and this project attempts to build on this anecdotal evidence to not only quantify the impact of polycultures, but to also determine what makes a mixture more or less effective in a particular environment. Our preliminary results suggest that increased crop species richness and functional group richness have many benefits including increased biomass production and decreased weed and insect abundance.

Introduction

It is well understood that biodiversity is important in natural systems: ecosystems with higher biodiversity tend to have higher productivity and are better able to withstand stress (Malézieux et al. 2009). In agricultural systems, the current practice of growing intense monocultures may have several negative consequences, including heavy reliance on inputs such as fertilizers and pesticides. Multi-species plantings (also known as polycultures, intercropping, cocktail mixtures) increase biodiversity and are suggested to have several benefits such as increased nutrient cycling, increased soil tilth and fertility, and reduced reliance on fertilizer and pesticide inputs (Lithourgidis et al. 2011).

In an annual cropping system, a forage polyculture can be included in a rotation to provide several ecosystem benefits while being grazed or baled as green feed. The benefits of this kind of system have been explored in Manitoba and in the northern United States, but in the semiarid region of southwestern Saskatchewan, evidence to date has been anecdotal. The **research objective** of this project was to quantify the impact of an annual forage polyculture in a semiarid region by determining the following factors:

1. Plant biomass production and feed value
2. Soil fertility and quality
3. Ecological impact

This study was initiated in the spring of 2013 and we report our preliminary findings here.

Methods

Twelve species from four functional groups were selected for field trials (Table 1). The four functional groups (cool season grasses, warm season grasses, legumes and brassicas) vary in their use of resources and contribution to the community. The 12 species were each grown in monoculture and in varying combinations of 2, 4, 8 and 12 species mixtures. Given the nearly unlimited number of combinations possible, we focussed on combinations that represented variation in functional group inclusion. A perennial treatment (alfalfa and meadow brome) was included as a comparison to a traditional forage system. In total, there were 34 treatments.

Table 1. Species used in the present study and the functional group they belong to.

Functional Group	Species
Cool Season Grasses (C_3 plants)	Barley (*Hordeum vulgare*)
	Oats (*Avena sativa*)
	Triticale (*Triticosecale*)
Warm Season Grasses (C_4 plants)	Corn (*Zea mays*)
	Millet (*Setaria italica*)
	Sorghum (*Sorghum bicolor*)
Legumes (nitrogen fixers)	Field Pea (*Pisum sativum*)
	Forage Pea (*Pisum sativum*)
	Hairy Vetch (*Vicia villosa*)
Brassicas (root crops)	Kale (*Brassica oleracea*, Acephala group)
	Radish (*Raphanus sativus*)
	Turnip (*Brassica rapa* subsp. *Rapa*)

Experimental design followed a randomized complete block design with four blocks. Each block had 34 plots measuring 6 m long by 1.8 m wide. The test plots were treated as "low input", as no fertilizers or herbicides were used. The field site was located at the Semi-Arid Prairie Agricultural Research Centre South Farm, south east of Swift Current, Saskatchewan. Several parameters were measured at different points in the growing season, including various soil measurements (e.g. nutrients, bulk density, moisture), plant measurements (e.g. biomass, percent composition, nutrients), and ecological community analysis (weeds and insects). The soil data was largely baseline data that will be compared over future seasons and is not included here. Instead we focus on a few key results from the first field season.

Results & Discussion

There were considerable differences between the monocultures (and functional groups) and mixtures. In regards to biomass production, all of the mixtures performed quite well, with several of the mixtures having higher biomass (Figure 1). On average, the cool season monocultures had higher biomass in July and August than all other treatments. The perennial treatment had the lowest biomass production, which was expected as the first year is an establishment year. Biomass was significantly positively correlated with both species richness and functional group richness in July and August (Figure 2).

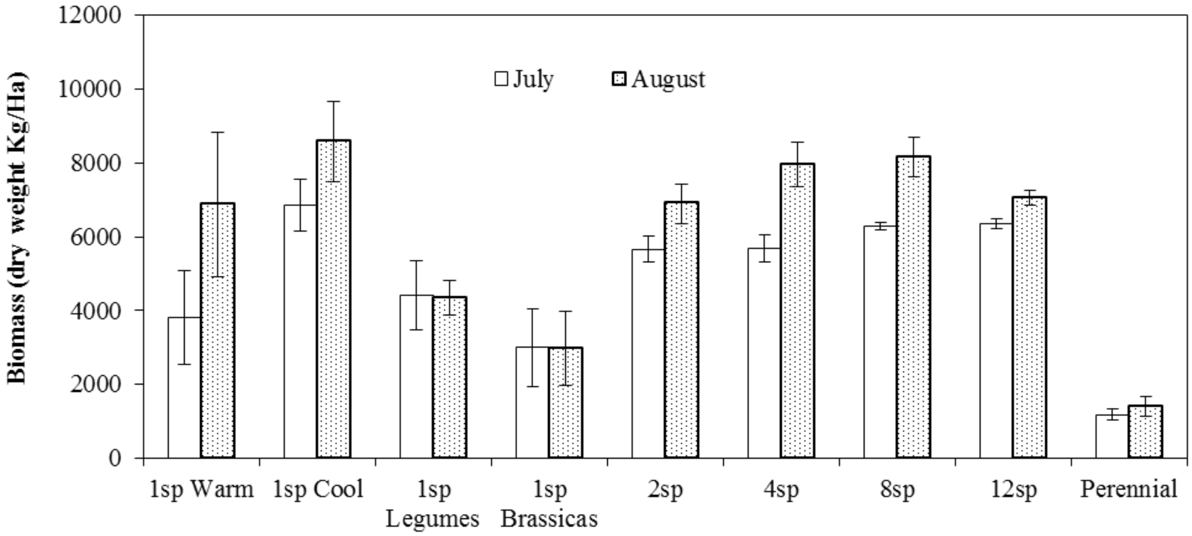

Figure 1. Biomass production in July and August for the monocultures (grouped by functional group) and polycultures (2, 4, 8 or 12 species).

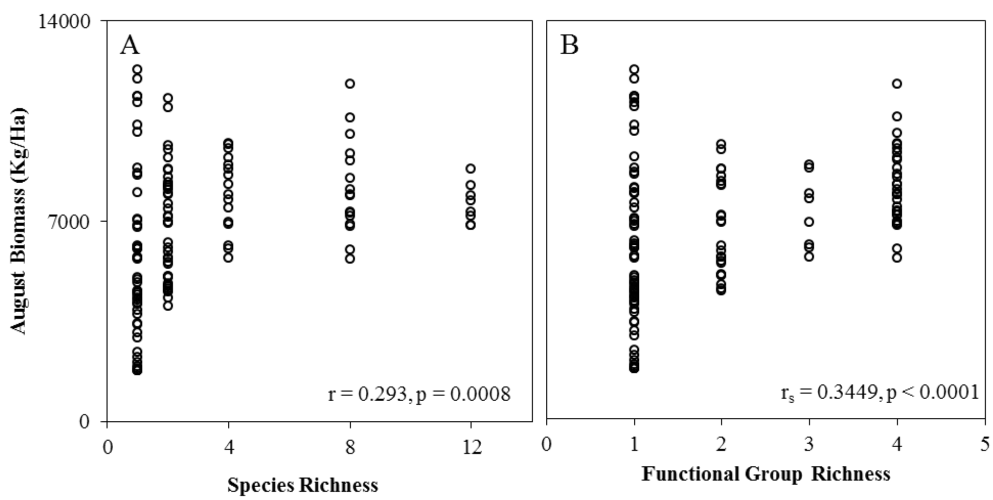

Figure 2. Relationship between August plant biomass and species richness (A) and functional group richness (B). Results were similar for July biomass (data not shown).

Interestingly, the composition data revealed that the mixtures were primarily dominated by cool season species. The 12 species mix was functionally more like a 9 species mix, due to some species performing very poorly in the mixture (e.g. kale, sorghum). In regards to community interactions, preliminary data analyses show that weed abundance was the lowest in the 12 species mix, while the perennial mix had the highest number of weeds present (Figure 3). There were no clear trends in the diversity of the weed species using Shannon's Diversity Index (Figure 3). The perennial treatment also had the highest abundance and diversity of insects (Figure 4). This is likely due to the increased diversity of weeds on these plots and the ability to attract and host more insect species.

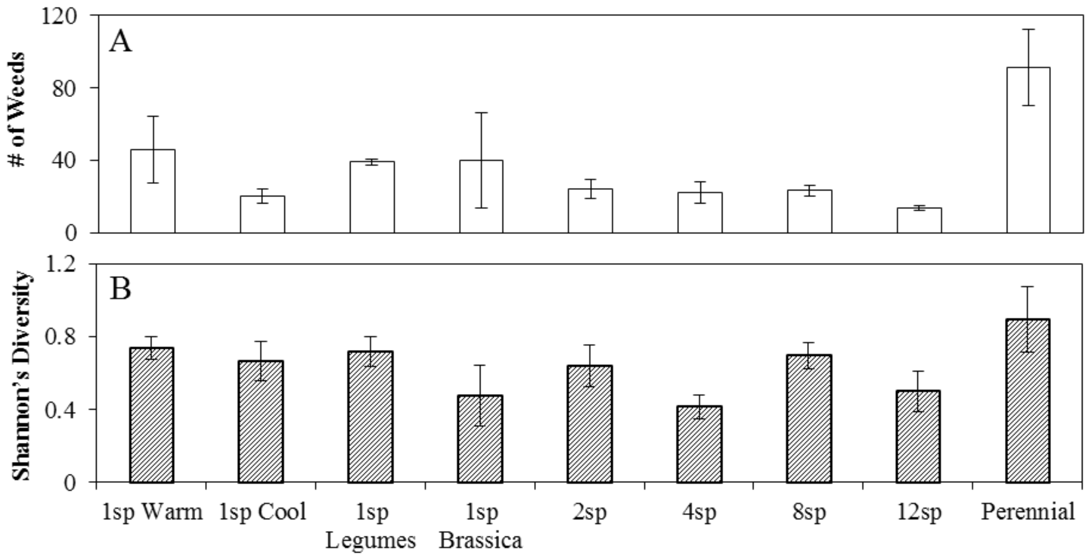

Figure 3. Weed abundance (A) and diversity (B) in the monoculture and polyculture treatments.

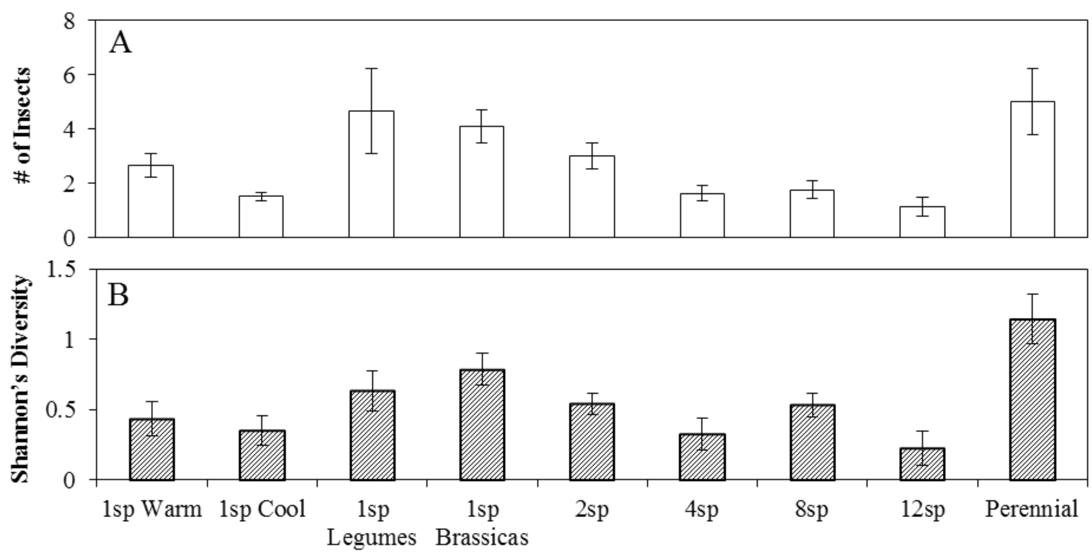

Figure 4. Insect abundance (A) and diversity (B) in the monoculture and polyculture treatments.

Conclusions

While much more work is needed (and is already underway: two more field seasons are planned for 2014 and 2015), it is evident that there are considerable differences between monocultures and polycultures. In the current study, the annual forage polycultures show promising results in regards to biomass production and weed and insect control. This appears to be due to the inclusion of plants from different functional groups. Additional data analyses are being conducted to determine which treatments have the best nutritional quality and which will have the greatest impact on soil fertility and quality.

Acknowledgements

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References

Lithourgidis, A.S., Dordas, C.A., Damalas, C.A., Vlachostergios, D.N. 2011. Annual intercrops: an alternative pathway for sustainable agriculture. Australian Journal of Crop Science 5: 396-410.

Malézieux, E., Crozat, Y., Dupraz, C., Laurans, M., Makowski, D., Ozier-Lafontaine, H., Rapidel, B., de Tourdonnet, S., Valantin-Morison, M. 2009. Mixing plant species in cropping systems: concepts, tools and models: a review. Agronomy for Sustainable Development 29: 43-62.