Impact of Cereal Grain Canopy Traits on Intercropped Legume Productivity

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Funding for this research was provided by the Leopold Center for Sustainable Agriculture

Introduction

Addition of winter cereal grains into the North Central U.S. Corn Belt can diversify cropping systems, break pest cycles (Cook, 1988) and improve yields of subsequent crops (Singer and Cox, 1998). Using a cereal grain to establish legumes can provide additional income during the establishment year, protect legume seedlings during establishment, and suppress weeds (Tesar and Marble, 1988). Managing the legume following grain harvest can provide forage for livestock, weed suppression (Blaser et al., 2006), and nitrogen for subsequent crops (Singer and Cox, 1998). Winter cereal grain production could expand in this region if forage legumes can be reliably established using interseeding methods. Singer et al. (2006) reported 22% mortality when establishing red clover (*Trifolium pratense* L.) under winter wheat (*Triticum aestivum* L.) versus no companion crop, while other studies report successful winter cereal/legume intercrops (Blaser et al., 2006; Singer and Cox, 1998). Therefore, there is a need for further research into the effects of cereal grains on legume establishment. Blaser et al. (2006) reported that cereal grain species transmitting different quantities of light influenced red clover establishment. However, canopy trait influence on light transmittance and legume establishment is not understood.

Objective

The objective of this study was to evaluate the impact of winter cereal grain cultivars and canopy traits on establishment and productivity of frost-seeded alfalfa and red clover.

Methods

A field study was conducted near Boone, IA (42º 00'N, 93º 50'W; elevation 341 m above sea level) from 2005-2006. The experimental design was a randomized complete block in a split block treatment arrangement with four replications. Main plots consisted of either 'Ernie', 'Goodstreak', or 'Kaskaskia' winter wheat or 'Décor', 'Lamberto', or 'NE426GT'winter triticale (*X Triticosecale* Wittmack). The cereal grains were no-till drilled following soybeans at 300 seeds m^{-2} on 5 and 7 Oct 2004 and 2005. Subplots were frost-seeded at 900 seeds m^{-2} to either 'Marathon' or 'Cherokee' red clover or 'Mycogen 4375LH' alfalfa (*Medicago sativa* L.). In 2005, 'Cherokee' was seeded on 23 March and 'Marathon' and 'Mycogen 4375LH' were seeded on 29 March. In 2006, all legumes were seeded on 15 March. Legume stand densities were measured from one permanent 0.5 m^2 quadrat per subplot. Legumes were first counted at the development of a trifoliate leaf and were counted weekly until grain harvest. Photosynthetically active radiation (PAR) transmittance to the legume intercrop was measured weekly using an AccuPAR Ceptometer, Model PAR-80 (Decagon Devices, Pullman, WA). The LAI-2000 Plant Canopy Analyzer (LI-COR, Lincoln, NE) was used to measure leaf area index (LAI) every 18 d beginning at jointing (GS 30; Zadoks et al., 1974) until grain harvest. Maximum cereal grain plant height was measured using a 0.25 m^2 circular transparent disk mounted on a meter stick (Oleson et al, 2004). All cereal grains were combine harvested on 13 and 17 July 2005 and 2006. Legume shoot dry matter (DM) was measured 40 d after grain harvest by clipping plants from two 0.25 m^2 quadrats per subplot. These harvests occurred on 22 and 25 Aug 2005 and 2006. All forage data are reported on a DM basis. Analysis of variance and regression analyses were performed using SAS (SAS Inst., Cary, NC). Analysis of variance was performed for each canopy trait and significant traits were then submitted to regression analysis. Data for regression analyses was based upon the average of the three legumes as ANOVA results reported no interaction between cereal cultivar and legume variety main effects.

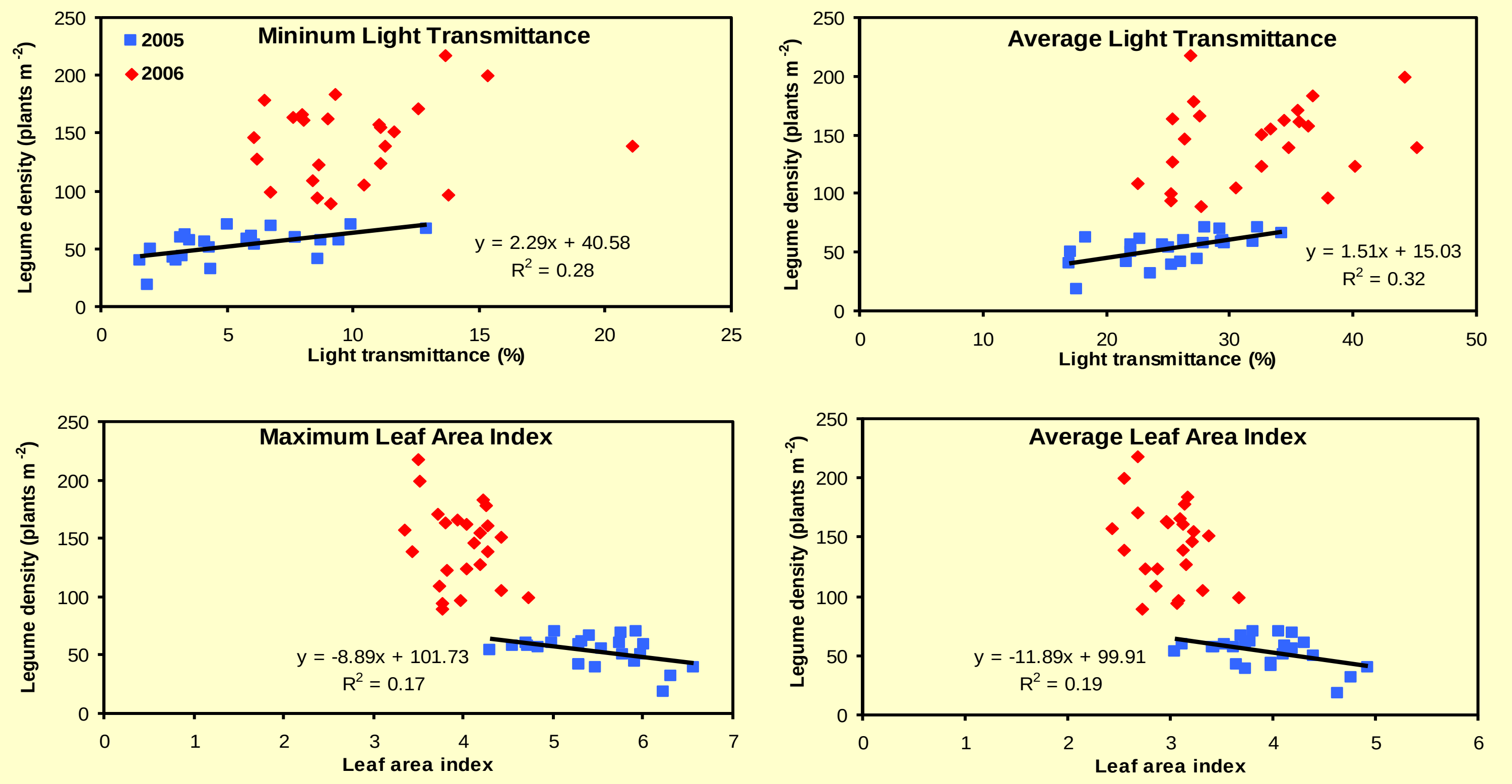

Figure 1. Regression analyses of legume densities with minimum and average light transmittance and maximum and average leaf area indices for the 2005 and 2006 seasons. Legume densities represent the average of all three legumes. Only significant regression equations and curves are presented.

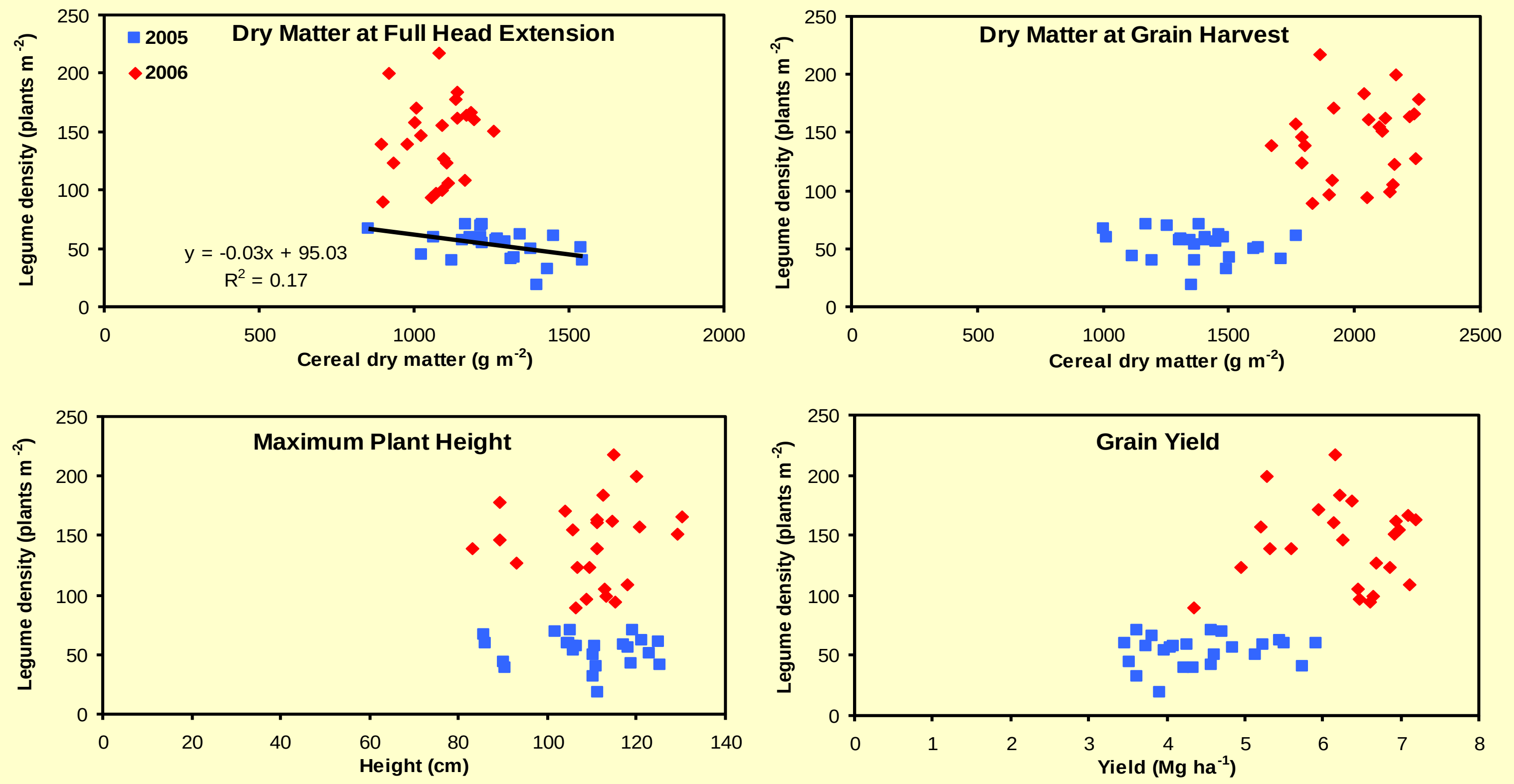

Figure 2. Regression analyses of legume densities with cereal grain dry matter at full head extension and harvest, maximum plant height, and grain yield for the 2005 and 2006 seasons. Legume densities represent the average of all three legumes. Only significant regression equations and curves are presented.

Table 1. Forage legume densities and legume dry matter (DM) 40 d after cereal grain harvest. Densities and harvests were measured near Boone, IA during 2005-06 growing seasons.

	2005		2006	
	Legume density†	40 d DM‡	Legume density	40 d DM
	plants m^{-2}	g m^{-2}	plants m^{-2}	g m^{-2}
Legume species/variety				
'Mycogen 4375LH' alfalfa	55a	106b	140b	151b
'Marathon' red clover	62a	171a	194a	188a
'Cherokee' red clover	43b	195a	100c	185a
P>*F*	0.003	<0.001	<0.001	0.032
LSD (0.05)	9	27	29	31
Cereal grain cultivar				
'Décor' triticale	60a	199a	140a	188a
'Lamberto' triticale	35b	101c	105a	123b
'NE426GT' triticale	54a	141b	169a	167a
'Ernie' wheat	53a	191a	148a	185a
'Goodstreak' wheat	57a	122bc	158a	187a
'Kaskaskia' wheat	61a	190a	147a	198a
P>*F*	0.002	<0.001	0.054	0.014
LSD (0.05)	13	38	NS§	43

† Final legume density measured prior to grain harvest on 8 and 6 July 2005 and 2006.
‡ Legume shoot DM measured 40 d after grain harvest on 22 and 25 Aug 2005 and 2006.
§ Not significant.

Results

- Legume density was influenced by legume species and variety, yet 40 d DM was only different between legume species (Table 1).
- Legume density increased as average and minimum light transmittance increased during 2005. Alternatively, legume densities decreased as LAI increased (Fig. 1).
- Increase in 2005 cereal DM at full head extension resulted in decreased legume densities (Fig. 2).
- Cereal plant height, DM at harvest, and yield did not influence legume density in 2005 (Fig. 2).
- Legume density was not influenced by cereal grain cultivar or any of the measured canopy traits in 2006 (Table 1; Figs. 1 and 2).

Conclusions

Light transmittance, LAI, and cereal DM at full head extension impacted legume densities in 2005. As light transmittance to the intercrop increased, higher densities were measured. The light compensation point for red clover has been reported at 6% of sunlight (Taylor and Smith, 1995). Legume densities were not affected by cereal cultivar or canopy traits in 2006, as the minimum light transmittance remained above 6% (Fig. 1). Maximum LAI must not exceed 5.4 in order to keep minimum light levels above 6% (data not shown). These minimum light levels are measured around the cereal development stage of heading (GS 50). For successful legume establishment with this intercrop, cereal grain breeders developing genotypes or producers selecting cultivars should select cereal grains that transmit at least 6% sunlight at heading.

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