Establishment of Perennial Groundcovers for Maize-Based Bioenergy Production Systems

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Introduction

As part of the Energy Independence and Security Act (EISA) of 2007, a revised Renewable Fuels Standard mandates the use of 36 billion gallons of renewable fuels by 2022, 16 billion gallons of which would be derived from cellulosic biofuels. Crop residue, including maize stover, from eligible lands was included as a feedstock for cellulosic biofuels production in the EISA, increasing economic incentives for maize corn stover removal. There exists, however, natural resources-related constraints for the removal of maize stover in maize-based production systems. Maize stover removal can enhance erosion, deplete soil organic matter and other nutrients, impacting the health of land and water resources external to specific operations.

Inclusion of perennial groundcover (PGC) may reconcile natural resources-related concerns in a maize-based biofuels system. Adoption of cover or companion crops can be used to enhance soil quality. Perennial groundcover significantly improves soil aggregation and stability over both conventional and no-till maize, and other annual cropping systems, which in turn enhance both soil organic matter content and carbon capture. Little information is available on establishment of perennial grasses as living mulch (LM) in either soybean or corn. We conducted a two site-year field study in Iowa to establish LM under either maize or soybean, and assess the impact of establishing LM on developmental morphology and yield of the primary crops of economic interest.

Materials and Methods

Experimental design at the Northern Research Farm, Kanawha, Iowa, in 2015 was a randomized complete block with three replicants and 12, 30 by 40 ft plots per block. The no LM controls included one of three glyphosate-resistant maize varieties: population sensitive, insensitive, or yield stable, to assess elite germplasm response to LM. Groundcover treatments included one LM species, either Kentucky bluegrass (KB) or creeping red fescue (CF), paired with each of the maize varieties. The soybean treatments included two LM species (KB and CF) and one glyphosate-resistant soybean variety, plus a no LM control.

Plots were fertilized and cultivated April 29 prior to grass seeding. Maize and soybeans were planted May 7. Herbicides were sprayed as needed, banded on LM plots, and broadcast on conventional plots. Stand density was measured at early vegetative and late reproductive stages. Maturity was assessed bi-weekly. Leaf Area Index (LAI) and normalized difference vegetative index (NDVI) for maize biomass was measured bi-weekly.

The four center rows were machine-harvested October 19 (maize) and October 6 (soybean), and analyzed for moisture, weight, and yield. A 1.32-m row of maize was hand-harvested at R6 on September 28 and at final harvest

October 19. Plant and ear number, fresh weight of stover and ears was recorded for a random 6-plant subsample from each plot, from which yield components (rows/ear) were estimated. A 1-m row of soybean was harvested at R6 to estimate total aboveground biomass (TAB), pod number, seed number, seed weight per pod, and harvest index (HI).

Grain quality was evaluated by transmittance Near Infrared Spectroscopy (NIRS). Final harvest maize stover was analyzed using sequential fiber analysis. Soybean and maize stover were analyzed for C and N content. Modified grid sampling technique was used post-harvest to assess PGC establishment.

Results and Discussion

Maize grain yield (averaging 207 bu/acre across treatments) and quality, as well as stover quality, were similar between the LM and control. Neither TAB nor stover quantity were negatively impacted by LM. Similarities in LAI and the bulk of NDVI collection dates were observed. Maize maturity, stand densities, HI (averaging 0.56 across treatments), and ethanol yield were largely similar. Sequential fiber results and stover C and N on a g/kg basis were similar.

Soybean grain yield and TAB were greater in the no LM control. Seeds/m ($P < 0.05$) and pod count ($P < 0.01$) were the only significantly different yield components, both lower in the LM treatments. No differences were observed in soybean maturity, stand densities, or HI (averaging 0.29). Fiber and carbohydrate averages were higher, although protein levels were lower for LM soybeans ($P < 0.01$). Stover C was similar and stover N was significantly higher for the control ($P < 0.05$).

Grass established best under soybean, attributable to later planting dates and resulting canopy closure for soybean than maize, plus an earlier harvest date, enhancing light capture by the grass seedlings.

Table 1. Data summary of perennial ground cover in maize trial at the ISU Northern Research Farm, Kanawha, IA.[1]

Trt averages†	GY	TAB	HI	PC	SC	SP	SM	Stover C	Stover N
	bu/ac	lb/ac		pods/m^2	seeds/m^2	seeds/pod	seeds/lb	—— % ——	
					Soybean				
1	72.4	7798	0.29	1,199	2,756	3.02	5007	46.8	2.08
2	56.8	6602	0.29	1,025	2,419	3.09	5062	46.7	1.93
3	56.0	6923	0.30	1,070	2,510	3.07	4862	47.4	1.73
Significance					**P-value**				
Control vs. LM	***‡	**	NS	**	*	NS	NS	NS	*
	GY	**TAB**	**HI**	**Stover**	**RE**	**Ethanol**	**Ethanol**	**Stover C**	**Stover N**
	bu/ac	lb/ac		lb/ac	rows/ear	gal/lb	gal/ac	—— % ——	
					Corn				
1	212.6	18,237	0.57	7,860	16.3	0.05	596.4	47.1	0.56
2	205.4	20,369	0.54	9,234	15.8	0.05	574.6	47.5	0.59
3	202.9	19,673	0.55	8,797	16.5	0.05	567.3	47.4	0.58
Significance					**P-value**				
Control vs. LM	NS	*	NS	**	NS	NS	NS	NS	NS
LM insensitive vs. LM sensitive	NS	NS	NS	NS	*	NS	NS	*	**

[1]Treatment averages (Trt averages) and significance for grain yield (GY), total aboveground biomass (TAB), harvest index (HI), stover C, stover N, as well as soybean pod count (PC), seed count (SC), seeds/pod (SP), seed mass (SM), and maize rows/ear (RE), stover and ethanol yield at ISU Northern Research Farm, Kanawha, IA in 2015. Grain yield was combine-harvested and expressed at 130 g/kg moisture content for soybean and 155 g/kg moisture content for maize. TAB, stover yield, HI, stover C, and stover N are on an oven-dry basis.

†Treatment average 1 is no LM conventional; treatment average 2 is KB LM; treatment average 3 is CF LM. LM = living mulch; KB = Kentucky bluegrass; CF = creeping red fescue.

‡NS = not significant; * = significant at $P < 0.05$; ** = significant at $P < 0.01$; *** = significant at $P < 0.001$.