Sustainable Corn Stover Removal Systems For Mushroom Substrate Production

C.D. Houser, G.W. Roth, M.H Hall and D.M. Beyer
Pennsylvania State University

Background

Corn stover has been identified as a potential feedstock for the production of mushroom compost, and has been evaluated at the Penn State Mushroom Testing and Demonstration Facility. Recently, the use of corn stover in commercial mushroom production has increased in Pennsylvania; over 249 million kg of mushrooms are produced each year. Corn stover harvesting has already provided corn growers in some parts of the state with an additional revenue source, but there could be consequences with the development of this resource. A key issue and concern is the potential impact of stover harvesting on the soil resource, and the impact on the yield and profitability of crops following stover harvest. Strategies are needed to minimize these potential impacts.

Materials and Methods

From 2009 to 2011, a field study was established on the Russell Larson Research Farm near State College, PA on a Hagerstown silt loam soil in a field previously cropped to corn. The study consisted of three treatments managed in a no-till system that involve stover harvest and SMS applications. Treatments included:
1) SH/SMS - 75% stover harvest in the spring followed by an SMS application prior to planting; 2) SH/NPK - 75% stover harvest in the spring followed by an application of NPK; 3) NSH/NPK - No stover harvest followed by an application of NPK. SMS application rates were based on the potential removal of the P and K during a six-year rotation of three years of corn followed by three years of alfalfa hay. NPK rates were also based on the amount of nutrients removed by harvesting the grain and stover.

Objectives

The main objective of this study was to measure the impact of the SMS cropping system on corn and stover yield. Another objective was to measure soil carbon gains and/or losses. The third objective was to determine if an SMS application could be combined with a stover harvest to offset the carbon losses and improve net returns.

Table 1. Corn and stover yields for the three different treatments.

Treatment	2009	2010	2011	Mean
Grain Yields kg/ha				
SH/ SMS	12218	11396	5407	9674
SH/ NPK	11415	10907	4986	9103
NSH/NPK	10788	10512	5112	8804
LSD (.05)	652	378	ns	351
Stover Yields kg/ha				
SH/ SMS	4048	5162	2505	3905
SH/ NPK	3877	4918	1996	3597
NSH/NPK	--	--	--	--
LSD (.05)	ns	ns	ns	ns

Table 3. Economic returns for the three different treatments.

	SH/SMS		SH/NPK		NSH/NPK	
	Cost	Income	Cost	Income	Cost	Income
	------------------------------$/ha---------------------					
Corn		8005		7538		7279
Corn Stover		1284		1186		0
Alfalfa		9263		9263		9263
Corn (N,P,K)	329		1398		1015	
SMS/trucking	296		0		0	
Alfalfa (P,K)	0		2437		2437	
Harvest Stover	94		94		0	
Other*	1899		1899		1899	
Totals	2806	18552	5832	17987	5449	16542
Net		15746		12155		11093

† Abbreviations: SH, Stover harvest: SMS, Spent mushroom substrate: NPK refers to traditional fertilizers Nitrogen, Potassium, and Phosphorous: NSH, no stover harvest.
*Other: Includes seed, planting, spraying, herbicide, and harvesting the grain.
Assumptions: corn revenue @ $.275/ kg, corn stover $89/ Mg, alfalfa $223/Mg, corn production (P205) $2 .09/kg (0,73,56 kg/ha), corn production (K2O) $1.19/kg (0,140,56 kg/ha)corn production (N) $1.19/kg (112,168,168 kg/ha), hybrid seed @$ 253/ha, herbicide @$ 88.92/ha, compost @ $ 185/ha, planting @ $ 62/ha, spraying @ $64/ha, loading/applying compost @ $49/ha, trucking of compost 80 km @$ 1.25, harvesting corn crop $86/ha, harvesting stover @ $94/ha.

Results

Grain yields in two of the three years were the highest in the SH/SMS treatment. Yields also tended to be higher in 2011, but drought caused yields to be lower and variability to be higher than in other years for both the grain and stover. Over the three years the SH/SMS treatment resulted in a 6.3% increase corn yield over the SH/NPK treatment and a 9.9% increase over the NSH/ NPK treatment (Table 1).

With the addition of SMS, the total carbon increased in the surface (0-5 cm) from 19.9 to 36.2 g/kg - an 81% increase. In the 0-25 cm soil profile, the total carbon increased 39.2%. In the deeper soil profile, there was less of a change in soil carbon (Table 2). In the SH/NPK treatment, soil carbon in the 0-5 cm declined 14%. Eventually, only enough SMS would need to be added to maintain soil carbon levels associated with the stover removal and that rate would be much lower.

The economic evaluation for the three year study and the additional three years of hypothetical alfalfa rotation reveals that the SH/SMS had the highest net return $15746/ha. This higher net return was due to a combination of several factors including higher corn yields, additional stover revenue, lower P and K inputs for the corn crop, and lower P and K inputs for the subsequent rotational alfalfa crop (Table 3).

Table 2. Soil carbon levels for the three treatments.

	0-5 cm			0-25 cm		
Treatment	2009	2011	Change	2009	2011	Change
	---g/kg-----		%	---g/kg------		%
SH/ SMS	19.9	36.2	81.6	13.5	18.7	39.2
SH/ NPK	20.9	18.0	-14.0	13.8	14.0	1.3
NSH/NPK	18.5	20.4	10.2	13.6	15.3	12.4
LSD (.05)	ns	4.8	19.3	ns	1.51	12.8

Acknowledgements

We are grateful for the financial support from the Giorgi Research Fund and the DOE North Central Regional Sun Grant Center that made this research possible.