Profitability and Risk Associated With Alternative Mixtures of High-Residue Cover Crops

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Abstract

Conservation tillage systems with cover crops may increase crop yields and net returns when compared to conventional tillage systems. This benefit may be further enhanced with mixtures of high-residue cover crops. The purpose of this paper is to examine the economic profitability and risk associated with alternative high-residue cover crops as part of a conservation tillage system. An experiment was conducted near Shorter, AL using a factorial arrangement of two management systems with six replications on a two-year corn (*Zea mays* L.) - cotton (*Gossypium hirsutum* L.) rotation with both phases of the rotation present each year from 2001 to 2003. The first management system was a conservation system with two groups of cover crops planted prior to corn and cotton. The first group of cover crops was a mixture of white lupin (*Lupinus albus* L.), crimson clover (*Trifolium Incarnatum* L.), and fodder radish (*Raphanus sativus* L.) planted prior to corn. The second group of cover crops was a mixture of black oat (*Avena strigosa* Shreb.) and rye (*Secale cereale* L.) planted prior to cotton. The second management system is a conventional tillage system with no cover crop. Results indicate that the use of alternative mixtures of high-residue cover crops, while being more costly to plant than more traditional cover crops, can increase crop yields and decrease the risk of obtaining lower crop yields and net returns in drought years. Given the conservation system with cover crop used was relatively immature; we would expect that these benefits would become more evident over time.

Introduction

Traditionally, cotton (*Gossypium hirsutum* L.) and corn (*Zea mays* L.) were grown in the Southeast under conventional tillage systems, resulting in degraded agricultural soils due to extensive soil erosion. In an attempt to curb this degradation, conservation tillage methods, such as no-till, reduced tillage and minimum tillage were developed; and have been readily adopted by a significant group of farmers in the Southeast. In Alabama, about 58 and 64 percent of farmers use conservation tillage systems for cotton and corn production, respectively (CTIC, 2004).

On Coastal Plain soils of Alabama, frequent occurrence of short-term droughts threatens crop growth due to the low water holding capacity of soils in this region. The use of cover crops as part of a conservation tillage system can help alleviate drought stress by increasing infiltration rates and increasing soil moisture content. In addition, cover crops can further improve soil quality by helping to relieve compaction, improve soil organic matter and reduce soil erosion (Reeves, 1994; Sustainable Agricultural Network, 1998). All of these characteristics have the potential to increase crop yields and in turn on-farm profits.

The purpose of this paper is to examine the economic profitability and risk associated with two alternative mixtures of high-residue cover crops used in a two-year corn-cotton rotation as part of a conservation tillage system. This information should provide insight concerning the economic viability of using different mixtures of cover crops in a relatively immature conservation tillage system.

MATERIALS AND METHODS

Two crop management systems, a conventional and conservation tillage systems were established on a 24-acre Coastal Plain field at the E.V. Smith Research and Extension Center near Shorter, AL. Prior to the experiment, the site had a long history of continuous cotton production under conventional tillage. The conventional tillage system resembled one commonly used on the southern Coastal Plain. Tillage included disking, chisel plowing, disking and cultivation to level the seedbed, and non-inversion tillage prior to planting. In addition, no cover crop was used, but winter weeds were not controlled. The conservation tillage system included the use of winter cover crops and non-inversion in-row subsoiling prior to planting to minimize surface soil disturbance and disrupt the inherent hardpan found in these soils. Two different groups of cover crops were planted. The first group (Group 1) was a mixture of white lupin (*Lupinus albus* L.), crimson clover (*Trifolium Incarnatum* L.), and fodder raddish (*Raphanus sativus* L.). The second group (Group 2) was a mixture of black oat (*Avena strigosa* Shreb.) and rye (*Secale cereale* L.). Group 1 was planted prior to corn, while Group 2 was planted prior to cotton. All cover crops were planted with a no-till drill. A mechanical roller was used in conjunction with herbicide to terminate each cover crop mixture prior to spring planting. The experimental design was a factorial arrangement of two management systems (with and without manure) using a corn-cotton rotation with both phases of the rotation present each year, with six replications imposed on 20-ft by 787-ft long strips across the field. Each strip in the field was divided into 20-ft by 60-ft cells. Treatments with manure were excluded from this analysis, but all agronomic experimental results were reported in Terra et al. (2004). The remainder of production practices, such as pesticide applications, followed Alabama Cooperative Extension System (AAES) recommendations. Using information on crop and input prices provided by the AAES (2004), net returns and risk associated with using each group of cover crops in a conservation tillage system was compared to a conventional tillage system with no cover crop.

RESULTS AND DISCUSSION

Net returns were estimated for the conservation tillage system with each cover crop group and for the conventional tillage system with no cover crop for both corn and cotton. Estimates of net returns and yields are provided for 2001, 2002 and 2003 (Tables 1 and 2). Negative returns to cotton in 2002 can be attributed to low prices and limited rainfall. The yearly average spot price in Alabama was \$0.28/lb in 2001 and \$0.44/lb in 2002. Rainfall was lower than average in 2001 and a short-term drought occurred during the summer of 2002. Of interest is that corn and cotton lint yields from 2001 to 2003 from the conservation tillage systems exceeded yields from the conventional tillage system by as much as 20 percent. These results are not surprising given the advantage conservation systems with cover crops have on increasing soil water use efficiency and soil organic matter (Snapp et al., 2005). In 2003, a high rainfall year, both yields and net returns (without cost share) of cotton for the conservation tillage system were 15 and 10 percent higher respectively, when compared to the conventional tillage system with no cover crop. For corn, net returns were lower in 2003 due to the high cost of establishing the cover crop.

Table 2 provides detailed estimates of the production costs for both corn and cotton in rotation for both tillage systems with and without cover crops in 2003. Production costs followed similar trends in 2001 and 2002. Machinery (both variable and fixed) and labor costs are lower for the conservation tillage system, but pesticide costs are higher due to the use of additional herbicide to terminate the cover crop. The lower machinery costs are due to less passes across the field, which translates into lower labor and fuel costs and saved time. In 2003, for cotton, this reduced labor costs by $3.64 per acre. On a 500 acre farm this would amount to a savings of $1820. Assuming other production costs do not change, the farmer could use this saved labor to farm an additional 57 acres of land this year, retaining the same labor costs as under the conventional tillage system on a 500 acre farm and increasing profits by almost $8000 (not adding in farm payments and cost share for cover crops). This provides some indication of the value of the "saved labor and time" that a conservation system and cover crop can provide.

The cover crop mixtures used in the conservation tillage system were relatively expensive, when compared to a small grain cover crop such as rye or wheat (*Triticum aestivum* L.), which could have been planted for about $20-$35 per acre using the same production costs (Table 2). The primary cost to plant each cover crop was the seed. Seeding rates for Group 1 were 90, 25 and 15 lbs per acre for white lupin, crimson clover, and fodder radish, respectively. Seeding rates for group 2 were 40 and 60 lbs per acre for rye and black oats respectively. The cost of seed was $0.80/lb for white lupin, $0.84/lb for crimson clover, $2.36/lb for fodder radish, $0.19/lb for rye and $0.63/lb for black oat. High seeding rates were used to test practicality of experimental germplasm to generate a high residue cover, and the high costs of certain cover crops were due to their limited commercial availability. Costs of establishing a cover crop may be reduced if nitrogen fertilization rates are decreased to take account of the nitrogen provided by legume cover crops and nitrogen mineralization from cover crop residues (Snapp et al., 2005). Furthermore, the Natural Resource Conservation Service (NRCS) of the USDA offers financial incentives for planting cover crops in Alabama through the Environmental Quality Incentives Program (EQIP) and the Conservation Security Program (CSP). Under EQIP, NRCS offers a cost share of $5/acre if there is greater than 30 percent residue cover on the field and $40/acre if there is greater than 50 percent for up to three years (NRCS, 2005). It is assumed that cost share was obtained from NRCS through EQIP when calculating estimates of net returns.

To examine the economic potential for these cover crop regimes, net revenues in 2002 were re-estimated using different prices of cover crop seed and spot prices for corn and cotton. This year was chosen due to the short-term drought and the fact that a cover crop can help alleviate some of the losses in income that could occur due to a drought. It is assumed that the price of seed for white lupin, rye and black oat change and the price of seed for crimson clover and fodder radish are equal to $0.80/lb. Results are reported in Table 3. The figures reported are the difference from what the farmer would have obtained had they used the conventional tillage system with no cover crop instead of the conservation tillage system with cover crop. Even with no change in the spot price of corn or cotton the results indicate that in 2002 use of these alternative mixtures of cover crops in a conservation tillage system could be more profitable than a conventional tillage system (Table 2). As spot prices increase, the difference in net returns between tillage systems grows, highlighting the economic advantage of the conservation tillage system with a cover crop. Similar trends are found for 2001 and 2003.

The ability to enhance profits is a significant concern for farmers when they are considering the use of cover crops, but not the only concern. Given that farmers are faced with uncertainties due to unpredictable factors when using a cover crop such as nutrient availability, weather, pests, etc., farmers may be concerned about the economic risks associated with using a cover crop, as well (Jaenicke et al., 2003). For example, a farmer may want to choose a cropping system that maximizes expected profit, while at the same time minimizes the variability in profits from year to year and across the field. Lu et al. (1999) found that a cropping system consisting of a corn-soybean [*Glycine Max (*L.) Merr.] rotation with hairy vetch (*Vicia villosa* L.) planted prior to corn and wheat prior to soybean had the lowest yield variability, highest gross margin and second lowest variability in gross margins over time when compared to conservation tillage systems with no cover, no tillage with manure and no tillage with a crown-vetch (*Coronill varia* L.) living mulch. Jaenicke et al. (2001) found that cotton grown after a wheat cover crop was the least risky cover crop alternative in terms of lowering net returns when compared to using no cover crop, crimson clover and hairy vetch. Larson et al. (2001) found that when considering the risk associated with obtaining lower net returns, risk-averse farmers are more likely to adopt a conventional tillage system over a no-tillage system for cotton, when taking into account the cost of planting a cover crop prior to cotton.

Give that soil conditions and topography can differ significantly within a given field, spatial variability may be of interest to a farmer. If conservation tillage systems with cover crops can reduce spatial variability of crop yields, then it may help to reduce variability in net returns. This would have the added benefit of lowering the risk of reduced revenues when converting to conservation tillage systems with cover crops. Given the experiment was conducted on 24-acre field, spatial variability was examined each year by calculating the coefficient of variation for crop yields and net returns for each tillage system, using the data from the cells in the corresponding strips in the field for each treatment examined (Table 4). The coefficient of variation provides a mechanism for comparing variability between different treatments. The results for 2002 provide evidence that conservation tillage systems with cover crops have the potential to reduce spatial variability of crop yields for corn and cotton; and net returns for cotton in years with low rainfall. In years of higher than average rainfall, the use of these mixtures of cover crops may actually increase the spatial variability of yields and net returns, especially for cotton. Thus, a farmer may expect that the conservation tillage system with alternative high residue cover crop examined may reduce the risk of lower net returns in drought years, but may increase the risk of lower net returns in years with more than average rainfall when the system is relatively immature.

CONCLUSION

A review of the literature by Snapp et al. (2005) in the northern Midwest found that the most direct benefit of using cover crops in different cropping systems was an increase in crop yields. A secondary benefit was greater long-term yield stability, especially in drought years. Both of these benefits are evidenced in this study. The use of mixtures of high-residue cover crops, while being more costly to plant than a single species, did increase yields for both corn and cotton; decreased the risk of obtaining lower crop yields for corn and cotton; and decreased the risk of lower net returns in drought years for cotton, when compared to a conventional tillage system with no cover crop. Given that the conservation system with cover crop used in the experiment was relatively immature, we would expect that these benefits would become more evident over time.

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Table 1: Yield for different tillage systems: 2001 – 2003.[a]

	Corn		Cotton	
	Tillage System			
	Conventional Tillage	Conservation Tillage	Conventional Tillage	Conservation Tillage
	bu/ac		lint lb/ac	
2001	154	161	959	1078
2002	111	141	438	559
2003	195	206	1032	1188

[a] Terra *et al*. (2004) found that differences between yields was statistically significant when comparing across tillage systems ($p < 0.001$) using a mixed model.

Table 2: Estimated revenues and costs for different tillage systems for 2003 and estimated net returns for 2001 to 2003.

	Corn		Cotton	
	Tillage System			
	Conventional Tillage	Conservation Tillage	Conventional Tillage	Conservation Tillage
	$/acre		$/acre	
Gross Receipts – Spot Price[a] (Corn: $2.61/bu, Lint: $0.56/lb)	$509.60	$538.06	$652.04	$750.27
Farm Payments[b]	25.20	25.20	103.63	103.63
Variable Costs of Crop Production				
Seed and Technology Fees	30.80	30.80	50.03	50.03
Fertilizer and Lime	71.43	71.43	53.43	53.43
Pesticides	31.16	38.10	65.60	72.54
Growth Regulators and Harvest Aids	0.00	0.00	21.31	21.31
Scouting and Soil Testing	8.00	8.00	16.00	16.00
Drying/Hauling/Storage	29.29	30.92	103.24	118.79
Crop Insurance	0.00	0.00	18.00	18.00
Tractor/Machinery	23.94	19.49	56.07	50.68
Interest on Operating Capital	6.32	6.68	12.47	13.02
Labor	22.12	16.25	35.43	31.79
Total Variable Costs	223.06	221.67	431.58	445.59
Fixed Costs of Crop Production				
Tractor and Machinery	64.87	55.01	75.21	70.87
General Overhead	14.07	13.85	27.73	28.97
Total Fixed Costs	78.94	68.86	102.94	99.84
Cost of Cover Crop				
Seed		115.40		45.20
Fertilizer/Machinery/Labor		10.03		19.73
NRCS Cost Share[c]		-40.00		-40.00
Total Cost of Cover Crop		85.43		24.93
Total Costs	302.00	375.96	534.52	570.36
Net Return[d]				
2001	$96.43	$58.96	$80.40	$149.85
2002	$64.67	$82.73	-$113.83	-$68.71
2003	$232.80	$187.30	$221.15	$283.54

Sources: AAES, 2004; NRCS, 2005; Terra *et al*., 2004.

[a] Estimates of gross receipts for cotton include sales of cottonseed at $0.04 per lb.

[b] Farm Payments include direct, countercyclical and loan deficiency payments. The loan deficiency payments varied by year due to fluctuations in crop prices. State average yields and prices were used to calculate all payment levels. Payment levels are the same for both tillage systems for each crop, because the basis was determined assuming conservation tillage was used prior to 2001 on the entire field.

[c] NRCS cost share is based on EQIP payment levels as of 01/12/05 for residue management at a fixed rate of $40/acre for 50%+ residue at planting (NRCS, 2005). This amount is subtracted from the total cost of planting the cover crop.

[d] Net return is equal to gross receipts plus farm payments minus total cost.

Table 3: Increase in net returns per acre for a conservation tillage system with high residue cover crop mixtures above a conventional tillage system using different prices of cover crop seed and spot prices for corn and cotton in 2002.

Spot Price[a]	Price of Cover Crop Seed[b]			
	$0.20/lb	$0.16/lb	$0.12/lb	$0.08/lb
Corn				
$2.72/bu	$45.49	$49.49	$53.49	$57.49
$2.75/bu	$46.37	$50.37	$54.37	$58.37
$2.80/bu	$47.87	$51.87	$55.87	$59.87
$2.85/bu	$49.37	$53.37	$57.37	$61.37
$2.90/bu	$50.87	$54.87	$58.87	$62.87
$3.00/bu	$53.87	$57.87	$61.87	$65.87
Cotton[c]				
$0.44/lb	$34.04	$38.04	$42.04	$46.04
$0.47/lb	$37.67	$41.67	$45.67	$49.67
$0.50/lb	$43.73	$47.73	$51.73	$55.73
$0.55/lb	$49.78	$53.78	$57.78	$61.78
$0.60/lb	$61.89	$65.89	$69.89	$73.89
$0.70/lb	$80.05	$84.05	$88.05	$92.05

[a] Spot price for cotton is for cotton lint. Spot price for cottonseed is assumed to be $0.04/lb

[b] It is assumed that the price of seed for white lupin, rye and black oat change and the price of seed for crimson clover and fodder radish are equal to $0.80/lb.

[c] Loan deficiency payments were calculated using average spot and loan market price in Alabama, resulting in a difference of $9.68 due to difference in cotton yields between the conventional and conservation tillage systems.

Table 4: Spatial variability in the field for different tillage systems with cover crops for corn and cotton.

Crop[a]	Year	Tillage System	Coefficient of Variation[b]	
			Yield	Net Returns
Corn	**2001**	**Conventional**	12.43	62.32
		Conservation	14.96	584.23
Cover Crops: Group 1	**2002**	**Conventional**	24.29	264.82
		Conservation	16.16	1706.10
	2003	**Conventional**	7.03	14.15
		Conservation	6.46	26.34
Cotton	**2001**	**Conventional**	9.49	8.87
		Conservation	9.48	9.21
Cover Crops: Group 2	**2002**	**Conventional**	21.68	12.19
		Conservation	12.53	11.43
	2003	**Conventional**	7.12	29.01
		Conservation	7.59	35.05

[a] Group 1 is white lupin, crimson clover and fodder radish. Group 2 is black oat and rye.

[b] The coefficient of variation is equal to $\left(\frac{\text{standard deviation}}{\text{mean}}\right)\times 100$ and is a measure of how much a variable will vary around its own mean.