THE ECONOMIC FOUNDATION FOR TILLAGE SYSTEM SELECTION

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Abstract

The purpose of this study is to identify the economic differences between tillage systems in two diverse cotton producing regions: the Southern Rolling Plains (SRP) of Texas and the Delta region of Mississippi. In both the SRP of Texas and the Delta Region of Mississippi, reduced and no-till cotton production systems demonstrate some superior cost management capabilities versus a conventional tillage system. This research indicates that the magnitude of the economic differences among cotton tillage systems is regionally specific, but much of the economic benefit of adopting a conservation tillage system is embedded in an improved fixed cost structure (i.e. reduced depreciation). These impacts do not immediately affect cash expenses and are sometimes difficult to observe. This may help to explain why widespread adoption of conservation tillage technologies has not been more rapidly embraced. This paper provides a preliminary basis to enable growers to evaluate the trade-offs between cash expenses, equipment requirements, labor requirements and overall profitability that can be expected from their choice of a cotton tillage system.

Introduction

Conservation tillage systems have been a long studied method for potential cost reductions for U.S. cotton producers as well as for providing positive soil improving qualities and other environmental benefits. The purpose of this study is to identify the economic differences between tillage systems in two diverse cotton producing regions: the Southern Rolling Plains (SRP) of Texas and the Delta region of Mississippi. These regions were selected because they represent two very different non-irrigated cotton production regimes and levels of input use. The SRP is a relatively low input and low cotton yielding region while the Delta region is a higher input region with higher expected yields. These regions provide a basis to evaluate alternative cotton tillage systems across a spectrum of growing conditions.

The Southern Rolling Plains (SRP) of Texas is an area which has historically planted 200,000 to 350,000 acres of cotton per year. Approximately 85 percent of the cotton production in this region is dry-land with about 15 percent receiving supplemental or full irrigation. The SRP is a relatively low input production area with low historical yields as compared to other regions of the state and country.

The Mississippi Delta is one of the largest contiguous agricultural areas in the U.S. with more than 4 million acres, deep alluvial soils, 220 to 260 frost-free days per year, and annual precipitation ranging from about 45 inches in the northern Delta to 60 inches in the southern Delta. The Mississippi Delta represents a region that is very productive under proper management.

Conservation tillage, in general, and no-till practices in particular, have increased over the past few years. Yet, despite the apparent advantages of conservation tillage, especially cost savings from reduced labor, fuel and machinery costs, conservation tillage has been adopted by some farmers, but not all (Martin, 2002). In many previous studies, there has been little to no increased yield from no-till or reduced tillage compared to conventional tillage but there are economic advantages. These come from: 1) reduced labor input 2) reduced fuel usage 3) fewer repairs and lower maintenance costs 4) better field accessibility 5) lower capital investment and 6) smaller horsepower equipment (Stichler, 2005).

A number of studies have attempted to quantify the economic benefits of conservation tillage systems for cotton production. Smart et al. (1999) identified reduced production costs of $55 to $66 per acre and higher net returns of $119 to $129 per acre for conservation tillage cotton production following grain sorghum versus conventional tillage systems in the semi-arid climate of south Texas. Bradley (2000) investigated the economics of conservation tillage systems across eight cotton belt states. This study showed reductions in cost of tillage for no till cotton systems

amounting to $20.68 and $45.08 per acre versus conservation tillage and conventional tillage, respectively. Further, labor requirements were found to be 0.5 hours per acre lower for conservation and no till systems versus conventional tillage systems.

Johnson and Polk (2004) found that growers employing conservation tillage systems (reduced tillage and no till) did not realize significantly lower estimated total costs of production. Conservation tillage systems did appear to provide cost savings for labor, fuel, machinery and equipment, and repairs and maintenance. However, these savings were offset by higher chemical expenses from the increased dependence on chemical applications to substitute for tillage activities. Conservation tillage systems were found, on average, to result in total variable costs that were $7 to $12 per acre higher and fixed costs that were $6 to $8 per acre lower. Collectively, the differences in total costs of production were estimated to be less than $4 per acre (approximately 3%) between tillage systems. However, Polk and Johnson (2007) identified that in non-irrigated cotton producing areas characterized by a high cotton acreage failure rate, conservation tillage systems could provide cost management flexibility advantages over conventional tillage systems.

Table 1 and 2 shows the ten-year production and yield history for non irrigated upland cotton in Tom Green County, Texas and Yazoo County, Mississippi, respectively. Cotton yields in Tom Green and Yazoo County averaged 337 and 810 pounds per harvested acre, respectively. Because the SRP of Texas is characterized by wide variations in rainfall, there is often a great divergence between planted upland cotton acres and harvested acres. For the SRP, the average failure rate, or difference between planted and harvested acres, averaged 31 percent. Alternatively, the Delta region experienced a failure rate averaging less than 8 percent.

Table 1. Historical production and yield of non-irrigated upland cotton for Tom Green County, Texas 1998-2007 (USDA, 1998-2007).

Year	Planted Acres	Harvested Acres	Production (bales)	Yield per Harvested Acre	Yield per Planted Acre
1998	71,600	17,000	10,200	288	68
1999	77,800	66,600	27,000	195	167
2000	104,600	16,300	1,900	56	9
2001	74,800	66,800	36,000	259	231
2002	58,200	53,000	24,800	225	205
2003	58,300	55,200	35,100	305	289
2004	59,800	58,000	59,200	490	475
2005	64,000	63,700	71,000	535	533
2006	65,900	23,900	9,100	183	66
2007	57,400	57,400	100,000	836	836
Average	**69,240**	**47,790**	**37,430**	**337**	**288**

Table 2. Historical production and yield of non-irrigated upland cotton for Yazoo County, Mississippi 1998-2007 (USDA, 1998-2007).

Year	Planted Acres	Harvested Acres	Production (bales)	Yield per Harvested Acre	Yield per Planted Acre
1998	57,000	56,800	93,200	788	785
1999	93,600	92,100	141,300	736	725
2000	100,000	98,400	123,000	600	590
2001	109,000	108,100	167,000	742	735
2002	71,800	70,900	114,500	775	765
2003	67,400	67,200	133,900	956	954
2004	54,300	54,100	115,700	1,027	1023
2005	52,300	52,200	90,900	836	834
2006	53,000	52,700	82,000	747	743
2007	22,700	22,600	41,800	888	884
Average	**73,340**	**67,510**	**110,330**	**810**	**804**

Methods

Table 3 illustrates the expected costs associated with conventional, reduced, and no-till production systems for each harvested acre of non-irrigated upland cotton in the SRP of Texas. These costs are estimated using farm level producer costs from the Texas Financial And Risk Management (FARM) database as well as Texas AgriLife Extension crop budgets (Texas A&M University, 2008). Expected seed costs reflect stacked gene varieties which are held constant across all tillage systems. Fertilizer and herbicide costs increased from conventional till to reduced till and from reduced till to no-till systems. Fuel costs were estimated using $2.33 per gallon for farm diesel and variable harvesting costs were $0.10 per pound.

Table 3. Non-irrigated upland cotton budgeted costs per harvested acre for conventional, reduced, and no-till systems in the Southern Rolling Plains of Texas.

Variable Costs	Conventional Till	Reduced Till	No-Till
Seed ($/acre)	23.15	23.15	23.15
Fertilizer ($/acre)	13.00	16.75	18.45
Herbicides ($/acre)	10.00	21.43	28.87
Insecticides ($/acre)	0	0	0
Fungicides ($/acre)	0	0	0
Custom Application ($/acre)	0	0	0
Scouting ($/acre)	0	0	0
Fuel ($/acre)	35.20	24.31	21.85
Defoliant ($/acre)	4.75	4.75	4.75
Harvesting ($/pound) @ 337 lbs.	37.00	37.00	37.00
Boll Weevil ($/acre)	8.00	8.00	8.00
Labor ($/acre)	18.36	12.86	12.04
Repairs & Maintenance	22.30	16.08	13.58
Int. on Operating Capital ($/acre)	6.20	5.54	7.18
Total Variable Cost ($/acre)	**177.96**	**169.87**	**174.87**
Fixed Costs - Equipment ($/acre)	**49.94**	**36.12**	**31.21**
Total Costs ($/acre)	**227.90**	**205.99**	**206.08**

Table 4 illustrates the expected costs associated with conventional, reduced, and no-till systems for each harvested acre of non-irrigated upland cotton in the Mississippi Delta region. These costs are estimated using Mississippi State Extension budgets (Mississippi State University, 2008). Expected seed costs reflect the prevailing varieties that were consistent with the respective tillage system. Fuel costs were estimated using $2.33 per gallon for farm diesel and variable harvesting costs were $0.09 per pound.

Table 4. Non-irrigated upland cotton budgeted costs per harvested acre for conventional, reduced, and no-till systems, Delta Region, Mississippi.

Variable Costs	Conventional Till	Reduced Till	No-Till
Seed ($/acre)	20.48	73.15	73.15
Fertilizer ($/acre)	67.50	67.50	75.50
Herbicides ($/acre)	47.05	30.46	30.46
Insecticides ($/acre)	97.34	52.33	52.33
Growth Regulators ($/acre)	6.35	5.64	5.64
Custom Application ($/acre)	48.75	46.25	46.25
Scouting ($/acre)	7.00	7.00	7.00
Fuel ($/acre)	48.18	37.87	33.50
Harvest Aids ($/acre)	15.38	15.38	15.38
Harvesting ($/pound) @ 810 lbs.	81.00	81.00	81.00
Eradication Fee ($/acre)	5.50	5.50	5.50
Labor ($/acre)	41.10	31.82	28.03
Repairs & Maintenance	29.44	26.00	23.67
Int. on Operating Capital ($/acre)	16.25	15.82	15.79
Total Variable Cost ($/acre)	**531.32**	**495.72**	**493.20**
Fixed Costs - Equipment ($/acre)	**134.20**	**114.93**	**106.29**
Total Costs ($/acre)	**665.52**	**610.65**	**599.49**

In both the Texas and Mississippi budgets, variable fuel, labor, repair costs, and interest on operating capital decreased across tillage systems (conventional to reduced and reduced to no-till) while boll weevil and scouting costs were constant across tillage systems. Other major costs for insecticides and herbicides varied based on the tillage system employed. In both the SRP and Delta Region budgets, reduced and no-till systems displayed significant fixed cost advantage versus conventional tillage systems.

Non-irrigated upland cotton budgets for each tillage system in Tom Green County and Yazoo County and historical county yields were inputted into the Financial And Risk Management (FARM) Assistance computerized decision aid. This decision aid links actual production and financial data with long-term projections of prices, interest rates, and inflations rates. It is a whole-farm decision support system designed to help producers' access likely outcomes of strategic decisions up to ten years into the future. Unique to FARM Assistance is the ability to evaluate the potential impacts of business alternatives under risk. Results from the FARM Assistance analysis provide a projection of the different financial performances of the alternative tillage systems over a ten-year study period.

A representative farm in each region was evaluated consisting of 1,000 acres planted to non-irrigated land upland cotton. In the SRP region, the prevailing planting pattern consisted of a 2 and 1 pattern which means that the equivalent of 667 continuous acres was built into the FARM Assistance decision aid. For the Delta region, the 1,000 acres were assumed to be solid planted rows. Price projections from the Food and Agricultural Policy Institute (FAPRI) were used to forecast cotton prices for 2008-1017. Since these price projections included cotton prices for the projection period that exceeded the U.S. loan rate, no government payments were included in this analysis. Because direct payments and counter-cyclical payments are not tied to current cotton production, it was decided to ignore these potential payments as they should not influence the decision to produce (or not produce) cotton. Projections for inflation based input costs were also taken from FAPRI. Three tillage systems were developed for representative farms in the SRP of Texas and the Delta Region of Mississippi. The representative farms utilized the variable and fixed cost structures illustrated in Tables 3 and 4 for each tillage system in order to provide a comparison within each cotton production region.

Results

Table 5 shows break-even price sensitivity estimates for Tom Green County, Texas for each tillage system (for both variable and total costs) with four alternative yield levels spanning the ten-year average yield. These break-even estimates reflect the credit producers receive for their cotton seed production valued at $150 per ton and an adjustment for variable harvesting costs. Table 6 presents the same information related to cotton production in

Yazoo County, Mississippi. The table identifies alternative yield levels and their respective break-even prices for cotton lint. Whenever the resulting yield level and break-even price to recover variable costs exceeds the prevailing cotton price (or cotton price plus pending loan deficiency payments), then the producer would actually be better off not producing cotton. Using the $0.52 loan rate level as a realistic price floor for cotton prices, producers in the SRP of Texas could expect to make contributions toward fixed costs using any tillage system provided they achieved average yields exceeding 275 pounds per acre. However, only producers employing reduced or no-till systems would recover variable and fixed costs with yields exceeding 350 pounds per acre.

Table 5. Break-even cotton prices ($/pound) to recover variable and total costs of production for Tom Green County, Texas.

	Yield (pounds per acre)			
Tillage System	**200**	**275**	**350**	**425**
Conventional				
Variable Costs	$0.7013	$0.5046	$0.3922	$0.3194
Total Costs	$0.9510	$0.6862	$0.5349	$0.4369
Reduced				
Variable Costs	$0.6609	$0.4752	$0.3691	$0.3004
Total Costs	$0.8415	$0.6065	$0.4723	$0.3854
No-Till				
Variable Costs	$0.6859	$0.4933	$0.3833	$0.3122
Total Costs	$0.8419	$0.6068	$0.4725	$0.3856

Table 6. Break-even cotton prices ($/pound) to recover variable and total costs of production for Yazoo County, Mississippi.

	Yield (pounds per acre)			
Tillage System	**600**	**750**	**900**	**1050**
Conventional				
Variable Costs	$0.7340	$0.5812	$0.5430	$0.4066
Total Costs	$0.9577	$0.7602	$0.7108	$0.5344
Reduced				
Variable Costs	$0.6747	$0.5338	$0.4985	$0.3727
Total Costs	$0.8663	$0.6870	$0.6422	$0.4821
No-Till				
Variable Costs	$0.6705	$0.5304	$0.4954	$0.3703
Total Costs	$0.8477	$0.6721	$0.6282	$0.4715

Applying this same analysis to the Yazoo County results, $0.52 cotton enables reduced and no-till producers to recover all of their variable costs and make contributions toward fixed costs with yields exceeding 900 pounds per acre. However, conventional tillage producers would be better off not producing cotton with a combined result of $0.52 cotton and an average yield of 900 pounds per acres. Although the sensitivity tables do indicate a cost advantage to the reduced and no-till systems, the primary implication is that yield appears to be a much greater determinant of financial success than specific tillage system selection.

Tables 7 - 9 provide selected results from the FARM Assistance analysis for Tom Green County, Texas. Table 7 shows the average forecasted net cash farm income by tillage system. Projected net cash farm incomes represent returns to land, management and equipment. Since depreciation is not a cash expense, this fixed cost component is not represented in these projections. Over the ten year projection period, average net cash farm income ranged from $36,120 to $41,070 across tillage systems. On a net cash farm income basis, superior returns were provided by the reduced tillage system followed by the no tillage and the conventional tillage system.

Table 7. Average forecasted net cash farm income by tillage system for Tom Green County, Texas.

Year	Conventional Till	Reduced Till	No-Till
2008	$20,240	$25,660	$22,310
2009	$20,920	$26,050	$22,120
2010	$24,840	$29,580	$25,270
2011	$25,960	$30,780	$26,200
2012	$28,220	$33,160	$28,460
2013	$35,420	$40,540	$35,700
2014	$44,890	$50,090	$45,060
2015	$48,860	$53,760	$48,620
2016	$55,340	$60,110	$54,670
2017	$56,490	$60,980	$55,300
Average	**$36,120**	**$41,070**	**$36,370**

Table 8. Average forecasted net farm returns to land and management by tillage system for Tom Green County, Texas.

Year	Conventional Till	Reduced Till	No-Till
2008	-$13,220	$ 1,460	$ 1,400
2009	-$12,540	$ 1,850	$ 1,210
2010	-$ 8,620	$ 5,380	$ 4,360
2011	-$ 7,500	$ 6,580	$ 5,290
2012	-$ 5,240	$ 8,960	$ 7,550
2013	$ 1,960	$16,340	$14,790
2014	$11,430	$25,890	$24,150
2015	$15,400	$29,560	$27,710
2016	$21,880	$35,910	$33,760
2017	$23,030	$36,780	$34,390
Average	**$ 2,660**	**$16,870**	**$15,460**

Table 9. Average forecasted annual operating expense/receipts by tillage system for Tom Green County, Texas.

Year	Conventional Till	Reduced Till	No-Till
2008	0.86	0.83	0.85
2009	0.87	0.83	0.86
2010	0.84	0.82	0.84
2011	0.84	0.81	0.84
2012	0.83	0.80	0.83
2013	0.80	0.77	0.80
2014	0.76	0.74	0.76
2015	0.75	0.72	0.75
2016	0.72	0.70	0.73
2017	0.72	0.69	0.72
Average	**0.80**	**0.77**	**0.80**

Table 8 reports the average forecasted net farm returns to land and management by tillage system. The difference between Table 7 and Table 8 is that net returns to land and management includes fixed costs and depreciation of equipment. Over the ten-year projection period, average net farm returns to land and management ranged from $2,660 to $16,870 across tillage systems. The conventional tillage system actually failed to provide sufficient returns to cover all fixed costs for the first five years of the ten year study period.

Table 9 illustrates the average forecasted annual operating expense to receipts ratio for each tillage system for Tom Green County, Texas. The operating expense to receipts ratio measures financial efficiency. This ratio proxies the cost of growing a dollar's worth of receipts. A ratio of 0.80 indicates that for every dollar's worth of receipts, 80

cents are tied up in operating costs with the remaining 20 cents available for returns to land, management, and equipment. The reduced tillage system proved to be the most efficient tillage system (0.77) with the no-till and conventional tillage systems exhibiting similar efficiency (0.80).

Tables 10 - 12 provide the selected results from the FARM Assistance analysis for Yazoo County, Mississippi. Table 10 shows the average forecasted net cash farm income by tillage system. Over the ten year projection period, average net cash farm income ranged from $75,680 to $114,060 across tillage systems. On a net cash farm income basis, similar superior returns were provided by the reduced tillage system and no-till systems with lagging performance exhibited by the conventional tillage system.

Table 10. Average forecasted net cash farm income by tillage system for Yazoo County, Mississippi.

Year	Conventional Till	Reduced Till	No-Till
2008	$58,990	$94,590	$97,110
2009	$87,130	$123,550	$124,630
2010	$71,260	$107,640	$108,050
2011	$81,090	$118,180	$118,590
2012	$64,740	$102,230	$102,700
2013	$74,730	$112,660	$113,250
2014	$75,080	$113,170	$113,880
2015	$78,230	$116,460	$117,230
2016	$82,160	$120,930	$121,750
2017	$83,430	$122,500	$123,410
Average	**$75,680**	**$113,190**	**$114,060**

Table 11. Average forecasted net farm returns to land and management by tillage system for Yazoo County, Mississippi.

Year	Conventional Till	Reduced Till	No-Till
2008	-$75,210	-$20,340	-$ 9,180
2009	-$47,070	$ 8,620	$18,340
2010	-$62,940	-$ 7,290	$ 1,760
2011	-$53,110	$ 3,250	$12,300
2012	-$69,460	-$12,700	-$ 3,590
2013	-$59,470	-$ 2,270	$ 6,960
2014	-$59,120	-$ 1,760	$ 7,590
2015	-$55,970	$ 1,530	$10,940
2016	-$52,040	$ 6,000	$15,460
2017	-$50,770	$ 7,570	$17,120
Average	**-$58,520**	**-$ 1,740**	**$ 7,770**

Table 12. Average forecasted annual operating expense/receipts by tillage system for Yazoo County, Mississippi.

Year	Conventional Till	Reduced Till	No-Till
2008	0.90	0.84	0.84
2009	0.87	0.81	0.81
2010	0.89	0.83	0.83
2011	0.88	0.82	0.82
2012	0.90	0.84	0.84
2013	0.89	0.83	0.83
2014	0.89	0.83	0.83
2015	0.89	0.83	0.83
2016	0.88	0.83	0.82
2017	0.88	0.82	0.82
Average	**0.89**	**0.83**	**0.83**

Table 11 reports the average forecasted net farm returns to land and management by tillage system. When fixed costs are included, the differential performance between tillage systems becomes readily apparent for Yazoo County producers. Over the ten-year projection period, average net farm returns to land and management ranged from a loss of $58,520 to $7,770 across tillage systems. The conventional tillage system actually failed to provide sufficient returns to cover all fixed costs during any year of the projection period. Reduced tillage systems recovered all fixed costs in five (of ten) years and no-till systems recovered all fixed costs in eight (of ten) years.

Table 12 illustrates the average forecasted annual operating expense to receipts ratio for each tillage system for Yazoo County, Mississippi. This operating expense to receipts ratio indicated a superior average financial efficiency of 0.83 for both reduced and no-till systems compared to 0.89 for conventional tillage systems. This means that an additional six cents for every dollar of receipts is dedicated to expenses with conventional tillage as compared to the reduced and no-till alternatives.

Conclusions

Wide variations in prices and yields present a precarious environment for cotton production in any region, but these impacts are especially prominent in non-irrigated production regions. Unfortunately the quest to adequately address these uncertainties does not end with proper tillage system selection. Appropriate farm size, realized cotton yields, and manageable input costs have proven to be prominent factors in the cost structure of a financially prosperous cotton operation. While tillage system selection can help to address some of these challenges, it should be considered the first of many tasks.

In both the SRP of Texas and the Delta Region of Mississippi, reduced and no-till cotton production systems demonstrate some superior cost management capabilities versus a conventional tillage system. However, extremely volatile input prices can magnify or lessen these advantages. This research indicates that the magnitude of the economic differences among cotton tillage systems is regionally specific. Growers need a comprehensive evaluation of the variable and fixed cost implications before switching to a new tillage system. This includes the trade-offs between cash expenses, equipment requirements, labor requirements and overall profitability that could reasonably be expected from any proposed transition.

This analysis did not assume any yield advantage for any tillage system over another. Any yield differences between tillage systems likely appear during years with limited moisture. As such, the yield advantage for conservation tillage systems is possibly masked by crop insurance indemnities compensating for overall poor yields and resulting revenue advantages. Further, no attempt was made to consider non-economic factors such as longer-term soil property characteristics that might be influenced by the selection of a specific tillage system. Therefore, the relative merit of alternative tillage systems remains open to further modification.

Farmers adopt new methods and technologies cautiously and only after direct observation of expected benefits. The investigation of the costs for the SRP of Texas and Delta Region of Mississippi indicate that much of the economic benefit of adopting a conservation tillage system is embedded in an improved fixed cost structure (i.e. reduced depreciation). These impacts do not immediately affect cash expenses and are sometimes difficult to observe. This may help to explain why widespread adoption of conservation tillage technologies has not been more rapidly embraced. The continuation of an environment of high and volatile input prices may provide the incentive that producers need to make necessary changes in their operation. Upon careful reflection, producers may determine that selecting an alternative tillage system is warranted.

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