Rodale Institute
Economic Analysis for the
Farming Systems Trial

Study site

The Farming Systems Trial (FST) is located at the Rodale Institute in Kutztown, Pennsylvania. Field investigations on this 12 acre site began in 1981. Prior to establishment of the experiment, the site was farmed conventionally with continuous corn for at least 25 years. The soil type is a moderately well drained Comly silt loam. The growing climate is sub-humid temperate (average temperature is 54 degrees Fahrenheit and average rainfall is 43.5 inches per year).

Three main cropping systems were initiated in 1981: 1) manure-based organic; 2) legume-based organic and 3) conventional. The experimental design was a split-plot randomized block with 8 replications for the three systems. Main plots were 60 x 300 ft, split into three 20 x 300 ft subplots, which allowed for comparison of three crops in any given year. The main plots were separated by 5-ft grass buffer strips. Farm-scale equipment was used for operations and harvesting.

In 2008, each of the original three systems was divided into a “tilled” and “no-till” portion yielding four replicate plots of the subsequent six farming systems (Table A). The organic no-till treatments in the FST are not continuous no-till systems. Small grains and cover crops are still established with tillage while the large seeded crops (corn and soybean) are planted without tillage. In our system winter annual cover crops (hairy vetch and rye) are converted into mulches for corn and soybeans using a roller-crimper. The roller is mounted to the front of the tractor while a planter attached to the tractor’s rear allows the farmer to roll/kill the cover crop and plant the main crop into the rolled cover crop in one field pass without any further seed bed preparation. The rolled cover crop has several functions: weed suppression, soil moisture conservation and nitrogen input (in the case of vetch).

In addition to including no-till in the trial, that year also saw the inclusion of genetically modified (GM) corn and soybeans in both the tilled and no-till conventional systems to keep this system up to date with current agricultural practices.

Farming Systems

1. Manure Organic

This system represents an organic dairy or beef operation. It features a long rotation including both annual feed grain crops and perennial forage crops (Table A). The system’s fertility is provided by

leguminous cover crops and periodic applications of manure or composted manure. The system does not use herbicides, relying instead on tillage and cultivation for weed control.

2. Legume Organic

This system represents an organic cash grain system without livestock. It features a mid-length rotation consisting of annual grain crops and cover crops (Table A). The system's sole source of fertility are leguminous cover crops. Like the organic manure system, it does not use herbicides, relying instead on tillage and cultivation.

3. Conventional

This system represents a conventional grain operation. It relies on synthetic nitrogen for fertility and herbicides for weed control (Table A). Fertilizer and pesticide applications follow Pennsylvania State University Cooperative Extension recommendations.

Data collection

All field operations and inputs were logged for contribution to the overall economic analyses. The economic analysis was conducted for the time period 2008-2010 (to reflect data collected for the most recent cropping system comparisons) using the free on-line Mississippi State Budget Generator (MSBG), developed by the Department of Agricultural Economics at Mississippi State University, (http://www.agecon.msstate.edu/what/farm/generator/).

When available, input and output data were taken directly from the Farming Systems Trial; otherwise default values from the Budget Generator were used. Input and output data for the 3 years (2008-2010) were averaged to make results more manageable.

Results

Net Returns

Overall, the two conventional systems had the lowest returns of all 6 systems: $170 and $210 per acre and year for the conventional no-till and tilled system, respectively. With profits between $491 and $653 per acre and year, the 4 organic systems were 2.9 to 3.8 times higher than the 2 conventional systems. The highest returns were achieved by the tilled Legume System followed by the tilled Manure System (Table 1 and Figure 1).

Across all three major systems (organic manure, organic legume and conventional), the tilled systems had the higher net return compared to the matching no-till systems (6% higher in the Manure, 23% higher in the Conventional and 33% higher in the Legume system).

The most profitable grain crop in all organic systems was wheat ($799-$886/acre/year) while soybeans were most profitable in both conventional systems ($303-$331/acre/year). No-till conventional corn was the least profitable crop at $27/acre/year (Table 1).

To summarize the results and to compare organic and conventional systems overall, the 4 organic systems and the 2 conventional systems were averaged: Net returns in the organic systems were almost 3 times higher than in the conventional systems: $558/acre/year vs. $190/acre/year. This large difference was mainly the result of a much higher income in the organic systems due to organic price premiums ($835/acre/year vs. $495/acre/year) (Figure 2). If organic price premiums are taken out of the equation, the net returns for the organic systems decrease to $165/acre/year, meaning the organic systems are still very competitive at only $25/acre/year below the conventional systems.

Expenses

Overall, the no-till Conventional System incurred the highest expenses ($328/acre/year) followed by the tilled Manure System ($319 acre/year). The no-till Legume System had the lowest expenses ($216/acre/year). Across all six cropping systems, the single greatest expense was for seeds, which made up between 33 to 49% of the total expenses. In the 4 organic systems the second and third highest direct expense was for custom hauling (22% in the Manure Systems, 11% in the Legume Systems) and fuel (11-16% of total expenses) while costs for herbicides (22%) and fertilizers (17-21%) were the second and third highest direct expense in the two conventional systems. Labor expenses made up 8-11% in the organic systems whereas they were only 4-5% in the two conventional systems. Due to higher equipment needs in the organic systems, fixed expenses comprised 12-16% in the 4 organic systems, about double the proportion as in the 2 conventional systems (Table 2 and Figure 3).

When the 4 organic and the 2 conventional systems were averaged, total expenses were very similar between the two treatments: $277/acre/year in the organic and $306/acre/year in the conventional systems. The single greatest expense across both treatments was for seeds which made up 35% of the total expenses in the organic systems and 29% in the conventional systems. In the organic systems the second and third highest direct expense was for custom hauling (16%) and fuel (14%) while costs for herbicides (22%) and fertilizers (19%) were the second and third highest direct expense in the conventional systems. Labor expenses made up 9% in the organic systems whereas they were only 4% in the conventional systems. Fixed expenses were almost double in the organic systems compared to the conventional systems: 14 vs. 8% respectively (Figure 4).

Comparison of net return and expenses for corn and soybeans (Table 1)

Note: Since all six systems have corn and soybean, it makes sense to compare the net return and expenses of these two crops under all rotations.

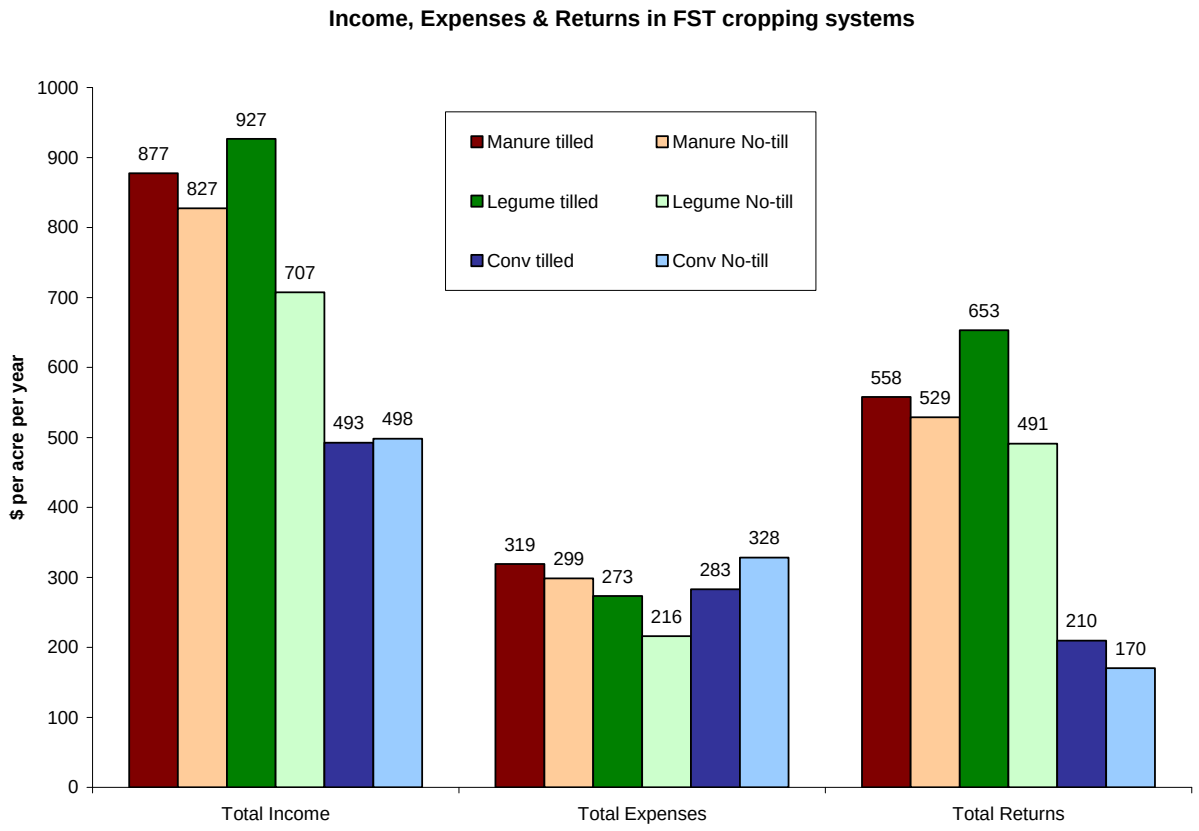
1. Corn had the highest net return in the tilled Manure System followed by the tilled Legume System.
2. Soybean had the highest net return in the tilled Legume System followed by the tilled Manure System.
3. Corn incurred the highest expenses in the no-till Conventional System followed by the tilled Conventional System.
4. Soybean incurred the highest expenses in the tilled Manure System followed by the no-till Conventional System.

Table 1: Income, Expenses and Returns for each cropping system in the Rodale Institute Farming Systems Trial (FST), 2008-2010.
Manure tilled, Manure no-till, Legume tilled and Legume no-till were managed organically, Conv tilled and Conv no-till were managed conventionally.

FST Economics: $/acre/year		CS1	CS2	CS3	CS4	CS5	CS6
		Manure tilled	Manure No-till	Legume tilled	Legume No-till	Conv tilled	Conv No-till
Corn	Income	961	853	945	828	515	564
	Expenses	325	248	325	248	426	537
	Returns	**636**	**604**	**620**	**580**	**89**	**27**
Oats	Income	475	415	458	379		
	Expenses	335	333	240	239		
	Returns	**140**	**82**	**218**	**140**		
Soybeans	Income	770	601	713	619	471	522
	Expenses	249	173	167	174	140	219
	Returns	**520**	**427**	**546**	**446**	**331**	**303**
Wheat 1	Income	1093	1063	995	1003		409
	Expenses	207	202	199	204		228
	Returns	**886**	**861**	**796**	**799**		**181**
Hay	Income	1278	1278				
	Expenses	716	716				
	Returns	**562**	**562**				
Corn silage	Income	1348	1348				
	Expenses	513	514				
	Returns	**834**	**833**				
Wheat 2	Income	1093	1063				
	Expenses	207	202				
	Returns	**886**	**861**				
Barley	Income			595			
	Expenses			163			
	Returns			**433**			
Years in rotation		8	8	4	4	2	3
	Total Income	877	827	927	707	493	498
	Total Expenses	319	299	273	216	283	328
	Total Returns	**558**	**529**	**653**	**491**	**210**	**170**

Table 2: Income, Expenses and Returns for each cropping system in the Rodale Institute Farming Systems Trial (FST), 2008-2010.
Manure tilled, Manure no-till, Legume tilled and Legume no-till were managed organically, Conv tilled and Conv no-till were managed conventionally.

FST Economics: $/acre/year	CS1	CS2	CS3	CS4	CS5	CS6
	Manure tilled	Manure No-till	Legume tilled	Legume No-till	Conv tilled	Conv No-till
Income						
Grain (bu), hay, silage (ton)	831	789	852	651	493	465
Straw (ton)	47	39	74	57	0	34
Total Income	**877**	**827**	**927**	**707**	**493**	**498**
Direct Expenses						
fertilizer	27	27	0	0	59	56
herbicide	0	0	0	0	30	46
adjuvants	0	0	0	0	33	25
seeds/plants	80	80	107	106	73	107
custom haul	69	67	30	22	17	23
hand labor	2	2	3	3	2	3
operator labor	27	22	28	16	12	10
fuel (gallons)	50	44	39	24	20	17
repair&maintenance	17	15	15	10	7	8
interest on op.cap.	7	6	7	5	7	9
Total direct expenses	**278**	**263**	**229**	**186**	**259**	**304**
Returns above direct expenses	**599**	**565**	**698**	**521**	**233**	**194**
Total Fixed Expenses	41	36	45	30	24	24
Total Specified Expenses	319	299	273	216	283	328
Returns above total specified expenses	**558**	**529**	**653**	**491**	**210**	**170**



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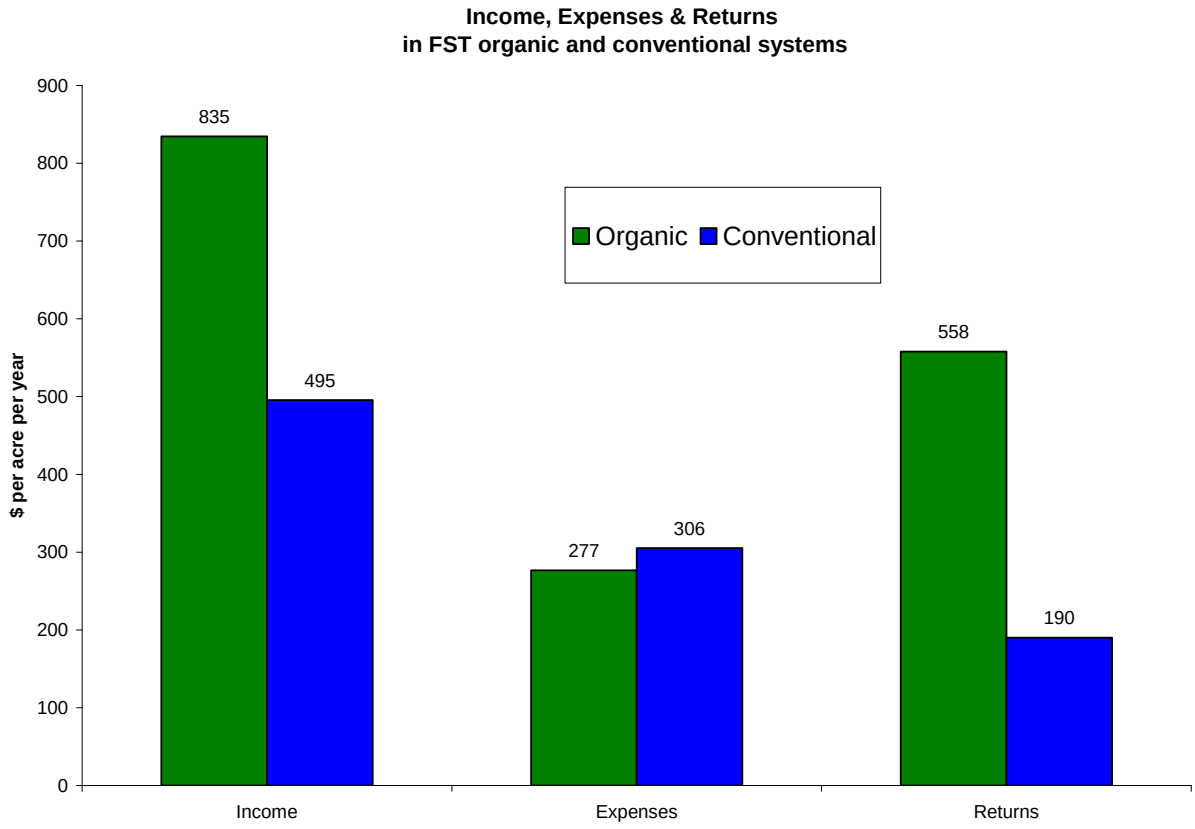

Figure 2: Income, Expenses and Returns for the organic and conventional cropping systems in the Rodale Institute Farming Systems Trial (FST), 2008-2010.
Organic = Average values for Manure tilled, Manure no-till, Legume tilled and Legume no-till,
Conventional = Average values for Conv tilled and Conv no-till.

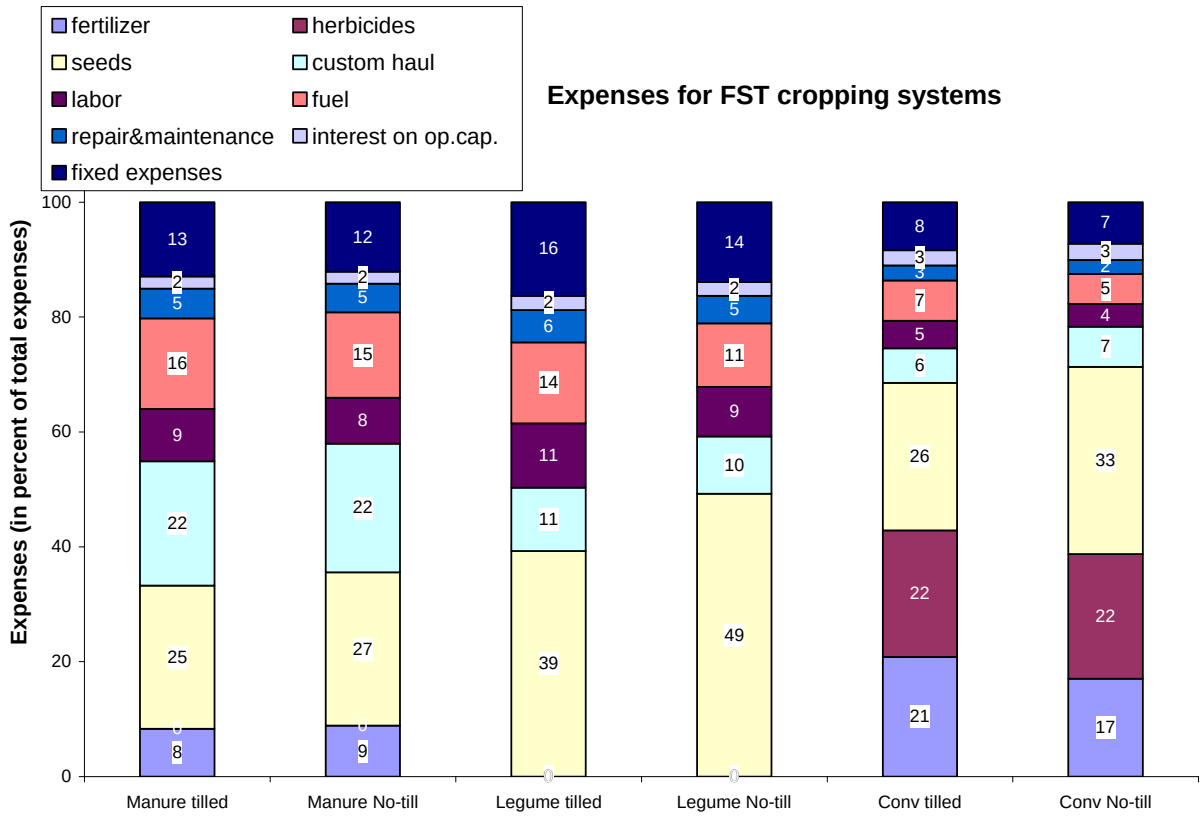

Figure 3: Direct and fixed expenses in the Rodale Institute Farming Systems Trial (FST), 2008-2010. Manure tilled, Manure no-till, Legume tilled and Legume no-till were managed organically, Conv tilled and Conv no-till were managed conventionally.

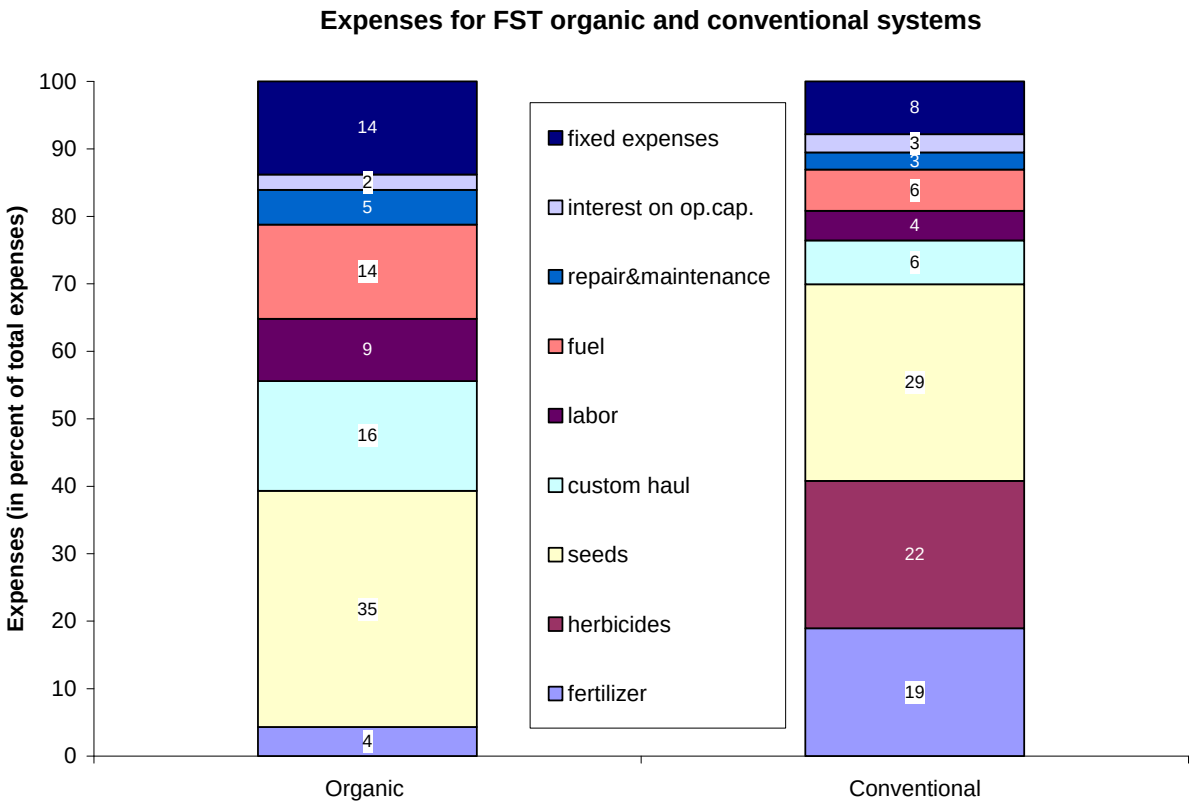

Figure 4: Direct and fixed expenses in the Rodale Institute Farming Systems Trial (FST), 2008-2010. Organic = Average values for Manure tilled, Manure no-till, Legume tilled and Legume no-till, Conventional = Average values for Conv tilled and Conv no-till.

Additional tables and figures

Table A: Overview of cropping systems management,

Rodale Institute Farming Systems Trial,

Cropping systems	Crop rotation[1]	Primary tillage[2]	Weed control[3]	Fertility[4]
Manure tilled	hv/C-r/O-r/SB-W-H-Csil-W	MB	tillage, RH/TW, RC	AM, GM, K
Manure No-till	hv/C-r/O-r/SB-W-H-Csil-W	MB and none	tillage, RH/TW, RC, CC	AM, GM, K
Legume tilled	hv/C-r/O-B/SB-W	MB	tillage, RH/TW, RC	GM, K
Legume No-till	hv/C-r/O-r/SB-W	MB and none	tillage, RH/TW, RC, CC	GM, K
Conventional tilled	C-SB	Ch	Tillage, Herbicides	N, P, K
Conventional no-till	hv/C-r/SB-W	None	Herbicides	N, P, K

[1] C=corn, SB=soybean, H=hay (either red clover, red clover+alfalfa or orchard grass+alfalfa), W=winter wheat, Csil=corn silage, B=winter barley, hv= hairy vetch cover crop, r= rye cover crop

[2] MB = moldboard plow, Ch=chisel plow

[3] RH=rotary hoe, TW=tine weed, RC=row cultivation, CC=rolled cover crop mat

[4] N included urea ammonium nitrate, P was monoammonium phosphate, K was potassium sulfate in organic and potassium chloride in conventional systems, GM=green manures, AM=animal manures (raw manure (1981-2002) or composted manure (2004-2010))

Crop Rotations in the Rodale Institute Farming Systems Trial (2008-present)

Year	1		2		3		4		5		6		7		8	
Tilled Manure System - 8 year rotation																
	^{P}hv (cc)	^{P}hv Corn	^{NT}rye (cc)	*Compost* ^{P}rye Oats	^{P}rye (cc)	^{P}rye Soybean	^{P}Wheat	Wheat ^{FS}Hay	Hay	Hay	Hay	Hay	Hay	*Compost* ^{P}Corn (silage)	^{P}Wheat	Wheat	^{P}hv (cc)
No-Till Manure System - 8 year rotation																
	^{P}hv (cc)	roll hv ^{NT}Corn	^{NT}rye (cc)	*Compost* ^{P}rye Oats	^{P}rye (cc)	roll rye ^{NT}Soybean	^{P}Wheat	Wheat ^{FS}Hay	Hay	Hay	Hay	Hay	Hay	*Compost* ^{P}Corn (silage)	^{P}Wheat	Wheat	^{P}hv (cc)

Year	1		2		3		4		5		6		7		8	
Tilled Legume System - 4 year rotation																
	^{P}hv (cc)	^{P}hv Corn	^{NT}rye (cc)	^{P}rye Oats/clover	^{P}Barley	Barley ^{P}Soybean	^{P}Wheat	Wheat	^{P}hv (cc)							
No-Till Legume System - 4 year rotation																
	^{P}hv (cc)	roll hv ^{NT}Corn	^{NT}rye (cc)	^{P} rye Oats/clover	^{P}rye (cc)	roll rye ^{NT}Soybean	^{P}Wheat	Wheat	^{P}hv (cc)							

Year	1		2		3		4		5		6		7		8	
Tilled Conventional System - 2 year rotation																
		No cover crops ^{CP}Corn		^{CP}Soybean												
No-Till Conventional System - 3 year rotation																
	^{NT}hv (cc)	burndown ^{NT}Corn	^{NT}rye (cc)	burndown ^{NT}Soybean	burndown ^{NT}Wheat	Wheat burndown	^{NT}hv (cc)									

Legend
hv = hairy vetch
cc = cover crop
P = Moldboard Plow
CP = Chisel Plow
NT = No-Till
FS = Frost seed

Superscript letters before crop names indicate the tillage/planting method to be used.
All crops in the standard-tilled Organic rotations will be planted into moldboard plowed soil, except for rye used as cover crop.
All crops in the Conventional system will be either planted into chisel plowed soil (for the standard-tilled plots) or no-till planted.

Figure A: Crop rotations in the Rodale Institute Farming Systems Trial (FST), 2008-2010.

Table B: Estimated fuel prices and interest rates

ITEM NAME	UNIT	PRICE
		dollars
FUEL TYPES		
Diesel Fuel	gal	3.53
Electricity	kWh	0.10
Gasoline	gal	3.56
INTEREST RATES		
Short-term	%	6.00
Intermediate-term	%	6.75

Source: MSBG, Mississippi, 2008 prices

Table C: Organic and Conventional grain prices in dollar per bushel ($/bu) (2008-2010) for grain crops grown in the Rodale Institute Farming Systems Trial (FST)

	Conventional grain prices ($/bu)				Organic grain prices ($/bu)			
	2008	**2009**	**2010**	**Average**	**2008**	**2009**	**2010**	**Average**
Barley: Feed Grade	5.06	2.57	2.93	**2.93**	7.75	5.50	5.50	**6.62**
Corn, #2 Yellow	5.36	3.92	4.40	**4.15**	11.03	7.65	5.48	**8.36**
Oats: Feed Grade	3.74	2.77		**2.96**	5.36	5.50		**5.47**
Soybeans: Feed Grade	11.84	10.00	9.92	**10.23**	21.99	18.24	16.01	**18.77**
Wheat: Hard Red	8.91	5.77	5.70	**6.29**	16.96	19.83	9.32	**19.12**

Source: Organic Price Report (OPR): Prices for organic grains are provided by large elevators or handlers that specialize in organic grains. Conventional prices for grains are also gathered by Agricultural Marketing Service (AMS). In an effort to present the most comparable prices, we selected AMS regions that handle product within the geographic location of the elevators or handlers.
http://www.rodaleinstitute.org/Organic-Price-Report

Table D: Hay, straw and corn silage prices for Pennsylvania

Hay:	$180/ton
Straw, conventional:	$140/ton
Straw, organic:	$170/ton
Corn silage, organic:	$75.28/ton

Source: Agricultural Marketing Service (AMS), http://search.ams.usda.gov/mnsearch/mnsearch.aspx, Penn State Agronomy Guide, http://bedford.extension.psu.edu/Agriculture/Agronomy/Pricing%20Corn%20Silage.htm, and Rodale Institute sales (2008-2010).

Table E: Yields for grain, hay, corn silage and straw in the Rodale Institute Farming Systems Trial (FST)

Yields in bu/a (tons/a for hay and silage)

at the following moisture values: 15.5% corn, 13% soybeans, 12% wheat, oats, barley, 0% hay, 65% silage

Systems	corn	soybeans	wheat	oats	barley	hay	silage
Tilled Manure	115	41	49	76	-	7.10	17.90
No-till Manure	102	32	49	65	-	7.10	17.90
Tilled Legume	113	38	46	71	73	-	-
No-till Legume	99	33	45	54	-	-	-
Tilled Conv	124	46	-	-	-	-	-
No-till Conv	136	51	49	-	-	-	-

Straw Yields in tons/a (dry weights from field)

Systems			wheat	oats	barley
Tilled Manure			0.92	0.35	-
No-till Manure			0.74	0.35	-
Tilled Legume			0.68	0.41	0.66
No-till Legume			0.84	0.49	-
Tilled Conv			-	-	-
No-till Conv			0.72	-	-