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ECONOMIC COMPARISON OF ALTERNATIVE TILLAGE SYSTEMS FOR DELAWARE GRAIN FARMS

Judy Ohannesian

INTRODUCTION

Modern farm management decisions deal with problems concerning the most profitable size and the best combination of enterprises for a given resource base. These decisions determine a farm's operational and/or organizational efficiency. In addition to selecting a new combination of enterprises, farm managers can make decisions on altering and changing their production practices. New methods allow the same products to be produced, but by a different technique. Situations may arise which also change a farm's resource base. A new method of production may enable a farm operator to continue at a desired output level, while decreasing a production input, thereby increasing efficiency of labor, land or capital.

DEFINITIONS

Conventional tillage consists of several operations involving the moldboard plow, springtooth harrow, disk harrow, cultivator and other types of equipment. The ground is tilled to produce a smooth and fine seedbed.

Reduced tillage is a technology practiced by an increasing number of farmers today. It involves the elimination of as many of these operations as is technologically, biologically and economically feasible. The different types of reduced tillage can range from systems involving chisel plowing the ground in place of moldboard plowing to no-tillage. Under no-tillage, the seed is placed in soil that still carries the previous crop's residue. Weed control is accomplished through herbicides and the old crop residue serves as a mulch which suppresses weed growth. Reduced tillage can reduce the amount of labor needed on a farm. In reduced tillage systems where the plowing operation is eliminated, crop residues left on top of the soil reduce moisture loss and soil erosion by wind and water. Legume cover crops can be used to supply nitrogen and provide a mulch cover.

OBJECTIVES

The primary objectives of this study were to examine the production costs and returns of different tillage systems on Delaware cash grain farms. The specific objectives are to:

1) Define and describe the specific requirements of each of the tillage systems examined.
2) Study the economic aspects of the tillage systems for different crops, farm sizes and cover crops, and
3) Develop guidelines for the selection of tillage systems and cover crops for the farmer.

Judy Ohannesian is a Graduate Student University of Delaware. The author is deeply indebted to Drs. G. Joachim Elterich, Raymond C. Smith and Gerald L. Cole for their help in reviewing this paper.

SURVEY

A survey of sixteen reduced tillage producers in Delaware was conducted in 1977. These producers were primarily cash grain farmers growing corn, soybeans, wheat and barley on farms ranging from 65-70,000 acres.

Information gathered included farm size, acreage of each crop grown, rotations followed, cover crop system followed, and perhaps most important of all, the exact specifications of the tillage system followed. Since the interpretation of tillage systems sometimes varied greatly between producers, each producer was asked to outline the specific operations of his tillage systems, i.e., how many trips over the field are required for each system. This information was used to select representative tillage systems to be used in the analysis. Information concerning soil type, specific quantities of fertilizers, insecticides, and herbicides used and a detailed machinery inventory were also included. Finally, a subjective portion was included which asked farmers to rank a list of reasons why they switched from conventional tillage to a reduced tillage system.

BUDGETING ANALYSIS AND SURVEY RESULTS

Most farmers practiced more than one tillage system on their farms. Farmers were following this type of program for several reasons: 1) certain fields may have soils which are heavy and more suited to a conventional system; 2) reduced tillage may be reserved for those fields which have lighter, more drought prone soils to conserve soil moisture; 3) using more than one system reduces the risk if problems develop with any one tillage system; and 4) farmers often devote only a few fields to reduced tillage while they gain experience. A disadvantage of these practices is that machinery must be purchased and maintained for all tillage systems used.

Farmers were asked to rank (in descending order, with one being the most important), a list of reasons why they switched from conventional to reduced tillage. The results were:

Reason	Average Ranking
Saves time	2.43
Saves soil moisture	2.50
Saves labor	3.38
Uses less fuel	4.64
Requires less machinery	4.71
Production costs lowered	5.07
Reduces erosion	5.28

Saving time and soil moisture were the most important factors considered for switching to reduced tillage.[1] Planting corn early (from April 20 to May 5) is an accepted method to insure higher yields in Delaware.[2] Since less time is spent preparing the seedbed in the spring, most farmers were confident that timeliness in planting was a definite advantage. Another very important benefit of reduced tillage practices on the Coastal Plains soils in the Mid-Atlantic region is that soil moisture can be conserved.

[1] Results from Analysis of Variance $F = 6.01$, $LSD_{(.05)} = 1.40120$.

[2] **See Grain and Forage Crops Guide, 1976-1978, p 12.**

The well-drained sandy soils of Delaware average a drought once every three years. Farmers can deal with the problem by either installing irrigation systems or following practices to conserve the soil moisture already present. Labor savings were ranked significantly higher than reductions in erosion and production costs. A 45 percent labor savings is possible by switching from conventional to no-tillage in corn production (Table 1). As the number of field operations is decreased, there is a corresponding decrease in the amount of fuel required. Most farmers appeared very unconcerned about the amount of fuel they use, since fuel is one of the least expensive inputs in farming and therefore, in their view not worth conserving. The majority of farmers interviewed followed a diversified tillage program by using more than one tillage system on their farms. In this case, there appears to be little if any savings in machinery costs. There is a potential for savings in the case of a young farmer who is just getting started and wishes to devote all acreage to one reduced tillage system. One of the farmers surveyed had a no-tillage machinery inventory worth only $12,500 for a 300 acre farm. The variable production costs for corn are lower for the conventional and chisel plant tillage systems than for either the disk plant or no-tillage systems. The reduction of erosion made possible by reduced tillage was ranked the lowest by farmers. Wind erosion on Delaware farms involves the serious loss of top soil, loss of herbicides and damage to seedlings from blowing sand. For the future, legal restraints such as the Federal Water Pollution Control Acts Amendments of 1972 (PL 92-500) will no doubt have an impact on the choice of tillage in certain areas.

TABLE 1.
Time and Diesel Fuel Requirements for Pre-harvest Operations for Four Tillage Systems in Corn Production.

		Reduced Tillage		
Operation	**Conventional**	**Chisel Plant**	**Disk Plant**	**No-tillage**
Time Requirements	1 hr 25 min.	1 hr 6 min	54 min	39 min
Fuel Requirements	5.32 gal	4.19 gal	3.07 gal	2.36 gal

Time and fuel requirements specify the amount of time and diesel fuel which is necessary to perform all pre-harvest operations in the field.

Source: "1973 Delaware Field Tests With No-Tillage Corn and Soybeans," Extension Bulletin #107, Cooperative Extension Service, University of Delaware, Newark, Delaware 19711, Dec. 1973.

"Energy Requirements for Tillage on Coastal Plains Soils," N. Collins, L. Kemble and T. H. Williams, Misc. Paper #761, Agricultural Experiment Station, University of Delaware, Newark, Delaware 19711.

BUDGET DEVELOPMENT

Three soil types of Delaware were considered. They range from silt loam found in the northern portion of the state with good water holding capacity, to a loamy sand with low water holding capacity. This latter soil is a very high risk soil for the production of corn and other crops which require large amounts of water in July and August. Irrigation is usually advised on this soil.

TABLE 2.
Costs of Producing an Acre of Corn with Four Tillage and Two Cover Crop Systems

	Conventional	Chisel Plant	Disk Plant	No-Tillage	No-Tillage w/Vetch
			— Per Acre Cost —		
Variable Inputs					
Seed	$ 8.04	$ 8.55	$ 9.59	$ 10.00	$ 10.00
Seed	1.00	1.00	1.00	1.00	1.00
Seed (vetch)					11.00
Fertilizers	40.30	40.30	40.30	45.30	30.30
Aerial Vetch Seeding					3.00
Spreading Charge for Fertilizer	2.50	2.50	2.50	2.50	2.50
Chemicals	12.24	12.24	18.76	26.01	26.01
Fuel (pre-harvest)	2.34	1.84	1.35	1.03	1.03
Labor (pre-harvest)	7.08	5.50	4.50	3.25	3.25
Miscellaneous	3.00	3.00	3.00	3.00	3.00
Subtotal	$ 76.50	$ 74.93	$ 81.00	$ 92.09	$ 91.09
Int. on Operating Capital 9% for 6 months	3.49	3.37	3.65	4.14	4.10
Repairs (pre-harvest)	4.50	4.20	4.06	3.32	3.32
Harvesting	5.04	5.04	5.04	5.04	5.04
Total Variable Costs	$ 89.53	$ 87.54	$ 93.75	$ 104.59	$ 103.55
Fixed Inputs					
Total Machinery Inventory	143,162.00	137,428.00	135,456.00	108,432.00	108,432.00
Annual Machinery Fixed Cost	19,428.00	18,625.00	18,349.00	14,855.00	14,855.00
Per acre Machinery Fixed Cost	38.86	37.25	36.70	29.71	29.71
Land Charge	40.00	40.00	40.00	40.00	40.00
Total Fixed Cost	$ 78.86	$ 77.25	$ 76.70	$ 69.71	$ 69.71
TOTAL COST	$ 168.39	$ 164.79	$ 170.45	$ 174.30	$ 173.26

Survey results and yield data from the University of Delaware Agricultural Experiment Station indicate soil type to have a greater effect on yield than choice of tillage or cover crop system. This is primarily due to the difference in water holding capacity of the three soil types, which directly affect yields. These figures were used to calculate partial budgets and break even prices.

Reduced tillage systems require increased amounts of certain variable inputs. However, they require a lower machinery inventory. The total costs of any tillage system are very sensitive to the magnitudes of these differences (Table 2). Variable costs are lowest for the chisel plant tillage system in corn production. The disk plant and no-tillage systems require increased amounts of seed, fertilizer and herbicides. These costs are greater than the reductions in fuel and labor and thus the variable costs of the chisel plant system are lowest. Total fixed costs are lowest for the no-tillage system. By adding the variable and fixed costs of the tillage systems, the chisel plant system has the lowest total production cost.

Break even prices were calculated from these costs and are in Table 3. On all soil types the lowest break even price is for the no-tillage system when a vetch cover crop is used. As in the case of yield, the break even price is much more sensitive to changes in soil type than to different tillage and cover crop systems.

TABLE 3

Breakeven Prices for Growing an Acre of Corn on Three Soil Types Using Four Tillage Systems and Two Cover Crop Systems

	Matapeake Silt Loam	Sassafras Sandy Loam	Evesboro Loamy Sand
	— dollars per bushel —		
Stubble Mulch Cover Crop			
Conventional	1.54	1.99	2.61
Chisel Plant	1.50	1.94	2.53
Disk Plant	1.55	2.01	2.62
No-Tillage	1.58	1.97	2.45
No-Tillage Vetch cover Crop	1.44	1.77	2.14

Total budgets were developed to examine the entire farm operation. All farms are assumed to be strictly crop farms with no livestock enterprises. Three different farm sizes (200, 500 and 900 acres) are considered. When all the acreage of a farm was devoted to each tillage system, the chisel plant or disk plant

TABLE 4

Total Farm Budget for 500 Acre Farm on Matapeake Silt Loam Soil

Variable Inputs	Non-Tillage Corn[a]	Conventional Corn[b]	Conventional Soybeans[c]	Total
Seed	$ 1,500	$ 1,206	$ 2,800	$ 5,506
Seed Treatment	150	150	100	400
Pesticides	3,902	1,836	1,330	7,068
Spreading Charge for Fertilizer	375	375	0	750
Fertilizers	6,795	6,045	3,020	15,860
Fuel (pre-harvest)	155	351	396	902
Labor (pre-harvest)	488	1,062	1,216	2,766
Miscellaneous	450	450	500	1,400
Subtotal	13,814	11,475	9,362	34,651
Interest on Operating Capital				
9% for 6 months	621	516	421	1,558
Harvesting	756	756	896	2,408
Repairs and Maintenance	498	675	900	2,073
Total Variable Cost	15,689	13,422	11,579	40,690
Fixed Inputs				
Annual Machinery Fixed Costs	5,828	5,828	7,771	19,428
Land Charges at $40/acre	6,000	6,000	8,000	20,000
Total Fixed Cost[d]	11,828	11,828	15,771	39,427
Total Cost	27,517	25,250	27,350	80,118
Total Revenue	$31,515	$31,515	$43,168	$106,198
Net Returns	$ 3,998	$ 6,265	$15,818	$ 26,081

[a]150.0 acres of no-tillage corn at 110 bu/acre and $1.91/bu.

[b]150.0 acres of conventional tillage corn at 110 bu/acre and $1.91/bu.

[c]200.0 acres of conventional tillage soybeans at 38 bu/acre and $5.68/bu.

[d]Certain minor overhead costs are not included.

systems usually resulted in the highest net returns. The no-tillage system with a vetch cover crop consistently yielded a higher net return than no-tillage with the stubble mulch system.

Total farm budgets were also developed for situations in which more than one tillage system was practiced on the farm. If for example, both no-tillage and conventional corn are grown on the same farm, the variable costs of the no-tillage enterprise are greater than for it's conventional counterpart. Since a conventional line of equipment must be purchased and maintained, the annual fixed costs of machinery for this farm are higher than if only a no-tillage line of equipment was needed (Table 4).

SUMMARY

The results of this study can be summarized as follows:

1) Reduced tillage methods can result in a savings of the following inputs in corn production:
   a) As much as 46 minutes per acre can be saved in labor.
   b) Farm fuel use can be decreased by 44 percent.
   c) Less machinery is required as the number of tillage operations are reduced. This ranges from an investment of $36,361 to $63,915 for a 200 acre farm.
2) The herbicide and insecticide use increases under a reduced tillage system as tillage operations and cultivation for weed control are replaced by chemicals.
3) The variable costs of reduced tillage systems are higher than the conventional system while the fixed costs are lower.
4) Soil erosion and surface runoff can be substantially reduced by the mulch cover that is characteristic of reduced tillage systems.
5) Break even prices are lowest for the no-tillage system when a vetch cover crop is used.
6) The total farm budgets indicate that when only one tillage system was practiced on the farm, the chisel plant or disk plant system resulted in highest net returns.
7) Although production costs are actually higher in most cases, farmers have found factors such as moisture conservation, erosion control and timeliness as incentives for switching to reduced tillage systems.

RECOMMENDATIONS

In making recommendations to farmers it is important to stress the individual situation of each farm. The adoption of reduced tillage systems should be considered in light of the specific limiting factors on a farm. Reduced tillage has the potential to substantially reduce the amount of labor needed to produce a crop. When labor is scarce, this particular advantage of reduced tillage systems may outweigh the additional variable costs. Farms that have an ample labor supply may consider reduced tillage for it's soil moisture conserving and erosion control properties.

REFERENCES

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