Effects of tillage systems and crop rotations on the economics of spring wheat, winter wheat, flax and field peas for a thin Black soil at Indian Head.

G. P. Lafond[1], R.P. Zentner[2] and R. Geremia[1]
[1] Indian Head Experimental Farm [2] Swift Current Research Station

ABSTRACT

The long term viability and profitability of agriculture in Western Canada is dependent on our ability to maintain or enhance the production potential of the soil. The current problems associated with wind and water erosion and the widespread use of soil degradative cultural practices threaten the long term sustainability of dryland crop production. The adoption of new soil conserving production systems requires that they be profitable in the short and long term. This paper discusses the economic performance of zero, minimum and conventional tillage management using three different crop rotations in the thin Black soil zone of east central Saskatchewan. All inputs were costed according to local prices quoted at the time of use. The same procedure was used for prices of commodities. The production costs for flax, spring wheat, and field peas grown on stubble were similar for all three tillage systems. The production costs for spring wheat grown on fallow was higher under zero till than either minimum or conventional tillage. Given similar production costs and higher yields for crops grown on stubble under zero and minimum tillage management, these production systems were more profitable than the traditional conventional tillage production system.

INTRODUCTION

The decline in soil productivity due to wind and water erosion is a function of the crop rotation and the cultural practices used. In the thin Black and Black soil zones of Saskatchewan, the movement away from fallow based crop rotations to more diversified continuous cropping rotations would greatly reduce the rate of soil degradation. The success of this strategy would be greatly increased if conservation tillage practices were also employed because of the greater potential for soil and water conservation, and hence better response to the added production inputs than with conventional tillage management. However, this approach will be adopted by producers only if the costs associated with making the change to conservation tillage can be justified on the basis of lower production costs or higher net returns.

The present study examines the economic performance of three tillage systems with three contrasting crop rotations on a thin Black soil at Indian Head, Saskatchewan.

MATERIALS AND METHODS

A detailed description of this study, which was initiated in 1986, can be found in the report by Lafond et al. (1991). The effects of the tillage systems and crop rotations on soil water conservation, seedling establishment, plant development, and crop production are also presented in Lafond et al. (1991).

ECONOMIC ANALYSIS

The final measure or yardstick used in evaluating the merit of a new production system is its economic performance. In order to provide a clearer overall picture of the economic performance of conservation tillage when compared to conventional tillage, detailed records of inputs and outputs are required. A major component of this project involved the maintenance of accurate records of production costs for the various tillage systems and crops for the sake of accurate economic comparisons. Table 1 lists the cost of operating various implements. Cost of field operations were determined by multiplying the suggested prices given in the Custom and Machinery Rental Guide published by the Economics Branch for the province of Saskatchewan, by 0.7. Table 2 lists the average commodity price for the last four years as well as the price range encountered during the study period. Local commodity prices at harvest were used in each year of the study for determining economic returns. The range reflects price fluctuations from year to year. Yields in a particular year were always matched with the commodity price of that year in order to determine net return. The same applies for fertilizer and herbicide costs. In order to facilitate comparisons between tillage systems, only those costs which differed between systems were included. Each crop will be discussed separately.

Table 1 Costs of field operations for various implements (1987-1990).

Implement	Cost $/ha	Cost $/acre
Rodweeder	6.25	2.50
Seeding (hoe press drill)	13.60	5.44
Spraying	3.75	1.50
Fertilizer broadcasting	3.75	1.50
Cultivation	7.50	3.00
Harvesting	22.50	9.00
Harrowing	2.75	1.10
Discing (heavy duty)	9.50	3.80

Table 2 Average commodity prices used in calculating returns for the various crops.

Crops	$/tonne (Range)	$/bus (Range)
Field peas	186.61 (158.00-238.36)	5.08 (4.30-6.48)
Flax	311.89 (212.80-403.90)	7.92 (5.40-10.26)
Winter Wheat	111.08 (98.85-129.21)	3.02 (2.69-3.52)
Spring Wheat	130.87 (115.74-150.00)	3.56 (3.15-4.08)

RESULTS AND DISCUSSION

Field Peas:

The economic performance of field pea production is shown in Table 3. Production costs were slightly higher for the conventional tillage than either of the zero or minimum tillage systems. The tillage costs in the conventional tillage system were greater than the herbicide costs associated with zero tillage. Due to the higher yields under zero and minimum tillage (average 1978 kg/ha vs 1795 kg/ha for conventional till), the resulting effect was a higher average return with the latter management systems.

Table 3 **Comparison of production costs and net returns for three tillage systems for field peas. Results are based on four years of investigation (1987-1990).**

Tillage System	Tillage Cost	Herbicide Cost	Herbicide Application	Total Cost	Gross Return	Net Return
	---------	------------	------$/ha-	----------	----------	----------
Zero	0.69	56.23	11.48	193.69	346.81	153.12
Minimum	10.94	44.16	9.38	189.76	357.54	167.77
Conv.	31.50	38.19	5.63	200.61	312.52	111.91

Flax:

The economic analysis for flax is given in Table 4. Production costs were similar for the minimum and conventional tillage system but somewhat lower for the zero till system. Given the higher yields under zero and minimum tillage (average 1459 kg/ha vs 1184 kg/ha for conventional till), the result was a net return that averaged $100/ha higher for these latter systems than for the conventional tillage system.

Table 4 **Comparison of production costs and net returns for three tillage systems for flax.**

Tillage System	Tillage Cost	Herbicide Cost	Herbicide Application	TOTAL Costs	Gross Return	Net Return
	---------	-----------	-------$/ha	----------	----------	----------
Zero	0.69	51.13	7.62	163.23	414.53	251.30
Minimum	10.94	51.13	7.62	173.23	421.80	248.32
Conv.	24.87	42.06	3.75	174.48	324.57	150.09

Winter Wheat:

Winter wheat is always direct seeded, regardless of the tillage system, to ensure the successful overwintering of the crop. Consequently, the resulting economic analysis in Table 5 shows no difference in production costs between the various tillage systems. Net returns were also similar among tillage systems because of similar yields (average 2029 kg/ha).

Table 5 Comparison of production costs and net returns for three tillage systems for winter wheat (1987-1990).

Tillage System	Tillage Costs	Herbicide Costs	Herbicide Application	Total Costs	Gross Return	Net Return
	---------	-----------	-------$/ha	----------	----------	----------
Zero	0.00	5.95	5.00	162.67	213.56	50.89
Minimum	0.00	5.95	5.00	162.67	228.68	60.02
Conv.	0.00	8.66	5.63	166.00	214.08	48.08

Spring Wheat:

The economic analysis of spring wheat is shown separately for the fallow and stubble cropping conditions (Table 6). The fallow production costs were lowest for minimum tillage, intermediate for conventional tillage and highest for zero tillage. This large difference can be accounted for by the higher cost associated with chemical fallow. Since there were no yield differences on fallow between the various tillage systems, the end result was lower net returns for the zero till system. Net returns (average 2540 kg/ha) were similar for spring wheat seeded on minimum and conventional till fallow.

Table 6 **Comparison of production costs and net returns for three tillage systems for spring wheat grown on fallow (1987-1990).**

Tillage System	Tillage Costs	Herbicide Costs	Herbicide Application	Fallow Costs	Total Costs	Gross Return	Net Return
	---------	----------	------$/ha	---------	---------	---------	---------
Zero	0.69	25.23	6.56	62.56	204.47	331.15	126.67
Minimum	4.63	25.23	6.56	46.14	171.99	340.65	148.66
Conv.	14.50	23.61	4.69	31.44	183.66	328.02	144.35

The economic analysis for spring wheat grown on stubble is given in Table 7. The production costs were lowest for zero till followed by minimum then conventional till. There was a difference in cost of $11/ha between zero and conventional till stubble wheat. Given the higher yields under zero and minimum tillage (average 1874 kg/ha vs 1526 kg/ha for conventional till), the end result was a higher net return for these two systems when compared to conventional tillage. The net returns were greater for winter than stubble spring wheat under a conventional tillage system. However, when spring wheat on stubble was produced using zero or minimum till management, the net returns favored spring wheat over winter wheat. When the ratio of winter wheat to spring wheat stubble yields was determined for the tillage systems, values of 110, 114 and 131% are obtained for the zero, minimum and conventional tillage systems, respectively. Previous comparisons of stubble spring wheat yields and winter wheat yields showed that winter wheat outyielded conventionally tilled spring wheat by 25%. However, when the yields are compared under direct seeding conditions, the yield difference between winter wheat and spring wheat averaged 10-14%, not 25%. The winter wheat economics could be improved if a cheaper source of N fertilizer was used. In this case, ammonium nitrate was used which is also the most expensive form.

Table 7 Comparison of production costs and net returns for three tillage systems for spring wheat grown on stubble (1987-1990).

Tillage System	Tillage Costs	Herbicide Costs	Herbicide Application	Total Costs	Gross Return	Net Return
	---------	----------	-------$/ha	----------	----------	----------
Zero	0.69	31.79	9.08	160.06	240.56	79.97
Minimum	10.94	27.40	8.50	165.86	245.84	79.98
Conv.	24.63	23.67	4.69	172.02	193.31	21.29

In order to highlight the implications of these results, the following crop production scenario was proposed (Table 8). It assumes a 1000 acre farm using the three crop rotations in the study. The acres seeded to each crop is given in the Table.

Table 8 Crop production scenarios based on the three crop rotations used in the study.

ROTATION A	# OF AC	ROTATION B	# OF AC	ROTATION C	# OF AC
Fallow	250	S. Wheat	250	S. Wheat	250
S. Wheat	250	S. Wheat	250	Flax	250
S. Wheat	250	Flax	250	W. Wheat	250
W. Wheat	250	W. Wheat	250	Peas	250
Total					
Cultivated	750		1000		1000
Fallow	250		0		0

The economic performance of the above scenario is shown in Table 9. The results represent the average net return per year obtained based on the economic analyses of the various crops presented in Table 3-7.

Table 9 **Average net returns for three crop rotations using different tillage management systems.**

Tillage System	Rotation A	Rotation B	Rotation C
	--------$/ha/yr	($/ac/yr)-------	----------------
Zero	64.57(25.82)	116.95(46.78)	135.24(54.10)
Minimum	72.35(28.94)	118.50(47.40)	140.44(56.18)
Conventional	53.27(21.43)	61.61(24.64)	84.26(33.71)

The first observation is that with the least diversified rotation (Rotation A), the net returns among the tillage systems were quite similar. As the crop rotation becomes more diversified, as is the case with Rotations B and C, the relative change in profitability is greater for zero and minimum than for conventional tillage. In fact, the relative change in profitability going from Rotation A to Rotation C is on the order of 2X for the zero and minimum till systems, compared to 1.6X for the conventional tillage system. These results emphasize the importance of crop diversification and that conservation tillage when combined with good management can be profitable as well as providing a solution to the problems of soil erosion and degradation due to excessive tillage. As well, the use of fallow cropping as an integral part of a cropping system is not a requirement for the thin Black and Black soil zones, based on the results and economic assumptions of this study.

Another point of interest is the environmental impact of these various production systems. One way of assessing this impact is to examine the relative use of herbicides for each tillage system and crop rotation (Table 10). Going from a conventional to a zero till production system for Rotation A, B and C results in a 2.1, 1.6 and 1.4 fold increase in herbicide use, respectively. The large increase in herbicide use in Rotation A is a function of using herbicides rather than tillage for weed control during the fallow period. Consequently, the risk associated with using energy intensive tillage and being vulnerable to wind and water erosion has to be weighed against the risk of using herbicides and not being vulnerable to soil erosion. The question then becomes; which of these systems is more sustainable. It should be remembered that many of the herbicides used in this study are biodegradable and as well, have very low toxicity. Another point of interest, from a producer's perspective, is that substituting herbicides for tillage results in similar or lower costs in the short term and significantly lowers equipment costs in the long term. It may be argued that a minimum tillage approach may lessen the dependence on herbicides; however, as indicated in Table 10, going from a minimum till to a zero till production system has a small impact on the level of herbicides used in a continuous crop rotation (ie: in the order of 12-13%).

Table 10 **The effects of tillage systems and crop rotations on herbicide use measured as gram of active ingredient per acre per year.**

	Rotations		
Tillage System	Fw-Sw-Sw-Ww	Sw-Sw-Fx-Ww	Sw-Fx-Ww-Peas
	----------------	gai/ha/year	-----------------
Zero	1325(212)	1225(158)	1225(144)
Minimum	1100(176)	1125(145)	1125(132)
Conventional	625(100)	775(100)	850(100)

(Values in brackets represent % of conventional tillage).

In summary, this preliminary economic analyses support the use of conservation tillage in the thin Black soil zone as part of an overall crop production system. These systems have the potential to protect the soil against erosion, are economically viable and can be more profitable in the short and long term.

REFERENCES

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