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Resource use under three tillage systems for winter wheat in northern Idaho

Bruce E. Lyman and Paul E. Patterson

Attention has recently focused on developing farming systems that are "sustainable." While an exact definition of sustainability is still somewhat elusive, two key elements of a sustainable system are to minimize the use of external (off-farm) resources and to use all resources efficiently. A sustainable system must also be environmentally compatible and economically viable over time.

With these points in mind, we compared the resource use and economic costs and returns of two common crop rotations under three different tillage systems in the Palouse area of northern Idaho. The rotations were a two-year rotation of winter wheat and spring peas and a three-year rotation of winter wheat, spring barley, and spring peas. The tillage systems were unrestricted tillage, reduced tillage, and minimum tillage. Resource comparisons included total labor, fertilizers, crop protection inputs, and fuel. We also estimated erosion potential of each cropping system.

University of Idaho 1990-91 enterprise budgets for each crop in each cropping system formed the basis of the analysis. The analysis assumed a farm with 750 acres of cropland. It did not consider the effect of government farm programs.

B[illegible]get information on crop yields, in[illegible] use, and production practices came from several sources, including crop specialists at the University of Idaho and Washington State University, farm chemical suppliers, and Extension agricultural agents. Information on soil erosion potential came from the USDA Soil Conservation Service. Information herein does not constitute specific production recommendations, but focuses on factors to consider when comparing production systems.

Budget assumptions

Production systems

Unrestricted tillage, reduced tillage, and minimum tillage are relative terms (Tables 1 and 2). The unrestricted tillage system uses a moldboard plow for primary tillage. Secondary tillage includes one or more operations with a tandem disk, field cultivator, and harrow. The goals of this tillage system are to bury and incorporate all previous crop residue, to provide a smooth seedbed, and to aid in weed control. Surface crop residue is almost entirely eliminated.

The reduced tillage system uses either a moldboard plow or an offset disk for primary tillage. Secondary tillage includes one or more passes with a field cultivator, tandem disk, and harrow. The emphasis is again on creating a smooth seedbed but using fewer operations than the unrestricted tillage system and maintaining more surface residue.

The minimum tillage system eliminates primary tillage or uses a chisel plow instead of a moldboard plow or offset disk. Secondary tillage, if used, involves only a single pass with a field cultivator and harrow. Winter wheat is no-till seeded into the pea stubble with no primary or secondary tillage. The no-till planter is rented. Minimum tillage maintains a maximum of surface residue.

Fertilizer rates were based on recommendations in 1989 University of Idaho fertilizer guides. Wheat and barley receive anhydrous ammonia supplemented with 10-34-0 and thiosol (12-0-0-26). Peas receive no fertilizer.

Pesticide rates were obtained from the 1990 *Pacific Northwest Weed Control Handbook.* Weed control measures include a preplant application of a wild oat herbicide (Far-Go) for all crops and a post-emergence spray for controlling broadleaf weeds. The minimum tillage system may have a higher incidence of winter annual grass weeds than a reduced tillage system. Therefore, the budgets for the minimum tillage systems include an application of metribuzin (Lexone or Sencor).

Land, labor, and capital

The budgets do not include land charges. Net returns were calculated as a return to land, owner's management, and risk. Interest on operating capital is charged from the time of input use

Table 1. Tillage comparisons for wheat-barley-pea rotation.

Classification	Primary tillage	Secondary tillage	Seeding
	Winter wheat after spring peas		
Minimum	None	None	No-till
Reduced	Offset disk	Field cultivator (2x) Harrow	Conventional
Unrestricted	Moldboard plow	Tandem disk Field cultivator (2x) Harrow (2x)	Conventional
	Spring barley after winter wheat		
Minimum	Chisel plow	Field cultivator Harrow	Conventional
Reduced	Moldboard plow	Tandem disk Field cultivator (2x) Harrow	Conventional
Unrestricted	Moldboard plow	Tandem disk (2x) Field cultivator (2x) Harrow (2x)	Conventional
	Spring peas after spring barley		
Minimum	Chisel plow	Field cultivator Harrow	Conventional
Reduced	Offset disk	Field cultivator (2x) Harrow (2x)	Conventional
Unrestricted	Moldboard plow	Tandem disk Field cultivator (2x) Harrow (2x)	Conventional

Note: 2x means the implement made two passes.

Table 2. Tillage comparisons for a wheat-pea rotation.

Classification	Primary tillage	Secondary tillage	Seeding
	Winter wheat after spring peas		
Minimum	None	None	No-till
Reduced	Offset disk	Field cultivator (2x) Harrow	Conventional
Unrestricted	Moldboard plow	Tandem disk Field cultivator (2x) Harrow (2x)	Conventional
	Spring peas after winter wheat		
Minimum	Chisel plow	Field cultivator Harrow	Conventional
Reduced	Offset disk	Field cultivator (2x) Harrow (2x)	Conventional
Unrestricted	Moldboard plow	Tandem disk Field cultivator (2x) Harrow (2x)	Conventional

Note: 2x means the implement made two passes.

until harvest and assumes a real (adjusted for inflation) rate of interest of 5.5 percent. The budgets include a charge of 2 percent of all cash operating expenses to cover overhead such as office expenses, shop expenses, and utilities.

The budgets assume that the owner/operator applies all fertilizers and pesticides and performs all labor and management duties or hires supplemental help when needed (for example, at planting and harvest). A no-till planter and all fertilizer and pesticide application equipment are rented on a per acre basis. The grower owns all other machinery. The budgets assume that none of the production systems requires additional equipment purchases.

Yields

The relative profitability of the three tillage systems depends heavily on crop yield. Yields assumed in the enterprise budgets are in Table 3.

Table 3. Yields used in enterprise budgets.

	Minimum tillage	Reduced tillage	Unrestricted tillage
	Wheat-barley-pea rotation		
Wheat (bu/acre)	75	65	65
Barley (cwt/acre)	30	30	30
Peas (cwt/acre)	18	17	17
	Wheat-pea rotation		
Wheat (bu/acre)	75	65	65
Peas (cwt/acre)	17	16	16

Erosion potential

Palouse soils are susceptible to sheet and rill erosion. Changing management practices, such as tillage, affect erosion potential. Management practices influence the amount of crop residue, which is expressed as part of the C factor in the Universal Soil Loss Equation. We gave each crop rotation a crop management C factor based on data from the USDA Soil Conservation Service. The larger the C factor, the greater the potential for soil erosion (Tables 5 and 7).

Results

In both the wheat-barley-pea and the wheat-pea rotations, the minimum tillage system provided a higher net return (gross cash receipts − total costs) than either the reduced or unrestricted tillage systems (Tables 4, 5, 6, and 7). Whole farm net returns (Tables 5 and 7) also showed the wheat-pea rotation to be more profitable than the three-year wheat-barley-pea rotation, given the assumptions of this study. This outcome may change with other assumptions, especially about crop yields, or when the analysis includes government commodity program payments.

The minimum and reduced tillage systems required fewer labor hours per acre (Tables 4 and 6). Labor hours are based on hours of machinery use and do not reflect the likely increase in management time that a reduced or minimum tillage system may require.

Both the reduced and unrestricted tillage systems required less pesticide use than the minimum tillage system

Table 4. Effects of tillage system on a wheat-barley-pea rotation, per acre summary.

	Wheat			Barley			Pea		
Input	Minimum	Reduced	Unrestricted	Minimum	Reduced	Unrestricted	Minimum	Reduced	Unrestricted
Labor (hr)	1.6	2	2.2	1.9	2.2	2.3	1.9	2.1	2.2
Diesel (gal)	8.6	12.8	15	11.5	14.5	16.4	11.7	13.5	16.1
Gas (gal)	2	2	2	2	2	2	2	2	2
N fertilizer (lb)	63	63	63	70	65	65	0	0	0
Other fertilizer (lb)	28	28	28	12	12	12	0	0	0
Pesticides (lb ai)	1.78	1.53	1.53	2.25	2	2	2	2	2
Net cash income ($)	141.26	115.80	109.89	41.23	41.71	36.38	75.85	62.26	57.33
Fixed costs ($)	54.68	73.94	78.74	84.57	96.39	81.69	91.39	78.06	80.77
Net returns ($)	86.58	41.86	31.15	−43.34	−54.68	−45.30	−15.54	−15.80	−23.44

Note: Net cash income = gross receipts − variable costs; net returns = net cash income − fixed costs.

Table 5. Effects of tillage system on a wheat-barley-pea rotation, whole farm summary (750 acres).

Input	Minimum	Reduced	Unrestricted
Labor (hr)	1,350	1,575	1,675
Diesel (gal)	7,950	10,200	11,875
Gas (gal)	1,500	1,500	1,500
N fertilizer (lb)	33,250	32,000	32,000
Other fertilizer (lb)	10,000	10,000	10,000
Pesticides (lb ai)	1,508	1,383	1,383
Net cash income ($)	64,585	54,943	50,900
Fixed costs ($)	57,660	62,098	60,300
Net returns ($)	6,925	−7,155	−9,400
C factor	.08	.17	.36

Note: Net cash income = gross receipts − variable costs; net returns = net cash income − fixed costs.

Table 6. Effects of tillage system on a wheat-pea rotation, per acre summary.

	Wheat			Pea		
Input	Minimum	Reduced	Unrestricted	Minimum	Reduced	Unrestricted
Labor (hr)	1.6	2	2.2	1.9	2.1	2.2
Diesel (gal)	8.6	12.8	15	11.7	13.5	16.1
Gas (gal)	2	2	2	2	2	2
N fertilizer (lb)	63	63	63	0	0	0
Other fertilizer (lb)	28	28	28	0	0	0
Pesticides (lb ai)	1.78	1.53	1.53	2	2	2
Net cash income ($)	141.28	115.81	110.05	66.04	52.28	47.48
Fixed costs ($)	55.58	74.77	80.80	94.94	78.49	82.15
Net returns ($)	85.70	41.04	29.25	−28.90	−26.21	−34.67

Note: Net cash income = gross receipts − variable costs; net returns = net cash income − fixed costs.

Table 7. Effects of tillage system on a wheat-pea rotation, whole farm summary (750 acres).

Input	Minimum	Reduced	Unrestricted
Labor (hr)	1,313	1,538	1,650
Diesel (gal)	7,613	9,863	11,663
Gas (gal)	1,500	1,500	1,500
N fertilizer (lb)	23,625	23,625	23,625
Other fertilizer (lb)	10,500	10,500	10,500
Pesticides (lb ai)	1,418	1,324	1,324
Net cash income ($)	77,745	63,034	59,074
Fixed costs ($)	56,445	57,473	61,106
Net returns ($)	21,300	5,561	−2,032
C Factor	.07	.18	.36

Note: Net cash income = gross receipts − variable costs; net returns = net cash income − fixed costs.

(Tables 4 and 6). This shows the trade-off that often occurs between tillage and chemical inputs: As one input is reduced, the other must often be increased. In the drive toward sustainable farming systems, choices may be necessary between more tillage (and an increased potential for soil erosion) and a higher level of crop protection chemicals (and a greater potential for groundwater and/or surface water degradation). The major emphasis in the Palouse area has been to control soil erosion, which may lead to increased use of crop chemical inputs.

The minimum tillage system provided the maximum erosion control benefits. Anticipated soil losses from erosion in the minimum tillage system were approximately one-half those of the reduced tillage system and approximately one-quarter those of the unrestricted tillage system. For example, on a Palouse silt loam soil with a 16 percent slope, 300 foot slope length, and C factors from Tables 5 and 7, soil losses predicted from the Universal Soil Loss Equation are as follows:

Wheat-barley-pea rotation

Minimum tillage	6.3 tons/acre/year
Reduced tillage	13.4 tons/acre/year
Unrestricted tillage	28.3 tons/acre/year

Wheat-pea rotation

Minimum tillage	7.1 tons/acre/year
Reduced tillage	14.2 tons/acre/year
Unrestricted tillage	29.1 tons/acre/year

The minimum tillage system used less fuel than the reduced or unrestricted tillage systems. In the wheat-barley-pea rotation, whole farm diesel use ranged from approximately 7,900 gallons in the minimum tillage system to about 11,900 gallons in the unrestricted tillage system (Table 5). Fuel consumption was similar in the wheat-pea rotation (Table 7).

Nitrogen fertilizer use varied little with tillage system; however, the wheat-pea rotation used more than

8,000 pounds less nitrogen than the wheat-barley-pea rotation.

Conclusions

This analysis shows some of the potential economic and environmental costs and benefits of changing to a conservation tillage system. In both rotations, the minimum tillage system provided environmental and economic advantages over the reduced or unrestricted tillage systems. A higher assumed yield at no increased management cost explains most of the economic benefit of the minimum tillage system. Given different farm situations or assumptions, results may differ from ours. For example, the complex issue of machinery investment analysis under changing management practices is a crucial issue for producers, but was not part of our analysis.

The environmental consequences of agricultural production practices are receiving greater attention. To avoid having excessively restrictive or punitive regulations imposed on them, growers should evaluate their current management practices and adopt economically viable alternatives that are more environmentally benign. Growers should start by examining their current production systems and using them as a baseline for comparing the possible effects of changes on their farms.

Enterprise budgets for Idaho's major crops are available from the Extension agricultural agent in your county. These budgets can help identify production costs and resource use. They should serve only as a secondary source of information, with individual farm records the primary source. Contact your Extension agricultural agent and the USDA Soil Conservation Service for information on specific practices and conservation information.

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The authors — Bruce E. Lyman is former Extension associate in the University of Idaho Department of Agricultural Economics and Rural Sociology, Moscow. Paul E. Patterson is Extension economist based at the UI Idaho Falls Research and Extension Center.

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Further reading

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