ECONOMICS OF TILLAGE MANAGEMENT SYSTEMS IN NORTHEASTERN ALBERTA

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ABSTRACT

The economic returns and riskiness of continuous barley production using four tillage management systems were compared at five sites in three soil zones in northeastern Alberta. The study used five years of data from a tillage experiment in northeastern Alberta. The four tillage systems included conventional one (C1), which leaves 5% standing stubble, conventional two (C2), which leaves 50% standing stubble, minimum-tillage (Min), and zero-tillage (ZT). Economic calculations were based on 1992 input costs and product prices. The systems were evaluated at barley prices of \$46, \$69, and \$92 t^{-1}, calculated with and without all risk crop insurance. Over the five sites the expected net returns were generally higher for ZT at all barley prices. Income variability was usually lower for ZT and C2 depending on the site. The study concluded that use of reduced tillage management systems by producers in northeastern Alberta could increase farm-level returns and reduce the risk of financial loss, while potentially decreasing the amount of soil erosion.

INTRODUCTION

Recent events have shown that most regions in northeastern Alberta are still subject to severe wind and water erosion. Soil loss by wind erosion typically occurs during May when fields are worked intensively for seedbed preparation. However, fallow fields may be subject to wind erosion at any time during the 21 month fallow period. Water erosion events are typically a result of intense summer storms. Cropped fields will generally resist water erosion by early July, however, prior to establishment of the plant root systems, all fields are at risk.

The potential for soil erosion can be minimized by adopting conservation tillage management practices or by a reduction in the frequency of fallow (Zentner et al. 1992). The adoption of soil conservation practices by producers is dependent on short-term economic benefits or the reduction in the financial risk (Crosson et al. 1986). The agronomic/soil benefits of reduced tillage systems include reduction in soil compaction, decreased rates of loss of organic matter, and increased grain yields (Dumanski et al. 1986). Potential economic benefits of these systems are a reduction in costs associated with energy, machinery use and investment, and labour (Zentner et al. 1992).

The objective of this study was to compare crop productivity and short-term economic performance and risk of four tillage management systems for continuous barley production to determine their potential use by producers in three soil-climatic regions of northeastern Alberta.

METHODS AND MATERIALS

Agronomic Considerations

The Alberta study sites were located in the Dark Brown soil zone at Alliance, Black soil zone at Wainwright and Hairy Hill, and Grey soil zone at Plamondon, and Elk Point. Four tillage management systems (TS) were compared at each site.

Two conventional tillage systems were included as benchmarks. The first (C1) consisted of harvesting the grain, followed by chopping and spreading the residue with a flail mower. Three cultivations were then performed in a one-day period followed by a single pass with the cultivator approximately three weeks later. Seedbed preparation involved one pass with the cultivator just prior to seeding. The second conventional tillage treatment (C2) was similar to C1, except that only one pass with the cultivator as opposed to three, was performed on the first fall tillage date. All conventional tillage was performed with a vibrashank field cultivator. The Minimum (MIN) tillage treatment consisted of the same treatment as the conventional tillage systems except that the only tillage treatment is one pass with the cultivator in the spring. As in the zero till treatment an appropriate fall herbicide is applied. Spring cultivation was done on the same dates as the seeding. The zero tillage (ZT) treatment consisted of removal of grain at harvest, followed by chopping and spreading of residue with a flail mower. A fall herbicide appropriate for weeds present was then applied. In the spring a broad spectrum herbicide was applied if required.

All plots were seeded to Leduc barley with a double disc zero till plot seeder.(Dyck and Tessier 1986). Nitrogen (46-0-0) was banded at a rate to bring total actual N (residual plus applied) to 100 kg ha^{-1}. Phosphorus (0-45-0) was seed placed at a rate of 20 kg ha^{-1} of actual P. Due to a severe deficiency potassium (0-0-60) was applied at Elk Point and Plamondon in 1988 at a rate of 400 kg ha^{-1} of actual K. Weeds were controlled with a variety of herbicides using recommended rates at the five sites to obtain the desired weed control. Grain yields were determined by using a small plot binder, dried at 60°C then left at room conditions to pick up moisture from the atmosphere. The approximate annual dates of spring cultivation, seeding, harvest, and fall cultivations are shown in Table 1. A variety of herbicides were used at the five sites to obtain the desired weed control.

Table 1. Average Annual Operation Dates

Site	Spring Cult.	Seeding	Harvest	1st Fall Cult.	2nd Fall Cult.
Alliance	May 11	May 11	Aug 17	Sept 17	Oct 13
Wainwright	May 11	May 11	Aug 18	Sept 18	Oct 9
Hairy Hill	May 10	May 10	Aug 13	Sept 11	Oct 5
Plamondon	May 12	May 12	Aug 13	Sept 13	Oct 9
Elk Point	May 14	May 14	Aug 17	Sept 15	Oct 8

Economic Considerations

The economic performance of each TS was modelled for a complete farm unit of 285 hectares in size. Machinery operation costs were modelled using a medium-aged complement of appropriately sized machinery required to perform the field operations in a timely manner. Production costs, net returns, and net present value (NPV) were calculated for the four TS using a budgeting framework (Zentner and Campbell, 1988). Net return was defined as the income remaining after paying all cash costs (seed, fertilizer, herbicide, fuel, oil, machine repair, crop insurance premiums, and land taxes, utilities, and interest on operating capital), labour, and depreciation on buildings and machinery. The NPV were calculated using a discount rate of 5% (Doll and Orazem, 1978). NPV recognizes that returns earned in the future are worth less than money earned today. This analysis did not include income tax or land equity cost considerations. Costs for inputs and field operations (Table 2) were held constant at their 1992 levels (Alberta Agriculture, 1992, Saskatchewan Agriculture and Food, 1992). Each system, was evaluated at three barley price levels (Table 2), and with and without participation in the Canada/Alberta Crop Insurance program. Participation was assumed to be at the 70% yield coverage option, and the premiums are specific to the risk area where the test sites were located (Alberta Hail and Crop Insurance, 1992).

Table 2: Summary of Economic Parameters

Item	Price/Cost	Units
Barley	46.00	$\$t^{-1}$
	69.00	$\$t^{-1}$
	92.00	$\$t^{-1}$
Fertilizer		
N	0.50	$\$kg^{-1}$
P_2O_5	0.55	$\$kg^{-1}$
K_2O	0.22	$\$kg^{-1}$
Herbicides		
Roundup	9.95	$\$L^{-1}$
2, 4-D Amine	3.90	$\$L^{-1}$
2, 4-D Ester	6.40	$\$L^{-1}$
Agsurf	6.49	$\$L^{-1}$
Avenge	8.90	$\$L^{-1}$
Bromox 720	12.00	$\$L^{-1}$
Hoegrass II	12.55	$\$L^{-1}$
MCPA Amine	4.90	$\$L^{-1}$
MCPA Ester	5.50	$\$L^{-1}$
MCPA K	4.15	$\$L^{-1}$
MCPA Na	3.70	$\$L^{-1}$
Stampede	9.21	$\$L^{-1}$
Acheive Extra	45.47	$\$Ha^{-1}$

Machine Operation	Cash Costs^{x}	Fixed Cost^{w}
	----	----
Cultivating	3.76	5.63
Banding	3.76	4.66
Seeding	10.24	20.44
Spraying	1.52	2.56
Swathing	4.10	6.08
Combining	3.88^{v}	28.70
Transport	2.17^{v}	1.59
Baling	2.13	4.21
Hauling	1.86	.68
Spot Spraying	.85	1.15

x Includes fuel, oil, machine repair, and labor.
w Includes depreciation and interest charges for machines.
v Cash costs depend on grain yields. Costs are shown for yield of 1500 kg ha^{-1}

At each sites, annual net returns and NPV were compared among TS using analysis of variance for a split plot design with years as main plot and tillage method as subplot (SAS Institute Inc., 1990). Differences among treatment means were determined by Duncan's Multiple Range Test (p=0.05) (Little and Hills, 1978). Riskiness of the tillage systems were assessed using stochastic dominance analysis (Goh et al., 1989). The set of risk efficient systems for each site were established for risk neutral producers and for producers with low-, medium-, and high-risk aversion levels as defined by Zentner et al. (1992), and scaled to the appropriate farm size (Raskin and Cochran, 1986). For risk neutral individuals, their sole objective is to maximize net returns regardless of the variability of profits, while risk averse individuals are willing to give up some expected return (profit) in order to obtain a reduction in the probability of a low or negative return occurring (Zentner et al 1992).

RESULTS AND DISCUSSION

Grain and Straw Yields

Over the five years and sites, average yields for ZT were 3729 kg ha^{-1} (Table 3). This was 8.6% higher than C1, 8.7% higher then C2 and 9.5% higher than MIN. The straw yields (Table 4) showed that ZT produced averaged 3740 kg ha^{-1} for ZT; this was 8.3% higher than C1, 13.6% higher than C2, and 7.2% higher than MIN. In general, Wainwright was consistently the highest yielding site, followed by Alliance, Hairy Hill, Plamondon, and Elk Point.

Table 3: Grain Yield as affected by Tillage Treatment, Year and Site

Tillage	Year	Alliance		Wainwright		Hairy Hill		Plamondon		Elk Point	
				($kg\ ha^{-1}$)							
Conventional(1)	1988	4481	def	3572	cd	3954	bc	4508	ab	3303	a
Conventional(2)	1988	4201	f	3394	cde	3878	bc	4728	a	2819	bc
Minimum	1988	4255	ef	3523	cd	4018	bc	4384	ab	3039	ab
Zero	1988	4933	bcd	3873	c	3965	bc	4728	a	3185	ab
Conventional (1)	1989	2518	ghi	3324	de	4470		4486		3211	
Conventional (2)	1989	2647	g	3604	cd	4459		4287		3109	
Minimum	1989	2609	g	3384	cde	4320		3862		3319	
Zero	1989	2555	gh	3755	cd	4927		4992		3636	
Conventional (1)	1990	5256	ab	5143	ab	2733	ef	3131	fg	----	
Conventional (2)	1990	4766	bcde	5352	ab	2819	e	3168	fg	----	
Minimum	1990	5498	a	5503	a	3308	d	3233	ef	----	
Zero	1990	5083	abc	5503	a	3642	cd	3604	de	----	
Conventional (1)	1991	4303	ef	4933	b	3658	cd	1834	i	2458	c
Conventional (2)	1991	4411	ef	5094	ab	3642	cd	2001	i	2539	c
Minimum	1991	4438	def	5304	ab	3771	bc	1942	i	2937	ab
Zero	1991	4658	cdef	5245	ab	3308	d	2437	h	2996	ab
Conventional (1)	1992	2044	hi	3012	e	1953	gh	2738	gh	1560	d
Conventional (2)	1992	2017	i	2942	e	2362	fg	2792	gh	1582	d
Minimum	1992	2582	g	1931	f	1840	h	1861	i	1151	e
Zero	1992	4047	f	2980	e	2587	efg	2555	h	1243	de
Significance		***		**		***		*		**	
Standard Dev.		640		527		463		576		430	
Conventional (1)		3722	bc	3991	b	3357	b	3341	b	2630	ab
Conventional (1)		3610	c	4083	ab	3432	ab	3394	b	2507	b
Minimum		3873	b	3932	b	3405	ab	3055	c	2609	b
Zero		4260	a	4271	a	3685	a	3663	a	2765	a
Significance		***		***		***		***		*	
Standard Dev.		640		527		463		581		446	

Table 4: Straw Yield as affected by Tillage Treatment Year and Site

Tillage	Year	Alliance		Wainwright		Hairy Hill		Plamondon		Elk Point
				($kg\ ha^{-1}$)						
Conventional (1)	1988	3690	fg	4390	cd	3950	de	4510	ab	2820
Conventional (2)	1988	3560	g	4220	de	3880	de	4780	ab	2640
Minimum	1988	3660	fg	4250	de	3970	de	4660	ab	2790
Zero	1988	4060	def	4600	bcd	4030	de	4610	ab	2680
Conventional (1)	1989	2360	ijk	3470	f	4810	bc	4600	ab	3850
Conventional (2)	1989	2500	ij	3710	f	4790	c	4670	ab	3590
Minimum	1989	2610	hi	3850	ef	5900	a	4670	ab	4010
Zero	1989	3030	g	4930	ab	5270	b	4900	a	3850
Conventional (1)	1990	5100	a	4770	abc	3330	f	3350	cde	----
Conventional (2)	1990	4620	bc	4890	ab	3410	f	3430	cd	----
Minimum	1990	4840	ab	4870	ab	3660	ef	3470	cd	----
Zero	1990	4250	cd	4960	ab	3970	de	4380	b	----
Conventional (1)	1991	3660	fg	5150	a	4000	de	2970	e	2470
Conventional (2)	1991	3780	efg	4940	ab	3940	de	3220	de	2390
Minimum	1991	3820	defg	4810	abc	4240	d	3220	de	2710
Zero	1991	4220	cde	4630	bcd	4230	d	3710	c	2740
Conventional (1)	1992	2070	jk	2480	g	1670	h	2380	fg	1240
Conventional (2)	1992	1960	k	2640	g	1940	h	2480	f	1290
Minimum	1992	2460	ij	1720	h	1610	h	1770	g	920
Zero	1992	3780	efg	2340	g	2600	g	2150	fg	960
Significance		***		***		**		***		NS
Standard Dev.		629		558		528		618		440
Conventional (1)		3380	b	4070	b	3550	c	3560		2590
Conventional (2)		3280	b	4080	b	3590	c	2720		2480
Minimum		3480	b	3900	b	3810	b	3560		2610
Zero		3870	a	4320	a	4020	a	3950		2560
Significance		**		*		***		NS		NS
Standard Dev.		629		558		528		618		440

Table 5: Costs of Production
The cash costs of seed ($6.89) and miscellaneous expenses ($8.81) which consist of land taxes and utilities are not shown.

Resource Category	C1 Mean	C1 S.D.	C2 Mean	C2 S.D.	MIN Mean	MIN S.D.	ZT Mean	ZT S.D.
	($ha^{-1})							
a) Site = Alliance								
Fertilizer	50.20	4.82	50.20	4.82	50.20	4.82	50.20	4.82
Herbicide	40.15	6.60	40.15	6.60	52.54	8.71	54.73	8.79
Variable Cost*	29.45	3.34	24.68	3.15	21.08	2.89	19.82	2.67
Labor	20.98	2.76	17.77	2.58	15.70	2.45	15.06	2.27
Crop Insurance +	5.71	----	5.71	----	5.71	----	5.71	----
Interest	8.11	0.55	7.71	0.55	8.06	0.55	8.06	0.50
Total Cash Cost	170.30	11.45	161.93	11.49	168.99	11.57	169.28	10.58
Fixed Cost**	105.58	7.71	93.76	7.29	85.27	6.59	82.07	6.22
Total Costs	275.88	17.68	255.69	17.41	264.26	16.60	251.35	14.65
b) Site = Elk point								
Fertilizer	68.13	9.93	68.13	9.93	58.53	9.28	59.92	7.51
Herbicide	38.57	15.00	38.57	15.00	52.19	16.72	56.57	14.44
Variable Cost*	27.62	2.47	22.78	2.15	19.34	2.52	17.93	2.94
Labor	19.17	1.85	15.92	1.59	13.87	1.90	13.09	2.29
Crop Insurance +	8.81	----	8.81	----	8.81	----	8.81	----
Interest	8.40	0.75	8.00	0.75	8.42	0.83	8.60	0.64
Total Cash Cost	176.39	15.66	167.91	15.72	176.87	17.33	180.62	13.51
Fixed Cost**	99.34	5.64	87.13	5.55	79.34	5.97	76.49	6.85
Total Costs	275.73	15.87	255.04	15.47	256.21	17.80	257.11	16.05
c) Site = Hairy Hill								
Fertilizer	46.40	4.60	47.60	3.56	48.80	3.31	47.60	3.56
Herbicide	21.41	16.77	21.41	16.77	35.99	16.26	38.18	19.09
Variable Cost*	28.19	2.26	23.84	1.89	20.12	2.26	18.73	2.39
Labor	20.00	1.91	17.15	1.60	14.88	1.92	14.14	2.05
Crop Insurance +	7.42	----	7.42	----	7.42	----	7.42	----
Interest	6.96	1.23	6.66	1.14	7.15	1.09	7.09	1.30
Total Cash Cost	146.09	25.81	139.78	23.94	150.06	22.94	148.86	27.28
Fixed Cost**	102.63	5.14	91.76	4.30	83.06	5.15	79.72	5.72
Total Costs	248.72	30.17	231.54	27.50	233.12	27.13	228.58	32.42
d) Site = Plamondon								
Fertilizer	57.08	13.93	57.08	13.93	58.90	10.39	58.98	10.39
Herbicide	20.80	15.99	20.80	15.99	35.38	18.05	39.50	19.62
Variable Cost*	28.61	3.10	24.22	3.19	19.75	3.27	19.04	3.48
Labor	20.28	2.51	17.39	2.58	14.48	2.65	14.35	2.88
Crop Insurance +	6.89	----	6.89	----	6.89	----	6.89	----
Interest	7.47	1.44	7.10	1.45	7.56	1.42	7.72	1.57
Total Cash Cost	156.83	30.26	149.18	30.36	158.74	29.81	162.19	33.05
Fixed Costs**	103.49	6.93	92.52	7.13	82.12	7.30	80.26	8.05
Total Costs	260.32	35.39	241.71	35.64	240.87	35.85	242.45	39.82
e) Site = Wainwright								
Fertilizer	47.29	8.28	47.29	8.28	46.68	9.18	45.90	6.55
Herbicide	38.25	5.83	38.25	5.83	50.64	8.47	55.02	8.87
Variable Cost*	29.59	2.63	25.26	2.69	21.20	3.26	20.14	2.65
Labor	21.19	2.23	18.35	2.28	15.80	2.76	15.42	2.25
Crop Insurance +	8.07	----	8.07	----	8.07	----	8.07	----
Interest	8.00	0.56	7.65	0.57	7.91	0.78	8.01	0.65
Total Cash Cost	168.10	11.84	160.56	11.98	166.00	16.31	168.26	13.65
Fixed Costs**	105.82	5.99	94.98	6.14	85.54	7.43	83.09	6.03
Total Costs	273.92	15.70	255.54	16.03	251.54	22.44	251.35	18.13

* Fuel, Oil and Machine Repair.
** Depreciation
\+ Crop Insurance is shown for a barley price of $68.90 t^{-1}

Table 6: Annual Net Returns and NPV

Rotation	CI.	Barley Price = $46 t^{-1} Mean	S.D.	NPV	Barley Price = $69 t^{-1} Mean	S.D.	NPV	Barley Price = $92 t^{-1} Mean	S.D.	NPV
		($ ha^{-1})								
a) Location = Alliance										
C1	Yes	-101	50	-432	- 19	81	- 78	62	112	276
C1	No	- 97	50	-416	- 14	81	- 53	69	113	310
C2	Yes	- 86	44	-369	- 7	72	- 26	71	101	316
C2	No	- 82	44	-351	- 1	72	0	79	101	351
Min	Yes	- 72	47	-310	13	78	- 58	97	108	426
Min	No	- 68	47	-293	19	78	84	105	108	460
ZT	Yes	- 51	44	-225	42	70	180	136	97	585
ZT	No	- 47	44	-208	48	71	205	14	98	618
b) Location = Elk Point										
C1	Yes	-154	39	-662	-101	57	-431	- 49	75	-199
C1	No	-153	41	-654	- 99	61	-418	- 46	81	-182
C2	Yes	-139	35	-597	- 89	51	-378	- 39	67	-159
C2	No	-137	37	-590	- 87	54	-367	- 36	72	-144
Min	Yes	-136	40	-583	- 84	59	-354	- 32	78	-125
Min	No	-134	43	-572	- 81	64	-338	- 27	85	-104
ZT	Yes	-128	41	-547	- 71	62	-299	- 14	84	- 50
ZT	No	-127	44	-543	- 70	68	-292	- 13	93	- 42
c) Location = Hairy Hill										
C1	Yes	- 89	25	-386	- 17	46	- 68	55	69	250
C1	No	- 85	26	-365	- 10	47	- 37	65	70	291
C2	Yes	- 69	22	-298	5	39	25	79	58	349
C2	No	- 64	22	-276	13	39	59	89	58	394
Min	Yes	- 68	25	-295	6	44	33	81	65	362
Min	No	- 65	28	-281	11	50	55	88	74	390
ZT	Yes	- 54	25	-236	25	43	114	105	64	463
ZT	No	- 49	25	-213	33	43	148	115	64	508
d) Location = Plamondon										
C1	Yes	-102	36	-439	- 30	59	-121	42	84	198
C1	No	- 97	37	-420	- 23	60	- 92	51	85	236
C2	Yes	- 81	37	-348	- 7	60	- 24	66	86	299
C2	No	- 76	37	-328	0	60	6	75	86	340
Min	Yes	- 93	32	-400	- 26	55	-105	40	80	190
Min	No	- 91	34	-390	- 23	59	- 89	45	86	211
ZT	Yes	- 70	35	-299	10	59	51	89	86	402
ZT	No	- 65	35	-278	17	59	83	99	86	444
e) Location = Wainwright										
C1	Yes	- 84	43	-368	3	69	8	90	96	384
C1	No	- 80	45	-347	10	72	39	99	99	426
C2	Yes	- 62	44	-272	27	71	112	116	98	496
C2	No	- 58	45	-251	34	73	143	125	101	538
Min	Yes	- 64	47	-277	22	79	97	108	112	470
Min	No	- 60	50	-260	28	84	121	115	118	503
ZT	Yes	- 50	48	-217	44	75	187	137	103	590
ZT	No	- 45	49	-195	51	77	219	147	106	634

Production Costs for Tillage Systems

Adoption of ZT from C1 may increase or decrease cash costs depending on the cost difference of substituting tillage and labour for herbicides. The cash costs averaged 1.4% higher for ZT than for C1(Table 5), 6.0% than C2, and 1.0% higher than MIN. At the site of Alliance cash costs for C1 averaged $170 ha^{-1} (range $147 to $182 ha^{-1}), for C2 $162 ha^{-1} (range $138 to $176 ha^{-1}), for MIN $169 ha^{-1} (range $147 to $184 ha^{-1}), and ZT $169 ha^{-1} (range ($149 to $182 ha^{-1}). Overhead costs associated with ownership decrease because of less tillage requirements for ZT to C1. In the study ZT fixed costs were 28.7%, 14.6%, and 3.4% lower then C1, C2, and MIN respectively. At Alliance these costs averaged $106, $94, $85, and $82 ha^{-1} for C1, C2, MIN, and ZT respectively. Overall total costs (cash plus overhead) averaged 8.4% higher for C1, 0.7% higher for C2, and 0.4% for MIN than for ZT. At Alliance these costs averaged $276, $256, $254, and $251 for C1, C2, MIN, and ZT respectively.

Similar cost relationships exist at the five sites. The costs over the four tillage systems were generally highest for Alliance and progressively less for Elk Point, Wainwright, Plamondon, and Hairy Hill.

Net Returns and NPV for Tillage Systems

Annual net returns (Table 6) generally reflected the grain yield patterns. At the low barley price ($\$46\ t^{-1}$) the tillage systems at all sites were not able to generate sufficient income to recover total costs. The potential profitability of the systems increased with barley price, with ZT consistently providing the largest profit (or smallest loss). At the medium barley price level ($\$69\ t^{-1}$) some tillage systems became profitable at most sites, while at the high barley price ($\$92\ t^{-1}$) all of the tillage systems were able to produce sufficient revenue to cover total costs, except at Elk Point. At Elk Point the weather was unfavourable throughout the study period such that none of the tillage systems were not able to generate profits, even at the highest barley price. The NPVs displayed similar trends as net returns, with ZT performing best, followed by C2 and MIN, and C1 consistently performing worst.

Crop Insurance Participation

Participation in the Canada/Alberta Crop Insurance Program reduced income variability as a result of the yield guaranteed. The trade-off for the reduced variability is the annual insurance premiums. At Elk Point for example, participation in all-risk crop insurance decreased the average annual income variability (S.D.) by 3% over the tillage systems and barley price. The reduction in net returns and NPV reflects added premiums, compared to the infrequency of payouts received from the insurance program.

Riskiness of Tillage Systems

When the probability distributions of the net returns were compared for producers with different risk preferences, and at the different price levels, the sets of risk efficient tillage systems were relatively small (Table 7). The ZT system was generally risk dominant at all sites, barley price, and risk aversion level. The more risk averse individuals tended to favour use of systems that included more tillage (i.e. MIN or C2) or alternatively to include crop insurance in their management decision.

The sites varied in timing of changes in tillage system or use of crop insurance over the aversion level and barley price. For example, at Alliance risk neutral and producers with low or medium risk aversion would select or prefer ZT without crop insurance (ZT^N) when barley price was low; however highly risk averse producers would select from ZT^N, ZT^W, and $C2^N$. At the medium barley price level we see a shift of the risk efficient set of ZT^W, ZT^N, $C2^N$ move from high risk averse to the medium risk averse, with the highly risk averse producer choosing $C2^N$. For the high barley price the preferences of producers are unchanged, except for the addition of minimum till without crop insurance (MIN^N) to the medium-risk averse set. At the other sites similar trends in shifts of TS to lower aversion levels and the use of crop insurance as we increase the barley price as is seen in Wainwright and Hairy Hill. At Elk Point and Plamondon changes in barley price has no effect on the choice of producers.

Table 7: Set of Risk efficient cropping systems for risk neutral and risk adverse producers.

Aversion Level	Alliance	Elk Point	Hairy Hill	Plamondon	Wainwright
a] Barley Price $46 t^{-1}					
Risk Neutral	N4	N4	I4	N4	N4
Low Risk Averse	N4	I4, N4	I4	N4	N4
Medium Risk Averse	N4	I4, N4	I4	N4	N4
High Risk Averse	I4, N2, N4	I4, N4	I4, N2	N4	N4
a] Barley Price $69 t^{-1}					
Risk Neutral	N4	N4	N4	N4	N4
Low Risk Averse	N4	I4, N4	N4	N4	N4
Medium Risk Averse	I4, N2, N4	I4, N4	N4	N4	I4, N4
High Risk Averse	N2	I4, N4	N4	N4	I4
a] Barley Price $92 t^{-1}					
Risk Neutral	N4	N4	N4	N4	N4
Low Risk Averse	N4	I4, N4	N4	N4	I4, N4
Medium Risk Averse	I4, N2, N3, N4	I4, N4	N4	N4	I4
High Risk Averse	N2	I4, N4	N4	N4	I4

N: No Crop Insurance
I: Crop Insurance

CONCLUSIONS

The use of zero tillage could be a viable alternative available to producers of northeastern Alberta as a means of decreasing costs, increasing yields and net returns, reducing the risk of financial loss, while potentially decreasing the amount of soil erosion. The results of this 5 year study showed that producers in northeastern Alberta could economically adopt zero and minimum tillage as alternatives to conventional tillage systems for a continuous barley production as product prices increase or costs decrease from their 1991-92 levels. The use of all-risk crop insurance is an effective means for producers minimize the risk of financial loss associated with adopting these new production systems.

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