Examining the Sources of Difference in Profitability and Costs for Conservation and Conventional Tillage in Eastern Washington

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INTRODUCTION

For more than one hundred years, farmers in the Pacific Northwest (PNW) have used conventional tillage (CVT) to prepare the soil for dryland grain production. Use of CVT buries most stubble, controls weeds, and inhibits some crop diseases. It also renders the soil vulnerable to wind and water erosion. Also, CVT can lead to soil compaction.

Following Veseth (1999), direct seeding (DS), sometimes referred to as no-till, is defined as "an agricultural production practice where the soil is left undisturbed from harvest to planting except for strips up to 1/3 of the row width." Use of DS reduces soil erosion by leaving more crop residue on the surface, reduces soil compaction, and enhances soil microorganisms. Growers using DS also can encounter weed and disease control problems in some Pacific Northwest environments.

In recent years, adoption of DS systems by U.S. farmers has been growing. However, several factors slow its adoption (Juergens et al. 2001, Upadhyay et al. 2003, and Young et al. 1999). First, the "learning curve" for DS can be slow. Site-specific DS research may not be available. Second, a large capital investment is required for the purchase of a no-till drill, or the modification of existing conventional drills. The associated financial risk has been reported as one of the road blocks to no-till adoption. Third, some perceive that yields from DS are lower than those from CVT. Fourth, the soil productivity benefits of DS occur only gradually.

Studies often compare point estimates of average profitability of CVT and DS systems. A literature survey showed only Pearce et al. (1999), in a study of rice production in Arkansas, performed statistical analysis to determine significant differences in components of costs and net returns among tillage practices. The objective of this study is to statistically compare selected revenue and cost components of CVT and DS in eastern Washington. In this analysis we hope to shed light on the sources of profit differences between CVT and DS in three agro-climatic zones of eastern Washington.

PREVIOUS RESEARCH

Weersink et al. (1992) compared the costs of three DS methods (chisel plow, ridge-till, and no-till) with a CVT moldboard plow tillage system in southern Ontario, Canada. They concluded that total variable costs per hectare for the DS systems were higher than those for the conventional system. However, labor costs could be reduced up to 61 percent annually for DS when compared with costs for CVT.

Wiese et al. (1994) compared profitability of dryland no-till and reduced tillage systems to conventional sweep plowing in the southern Great Plains. Overall, because of low variable costs, conventional sweep plowing was the most profitable in both the short and long term. Halvorson et al. (1994) compared the economic returns of conventional stubble-mulch tillage with no-till and reduced tillage using estimated farmer costs or custom costs. They concluded that yields from the three tillage systems were not significantly different, but costs differed slightly.

Dhuyvetter et al. (1996) reviewed research from the U.S. Great Plains and concluded that cropping systems using less tillage and more intensive rotations generated higher net returns and lower financial risk than the conventional wheat-fallow rotation. The conservation systems also remained in compliance with the 1990 Farm Bill.

Janosky et al. (2002) examined yields and profitability of minimum tillage (MT), delayed-MT, and CVT wheat-fallow farming systems at Lind, Washington. Grain yields and profitability were not significantly different among the three systems. The MT practice substitutes herbicides for tillage when feasible. Also, the noninversion V-sweep implement is used for primary spring tillage. Delayed-MT is similar to MT except primary spring tillage is delayed until at least late May (Janosky et al. 2002). However, an update of this study based on input prices for 2005 instead of 1998 showed statistically higher profits for MT and delayed-MT compared with CVT (Nail et al. 2005b). During the later period, the real price of diesel fuel had increased markedly, while the price for glyphosate herbicide had decreased. These conditions favored the MT systems.

Similarly, Juergens et al. (2004) found that continuous annual no-till spring wheat had equivalent profitability with CVT wheat-fallow at Ritzville, Washington, during 1997-2000. However, when the experiment was extended through 2004, the no-till spring grain systems lagged CVT wheat-fallow by $20 to $25 per acre (Nail et al. 2005a). The last 4 years experienced drier weather.

The agronomic and economic conditions under which producers must choose between DS and CVT influence the systems' profitability. The crop, climate, soils, conservation methods, production costs, crop prices, and availability of insurance all influence the competitiveness of tillage methods (Williams 1988, Weersink et al. 1992, Uri 1999, Pearce et al. 1999).

In contrast to the studies discussed above based on agronomic experiments, Young et al. (1984) conducted a survey of 272 farmers in eastern Washington. They found farmers' perceptions of yields and profitability to be lower for DS at that time. Camara et al. (1999a, 1999b) conducted an in depth survey of long-term no-till farmers growing wheat and barley in two precipitation zones of eastern Washington. They found variable, fixed, and total production costs varied among farmers. However, DS for this group of no-till growers often was competitive with CVT

DATA AND METHODS

This study utilizes data from Camara et al.'s (1999a, 1999b) survey of long-term DS growers from two precipitation zones and Monson et al.'s (2002) study of DS growers in a third zone. Camara et al. (1999a, 1999b) conducted in depth personal interviews of six long-term DS grain growers from the high precipitation zone (19-22 inches ppt/yr or wet region) and four from the low precipitation zone (8-13 inches ppt/yr or dry region) of eastern Washington. Two additional personal interviews of long-term DS farmers were conducted for the intermediate precipitation zone (14-18 inches ppt/yr) by Monson et al. (2002). Few growers who had used DS over most or all of their farms for several years were present in these regions at the time of the surveys.

The long-term DS growers were interviewed to determine their crop rotations, machine operations, input rates, yields, and machinery complements. Published enterprise budgets for three conventional cropping systems, based on farmer panels from the respective regions, served as the benchmark CVT systems (Hinman and Esser 1999, Painter et al. 1995). Cost components of the DS budgets were compared with Washington State University Extension CVT budgets.

Based on consultation with Washington State University Extension and USDA Natural Resources Conservation Service personnel, the sample of 12 DS farmers represented an estimated 25 percent of the approximately 40 to 60 long-term farm-wide DS growers in eastern Washington at the time of the survey. The sample proportion of 25 percent was assumed equal for all precipitation zones.

Standard enterprise budgeting procedures are used for computing fixed costs for land and machinery. Land cost is calculated as net land rent foregone. This is the minimum return the owner-operator must have to justify growing the crop on the land himself rather than renting the land to another grower. Machinery fixed costs include depreciation, interest on investment, property taxes, and insurance. Variable costs, such as labor, fertilizer, herbicides, seed, repairs, and fuel, vary with the crop grown and number of acres in production. The cost per rotational acre is calculated by averaging costs of all crops in the rotation, including fallow. For example, costs and returns for a winter wheat-fallow rotation are those for one-half acre of winter wheat and one-half acre of fallow.

Revenues are also presented on a rotational acre basis. Total revenue equals yield times crop price. The surveyed producers provided their 5-year average DS yields, while CVT yields are the averages from the WSU Extension enterprise budgets, which in turn were based on farmer panels from the region. Average input prices for both groups were 1998 prices from Pullman, Washington, agricultural input dealers. The same input and output prices were used throughout for DS and CVT to focus on production efficiency differences (Camara et al. 1999a, 1999b). Crop prices used are the Washington marketing year averages for 1993-94 through 1997-98 (Camara et al. 1999a, 1999b).

Profit is computed as returns over total (fixed plus variable) costs. These costs include a fair market return for the farmer's labor, land, machinery, and other resources. A "normal" profit over total costs would be zero. Any profit over zero indicates better than average market returns for the farmer's resources.

Winter wheat-spring wheat-lentils is the dominant rotation for the DS sample in the wet region. This rotation is also used as the dominant CVT rotation in this region. For the remaining two regions, the representative CVT rotations are winter wheat-spring barley-fallow for the intermediate region, and a 2-year rotation of winter wheat-fallow for the dry region.

Finite population correction statistical methods are used to compare DS and CVT means. It was hypothesized that average crop yields from DS systems are the same or better than yields from CVT acreage. Similarly, revenue and profits from DS systems are assumed to be higher or equal to those of their CVT counterparts. Due to an increase in weeds, herbicide costs are expected to be higher for DS growers. Also, variable machinery costs and total variable costs are expected to be higher for the DS systems. On the other hand, labor, machinery fixed costs, and total fixed costs are expected to be lower for the DS systems.

One-tailed hypothesis tests consistent with the above expectations are used to determine whether a) the DS machinery fixed costs, labor, and total fixed costs are less than the benchmark CVT values, and b) DS yields, revenues, and profits, total variable costs, machinery variable costs, and herbicide costs are greater than the benchmark CVT values. Hypothesis tests are structured so that rejection of the null hypothesis (H_0) results in acceptance of an alternative hypothesis (H_a), which is consistent with prior expectations. A significance level of 10 percent is used throughout. Probability or p-values for rejection of H_0 are presented when the value of the DS sample mean relative to the CVT benchmark is consistent with prior expectations. The CVT benchmarks are considered as fixed values.

The two pairs of hypotheses may be expressed as follows.

For yields, revenues, profits, variable costs, herbicide costs, and machine variable costs:

$$H_0 : \bar{x} \le \mu$$

$$H_a : \bar{x} > \mu$$

For machine fixed costs, labor costs, and total fixed costs:

$$H_0 : \bar{x} \ge \mu$$

$$H_a : \bar{x} < \mu$$

where $\bar{x}$ is the DS sample mean of the selected parameter, and μ is the corresponding CVT value.

Given that the small samples of DS growers are relatively large (25%) compared to the population, we use the t-statistic

$$t = \frac{\bar{x} - \mu}{s_{\bar{x}}},$$

where $\bar{x}$ and μ are as defined before. The denominator of the t-statistic is the adjusted estimated standard error of the sample mean (Hamburg 1977, 217),

$$s_{\bar{x}} = \frac{s}{\sqrt{n}} \sqrt{\frac{N-n}{N-1}}.$$

Here, n is the sample size, and N is the total population of long-term DS growers in eastern

Washington. The factor $\sqrt{\frac{N-n}{N-1}}$ is known as the *finite population correction (fpc)* and can be used, as a rule, where the sample size is equal to or more than 5 percent of total population (Hamburg 1977, 218). The population size enters only through the fpc and has a negligible effect on the standard error, $s_{\bar{x}}$ unless n is large relative to N, as in this study.

RESULTS

Table 1 presents crop yield averages for the three precipitation regions. The yields are 5-year averages elicited from the DS growers, while those for CVT benchmarks are averages for good management based on panels of farmers surveyed by WSU Extension. The cropping rotation associated with each yield average also is listed. Table 2 presents average revenue, total costs and profits per region for the DS growers and CVT. As expected, average yield, revenue, costs, and net returns differ considerably among farmers and across the three regions (table 2). Table 3 presents costs and profitability data for DS farmers and CVT, with costs broken down by component. Tables 4, 5, and 6 present the hypothesis tests comparing DS and CVT results for the wet, intermediate, and dry regions, respectively.

In the wet region the long-term DS growers' mean yields for dominant crops were winter wheat (86 bu/a), spring wheat (61 bu/a) and lentils (1400 lb/a) (table 4). All are significantly higher at the 0.10 levels than the corresponding CVT values. For the DS spring barley, however, we fail to reject the H_0 that the average yield of 1.86 ton/a is less than or equal to the CVT value of 1.75 ton/a. More importantly, DS growers' revenue ($244.97/a) and profits ($40.63/a) are significantly higher than the CVT values of $215.33/a and -$5.25/a, respectively. For costs, machinery fixed costs, total fixed costs, and labor costs for the DS are significantly lower than the CVT values (table 4). However, for total variable costs, machinery variable costs, and herbicide costs, we fail to reject H_0 that these DS results are less than or equal to the corresponding CVT values. Total cost, which is the sum of variable and fixed costs, is significantly less for the DS sample of growers in this region, consistent with expectations.

Both higher yields and lower costs generated profitable results for this sample of long-term no-till farmers in the wet region. These results for this region comply with prior expectations, except for total variable costs, machinery variable costs, and herbicide costs. Possibly DS yields were aided by higher precipitation in this region, but further research would be necessary to evaluate this.

The small sample size of only two DS growers in the intermediate precipitation region limits generalizations for this region. However, results presented provide some tentative information (table 5). The DS winter wheat mean yield of 53.15 bu/a is lower than the CVT yield of 70 bu/a. We also fail to reject H_0 that the spring wheat yield (45 bu/a) is less than or equal to the CVT yield of 50 bu/a. The CVT system included summer fallow in its rotation (table 1), which likely accounted for its yield advantage over the continuous cropping rotations of the two intermediate region DS farmers (farmers G and H in tables). Recall, however, the summer fallow cost and returns effect is accounted for in the economic analysis by reporting results per rotational acre. In the intermediate region, the DS revenue of $174/a is significantly higher than the CVT revenue of $136.38/a. However, due to higher costs, we fail to reject H_0 that DS profit ($-4.65) is less than or equal to the CVT value of $-0.18/a. Nonetheless, the point estimates of profit are close for the two systems. As expected, DS variable costs, machinery variable costs, and herbicide costs are all significantly higher than the corresponding CVT values in the intermediate region (table 5).

In the dry region, the statistical tests do not permit concluding that the average DS growers' yields of winter wheat (58.75 bu/a) and spring wheat (34.75 bu/a) are significantly higher than the CVT values of 52 bu/a and 35 bu/a respectively, (table 6); yet the point estimates of yields for both systems are close. The DS spring barley yield of 1.74 ton/a is significantly higher than the CVT yield of 1.25 ton/a. The DS growers' revenue of $139.19/a is significantly higher than the CVT value. Profits are not significantly different for this arid region. The DS total variable costs, herbicide costs, and machine variable costs are all significantly higher than the corresponding CVT values, consistent with expectations. Contrary to expectations, the data do not show significantly lower machinery fixed cost, labor cost, total fixed cost, or total cost for the sample of DS growers. However, more recent reduced tillage systems utilizing the V-sweep undercutter might have potential for improving economics of conservation tillage in dry areas (Janosky et al. 2002, Nail et al. 2005a).

CONCLUSIONS

The general goal of this study was to assess the long-term economic feasibility of DS in three eastern Washington precipitation zones by statistically comparing a number of economic variables for DS and CVT systems. A dozen long-term DS growers from three agro-climatic zones were surveyed in depth to determine their cost of production, yields, and profit. Benchmark extension CVT budgets representative of these regions were compared with the DS growers' results.

Most comparisons of DS and CVT economic variables supported expectations in the wet region. Average yields, revenues, and profit were always significantly higher for the sample of DS growers compared with the CVT benchmarks, with the exception of spring barley yields. Cost patterns for DS and CVT in the wet regions also followed expectations with only two exceptions. The superior economic performance of this sample of DS growers in the high precipitation region of eastern Washington provides promise for DS in this area.

Statistical comparisons of DS and CVT in the intermediate and dry regions were less definitive. It usually was not possible to show statistically significant higher yields or profits for DS, but point estimates were usually quite close for DS and CVT in these regions. Most costs and total revenues were generally higher for DS than for CVT because DS farmers often increased cropping intensity by reducing fallow more than CVT farmers did.

These survey sample results show that DS's economic advantage decreases as annual average precipitation decreases, but even in the intermediate and dry regions DS average profit was close to that for CVT. While these economic results for DS are promising, other factors such as reluctance to try new practices for some, especially older, farmers could slow adoption of DS.

Two important qualifications should be kept in mind when interpreting these results. First, Camara et al.'s (1999a, 1999b) survey of the low and high precipitation region DS farmers was conducted in 1998. Monson's survey occurred in 2001. Both survey samples were relatively small. Technology for both DS and CVT has changed since the surveys, as have economic conditions. However, it is likely that these changes have been modest and have taken place in somewhat parallel fashion for DS and CVT, preserving some useful insights from the comparisons presented here.

The second qualification is the farms surveyed were not a random sample of all farmers in eastern Washington who have tried DS. They were, instead, a sample of DS farmers with 3 to 15 years of experience over most of their farmland. These individuals had negotiated the sometimes challenging agronomic and financial transition to DS farming. Consequently, these results describe the economic performance of 12 DS growers who were able to "make it work" on their farms by 1998-2001. These survey results show economic potential for DS and support further research and farmer experience to refine this environmentally and economically promising technology in the Pacific Northwest.

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Table 1: Direct Seed Farmers' and Extension Conventional Tillage Average Crop Yields

Farmer	Rotation	WW[1] (bu/ac)	SW (bu/ac)	SB (tons/ac)	Peas (lb/ac)	Lentils (lb/ac)
Wet						
A	WW/SB	85		1.37		
B	WW/SB/SW	110	70	2.35		
C	WW/SW/L	85	55			1500
D	WW/SW/L	72	59			1200
E	WW/SW/P	75	56		1951	
F	WW/SW/L	92	65			1500
EXT	WW/SW/L	75	50	1.75	2000	1200
Intermediate						
G	WW/SB/SW	52.3	52	1.66		
H	WW/SW	54	38			
EXT	F/WW/SB	70	50	1.75		
Dry						
I	SW		38.5			
J	F/WW/SB	75		1.85		
K	SW		31			
L	F/WW/SB	42.5		1.62		
EXT	F/WW	52	35	1.25		

Source: Adapted from Camara et al. 1999a, 1999b.

[1] WW stands for winter wheat, SW for spring wheat, SB for spring barley, L for lentils, P for peas, and F for summer fallow. Yields are presented for all crops listed in the WSU Extension bulletins even when these crops did not appear on surveyed farms.

Table 2: Farmers' Costs, Revenue and Profit ($/rotational acre)

Farmer	Rotation	Variable Cost	Fixed Cost	Total Cost	Revenue	Profit
WET						
A	WW/SB[1]	113.68	71.16	184.84	216.33	31.49
B	WW/SB/SW	130.63	112.42	243.05	290.25	47.20
C	WW/SW/L	111.31	84.81	196.12	248.97	52.85
D	WW/SW/L	100.96	100.70	201.66	222.83	21.17
E	WW/SW/P	98.37	80.77	179.14	221.34	42.20
F	WW/SW/L	103.98	113.52	217.50	270.11	52.61
EXT	WW/SW/L	108.06	112.52	220.58	215.33	-5.25
INTERMEDIATE						
G	WW/SB/SW	116.99	57.56	174.55	176.71	2.16
H	WW/SW	122.47	60.50	182.97	171.50	-11.47
EXT	F/WW/SB	59.05	77.50	136.55	136.38	-0.17
DRY						
I	SW	71.30	77.03	148.33	173.25	24.92
J	F/WW/SB	54.36	58.71	113.07	145.42	32.35
K	SW	81.07	64.76	145.81	139.50	-6.33
L	F/WW/SB	27.78	47.69	75.47	98.60	23.13
EXT	F/WW	19.04	58.41	77.45	96.72	19.27

Source: Adapted from Camara et al. 1999a, 1999b.

[1] WW stands for winter wheat, SW for spring wheat, SB for spring barley, L for lentils, P for peas, and F for summer fallow.

Table 3: Farmers' Costs by Component and Profit ($/rotational acre).

Farmer	A	B	C	D	E	F	EXT	G	H	EXT	I	J	K	L	EXT
Total Revenue	216.33	290.25	248.97	222.83	221.34	270.11	215.33	176.71	171.50	136.38	173.25	145.42	139.50	98.60	96.72
VARIABLE COST															
Seeding	14.00	17.98	17.97	12.63	16.53	12.37	12.30	9.99	10.59	6.97	12.60	7.47	14.00	5.60	5.04
Herbicides	29.73	20.69	29.33	29.44	27.31	29.62	28.91	23.54	24.46	10.19	10.81	12.07	11.45	7.26	1.20
Fertilizers	27.08	44.05	17.00	16.00	21.35	20.84	15.10	28.35	22.84	11.01	25.10	19.87	29.45	5.82	1.25
Overhead	10.92	11.20	9.30	8.03	8.85	8.52	9.25	15.31	16.30	8.47	5.88	5.23	6.87	2.29	1.76
Tractor Costs	4.38	4.89	0.94	7.82	4.82	10.06	10.28	4.25	8.54	5.21	1.34	1.60	5.70	0.62	0.46
Machine Costs	15.57	13.68	13.87	14.71	9.22	9.40	14.17	22.41	23.65	7.36	7.77	2.85	6.29	1.49	2.08
Labor Costs	12.00	18.15	22.90	12.33	10.29	13.17	18.05	13.14	16.10	9.85	7.80	5.27	7.31	4.70	7.25
Total Variable Cost	113.68	130.63	111.31	100.96	98.37	103.98	108.06	116.99	122.47	59.05	71.30	54.36	81.07	27.78	19.04
Fixed Cost															
Tractor Costs	3.18	6.14	2.31	9.95	2.96	12.08	12.40	3.18	6.63	4.08	10.57	2.62	13.00	0.38	0.61
Machine Costs	9.72	32.03	15.22	31.74	19.85	27.86	43.61	9.79	11.23	10.45	20.66	7.87	18.89	2.96	4.79
Land Costs	55.76	74.26	67.28	59.01	57.96	73.58	56.51	44.59	42.64	34.01	45.79	35.63	32.87	25.08	27.59
Summer Fallow										28.98		12.59		19.27	25.42
Total Fixed Cost	71.16	112.42	84.81	100.70	80.77	113.52	112.52	57.56	60.50	77.50	77.03	58.71	64.76	47.69	58.41
Total Cost	184.84	243.05	196.12	201.66	179.14	217.50	220.58	174.55	182.97	136.55	148.33	113.07	145.81	75.47	77.45
Profit	31.49	47.20	52.85	21.17	42.20	52.61	-5.25	2.16	-11.47	-0.17	24.92	32.35	-6.33	23.13	19.27

Source: Adapted from Camara et al. 1999a, 1999b.

Table 4: Statistical Tests of Means of Economic Variables for DS Farmers Compared with CVT Values, Wet Region

Activity	Mean ($\bar{x}$)	CVT Val (μ)	Test: α=0.10	p-Val[1]
Yield[2] – WW	86.33	75.00	Reject H_0: $\bar{x} \leq 75$	0.0343
- SW	61.00	50.00	Reject H_0: $\bar{x} \leq 50$	0.0061
- SB	1.86	1.75	Fail to reject H_0: $\bar{x} \leq 1.75$	0.4244
- L	1400	1200	Reject H_0: $\bar{x} \leq 1200$	0.0789
($/ac)				
Revenue	244.97	215.33	Reject H_0: $\bar{x} \leq 215.33$	0.0210
Profit	40.63	-5.25	Reject H_0: $\bar{x} \leq -5.25$	0.0002
Variable Cost	110.47	108.06	Fail to reject H_0: $\bar{x} \leq 108.06$	0.2913
Herbicide Cost	28.04	28.91	Fail to reject H_0: $\bar{x} \leq 28.91$	---[3]
Mach. Var. Cost	12.74	14.17	Fail to reject H_0: $\bar{x} \leq 14.17$	---
Mach. Fixed Cost	22.93	43.61	Reject H_0: $\bar{x} \geq 43.61$	0.0009
Labor Cost	14.64	18.50	Reject H_0: $\bar{x} \geq 18.50$	0.0422
Fixed Cost	93.88	112.52	Reject H_0: $\bar{x} \geq 112.52$	0.0191
Total Cost	204.34	220.58	Reject H_0: $\bar{x} \geq 220.58$	0.0629

[1]The probability value (p-Val) is computed assuming the null hypothesis is true. If the p-Value is below the significance level (α = 0.10), then the null hypothesis is rejected.

[2] Winter wheat (WW) and spring wheat (SW) are in bu/a, spring barley (SB) in ton/a, and lentils (L) in lb/a

[3] p-values for rejection of H_0 are presented only when the value of the DS sample mean relative to the CVT benchmark is consistent with prior expectations. In the opposite case, failure to reject is obvious from the sign of ($\bar{x}$ - μ).

Table 5: **Statistical Tests of Means of Economic Variables for DS Farmers Compared with CVT Values, Intermediate Region**

Activity	Mean($\bar{x}$)	CVT Val (μ)	Test: ($\alpha = 0.10$)	p-Val[1]
Yield[2] – WW	53.15	70.00	Fail to reject H_0: $\bar{x} \leq 70$	---[3]
- SW	45.00	50.00	Fail to reject H_0: $\bar{x} \leq 50$	---
($/ac)				
Revenue	174.11	136.38	Reject H_0: $\bar{x} \leq 136.38$	0.0203
Profit	-4.65	-0.18	Fail to reject H_0: $\bar{x} \leq -0.18$	---
Variable Cost	119.73	59.06	Reject H_0: $\bar{x} \leq 59.06$	0.0124
Herbicide Cost	24.00	10.19	Reject H_0: $\bar{x} \leq 10.19$	0.0098
Mac. Var. Cost	23.03	7.36	Reject H_0: $\bar{x} \leq 7.36$	0.0117
Mach. Fixed Cost	10.51	10.45	Fail to reject H_0: $\bar{x} \geq 10.45$	---
Labor Cost	14.62	9.85	Fail to reject H_0: $\bar{x} \geq 9.85$	---
Fixed Cost	59.03	77.51	Reject H_0: $\bar{x} \geq 77.51$	0.0234
Total Cost	178.76	136.56	Fail to reject H_0: $\bar{x} \geq 136.56$	---

[1]The probability value (p-Val) is computed assuming the null hypothesis is true. If the p-Value is below the significance level (α = 0.10), then the null hypothesis is rejected.

[2] Winter wheat (WW) and spring wheat (SW) are in bu/a.

[3] p-values for rejection of H_0 are presented only when the value of the DS sample mean relative to the CVT benchmark is consistent with prior expectations. In the opposite case, failure to reject is obvious from the sign of ($\bar{x} - \mu$).

Table 6: **Statistical Tests of Means of Economic Variables for DS Farmers Compared with CVT Values, Dry Region**

Activity	**Mean ($\bar{x}$)**	**CVT Val (μ)**	**Test: α=0.10**	**p-Val[1]**
Yield[2] – WW	58.75	52.00	Fail to reject H_0: $\bar{x} \leq 52$	0.3658
- SW	34.75	35.00	Fail to reject H_0: $\bar{x} \leq 35$	---[3]
- SB	1.74	1.25	Reject H_0: $\bar{x} \leq 1.25$	0.0688
($/ac)				
Revenue	139.19	96.72	Reject H_0: $\bar{x} \leq 96.72$	0.0270
Profit	18.52	19.28	Fail to reject H_0: $\bar{x} \leq 19.28$	---
Variable Cost	58.63	19.04	Reject H_0: $\bar{x} \leq 19.04$	0.0148
Herbicide Cost	10.40	1.20	Reject H_0: $\bar{x} \leq 1.20$	0.0012
Mach. Var. Cost	4.60	2.08	Reject H_0: $\bar{x} \leq 2.08$	0.0748
Mach. Fixed Cost	12.59	4.79	Fail to reject H_0: $\bar{x} \geq 4.79$	---
Labor Cost	6.47	7.25	Fail to reject H_0: $\bar{x} \geq 7.25$	0.1074
Fixed Cost	62.04	58.41	Fail to reject H_0: $\bar{x} \geq 58.41$	---
Total Cost	120.67	77.44	Fail to reject H_0: $\bar{x} \geq 77.44$	---

[1]The probability value (p-Val) is computed assuming the null hypothesis is true. If the p-Value is below the significance level (α = 0.10), then the null hypothesis is rejected.

[2] Winter wheat (WW) and spring wheat (SW) are in bu/a, and spring barley (SB) in ton/a.

[3] p-values for rejection of H_0 are presented only when the value of the DS sample mean relative to the CVT benchmark is consistent with prior expectations. In the opposite case, failure to reject is obvious from the sign of ($\bar{x}$ - μ).

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