AGRONOMIC AND ECONOMIC COMPARISON OF CONVENTIONAL AND DIRECT-SEEDING IN THE INTERMEDIATE RAINFALL ZONE

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ABSTRACT

The predominant dryland cropping system in the low (<12 inch) and intermediate (12-18 inch) rainfall areas of the Pacific Northwest (PNW) is winter wheat (*Triticum aestivum* L.) summer-fallow using conventional tillage. Tillage increases the rate of soil organic matter oxidation which has an adverse effect on soil physical, biological and chemical properties. A field experiment comparing conventional tillage-based summer-fallow with chemical summer-fallow and direct-seeding was conducted from 1997 through 2004 at the Pendleton Experiment Station to evaluate the effects of tillage and N fertilization rates on winter wheat yields and economic returns. The winter wheat grain yield was greater in the conventional tillage (CT) than in either of two direct-seed systems (NTA and NTB), although the differences are not statistically significant. Crop input costs and fallow costs were roughly equal at equal N application rates in the different tillage systems. The economically optimum N application rate was 80 lbs N/acre in the NTA plots and 120 lbs N/acre in the NTB plots. Winter wheat yield was greatest and the partial net return was greatest at 120 lbs N/acre in the CT plots. Including the available payments under the Conservation Security Program for the NT treatments brought the partial net returns up to about the same as the CT treatments.

INTRODUCTION

The predominant cropping system in the low (<12 inch) and intermediate (12-18 inch) rainfall dryland areas of the Pacific Northwest (PNW) is winter wheat (*Triticum aestivum* L.)-summer-fallow using conventional tillage. Tillage increases the rate of soil organic matter oxidation leading to the loss of soil organic matter with adverse effects on soil physical, biological, and chemical properties. The long-term continued decline in these soil properties has led to the conclusion that conventional tillage systems are not biologically sustainable (Duff et al. 1995). There is no tillage in direct-seeding systems (Veseth 1999) although some growers do perform limited tillage on occasion. Weeds are controlled by herbicides and the crop is sown directly into the stubble from the previous crop. Direct-seeding can reduce soil erosion, slow the loss of organic matter and halt the degradation of soil physical properties. However, lack of adequate seed zone moisture in the fall may delay seeding (Schillinger and Bolton 1992) and cooler soil temperatures may delay crop development reducing yield potential (Machado et al. 2004a, Machado et al. 2004b, Petrie et al. 2004)

Diesel fuel prices skyrocketed in the last 3 months of 2005 and remained high in 2006 leading to markedly increased costs for tillage operations. This dramatic increase in tillage costs coupled with the continued decline in price for contact, non-selective herbicides (glyphosphate) have led many growers to consider direct-seeding as a way to reduce input costs. However, the potential cost saving from direct-seeding may be offset if direct-seeding requires increased N fertilizer application rates or if yields are reduced in direct-seed systems. Comparisons of economic returns from conventional and direct-seed systems have shown mixed results. In some cases, the economic returns from direct-seeding are equivalent to the returns from conventional systems (Janosky et al. 2002), primarily due to reduced equipment and fuel costs. However, in studies of continuous cropping using winter wheat, spring wheat or spring barley, conventional tillage was more profitable than direct-seeding (Machado et al. 2004a, Machado et al. 2004b, Petrie et al. 2005).

A field experiment comparing conventional tillage-based summer-fallow with chemical summer-fallow and direct-seeding was conducted from 1997 through 2004 at the Pendleton Experiment Station. The objectives of this research were to evaluate the effects of tillage and N fertilization rates on winter wheat yields and economic returns.

MATERIALS AND METHODS

The data reported in this paper are from a long-term experiment at the Pendleton Experiment Station. The 75-year average crop-year (September 1 to August 30) precipitation is 16.5 inches; 75% falls between October 1 and April 30. The soil is a Walla Walla silt loam (coarse-silty, mixed, superactive, mesic Typic Haploxeroll). A direct-seed chemical fallow experiment (NTA) was established in 1982 and a second set of direct-seed chemical fallow plots (NTB) and conventionally tilled summer-fallow (CT) plots were added in 1997. The two sets of NT plots were managed the same. Weeds were controlled by herbicides in the NT plots, while both tillage and herbicides were used in the CT plots. The CT plots were plowed, cultivated, and rod-weeded three or four times during the summer. NT plots received applications of various glyphosate formulations two to four times in the summer. NT plots received either 0, 40, 80, 120, or 160 lb N/acre while the CT plots received 0 or 120 lb N/acre; available space limited the N rates in the CT plots. Solution 32 was used for all treatments. Plots also received P and S as ammonium polyphosphate (10-34-0) and ammonium thiosulfate (12-0-0-26). All treatments were fertilized at seeding. Individual plots were 8 by 110 ft, the tillage treatments were arranged in a randomized complete block design and the N rates were randomized within the tillage treatments; there were four replications. ‘Stephens’ winter wheat was seeded in mid- to late-October. Both crop and fallow phases were present each year so data were collected annually. The yield data were analyzed with the General Linear Model in SAS (SAS Institute, Cary, NC) with N rates experiment (NTA, NTB, or CT) and year (1998 to 2004) as factors.

A partial net economic analysis was performed by subtracting the variable input costs from the gross crop value. Variable input costs for herbicides, fertilizer, and seed were based on the average of retail price quotes from three local input suppliers in June, 2005. Tillage, herbicide application, and seeding costs were based on the Oregon State University Enterprise Budget for Wheat (Macnab 2003), adjusted to reflect increased fuel costs. Costs were broken into crop input (planting through harvest, about 10 months) and fallow phase (harvest through seeding, about 14 months). The wheat price was taken to be $4.00/bushel. The costs in the analysis do not include government program payments, crop insurance, or fixed costs such as cash rent or taxes. Payments for conservation practices were determined based on the NRCS worksheets used in the Conservation Security Program.

Table 1. Costs for tillage and inputs used in economic analysis of NT and CT plots at Pendleton.

Input	Cost
	$ / acre
Tillage	
Plowing or flailing	17.67
Cultivating	4.74
Rod weeding	3.62
Herbicides	
Banvel + Bronate	13.55
Banvel + Sencor	18.62
Fargo	13.80
Landmaster	9.62
Paraquat	11.70
Glyphosate	3.85
Application	3.81
Seeding	
Seed	16.00
Seeding NT plots	10.00
Seeding CT plots	8.20
Fertilizer	
Solution 32 (32-0-0)	$0.40/lb of N
10-34-0	$1.93/gallon
Thio-Sul (12-0-0-26)	$1.30/gallon

RESULTS AND DISCUSSION

Tillage and N effect on grain yield

Averaged across the 7 years of the study, N fertilization markedly increased grain yield in all treatments (Table 2). Yields increased as the N application rate increased from 0 to 80 lbs/acre but only small yield increases were observed at greater N application rates. However, mean yields did not decline even at the highest rate of applied N. The check plot yield in the CT plots was about the same as the yield in the NT plots that received 40 lbs N/acre. We speculate that tillage increased soil organic matter mineralization and the resulting increase in plant available N was approximately equal to 40 lbs N/acre. Mean yields in the CT treatment were significantly greater than those of the NTA and NTB treatments when no N was applied. However, mean yields were not significantly different between these treatments when 120 lbs N/acre was applied. In addition, mean yield in the NTB experiment was not significantly greater than the mean yield in the NTA experiment. Unfortunately, space limitations precluded other rates of N in the CT experiment.

At each N rate, the lowest mean yield was usually observed in the NTA treatments, the older of the two direct-seed treatments. In addition, the yield in the CT experiment was nearly always greater than the yield in either of the NT experiments. The reason for the slight yield difference between the NT trials is not clear but it may be related to either the slower release of N from soil organic matter mineralization or the increased immobilization of N in soil organic matter or some other factor(s).

Table 2. Mean yields of NTA, NTB, and CT treatments at Pendleton, 1997-2004.

	N application rate				
	lbs N / acre				
Tillage	0	40	80	120	160
	bu / acre				
NTA	40.4	64.0	83.4	85.9	86.6
NTB	48.0	68.5	82.4	88.8	91.3
CT	64.6	---	---	93.8	---

Economic analysis

A partial economic analysis of the various tillage systems and N rates used in this study was conducted. We evaluated only the costs for the variable inputs used in the different systems and the associated crop value. The partial net return that was determined provides a relative comparison of the differences in the economic returns between the systems we studied. We also determined the standard deviation of the crop value and input costs as an indication of the "riskiness" associated with each tillage system and N rate. Riskiness is an important factor that growers and the financial community use to evaluate the financial viability of different cropping systems (D.Young, personal comm.)

Fallow costs

The fallow costs were incurred during the time from post-harvest weed control to seeding. Input costs varied between years in both the NT and CT plots, depending on the need for weed control. The summer-fallow cost in the CT plots ranged from $33.27 to $44.55/acre with an average of $38.16/acre; the standard deviation was $3.58/acre. Chemical fallow costs in the NT plots ranged from $21.09 to $42.18/acre with an average cost of $35.68/acre; the standard deviation was $7.19/acre. Chemical fallow cost an average of $2.48/acre less than conventional fallow but the standard deviation in cost was twice as great.

Crop value, crop input cost, and partial net return

The average crop value, crop input costs, and partial net returns for the tillage treatments are shown in Table 3. Crop value was calculated by multiplying the crop yield by $4.00/bushel. Crop value ranged from a low of $161.65 when no fertilizer was applied in the NTA plots to a high of $375.30 when 120 lbs N/acre was applied in the CT plots. Variable input costs were less for the CT than the NT plots at comparable N fertilizer rates because the residue in the NT plots was flail mowed about half of the years to permit successful seeding. The plots were flail mowed more frequently at the higher N rates and following larger yields. Use of a straw chopper and a different drill might reduce or eliminate the requirement for flail mowing. Increasing the N fertilizer rate increased the average input costs although other costs, except for the flail mowing, were unaffected by the N fertilizer rate. The standard deviation of the NTA and NTB input costs was about $15.00/acre while the standard deviation of the CT input costs was less than $10.00/acre.

Table 3. Mean crop value, variable inputs, and partial net return at Pendleton, 1997-2004.

Trial	N rate	Crop value		Crop input costs		Partial net return	
	lb/acre	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
		---------------------------------- $/acre					
NTA	0	161.65	8.76	59.61	16.28	66.36	20.74
	40	255.83	18.97	82.07	16.28	138.07	9.44
	80	333.48	45.15	109.58	15.14	188.22	31.37
	120	343.59	87.91	132.04	15.04	175.87	76.55
	160	346.42	83.84	154.50	15.14	156.24	72.97
NTB	0	192.19	24.29	62.86	16.74	93.65	31.14
	40	274.07	29.12	85.32	16.74	153.07	29.29
	80	329.75	47.61	110.30	14.49	183.07	36.39
	120	355.17	65.51	132.76	14.49	186.73	55.33
	160	365.30	87.34	155.22	14.49	174.40	75.62
CT	0	258.20	21.75	52.06	9.20	167.97	26.09
	120	375.30	69.04	119.44	9.20	217.70	66.35

The partial net return was calculated by subtracting the total variable input costs (crop inputs + fallow costs) from the crop value; the fallow cost is not shown in the tables. This figure is NOT net profit as we did not consider land costs, cash rent, or other fixed costs in the analysis. This figure represents two years as it is the combination of the fallow phase and the crop phase.

Crop value increased as each additional increment of N fertilizer was applied. Partial net return increased as the N fertilizer application rate increased to the optimum rate and then decreased as the value of the slight yield increases was less than the cost of the additional N fertilizer. The economically optimum N rate was 80 lbs N/acre in the NTA plots and 120 lbs N/acre in the NTB plots. We could not estimate the optimum N application rate for the CT plots because there were only two rates – 0 and 120 lbs N/acre. However, the greatest partial net return in the study, $217.60/acre, resulted from the application of 120 lbs N/acre in the CT plots. The standard deviation increased markedly as the N application rate increased to 120 or 160 lbs/acre.

For a typical 3,000-acre farm with half in winter wheat and half in summer-fallow, the whole farm partial net return would be $282,330, $280,095 and $326,550 for the NTA, NTB and CT treatments, respectively. It is also important to recognize that there are other, non-economic factors that may be of great value but that are difficult to quantify, such as the value of time spent in the field away from one's family or potential offsite costs due to soil erosion. These factors are not included in this analysis as each situation is unique, but nonetheless, these factors may play a key role in determining the overall satisfaction and total cost associated with a specific farming system.

Effect of Conservation Security Program

The Conservation Security Program (CSP) was established in the 2002 Farm Bill. Payments in the CSP program are based on the soil and slope at the site and the practices that are used as well as the Tier Level for which the farm qualifies. The practices used in the NT treatments would be eligible for a direct payment of $24.40/acre, up to a maximum of $20,000, $35,000, or $45,000/year for Tier I, Tier II, and Tier III, respectively. In our example with a 3,000-acre farm, the CSP payment would be either $35,000 for Tier II or $45,000 for Tier III. Adding the CSP payments to the values for partial net return for the NTA and NTB treatments for the "typical" 3,000-acre farm in our example increases the partial net return to either $317,330 or $327,330 for the NTA treatments and $315,095 or $325, 095 for the NTB treatments. These values are competitive with the partial net return of $326,550 from the CT plots.

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