Agronomic and Economic Comparison of Annual-Cropped Conventional Tillage and No-tillage. II. Spring Wheat

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Introduction

The predominant cropping system in the dryland Pacific Northwest (PNW), where annual precipitation is <425 mm, is winter wheat (*Triticum aestivum* L.) tillage-based summer fallow. About 70% of the precipitation occurs between September and March. Tillage fallow is practiced to control weeds, accumulate nutrients, and slow the evaporative loss of soil moisture. Soil tillage aerates the soil and enhances biological oxidation and loss of soil organic matter. Intensive or continuous cropping in conjunction with no-tillage (NT) may retard SOM loss and maintain or improve soil productivity. However, nutrient deficiencies and pest pressures may increase under NT resulting in reduced yields. In lower precipitation zones of PNW spring wheat is preferable because it uses less water, enables better control of winter annual grasses, and spreads labor demands. Information on crop productivity and profitability of continuous spring wheat under CT and NT cropping systems in the PNW is limited. The objective of our experiment is to determine the effects of annual mono-cropping of spring wheat on grain yield and profitability under CT and NT cropping systems.

Materials and Methods

The experiment was conducted at the Columbia Basin Agricultural Research Center (CBARC), Oregon State University (OSU), near Pendleton, Oregon. The soil is a coarse, silty, mixed, mesic Typic Haploxeroll (Walla Walla silt loam); the soil is 1.2 m to caliche and about 2.4 m to bed-rock. Average annual precipitation is about 400 mm. The CT spring wheat plots have been in continuous cereal since 1931. Since 1977 the plots have received 90, 10, 16 kg N, P, S ha^{-1}, respectively, annually. A zero fertilizer control was imposed in 1993. NT companion plots were established in the spring of 1998 with unfertilized and fertilized plots. Fertilized plots received 100, 10, 16 kg N, P, S ha^{-1}, respectively, annually. Data obtained from 1998 to 2003 is presented. All plots were seeded in March at 280 and 312 seeds m^{-2} for the CT and NT plots, respectively. A double disk drill was used to seed CT plots and a hoe drill was used to seed the NT plots. Weeds were controlled by glyphosate, glyphosate + 2,4-D, and bromoxynil. Grain was harvested by a plot combine and weighed. Yield components were determined from a 1-m quadrat in each plot. PROC MIXED and REPEATED MEASURES procedures (SAS) were used to analyze data. A partial economic analysis was performed. Fixed costs, crop insurance costs and government programs benefits were excluded. Variable costs were assigned to residue management and tillage for seedbed establishment, seeding, fertilizing, weed control, and interest. Variable costs were based on the OSU Enterprise Budget for Winter Wheat. Fertilizer and pesticide costs were based on local dealers. Prices for soft white wheat were the Portland, OR November average price for the harvest year crop

Results and Discussion – Agronomy

Precipitation

The relative distribution of winter and spring precipitation markedly influenced spring wheat yield during the six years of this study. Crop year precipitation (1 Sep to 31 Aug) was greatest in 2000 and least in 2002 while winter precipitation was greatest in 1999 and least in 2002. Spring precipitation was highest in 2000 and lowest in 1999.

Grain Yield

Grain yields of unfertilized CT were significantly correlated with winter precipitation while grain yield of unfertilized NT spring wheat was not correlated with precipitation (Table. 1). Grain yield of both unfertilized CT and NT spring wheat declined for the first five years of the experiment from 1998 to 2002 before picking up in 2003 (Fig. 1). The decline was more gradual under CT than under NT. The decline in CT yields was attributed to the effect of winter precipitation that also decreased from 1999 to 2002; the yield increased in 2003 when the winter and total crop year precipitation increased. The decline in grain yields of unfertilized NT spring wheat from 1998 to 2000, despite the increase in crop year precipitation in the same period, was attributed to a decline in fertility and increased disease and weed pressure. Unfertilized CT spring wheat produced higher grain yield than NT spring wheat in four of six years indicating problems in annual NT spring wheat production.

Fertilization significantly increased grain yield of both CT and NT spring wheat in five of six years. Under CT, fertilization increased grain yields in all years except 2003 when spring precipitation was very low and poorly distributed. Grain yield of fertilized CT spring wheat followed trends in spring precipitation (Fig. 1) and was more closely correlated with spring than with winter precipitation (Table 1). Grain yield of fertilized NT spring wheat declined gradually from 1998 to 2003. The decline was confounded with the decline in winter precipitation but other factors associated with NT conditions are suspected to have influenced grain yield. When fertilized, CT spring wheat produced significantly higher grain yields than NT spring wheat in five of six years (Fig. 1) indicating that NT spring wheat yields were affected by other factors.

Overall, grain yield of continuous CT spring wheat was significantly higher than grain yield of continuous NT spring wheat with or without fertilization. Although there were significantly higher numbers of heads m^{-2} in NT spring wheat, the reduction in kernel weight in NT wheat probably caused the reduction in grain yield (data not shown). Fertilized CT spring wheat produced higher grain yields than NT spring wheat through high heads m^{-2} (data not shown).

Table 1. Correlations between grain yield of unfertilized and fertilized continuous spring wheat grown under conventional tillage and no-tillage systems

	Conventional Tillage Yield		No-tillage Yield	
Fertilizer	0	100,10,16 kg N,P,S ha-1	0	112,10,16 kg N,P,S ha-1
Crop year ppt	†0.49**	0.76**	-0.09	0.65**
Winter ppt	0.47**	0.45**	-0.08	0.53**
Spring ppt	0.18	0.73**	-0.05	0.40**

†*,** significant at 0.05 and 0.01 probability levels, respectively

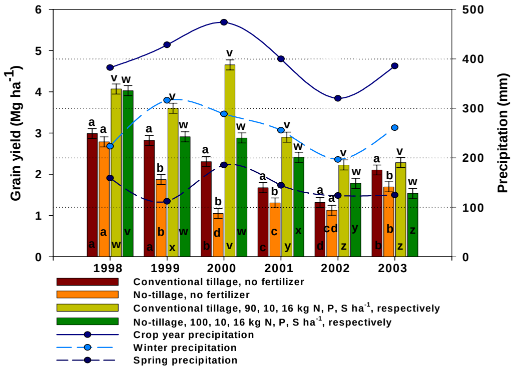

Fig. 1. Precipitation, tillage, and fertilization effects on the grain yield of continuous spring wheat, CBARC, Pendleton, OR, 1998-2003. Means with same letters are not significantly different from each other at the 0.05 probability level. Letters a,b at the top of bars compare unfertilized plots and v,w compare fertilized plots within each year. Letters within bars compare the same fertilizer treatment between years (a,b,c,d,e for unfertilized plots and v,w,x,y,z for fertilized plots)

Results and Discussion – Economic Analysis

The average cost of the residue management in NT plots was \$32.93 ha^{-1} compared to average tillage costs for the CT plots of \$66.52 ha^{-1}. Fertilization costs were similar for each system. Planting costs, including the seed and seeding, were about \$11 ha^{-1} greater for the NT than the CT plots because the seeding rate was increased and the cost of seeding with a no-till drill was greater than with a conventional drill. Herbicide costs tended to remain about the same for the CT plots during the six years of the study while the herbicide costs increased yearly in the NT plots. In the 2003 crop, herbicide costs for the CT wheat were \$55.70 ha^{-1} compared to \$141.46 ha^{-1} in the NT wheat. Total average annual variable input costs were \$293.14 ha^{-1} and \$316.08 ha^{-1} for the CT and NT plots, respectively.

Crop yields, crop values, variable input costs, and partial net returns are shown in Table 2. Crop values varied in response to changes in the crop yields and crop prices; the mean crop value for the CT wheat was about \$88 ha^{-1} greater than the mean crop value of the NT plots. The variable input costs were greater for the NT than the CT plots, primarily due to the greater herbicide expense in the NT plots. The partial net returns were extremely variable, due to the interacting effects of crop yields, crop prices, and variable input costs. The partial net returns from the CT plots ranged from \$193.95 to \$ 38.33 ha^{-1} with a mean partial net return of \$120.37 ha^{-1}. The partial net returns from the NT plots ranged from \$188.95 ha^{-1} to a partial net loss of \$105.42 ha^{-1}; the average annual partial net return was only \$9.39 ha^{-1}.

Table 2. Crop yield, crop value, variable costs, and partial returns from fertilized CT and NT spring wheat at CBARC, 1998-2003.

Year	Crop Yield		Crop Value		Variable costs		Partial net return	
	CT	NT	CT	NT	CT	NT	CT	NT
	Mg ha^{-1}		---------- Mg ha^{-1} ----------					
1998	4.08	4.03	471.30	466.68	288.13	277.73	183.17	188.95
1999	3.61	2.91	408.92	330.33	287.95	316.16	120.97	14.14
2000	4.66	2.89	502.38	311.40	308.43	330.12	193.95	-18.72
2001	2.91	2.42	407.38	332.38	301.09	327.84	106.29	4.54
2002	2.23	1.78	366.16	293.16	286.62	320.33	79.54	-27.17
2003	2.29	1.54	324.82	218.87	286.49	324.29	38.33	-105.42
Mean	3.29	2.60	413.49	325.47	293.14	316.08	120.37	9.39

Summary and Conclusions

- Continuous CT spring wheat was more productive than continuous NT spring wheat regardless of the fertilization rate.
- Low NT yields indicate problems associated with NT systems that need to be addressed. Breeding and agronomic research should be conducted to improve the yield potential of spring wheat varieties under NT conditions.
- Continuous CT spring wheat had lower variable costs of production, especially herbicides, and markedly greater economic returns than NT spring wheat.