Agronomic and Economic Comparison of Annual-Cropped Conventional Tillage and No-tillage. III. Spring Barley

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Introduction

Winter wheat tillage-based summer fallow under conventional tillage (CT) is the predominant cropping system in the dryland PNW where precipitation is <425 mm. Seventy percent of annual precipitation is received between September and March. Tillage fallow is practiced to control weeds, accumulate nutrients, and slow the evaporative loss of soil moisture. However, tillage accelerates biological oxidation and loss of soil organic matter. Conservation tillage and annual cropping have the potential to reduce loss of SOM and soil erosion and improve soil productivity. No-tillage (NT) systems increase surface residues that protect the soil from erosion; increase soil organic matter; and increase water infiltration. Nutrient deficiencies and pest pressures may, however, increase under NT cropping systems resulting in reduced yields. Since the introduction of NT cropping systems, there has been a renewed interest in annual cropping of spring cereals. Information on crop productivity and profitability of continuous spring barley (*Hordeum vulgare* L.) under CT and NT cropping systems in the PNW is limited. Spring barley offers advantages over spring wheat including more rapid soil coverage in the spring and earlier maturity that helps barley avoid the terminal drought that is common in the PNW. The objective of our experiment is to determine the effects of annual mono-cropping of spring barley 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. CT spring barley plots were established in 1982 on land that has been in continuous spring cereal crops 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, which received 100, 10, 16 kg N, P, S ha^{-1} and a control, were established adjacent to the CT plots in 1998. Plots were seeded in March at 280 and 312 seeds m^{-2} for the CT and NT, 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 or 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 feed barley were the Portland, OR November average price for the harvest year crop

Results and Discussion: Agronomy

Precipitation

Crop year (1 Sep to 31 Aug) precipitation 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. The relative distribution of winter and spring precipitation markedly influenced spring wheat yield during the six years of this study.

Grain Yield

Grain yields of unfertilized CT spring barley were positively correlated with winter precipitation while grain yields of unfertilized barley were negatively correlated with winter precipitation (Table. 1). Unfertilized CT barley yields closely followed trends in winter precipitation while yields of unfertilized NT barley decreased drastically in the first three years of the experiment when winter precipitation was increasing (Fig. 1). The decline in NT yields was attributed to a decline in fertility and increase in disease and weed pressure. Unfertilized CT spring barley produced significantly higher grain yields than unfertilized NT spring barley in all the six years of study (Fig. 1).

Applying N, P, and S significantly increased the grain yield of CT spring barley in all years and in five of six years in NT spring barley. Both fertilized CT and NT spring barley followed trends in spring precipitation (Fig. 1). Correlation values indicate that fertilized spring barley was significantly correlated with spring precipitation (Table. 1). Fertilized CT spring barley produced significantly higher grain yields than fertilized NT spring barley in four of six years (Fig. 1) indicating that there were other factors affecting NT yields.

On average, the grain yield of continuous CT spring barley was significantly higher than the grain yield of continuous NT spring barley with or without fertilizer. CT spring barley produced more heads m^{-2} (data not shown) than NT spring barley in both unfertilized and fertilized plots indicating tiller production was reduced under NT conditions. Low grain yields under NT conditions can be attributed to a number of factors that include nutrient deficiency due to N immobilization, slow growth and development due cold and wet soils, increased disease and weed pressure, and residue toxicity.

Table 1. Correlations between grain yield of unfertilized and fertilized continuous spring barley 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	†0.64**	0.71**	-0.44**	0.52**
Winter ppt	0.59**	0.33**	-0.56**	0.20
Spring ppt	0.26	0.81**	0.05	0.67**

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

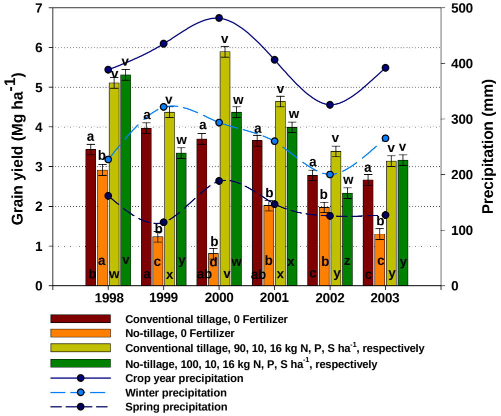

Fig. 1. Precipitation, tillage, and fertilization effects on the grain yield of continuous spring barley, CBARC, Pendleton, OR, 1998-2003. Means with same letters are not significantly different from each other at the 0.05 probability level. Letters a,b at the top of bars compare unfertilized plots and 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 \$66.51 ha^{-1}. Fertilization costs were similar for each system. Planting costs, including the seed and seeding, were about \$10 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 were the single largest input for the NT plots; costs increased from \$74.00 to \$141.46 ha^{-1} for the NT plots compared to \$55.70 for the CT plots in 2003. Total average annual variable input costs were \$287.10 ha^{-1} and \$308.83 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 plots was about \$70 ha-1 greater than 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 \$341.55 to \$119.10 ha^{-1} with a mean partial net return of \$190.61 ha^{-1}. The partial net returns from the NT plots ranged from \$202.44 ha^{-1} to -\$5.51 ha^{-1}; the average annual partial net return was \$93.32 ha^{-1}.

Table 2. Crop yield, crop value, variable costs, and partial returns from fertilized CT and NT spring barley 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	5.11	5.31	458.11	476.04	284.27	273.60	173.84	202.44
1999	4.37	3.34	412.18	315.03	282.20	310.07	129.99	4.96
2000	5.89	4.35	642.30	474.37	300.75	320.18	341.55	154.19
2001	4.64	3.99	509.00	437.70	293.39	318.05	215.61	119.65
2002	3.38	2.33	443.29	305.58	279.70	311.09	163.59	-5.51
2003	3.14	3.16	401.37	404.20	282.26	320.00	119.10	84.20
Mean	4.42	3.75	477.71	402.15	287.09	308.83	190.61	93.32

Summary and Conclusions

- Continuous CT spring barley was more productive than continuous NT spring barley 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 barley varieties under NT conditions.
- Continuous CT spring barley had lower variable costs of production, especially herbicides, and markedly greater economic returns than NT spring barley.