CORN AND SOYBEAN RESPONSE TO ROTATION SEQUENCE AND TILLAGE SYSTEM.

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Abstract

The response of corn (*Zea mays* L.) and soybean [*Glycine max* L. (Merr.)] to tillage system and rotation sequence has been investigated for 15 years in Wisconsin. Our objective was to compare yield and economics of conventional and no-tillage systems with different rotation sequences involving 1st-, 2nd-, 3rd-, 4th-, 5th-yr corn or soybean, alternate corn and soybean, and continuous corn or soybean. There was an interaction of corn yield with tillage system and rotation sequence. Averaged over years, tillage increased corn yield 8%, but did not affect soybean yield. Both 1st-yr corn and soybean produced the highest yields at 172 bu acre^{-1} and 59 bu acre^{-1} compared to the other six rotation sequences that averaged 148 bu acre^{-1} and 54 bu acre^{-1}, respectively. Both 1st-yr corn and soybean produced the highest grower return at \$80 acre^{-1} and \$108 acre^{-1}, respectively. Interactions for both corn and soybean grower return were found with tillage system and rotation sequence. Averaged over years, tillage increased corn grower return by \$27 acre^{-1}, but did not affect soybean grower return. It was concluded that 1st-year corn or soybean and alternating corn and soybean were the most profitable rotation sequences over the last 15 years in Wisconsin.

Introduction

Crop rotation and tillage systems have an impact on both production cost and yield. The use of an alternating corn and soybean rotation rather than continuous corn or soybean typically results in higher net return and lower variability since the economics of crop rotations are largely tied up with the effect of introducing a break crop. The possible financial effects on the whole farm are the net return of the break crop itself, the effect on the variable costs of the continuous grown crop, and the beneficial effect on the yields of the following crop after the break crop. These financial effects on the whole farm can be combined to measure the likely difference in net return of different rotations. Numerous reports have been published on rotating corn and soybean and its influence on tillage systems, seeding rates, row spacing, and nitrogen (Pedersen and Lauer, 2002; 2003). However, few studies have been conducted in the Midwest to document the long-term economic comparisons of different corn-soybean rotations using different tillage systems. The objective of this study was to determine the long-term effect on yield and profitability with continuous corn or soybean vs. rotated corn and soybean using different tillage systems.

Materials and methods

This experiment was conducted during 1987 to 2001 at the University of Wisconsin – Arlington Agricultural Research Station on a Plano silt loam (fine-silty, mixed, mesic, Typic Argiudoll). The experimental design was a randomized complete block in a split-split plot arrangement with four replications. Main plots were no-tillage systems and conventional tillage systems that were established in 1986. Tillage operations for conventional tillage were moldboard plowing in the fall and field cultivation in the spring before planting. For no-tillage, crops were planted directly into the residue of the previous crop. Subplots consist of 14 rotation sequences involving corn and soybean. The sequences were initiated in 1983 on land previously planted to corn. The sequences allow comparisons to be made during 1987 to 2001 of (i) 1st-year corn and soybean (after 5 consecutive years of the other crop); (ii) corn and soybean alternated annually with the other crop; and (iii) 2,3,4, and 5 years of continuous corn and soybean. Plot size of the sub-sub plots was 10 ft by 37.5 ft. The sub-sub plots were over the years used to compare the impact of different hybrids and cultivars, different plant populations, and row spacing on the different rotation sequences and tillage systems. All corn plots were fertilized after planting with 28% urea ammonium nitrate at a rate of 150 lbs per acre. Weed management was done exclusively with herbicides based on sufficient weed population to justify application of herbicides, and available herbicides to use.

Production costs for the different tillage systems and rotation sequences were obtained from Iowa (Duffy and Smith, 1987-2001; Table 1). Expected price for corn and soybean were calculated using a weighted price where 50% is November average cash price + 25% March CBOT futures price ($0.15 basis) + 25% July CBOT futures price ($0.10 basis). November average cash price was derived from Wisconsin Agricultural Statistics; CBOT futures prices derived from closing price on first business day in December. The soybean LDP prices were used in 1999-2001.

The center 5 ft by 33.5 ft of each plot was harvest with either a Kincaid Plot Combine (Kincaid Equipment Manufacturing, Haven, KS) or an Almaco plot combine (Allen Machine Co., Nevada, IA). Grain yields were adjusted to 15.5 % (corn) and 13.0 % (soybean). All data were subjected to an analysis of variance using the MIXED procedure of SAS. The restricted maximum likelihood method was used for variance component estimation. Data were analyzed across years with year and replicates considered random in determining the expected mean squares and appropriate *F*-tests in the analysis of variance. Mean comparisons were made using Fisher's protected LSD test ($P \leq 0.05$).

Table 1. Corn and soybean production costs from 1987 to 2001 (Duffy and Smith, 1987-2001).

Year	Corn production cost				Soybean production cost†	
	Yield	After corn	Yield	After soybean	Yield	After corn
	Bu $acre^{-1}$	\$ $acre^{-1}$	Bu $acre^{-1}$	\$ $acre^{-1}$	Bu $acre^{-1}$	\$ $acre^{-1}$
1987	115	278	125	259	38	199
1988	115	285	125	365	38	210
1989	115	307	125	286	38	226
1990	115	306	125	284	38	226
1991	115	314	125	294	38	239
1992	115	295	125	276	38	224
1993	120	307	135	291	45	234
1994	120	314	135	297	45	239
1995	120	331	135	312	45	247
1996	120	335	135	317	45	253
1997	120	349	135	330	45	264
1998	120	353	135	333	45	270
1999	120	353	135	333	45	270
2000	120	347	135	328	45	271
2001	120	366	135	346	45	271

†Production costs for soybean are assumed to be the same after soybean and corn.

Results

Corn

There was an interaction with rotation sequence and tillage system on corn yield (Figure 1). No differences were found between tillage system for 1^{st} year corn or annually rotated corn. Averaged over the remaining five rotations, corn planted in the conventional tillage system yielded 13% (152 bu $acre^{-1}$) greater than corn planted in a no-tillage system (135 bu $acre^{-1}$). Corn planted in conventional tillage system yielded (173 bu $acre^{-1}$) 15% more for first-year corn than the continuous grown corn (150 bu $acre^{-1}$). Corn planted in no-tillage system yielded 32% more for first-year corn (172 bu $acre^{-1}$) than continuous grown corn (131 bu $acre^{-1}$). In general, no differences were found between the remaining five rotation sequences that averaged 8% less than the first-year corn after 5 yr soybean and annually rotated corn. First year corn (172 bu $acre^{-1}$) and corn rotated annually with soybean (169 bu $acre^{-1}$) yielded 19% and 17% respectively more than continuous corn (140 bu $acre^{-1}$), respectively.

No differences were found between tillage system for 1^{st} year corn or annually rotated corn (Figure 2). Averaged over the remaining five rotations, corn planted in the conventional tillage system resulted in 13% (\$13 $acre^{-1}$) greater grower return than corn planted in a no-tillage system (-\$20 $acre^{-1}$). First year corn (\$80 $acre^{-1}$), corn rotated annually with soybean (\$71 $acre^{-1}$), and 2^{nd} year corn (\$10 $acre^{-1}$) were the only three corn rotations with a positive grower return (Figure 2). Using no-tillage system in corn resulted in an average grower return of \$4 $acre^{-1}$, whereas the conventional tillage system resulted in an average grower return of \$31 $acre^{-1}$.

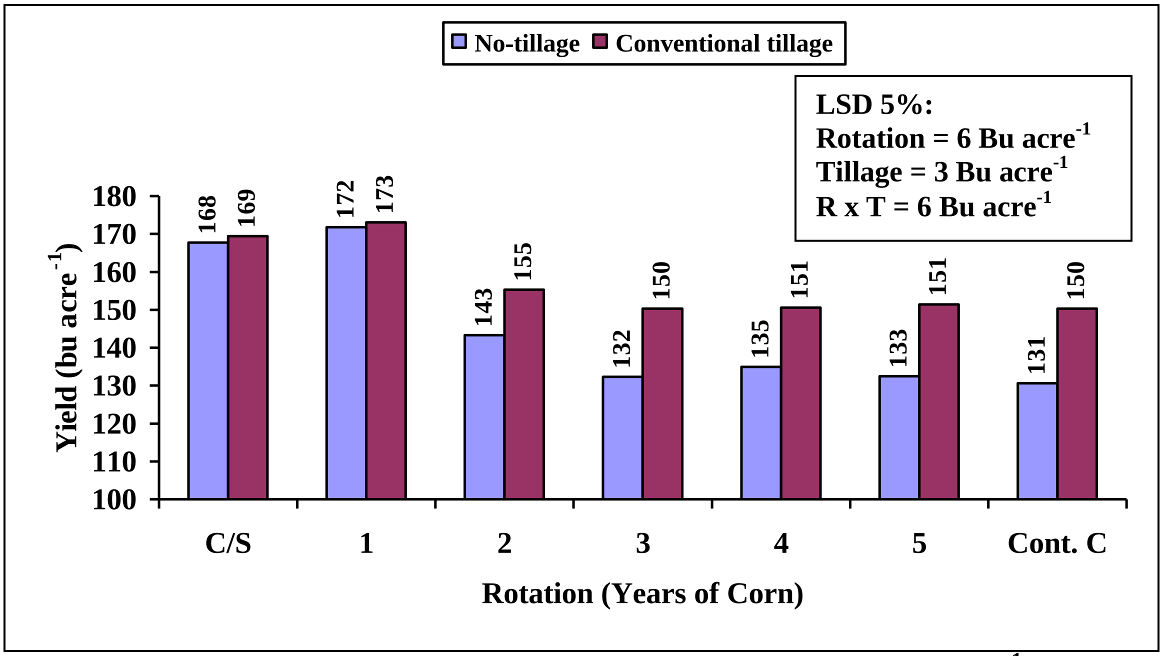

Figure 1. Interaction of rotation (R) and tillage (T) on corn yield (Bu acre^{-1}), 1987-2000. 1 = 1st-year corn (after 5 consecutive years of soybean); 2, 3, 4, and 5 = 2, 3, 4, and 5 years of continuous corn; Cont. = continuous corn since 1986; C/S = corn and soybean alternated annually.

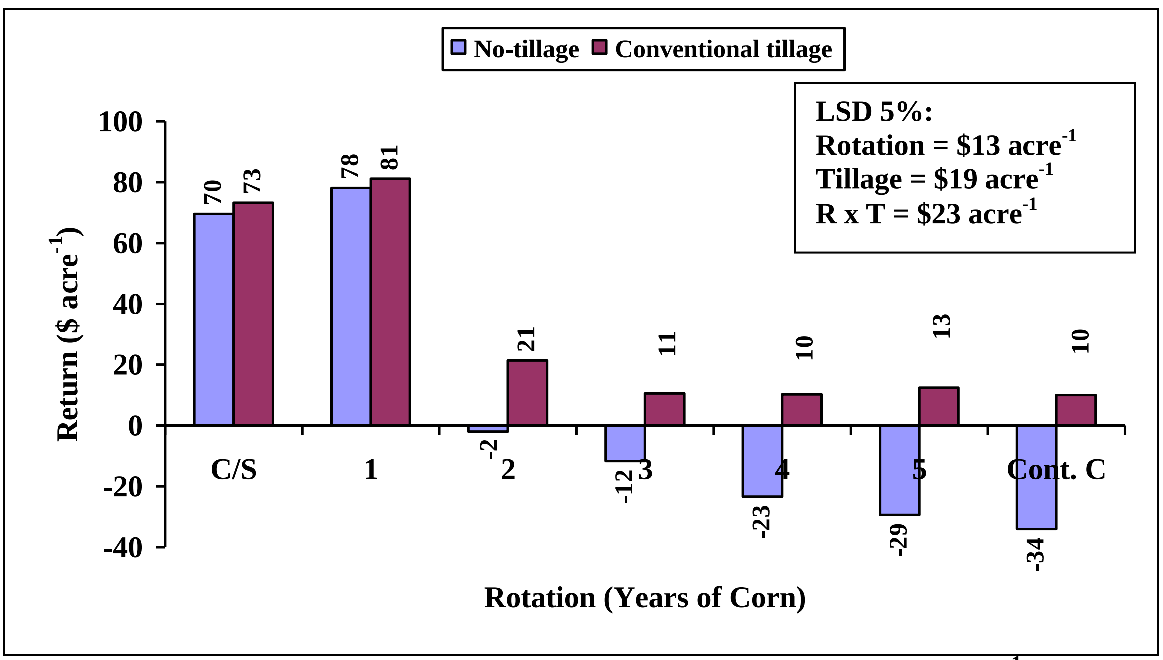

Figure 2. Interaction of rotation (R) and tillage (T) on corn return ($ acre^{-1}), 1987-2000. 1 = 1st-year corn (after 5 consecutive years of soybean); 2, 3, 4, and 5 = 2, 3, 4, and 5 years of continuous corn; Cont. = continuous corn since 1986; C/S = corn and soybean alternated annually.

Soybean

A tillage system by rotation sequence interaction was found for soybean yield, but with variable results (Figure 3). Soybean planted in conventional tillage system yielded 3 bu/acre and 4 bu/acre greater for second-year and third-year soybean compared to the no-tillage system. No differences were found between tillage systems for the remaining five rotation sequences. Tillage system did not affect soybean yield. First year soybean yields (59 bu acre^{-1}) were 12% higher than the other 6 rotation sequences (avg. 53 bu acre^{-1}).

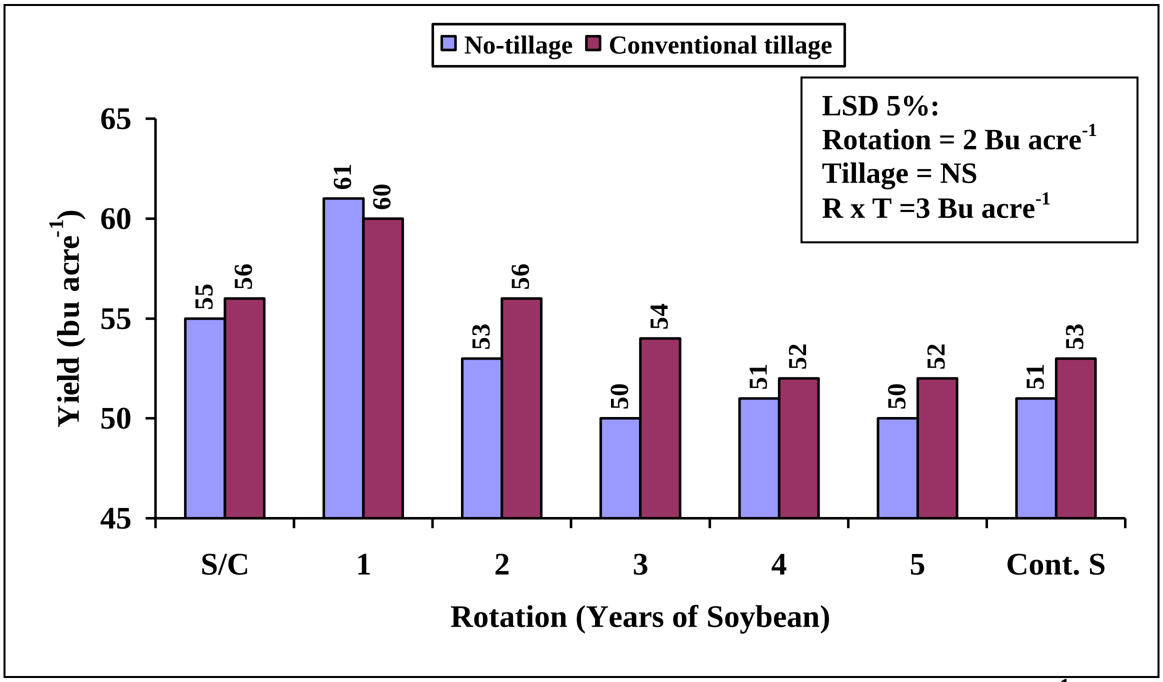

Figure 3. Interaction of rotation (R) and tillage (T) on soybean yield (Bu acre^{-1}), 1987-2000. 1 = 1st-year soybean (after 5 consecutive years of corn); 2, 3, 4, and 5 = 2, 3, 4, and 5 years of continuous soybean; Cont. = continuous soybean since 1986; S/C = soybean and corn alternated annually.

All soybean rotation sequences had a positive grower return (Figure 4). Tillage system influenced grower return for second-year and third-year soybean with 26 and 38% greater grower return found for conventional tillage system compared to no-tillage system. No differences were found for grower return between tillage systems for the remaining five rotation sequences. Highest grower return was found for first-year soybean ($108 acre^{-1}) that was 33 and 43% higher than soybean rotated annually with corn and continuous soybean, respectively. Tillage did not affect grower return.

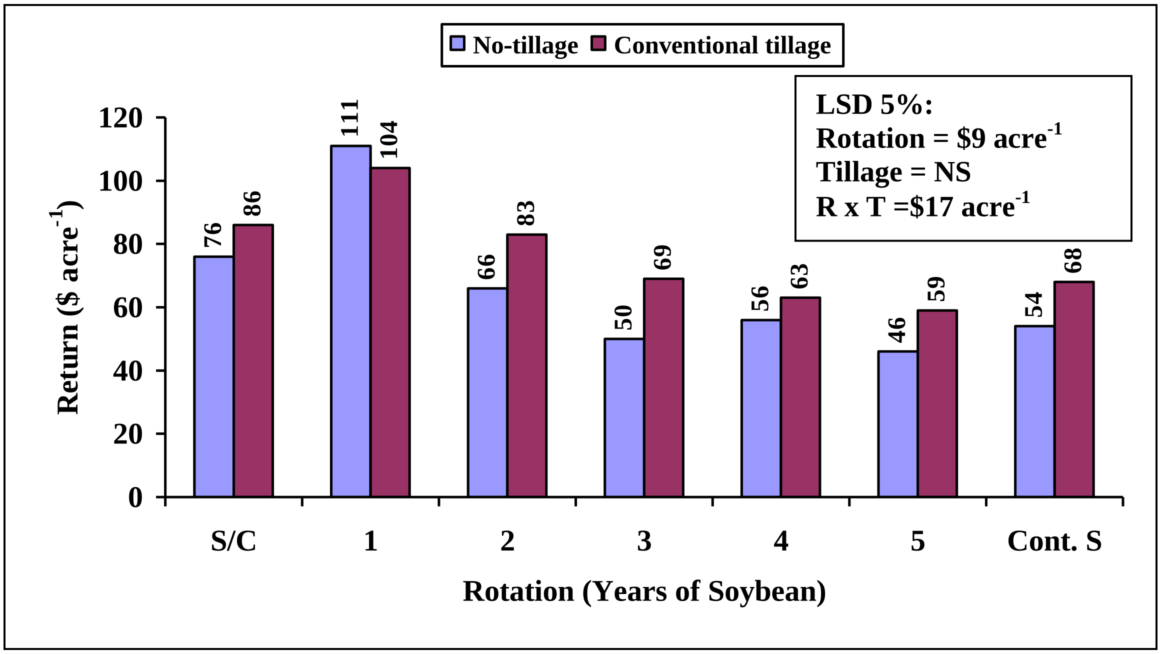

Figure 4. Interaction of rotation (R) and tillage (T) on soybean grower return ($ acre^{-1}), 1987-2000. 1 = 1st-year soybean (after 5 consecutive years of corn); 2, 3, 4, and 5 = 2, 3, 4, and 5 years of continuous soybean; Cont. = continuous soybean since 1986; S/C = soybean and corn alternated annually.

Summary

This research from Wisconsin indicates that growers should continue to rotate corn with soybean to improve both corn and soybean yield and grower return. Corn yields and grower returns were higher with conventional tillage than with no-tillage. Tillage system did not affect soybean yield or grower return. First yr corn and corn rotated annually with soybean yielded 19% and 17% respectively more than continuous corn, respectively. Corn yields resulting from increasing years of consecutive corn planting were no different from continuous corn yields. First yr corn, corn rotated annually with soybean, and second-year corn were the only three corn rotations with a positive grower return. First yr soybean yields were 12% higher than the over 6 soybean rotation sequences. All soybean rotations had a positive economic return with the highest grower return found for first-year soybean that was 43% higher than continuous soybean. This analysis combined Wisconsin agronomic production data and Iowa economic data. Soybean is relatively new to Wisconsin and in this trial likely experienced relatively less pest pressure and higher yields compared to more southerly areas of the Corn Belt. Likewise corn yield potential is lower in northerly locations with shorter-season hybrids. It was concluded that 1st-year corn or soybean and alternating corn and soybean were the most profitable rotation sequences over the last 15 years in Wisconsin.

References

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