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Tillage Study for Corn and Soybeans: Comparing Vertical, Deep, and No-Tillage / Year 10

E. Adee

Summary

Trends from a tillage study conducted since 2011 have shown no clear differences between tillage systems for either corn or soybeans in lighter soils under irrigation. One year out of eight years has shown a yield advantage for either corn or soybeans for any tillage system, which appears to be related to environmental conditions experienced during the season. Averaged across all years of the study, the treatments with deep tillage either every or every-other year had about 4.5% higher corn yields, and soybeans had up to a 3.2% yield increase with some form of tillage.

Introduction

The need for tillage in corn and soybean production in the Kansas River Valley continues to be debated. The soils of the Kansas River Valley are highly variable, with much of the soil sandy to silty loam in texture. These soils tend to be relatively low in organic matter (< 2%) and susceptible to wind erosion. Although typically well drained, these soils can develop compaction layers under certain conditions. A tillage study was initiated in the fall of 2011 at the Kansas State University Kansas River Valley Experiment Field near Topeka to compare deep vs. shallow vs. no-tillage vs. deep tillage in alternate years. Corn and soybean crops are rotated annually. This is intended to be a long-term study to determine if soil characteristics and yields change in response to a history of each tillage system.

Procedures

A tillage study was laid out in the fall of 2011 in a field that had been planted with soybean. The tillage treatments were (1) no-tillage, (2) deep tillage in the fall and shallow tillage in the spring every year, (3) shallow tillage in the fall following both crops, and (4) deep tillage followed by a shallow tillage in the spring only after soybean, and shallow tillage in the fall after corn. In the fall of 2010, prior to the soybean crop, the entire field was subsoiled with a John Deere V-ripper. After soybean harvest, 30- × 100-ft individual plots were tilled with a Great Plains TurboMax vertical tillage tool at 3 in. deep or a John Deere V-ripper at 14 in. deep. Spring tillage was conducted with a field cultivator. Starting in the fall of 2012 through fall of 2017, the treatments were conducted with the TurboMax or a Great Plains Sub-soiler Inline Ripper SS0300. Spring tillage in 2013–2016 was conducted with the TurboMax, and a field cultivator in 2017 on the required treatments. Starting in the fall of 2017, the vertical tillage treatments were made using a Kuhn Krause Excelerator 8005. Each tillage treatment had 4 replications.

Dry fertilizer (11-52-60 nitrogen (N), phosphorus (P), and potassium (K)) was applied to the entire field prior to fall tillage in 2012 and to the soybean stubble in 2013 and 2014. In the fall of 2015, 2016, and 2017, 14-52-40-10 (N, P, K, and sulfur (S)) fertilizer was applied to the soybean stubble prior to fall tillage. The application of 16-75-75-10 (S) was conducted similarly in the fall of 2019, and 20-94-94-12.5 (S) was applied in the fall of 2020. Nitrogen (150 lb in 2012 and 2013; 180 lb in 2014, 2015, 2016, 2017, 2018, 2020, and 2021; and 160 lb in 2019) was applied in March prior to corn planting. Soybeans were planted after soybeans in the setup year. Planting, harvest, and irrigation information for the study is included in Table 1. Irrigation was calibrated to meet evapotranspiration (ET) rates. All corn was planted in 30-inch rows, as well as soybeans through 2016. Soybeans were planted in 15-inch rows in 2017 through 2020. Soybeans were planted in 30-in. rows in 2021 and 2022.

Results

Yields of corn or soybeans did not differ due to tillage in the setup year (2012) of the study (Table 2). The yields were respectable considering the extreme heat and drought experienced this growing season. The growing conditions were better in 2013, resulting in higher yields in both corn and soybeans, but with no significant differences between tillage treatments (Tables 3 and 4). In 2014, the corn yields were very good and Sudden Death Syndrome lowered soybean yields, but there were no differences between tillage treatments (Tables 3 and 4). The cool and rainy start to the season in 2015 slowed corn growth and lowered yields, while the soybeans had very good yields (Tables 3 and 4). In 2016, extremes in soil moisture from dry to saturated resulted in higher yields for the deep tillage treatments than did shallow tillage in corn, but soybean yields were similar for both tillage treatments. There were soil moisture extremes again in 2017, but a cooler August was very favorable for yields of both crops, with no differences between yields with the different tillage systems. The 2018 growing season started off very cool, but quickly had above normal temperatures. The corn yields were very good, with no difference between tillage systems. The soybean yields were very good, the highest was with the more conventional annual tillage and the vertical tillage systems. The 2019 season started off cool for most of May, then had near average temperatures for June and July, followed by a cooler August. The growing season was very wet except for July. The corn yields in 2019 were very good and the soybean yield was the highest observed in the study to date. The season in 2020 started off cool, but turned very hot and dry in June, requiring irrigation. July was very wet, with August near normal, resulting in average corn yields and very good soybean yields (no SDS symptoms). The 2021 season started off very similar to 2020 through June, with July and August drier at near normal temperatures with corn yields down some, and soybean yields were very good. In 2022, the temperatures were average to above average in the spring, with one cool week the first part of May, which had rainfall twice the monthly average. Then the weather turned hot and dry the rest of the growing season, requiring irrigation to start 2 to 3 weeks earlier than normal for both crops.

Combining data from 2013–2022 for analysis showed corn yields are favored by deep tillage, and soybean yields were higher with any kind of tillage (Tables 3 and 4). Corn with deep tillage showed significant yield advantages in 4 of the 10 years, while soybeans were not as responsive in a given year to tillage. Averages of stand counts taken at the V5 stage in the corn for 2014–2022 did not show any differences (Table 3). We anticipated that it would take several years for any characteristics of a given tillage system to build up to the point of influencing yields. Deep soil samples were collected in the fall of 2020 to compare soil properties and soil health between tillage systems. Results of those data will be reported when analysis completed.

Conclusions

The influence of tillage system on corn or soybean yield appears to be dependent on the year. A given set of environmental conditions may favor a system, but in Kansas the conditions can vary considerably each year. Corn is more responsive in yield to a tillage system, probably because uniform emergence is a foundational factor for yield potential. While there were no differences in population count in corn, data were not collected on uniformity of emergence. In contrast, soybeans were much less sensitive to population and uniformity in emergence, with their ability to compensate for missing or late plants through the season. Therefore, early season differences in soybeans with the different tillage systems will probably not have an effect on the yield.

These studies were conducted on well-drained soils under irrigation. As a result, any potential benefits for a specific tillage system to have an advantage in either too wet or too dry conditions were not as pronounced. In heavier soils and/or under dryland conditions, the advantages of any of these tillage systems would probably be greater in a given year.

Numerous other factors need to be considered when comparing tillage systems, such as soil erosion, water conservation, weed control options (becoming more challenging with herbicide-resistant weeds), labor, equipment costs, and time available to conduct field work. The yield-limiting conditions may vary between fields based on soil type and environmental conditions during a season and over the long term.

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Table 1. Cropping details for tillage study at Kansas River Valley Experiment Field

	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Corn										
Planting date	30-Apr	21-Apr	14-Apr	11-Apr	24-Apr	23-Apr	22-Apr	22-Apr	April 26	April 21
Hybrid/variety	Pioneer P1498 HR AQ	Pioneer P1105AM	Pioneer P1105AM	AgriGold 6538	Midland 534	Golden Harvest 11B63	Pioneer 1197	Pioneer 1197	NK 13-54	DeKalb 65-95
Seeding rate	30K	32K	31.7K	31.7K	32K	32K	32.4K	32.4K	33K	31.7K
Row spacing (inches)	30	30	30	30	30	30	30	30	30	30
Harvest date	27-Sep	11-Sep	10-Sep	19-Sep	20-Sep	31-Aug	17-Sept	15-Sept	Sept 13	Sept 21
Irrigation (inches)										
May	0	0	0	0	0	0	0	0	0	0
June	1.58	0	1.58	2.24	2.88	4.71	1.03	4.8	1.7	.68
July	3.51	4.74	2.29	4.40	3.63	6.55	2.36	0.8	2.55	3.93
August	0.77	2.19	2.87	0.70	1.81	0.84	0	.8	2.55	2.42
September	0	0	0	0	0	0	0	0	0	0
Soybean										
Planting date	15-May	21-May	1-Jun	31-May	26-May	7-May	6-June	19-May	13-May	9-May
Hybrid/variety	Pioneer P94Y01	Asgrow 3833	Midland 3884NR2 + ILeVO	Stine 42RE02	Pioneer P39T67 + ILeVO	Midland 4373 RR2	Asgrow 36x6 + ILeVO	Pioneer P37A27+ ILeVO	AG40X70+ ILeVO	AG43XF2 + ILeVO
Seeding rate	144K	140K	144K	140K	140K	140K	140K	140K	140K	136K
Row spacing (inches)	30	30	30	30	15	15	15	15	30	30
Harvest date	8-Oct	9-Oct	13-Oct	17-Oct	17-Oct	17-Oct	17-Oct	9-Oct	Oct 7	Oct 18
Irrigation (inches)										
May	0	0	0	0	0	0	0	0	0	0
June	1.58	0	0.74	0.74	0	0	0	0	0	0
July	3.51	1.55	0.74	4.40	1.82	3.90	1.51	0	.85	.85
August	2.27	2.19	2.87	1.54	1.81	0.84	0	1.6	2.55	1.08
September	2.18	0	0	0	0	0	0	0	.85	.99

Table 2. Effects of tillage treatments on corn and soybean yields in 2012 at Kansas River Valley experiment fields

Tillage treatment	Corn yield	Soybean yield
	------------------------------ bu/a ------------------------------	
No-tillage	196	59.9
Fall subsoil/spring field cultivate	202	55.5
Fall vertical tillage	198	57.9
Pr>F *	0.64	0.14

*The lower the Pr>F value, the greater probability that there is a significant difference between yields.

Table 3. Effects of tillage treatments on corn yields and plant stands in 2013–2022 at Kansas River Valley experiment fields

	Corn yield, bu/a										Average corn yield	Average stand, plants/a
Tillage treatment	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2013–2022	2014–2022
No-tillage	221	243	205 b	183 b*	226	206	218	207	187 b	199 b	209 b	31,807
Fall subsoil/spring field cultivate	223	259	215 a	202 a	236	214	228	212	202 a	231 a	222 a	31,693
Fall vertical tillage	196	259	207 b	189 b	226	210	219	211	191 b	234 a	214 b	31,775
Fall subsoil after soybean/vertical tillage after corn	214	256	211 ab	195 a	231	209	227	216	198 a	235 a	220 a	31,499
Pr>F#	0.14	0.27	0.05	0.005	0.46	0.7	0.22	0.36	0.006	0.0002	0.001	0.70

*Values followed by the same letter are not significantly different at $P = 0.05$.
#The lower the Pr>F value, the greater probability that there is a significant difference between yields.

Table 4. Effects of tillage treatments on soybean yields in 2013–2022 at Kansas River Valley experiment fields

	Soybean yield, bu/a										Average soybean yield
Tillage treatment	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2013–2022
No-tillage	62.4	52.8	69.7	80.2	67.4	69.3	78.1	73.1	80.3	67.0 b	69.0 b
Fall subsoil/spring field cultivate	64.3	55.2	73.1	76.0	72.8	71.2	79.2	72.5	85.8	72.8 a	71.3 a
Fall vertical tillage	64.4	55.5	72.8	78.6	68.1	75.0	80.5	76.0	84.4	72.8 a	71.6 a
Fall subsoil after soybean/vertical tillage after corn	66.3	52.8	70.9	75.8	70.1	70.2	80.1	74.0	82.9	66.8 b	70.3 ab
Pr>F#	0.52	0.40	0.23	0.12	0.098	0.51	0.87	0.54	0.32	0.002	0.01

*Values followed by the same letter are not significantly different at $P = 0.05$.
#The lower the Pr>F value, the greater probability that there is a significant difference between yields.