ROLE OF ROTATION IN SOYBEAN PRODUCTION

Crop rotation is a term used to describe the pattern of growing two or more crop species in a given field in some consecutive order. Soybean is commonly rotated with corn, wheat, rice, or grain sorghum in the U.S. Reasons given for growing soybean in rotation rather than continuously are 1) higher yields of one or both crops, 2) a decrease in amount of nitrogen [N] fertilizer for the grain crop following soybean, 3) increased residue cover, 4) mitigation of pest and weed cycles, and 5) improved economic potential.

The perception is that rotation of soybean with a grain crop provides positive agronomic, environmental, and economic benefits. This is based on long-term soybean:corn rotation research that has been conducted in the midwestern U.S. Results from those studies are provided here to underline the potential for rotational cropping systems to be used in the midsouthern U.S. to gain the same advantages.

In the Corn Belt, the vast majority of soybean is rotated biennially with corn [Wiebold and Belt 2006]. In the western Corn Belt, soybean rotated with grain sorghum is a major production system [Wortmann et al. 2007] because grain sorghum production costs are lower than corn production costs [Staggenborg et al. 2008], and corn is less able than sorghum to withstand drought and high temperature stresses that are common in the region [Staggenborg et al. 2008; Yamoah et al. 1998].

In the midsouthern U.S., there is a lack of long-term research that documents how a biennial rotation of soybean and other crops will perform. However, there is a significant acreage of corn and rice grown and harvested in Arkansas, Louisiana, Mississippi, and Tennessee each year. All of these grain acres can potentially be rotated with soybean.

Rotation and Yield

Yields of both corn and soybean are increased when planted in rotation with each other in the midwestern U.S. or Corn Belt **[Table 1]**. The increase is greatest when the crops are rotated biennially and in the first year of either crop following consecutive years of the other [Pedersen and Lauer 2003; Porter et al. 1997; Mourtzinis et al., 2017].

A summary of over 20 years of corn-soybean rotation research conducted in Northeast Iowa is reported by Mallarino et al. [2005]. Results from that research follow.

- Average yield of corn following soybeans exceeded yield of corn following corn by 34% [144 vs. 107 bu/acre] when 80 lb/acre of N was used for corn, by 17% [154 vs. 131 bu/acre] when 160 lb/acre of N was used for corn, and by 13% [158 vs. 139 bu/acre] when 240 lb/acre of N was applied to corn.
- Corn following soybeans required less fertilizer N than corn following corn.
- Average yield of soybeans following corn exceeded yield of soybeans following soybeans by 15% [46.1 vs. 39.9 bu/acre].
- N added to soybeans did not increase yield in either system.

Varvel and Wilhelm [2003] provide results from two long-term studies (20 years dryland and 10 years irrigated) conducted in Nebraska that showed the following.

- Dryland corn following soybeans vs. following corn yielded 17% more [137 vs. 117 bu/acre] and 4.5% more [135 vs. 129 bu/acre] when 80 and 160 lb/acre of N was applied to the corn, respectively.
- Irrigated corn following soybeans vs. following corn yielded 9.5% more [184 vs. 168 bu/acre] and 4.6% more [183 vs. 175 bu/acre] when 90 and 135 lb/acre of N was applied to the corn, respectively.
- The amount of N supplied by soybeans to the following corn crop in both the dryland and irrigated studies was estimated to be approximately 60 lb/acre/yr. This additional N does not become available until late in the growing season, thus making it difficult to detect with late-fall or early-spring soil testing.

A report [Al-Kaisi et al., 2015] from a long-term (2003-2013) study conducted at seven locations in Iowa provided the following results.

- Three crop rotations [corn-corn, C-C; corn-soybean, C-S; and corn-corn-soybean, C-C-S] were evaluated.
- Yield and economic returns from the three rotations in descending order were C-S > C-C-S > C-C.
- The yield penalty associated with C-C was location specific, but still ranged from 11 to 28%.
- The C-C system led to a significant decline in corn yield and economic return regardless of tillage system that included no-till, strip-till, chisel plow, deep rip, and moldboard plow.
- Across all locations, average economic returns/acre were $388 for C-S, $333 for C-C-S, and $227 for C-C.
- These results confirm the usual trend of corn yield decline in a C-C vs. a C-S rotation.

A report [Seifert et al., 2017] from an analysis of 748,374 yield records in the 2007-2012 period across the midwestern U.S. provided the following results.

- The continuous corn yield penalty [CCYP] averaged 4.3%, and was more severe in low-moisture and low-yield environments.
- The continuous soybean yield penalty [CSYP] averaged 10.3%, and was more severe in low-yielding years.
- The CCYP got larger with up to 3 years of continuous corn, then leveled off.
- The CSYP increased with the number of years of continuous soybean.
- These results indicate that the CCYP and CSYP can be reproduced outside of controlled experiments.

Corn grain yield variability over the long term in the western Corn Belt is reduced by rotation with soybean [Varvel 2000]. Rotations of corn and soybean are more profitable than either one grown as a monocrop [DeWitt et al. 2002; Katsvairo and Cox 2000a; Pedersen and Lauer 2003; Stanger et al. 2008]. The energy output:input ratios for corn and grain sorghum are greater when grown in rotation with soybean than when grown as monocrops [Franzluebbers and Francis 1995; Rathke et al. 2007].

Yields of both soybean and grain sorghum are also increased when grown in rotation in the western Corn Belt **[Table 2]**. The increase in yield of sorghum following soybean is greatest when they are rotated biennially and in the first year of sorghum following consecutive years of soybean [Kelley 2005]. Yamoah et al. [1998] measured a greater rotation effect on sorghum yield in cooler, wetter years.

Varvel [1995] determined that soybean and grain sorghum are less affected by the previous crop in a nonirrigated rotation than is corn in the limited-rainfall western Corn Belt. Thus, grain sorghum will have a much more stable production in rotation with soybean than will corn in dryland production systems in this region. Grain sorghum yield variability over the long term in the western Corn Belt is reduced by rotation with soybean [Varvel 2000]. It is likely that these occurrences will also be the case in the midsouthern U.S.

Rotation and N

Soybean preceding a grain crop in a rotation is considered to provide an “N credit” to the grain crop. The N contribution from soybean is an important aspect of reducing yield variability in the following grain crop [Varvel 2000]. Late-fall or early-spring soil tests have not been able to detect or reflect this soybean N credit, however [Varvel and Wilhelm 2003].

Results from several soybean/grain crop rotation studies have estimated the soybean N credit. Results from a long-term study by Varvel and Wilhelm [2003] indicated a soybean N credit of 58 and 71 lb. N/acre for a following corn or sorghum crop, respectively. An N credit from soybean to corn of 70 to 80 lb/acre was extrapolated from the results of Bergerou et al. [2004], DeWitt et al. 2002, Mallarino et al. [2005], and Stanger et al. [2008]. Roder et al. [1989] determined the soybean N credit to a succeeding grain sorghum crop was about 80 lb/acre. Yamoah et al. [1998] estimated an N contribution of 55 lb/acre from soybean to sorghum.

In an 11-year rotation study in Texas, 40% more N fertilizer was required to achieve optimal grain yield from continuous sorghum than from rotated sorghum [Franzluebbers et al. 1995]. Grain sorghum producers in the western Corn Belt can reduce fertilizer N by 40 lb/acre when sorghum follows soybean vs. itself (Kelley 2005). Nitrogen fertilizer replacement values of soybean for corn in a soybean–corn rotation from various studies are presented by Swink et al. [2007].

The reduction in the amount of N fertilizer that should be applied to a grain crop following soybean is a significant economic and environmental consideration. Accounting for this N credit will prevent excessive N fertilizer application to the grain crop, thus decreasing expense and potential nitrogen loss to the surrounding environment [Franzluebbers et al. 1994]. A reduction in N fertilizer application to a grain crop following soybean also reduces the total energy input for the production of the grain crop, which is particularly important for corn since N fertilization accounts for about half of the total energy input for its production [Rathke et al. 2007]. This reduction in N fertilization of the grain crop also contributes to a higher output:input energy ratio from rotated crops [Franzluebbers and Francis 1995; Rathke et al. 2007].

Rotation and Residue Cover/Erosion Control

Crops such as corn and grain sorghum that are rotated with soybean generally produce more dry matter and subsequent residue following harvest, and maintain more surface residue following tillage and/or planting operations than does soybean **[Table 3]**. This increased residue resulting from rotation of soybean with a grain crop may lead to improved water infiltration, soil tilth, and organic matter. Over the long term, soil organic carbon [C] levels and crop residue produced and returned to a field are greater in a soybean–corn rotation compared to a continuous soybean system [Omay et al. 1997; Varvel and Wilhelm 2008].

Crop rotation can be used to decrease erosion potential. As shown in **Table 4**, culture of some crops results in more of an erosion hazard than others. Soils planted to soybean may have as much as 10 to 100% greater soil loss potential than do soils planted to corn or grain sorghum [Triplett and Dabney 1999]. Reasons for this are 1) soybean does not produce a large volume of residue that covers the soil during the off-season, and 2) soybean residue decomposes more rapidly than the stalks and leaves of non-leguminous crops. Rotation of corn or grain sorghum with soybean, and with soybean planted no-till, allows the grain crop residue cover to persist into the soybean growing season, thus reducing erosion potential.

Click here to access a White Paper on this website that provides greater detail about how a corn-soybean rotation system and associated tillage practices affect residue cover and subsequent erosion and/or soil loss.

Rotation and Pest Management

According to a review by Heatherly and Elmore [2004], soybean in a rotation with corn may mitigate the need for some of the pesticides that are used to control pests. Growing another crop between soybean crops can break pest cycles and thus require less expenditure for control of insects and diseases. The continuous growing of either crop maximizes the opportunities to increase those weed species best adapted to compete with the monocropped crop. Rotation of corn and soybean allows the rotation of herbicides, which may limit or delay the occurrence of resistant weed species. In New York, Katsvairo and Cox [2000a] found that a soybean-corn rotation resulted in reduced fertilizer, herbicide, and pesticide use compared to a continuous corn system.

Summary of Results from Midwestern Research

- When soybean is rotated with either corn or grain sorghum, yield of each crop following the other is greater than yield of each crop following itself.
- The N fertilizer requirement for a grain crop following soybean is less than for the crop following itself, and the N contribution from soybean is an important aspect of reducing yield variability in the grain crop.
- Both economic and agronomic incentives favor a 2-yr soybean–grain crop rotation in the Corn Belt.

Important Points for Midsouth Soybean Rotation Systems

It is unreasonable to assume that results from Midwest research will directly transfer to the Midsouth for the following reasons.

- Midsouth soil properties present a much different environment for off-season maintenance of soil N levels because of higher soil temperatures and frequent long-term soil saturation that results in anaerobic conditions. This results in greater loss of soil N in the Midsouth during the winter months.
- Higher temperatures in the Midsouth during the winter months will result in greater decomposition of crop residues between harvest and next season's planting.
- Lower dryland yields in the Midsouth will presumably result in different N use patterns by corn, and subsequently, less crop residues.
- The above factors will affect residual soil N levels.
- The presence or absence of irrigation will be a key factor in soybean rotation systems in the midsouthern U.S.

The below factors should also be accounted for when considering rotation of soybean with any crop.

- Long-term commodity price prospects should be used to project the potential net returns of varying cropping systems that may involve rotation.
- In a soybean-corn rotation system, it is important to use a similar tillage system for both crops to save on average annual machinery costs.
- The decision to rotate soybean with other crops should be evaluated from both agronomic and economic perspectives. In most cases, soybean rotated with another summer crop will enhance economical and sustainable production.

There is a lack of long-term research that documents just how a soybean-corn rotation will perform outside the midwestern U.S. There is anecdotal evidence that corn yields will be greater following soybeans in the Midsouth, and this naturally leads to the assumption that rotation of the two crops will change the dynamics of their production.

A report by Watts and Torbert [2011] presents results from a 1991-2001 soybean-corn rotation study conducted on a site with a fine sandy loam soil at the Sand Mountain Research and Extension Center near Crossville, Alabama. [The latitude of this location is the same as that of Verona and Clarksdale, Miss.]. Results from that study follow.

- Average yield of corn following soybeans was 19% [19.6 bu/acre] greater than average yield of corn following corn.
- Average yield of soybeans following corn was only 3.5% [1.3 bu/acre] more than average yield of soybeans following soybeans.

A report [Ashworth et al., 2017] of results from experiments conducted at two locations in Tennessee provided the following results.

- Including corn once in a 4-year rotation resulted in 8% greater yield than from continuous soybean.
- Cotton included in a 4-year rotation had no effect on soybean yield.
- Poultry litter included in the rotations increased soybean yield by 11% across locations and years compared to a wheat cover crop.

As stated above and repeated here for effect, it is unreasonable to automatically assume that results from the above-cited Midwest research will directly transfer to the Midsouth. However, the results from midwestern U.S. research indicate that soybean production in the Midsouth could benefit from rotation with a grain crop, especially corn. And with the large corn acreage in the region, there is certainly ample acreage from which producers can gain this potential benefit.

Soybean-Rice Rotation

In an 8-yr study at Stoneville, Miss., Kurtz et al. [1993] reported yields of 18.4 and 27.7 bu/acre from nonirrigated [NI] soybean that was grown continuously and in rotation with rice, respectively. Net returns from the NI soybean following rice were higher. Rice yields and net returns also were increased by rotation with soybean, and 8-yr average net returns from soybean-rice rotations exceeded those from both continuous NI soybean and continuous rice. This same result from NI soybean following rice was also achieved in later work at this location [Wesley, Soybean Production in the Midsouth, p. 157-170, CRC Press]. Where soybean was irrigated [which will be the case in a soybean-rice rotation], soybean that was cropped in a 1:1 rotation with rice produced yields and net returns that were similar to those from continuous soybean. Since irrigated soybean yields following rice do not appear to be enhanced by the rotation with rice, the advantages of rotating soybean with rice where both are irrigated must accrue from benefits such as enhanced rice yields and disruption of pest and weed cycles rather than a yield benefit to the soybean. Also, should water for soybean irrigation become limited, a rotation of NI soybean-irrigated rice would apparently ensure a greater NI soybean yield.

Rotation and Nematode Management

Nematodes are a serious pest of soybean in the United States. In areas with severe infestations, producing soybean without control measures is not economically feasible. Heatherly and Elmore [2004] provide a summary of how crop rotation can be used to control or mitigate the effects of nematodes. Kirkpatrick and Thomas [Univ. of Ark. FSA7550] published an article titled "Crop Rotation for Management of Nematodes in Cotton and Soybean" that is also a good source of information about cropping effects on nematodes.

The soybean cyst nematode [SCN] is a serious nematode pest in all U.S. soybean-producing regions. Major damage to soybean by SCN infestation occurs primarily when the crop is grown on medium-and coarse-textured soils. Rotating soybean with nonhost summer crops such as corn, cotton, and grain sorghum successfully reduces SCN populations on these soils [Mourtzinis et al., 2017]. Rotating resistant and susceptible soybean varieties with a nonhost crop produces greater long-term soybean yields and slows the shift toward new SCN races/types in the field.

Root-knot [RKN] and reniform [RN] nematodes are significant pests of soybean grown in portions of the midsouthern U.S. Varieties resistant to RN have not been widely developed. Therefore, rotation of soybean with other crops may be the only way to avoid serious damage from this nematode. Use of resistant varieties is effective for managing RKN. However, rotation to grasses, which are poor hosts for the pest, is also an effective management tool.

Click here and here for more information about how crop rotation can be used to mitigate the adverse effects of nematodes on soybeans.

Rotation Diversification

Nationally, the majority of the corn and soybean acres are rotated with each other. In the Midsouth, soybean is rotated with rice and cotton in addition to corn. Evidence that a diverse rotation that involves more than corn and soybeans grown in rotation will improve both soil health and yield of rotated crops is supported by results reported in the following articles.

More diverse crop rotations improve yield, yield stability, and soil health by Wagner, Jin, and Schmer reports results from a long-term dryland no-till crop rotation and N fertilizer systems study [started in 1972, converted to no-till in 2007-2013] that was conducted in Nebraska. Rotations consisted of continuous corn, continuous soybean, continuous grain sorghum, corn-soybean, grain sorghum-soybean, corn-soybean-grain sorghum-oat/clover, and corn-oat/clover-grain sorghum-soybean. Results showed that diverse crop rotations provided more agronomic and soil benefits than applying N fertilizer alone–i.e. fertilizer N was no substitute for crop rotation. Overall, rotating crops improved soil and crop yields with concurrent lower fertilizer-N costs.

Long-term research reveals advantages of diverse crop rotations from South Dakota Soil Health Coalition reports results from a 4-year crop rotation study that included combinations of corn, soybean, spring wheat, winter wheat, oats, field peas, and sunflower. Increasing rotation diversity resulted in more carbon [C] in the soil, more soil organic matter [SOM], and an overall improvement in soil health.

Increasing crop rotational diversity can enhance cereal yields by Smith et al. uses yield data of small grain cereals and corn from 32 long-term experiments across Europe and North America to show that crop rotational diversity [measured as crop species diversity and functional richness] enhanced grain yield, and the yield benefit increased with time. They showed that this enabled a lower dependence on N fertilizers, which in turn reduced greenhouse gas emissions and N pollution. Their results indicate that increasing crop functional richness rather than species diversity may be a strategy for supporting and stabilizing grain yields in multiple environments. The authors state that "**individual farmers would need to assess this yield benefit against other aspects such as market value of the crops included in the more diverse rotation...**".

Responses of soil organic carbon, aggregate stability, carbon and nitrogen fractions to 15 and 24 years of no-till diversified crop rotations by Maiga et al. reports results from research where rotations that consisted of corn-soybean [2-year rotation] and corn-soybean-winter wheat-oat [4-year rotation] were used. The results from this research that was conducted in South Dakota showed that use of diverse 4-year crop rotations for a long duration enhanced soil organic carbon [SOC], C and N fractions, and soil aggregation compared to those same variables under a 2-year rotation of corn and soybean.

An article titled Diversified no-till crop rotation reduces nitrous oxide emissions, increases soybean yields, and promotes soil carbon accrual by Lehman, Osborne, and Duke reports results from a study where rotations consisted of corn-soybean [2-year rotation] and corn-field peas-winter wheat-soybean [4-year rotation]. Results from the research conducted in South Dakota and presented in this article showed that diverse rotations covering 4 years can decrease nitrous oxide [N_2O] emissions, increase or accelerate SOC gains, accrue soil C earlier and deeper in the soil profile, and increase soybean yields vs. those same variables in a 2-year rotation of corn and soybean.

Complex crop rotations improve organic nitrogen cycling by Breza et al. reports results from a study where rotations consisted of corn-corn, corn-soybean, and corn-soybean-grain sorghum-oat/clover. The results showed that internal N cycling is stimulated by increased complexity of a cropping system. However, N fertilization suppresses some of the benefits of crop rotation diversity. The authors concluded that balancing reduced N fertilizer application with increased rotational cropping complexity has the potential to promote/increase internal N cycling while simultaneously reducing/minimizing environmental N losses.

Long-term rotation diversity and nitrogen effects on soil organic carbon and nitrogen stocks by Schmer et al. reports results from an experiment with monocrops of corn, soybean, and grain sorghum, plus 2-year rotations of corn-soybean and grain sorghum-soybean, and 4-year rotations of corn-soybean-grain sorghum-oat+clover and corn-oat+clover-grain sorghum-soybean that was conducted in Nebraska. Fertilizer N effects on SOC and N soil stocks were primarily confined to the surface soil depth, while crop rotation complexity affected SOC and soil N stocks throughout the 0-60 in. soil profile. The positive effects of rotation on SOC and soil N stocks were only manifested after prolonged rotation complexity.

Long-term evidence shows that crop rotation diversification increases agricultural resilience to adverse growing conditions in North America by Bowles et al. reports results from 11 experiments covering 347 site-years. More diverse rotations resulted in increased corn yields over time under both favorable and unfavorable growing conditions. The authors concluded that crop rotation diversification should be considered as a central component for risk reduction and crop yield resilience when growing commodity crops such as corn under changing climate conditions. They also concluded that a transition to crop rotation diversity is urgent and should be supported over the long term.

An article titled Diversified cropping systems with limited carbon accrual but increased nitrogen supply provides results from an Iowa study that examined SOC stocks and N dynamics in a conventional soybean-corn rotation and in diversified systems that included oats, alfalfa or clover, and the addition of livestock manure to replace N fertilizer. Following are important points from that article.

- Over the 20 years of field experiments and lab studies, there were no differences in profile SOC and N stocks.
- Diversified systems used in this study increased N mineralization rates and decomposition of old corn stalks.
- These findings highlight a trade-off between C storage and N supply in the diversified systems used in this study.
- The authors concluded that their findings demonstrate that the key climate benefits from using diversified cropping systems and livestock manure such as in this study may be a decrease in synthetic N fertilizer use, but not a contribution to increased C sequestration in the soil. Thus, more diverse rotations of crops that are fertilized with livestock manure may be environmentally beneficial because of decreased synthetic N fertilizer use and subsequent reduced nitrous oxide emissions, but increased C sequestration in the soil apparently will not be a benefit.
- Click here and here for summaries of this research compiled by Iowa State Univ. personnel.

All of the results reported in the above-linked articles are from research conducted at non-midsouthern U.S. locations. While they do paint a positive picture of the environmental, yield, and soil benefits that will accrue from increasing crop rotation diversity, there are questions that must be addressed before increased rotation diversity can or will be adopted by midsouthern U.S. producers.

- Is there now or will there soon be a market for the harvested products that will be forthcoming from the alternate crops [those other than soybeans and corn] that will be grown in more diverse rotations? In other words, the ability to market or use products from each crop in a diverse rotation for annual economic gain will affect a producer's decision to increase rotation diversity.
- Will markets that support increased rotation diversity be available or can they be quickly developed for all soybean/corn growing regions of the U.S.?
- Will the income from the alternate crops grown to increase rotational diversity be sufficient to offset the income that may be lost from not growing only soybeans and corn in rotation? If the answer to this question is no, then producers may not have the time, inclination, and/or resources needed to transition to rotation diversification, or they may not be able to wait for development of suitable markets for products from alternate crops grown in more diversified rotations. After all, crop producers must have income every year that is sufficient to support their continued ability to produce marketable crops and pay the bills.

- Midsouth soybean producers are encouraged to explore the use of rotational diversification in their operations. However, they must first determine if cash crops are available that can replace the current summer cash crops–e.g. corn and rice–now used in short-term rotations with soybeans. Research is needed to discern such alternate crops that can be grown and marketed profitably to increase rotational diversification in the region, and to determine and/or develop and/or enhance markets for such crops.

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Table 1. Corn and soybean yields when grown continuously and in rotation with each other in long-term studies, and advantage from rotation.

		Yield of corn following:			Yield of soybean following:		
State	Site-yr no.	Corn	Soybean	Adv.†	Soybean	Corn	Adv.†
		------bu/acre-----		%	-----bu acre-----		%
		Hoeft et al. (2000), Univ. of Ill., Modern Corn & Soybean Prod.					
IL	17	144	170	18	---	---	---
IN	20	166	179	8	45.7	50.9	11
IA	8	128	145	13	31.9	35.8	12
MN	20	122	136	12	36.0	40.8	13
NY	12	127	139	9	---	---	---
WI	9	131	152	16	52.2	55.0	5
			Erickson [2008]				
KY	14	125	136	9	---	---	---
IA	25	131	154	18	38.7	45.3	17
SD	10	96	112	17	---	---	---
MN	11	115	131	14	35.4	40.9	16
MN	10	130	142	9	36.8	40.6	10
MN	9	131	152	16	52.2	55.1	6
WI	15	145	161	11	---	---	---
IN	10	181	190	5	---	---	---
IN	21	168	180	7	---	---	---
			Pedersen and Lauer [2003]				
WI	15	140	168	20	---	---	---
			DeWitt et al. [2002]				
IA	20	128	148	16	36.0	43.0	19
			Varvel and Wilhelm [2003]				
NE	20	117	137	17	---	---	---
NE	10	168	184	10	---	---	---
			Wilhelm and Wortmann [2004]				
NE	16	95	112	18	34.2	38.7	13
			Katsvairo and Cox [2000])				
NY	5	121	142	17	---	---	-
			Mourtzinis et al. [2017]				
WI	30	187	226	21	49.6	62.5	26

†Advantage to rotation.

Table 2. Grain sorghum (GS) and soybean yields when grown continuously and in rotation with each other in rotation studies, and advantage from rotation.

State	Site-yr no.	Yield of GS following:			Yield of soybean following:		
		GS	Soybean	Adv.†	Soybean	GS	Adv.†
		------bu/acre-------		%	-----bu acre-----		%
			Varvel and Wilhelm [2003]				
NE	20	99	104	5	---	---	---
			Roder et al. [1989]				
NE	7	96	101	6	38.2	41.4	8
			Yamoah et al. [1998]				
NE	18	93	105	13	---	---	---
			Kelley [2005]				
KS	5	75	97	29	24.5	30.3	24
			Leikam et al. [2007]				
KS	5	79	88	11	---	---	---
KS	5	103	120	16	---	---	---
			Watson (2003)				
KS	18	76	90	18	31	41	32
			Gordon et al. [2001]				
KS	19	88	101	15	---	34	

†Advantage from rotation.

Table 3. Measured surface cover and soil loss for various tillage systems used for corn and soybean production in Kansas and Nebraska. Source: Heatherly and Elmore 2004.

Residue type/ tillage system	Residue cover	Erosion	Erosion reduction from moldboard plow
	%	ton/acre	%
	Corn residue[a]		
Moldboard plow, disk 2X, plant	7	7.8	--
Chisel plow, disk, plant	35	2.1	74
Disk 2X, plant	21	2.2	72
Rotary-till, plant	27	1.9	76
Till-plant	34	1.1	86
No-till, plant	39	0.7	92
	Soybean residue[b]		
Moldboard plow, disk 2X, plant	2	14.3	--
Disk 2X, plant	5	14.3	0
Chisel plow, disk, plant	7	9.6	32
Disk, plant	9	10.6	26
Field cultivate, plant	18	7.6	46
No-till, plant	27	5.1	64

aAfter tillage and planting on a silt loam soil having a 10% slope and 2 in. water applied in 45 min.

[b]After tillage and planting on a silty clay loam soil having 5% slope and 2 in. water applied in 45 min.

Table 4. Annual soil loss from plots with 5% slope in the brown loam soil region of Mississippi. Source: Heatherly and Elmore 2004.

	Conventional tillage		No-till	
	Soil loss/year		Soil loss/year	
Crop	C Factor[a]	ton/acre	C factor[a]	ton/acre
Sorghum	0.04	4.2	0.005	0.6
Corn (grain)	0.09	7.2	0.005	0.4
Corn (silage)	0.14	11.2	0.003	0.3
Soybean	0.12	21.1	0.006	1.2
Soybean	0.10	19.6	0.008	1.4
Cotton	0.31	31.2	0.053	5.4

[a]Factor used in the Universal Soil Loss Equation to reflect influence of soil management and cropping methods on water erosion. Kind and time of tillage, implements used, time of planting, crops planted, postemergence cultivation, crop sequence, residue cover on the soil surface, and changes in soil organic matter all affect C factor.