Corn residue cover on the soil surface after planting for various tillage and planting systems

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ABSTRACT: Crop residue left on the soil surface after planting is one of the most cost-effective soil erosion control practices, and is a primary component of the majority of conservation plans that have been developed to comply with the conservation provisions of the 1985 Food Security Act. However, from contacts in Extension meetings and demonstrations, it became apparent that farmers frequently misunderstood certain aspects of crop residue management, particularly the effects that tillage and other operations had on residue cover. To help address some of these questions, we measured percent residue cover remaining on the soil surface after planting for 69 tillage and planting system treatments used in corn (Zea mays *L.) residue. Eleven tillage systems, in conjunction with combinations of the use, and timing, of a stalk chopper and/or a knife-type fertilizer applicator, were evaluated. Only 24 of these stalk chopper/knife applicator/tillage system treatment combinations could be classified as conservation tillage when a criterion of 30% or greater residue cover after planting was used. No-till was the only system that consistently provided residue cover levels that were statistically equal to or greater than 40%, the value used in a field study conducted by the Soil and Water Conservation Society to assess conservation plans.*

The erosion-reducing benefits of crop residue left on the soil surface are well recognized (Dickey et al. 1983; Dickey et al. 1984; Dickey et al. 1985; Laflen and Colvin; Laflen et al. 1980; Shelton et al.). Crop residue management is widely promoted by the Natural Resources Conservation Service, Cooperative Extension, and other agencies and organizations. In the United States, more than 65% of the conservation plans that have been developed to comply with the conservation provisions of the 1985 Food Security Act use some form of crop residue management as a primary method of reducing soil erosion (Soil and Water Conservation Society 1989).

From contacts in Extension meetings and demonstrations, it became apparent that residue management and percent residue cover were relatively new concepts to many farmers. They often tended to think in terms of tillage operations for weed control, chemical incorporation, or even residue removal, rather than the objective of managing the residue for soil erosion control. When asked to estimate visually the percent cover of two residue-covered display boards, farmers tended to overestimate the amount of cover by more than a factor of two (Dickey et al. 1989). We also determined that a perception existed among some farmers that because they no longer used a moldboard plow, they had adopted conservation tillage or crop residue management (Dickey et al. 1987). In addition, we found that when evaluating a sequence of tillage and planting operations to determine if the residue cover after planting was likely to be within conservation plan guidelines, producers frequently overlooked the potential residue cover reducing effects of a soil-engaging knife operation, such as for fertilizer application, and/or the effects of stalk chopping. Therefore, we designed an experiment to help address many of these questions and concerns.

Experiment objective

The overall objective of this research was to measure and compare the percent corn (*Zea mays* L.) residue cover remaining on the soil surface following the conduct of selected complete tillage and planting systems that included stalk chopper and/or knife-type applicator operations.

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Table 1. Use and timing of stalk chopper and knife-type applicator treatments

Stalk chopper/knife applicator treatment	Designation	Year(s) used
None/None	N/N	1 and 2
None/Fall	N/F	1 only
None/Spring	N/S	1 and 2
Fall/None	F/N	1 only
Fall/Fall	F/F	1 and 2
Spring/None	S/N	1 only
Spring/Spring	S/S	1 only

Table 2. Tillage and planting systems used

Tillage and planting system description*	Designation
Chisel plow (fall), Disk, Plant†	C(f)DP
Chisel plow, Disk, Plant	CDP
Disk (fall), Disk, Plant	D(f)DP
Disk, Disk, Plant	DDP
Disk, Field cultivate, Plant‡	DFP
Disk, Plant	DP
Field cultivate, Plant	FP
Blade plow, Till-plant	BTP
Blade plow, Plant	BP
Till-plant	TP
No-till plant	NT

*All operations conducted in the spring unless otherwise noted.
†Only used in Year 1.
‡Only used in Year 2.

Approach and methods

The experiment site was at the University of Nebraska Northeast Research and Extension Center in Dixon County, near Concord, Nebraska. Predominant soils were a Baltic silty clay (fine, montmorillonitic (calcareous), mesic Cumulic Haplaquolls) and Colo silty clay loam (fine-silty, mixed, mesic Cumulic Haplaquolls) (Soil Conservation Service), with a 1% slope. Percent residue cover was evaluated during two crop years, 1986-87 (Year 1) and 1987-88 (Year 2).

Each year, a field that had produced soybeans (*Glycine max* L. Merr.) the previous year was cleanly tilled prior to planting corn to be used for the residue study. A short-season (105 day maturity group) corn variety was planted in 76 cm (30 in) spaced rows at approximately 44,200 seeds per hectare (17,900 seeds/ac), a seeding rate typical in northeast Nebraska for non-irrigated corn production. Planting occurred on May 22, 1986, and on June 9, 1987, for Years 1 and 2 of the study, respectively. The corn was not irrigated or cultivated.

During Year 1, corn was harvested on November 3, 1986. Harvest occurred on October 27, 1987, for Year 2. Corn grain yields were 8,100 and 6,210 kg/ha (129 and 99 bu/ac) for Years 1 and 2, respectively. This yield difference was not totally unexpected, since during Year 2 the crop was planted later and, following a frost, was harvested somewhat earlier than in Year 1. However, the crop yield in Year 2 exceeded the statewide average non-irrigated corn for grain yield of 5,810 kg/ha (92 bu/ac) (Nebraska Agricultural Statistics Service 1990). In Year 1, the yield approached the average Nebraska yield of 8,820 kg/ha (140 bu/ac) for irrigated corn production (Nebraska Agricultural Statistics Service 1989).

Each year after harvest, the field was divided into four areas, each 61 m (200 ft) wide by 115 m (375 ft) long, providing four replicated main blocks. Each main block was then divided into sub-blocks for the stalk chopper and/or knife applicator treatments (Figure 1). Seven sub-blocks, each 61 m (200 ft) wide by 16 m (54 ft) long, were established in each main block during Year 1; and three sub-blocks, each 61 m (200 ft) wide by 38 m (125 ft) long, were used in Year 2. Combinations of the use, and timing, of stalk chopper and knife applicator operations were randomly assigned to these sub-blocks. A listing of the stalk chopper/knife applicator treatment combinations used in each of the two years is presented in Table 1.

Each main block was also sub-divided into 6.1 m (20 ft) wide by 115 m (375 ft) long tillage treatment strips, allowing 10 tillage and planting systems to be randomly assigned within each main block. Thus, each main block had 70 and 30 individual stalk chopper/knife applicator/tillage system treatment subplots during Year 1 and Year 2, respectively (Figure 1). Within each year, the experimental design was a split-block arrangement, with the stalk chopper/knife applicator treatments as the rows and the tillage system treatments as the columns. We chose this design to facilitate the use of standard implements, and to allow adequate distance for the implements to reach normal operating speeds.

Nine tillage and planting systems were evaluated during both years of the experiment. Each year, an additional system was also used. The field operations that comprised each individual tillage and planting system are listed in Table 2. All operations were conducted in the spring unless otherwise noted. Implement travel direction was parallel to the old corn rows. The knife applicator shanks were centered between the old rows, and, where possible, the planting operation was centered on the old rows.

For those treatment combinations that specified stalk chopping, this was the first operation following harvest in the fall or the first spring field operation. However, if fall tillage (C(f)DP and D(f)DP tillage systems, Table 2) was conducted, the stalks were not chopped in the spring on those individual tillage system subplots. The knife applicator operation preceded all other tillage and planting operations except for the two treatment combinations that called for fall tillage and a spring knifing operation. In total, 69 stalk chopper/knife applicator/tillage system treatment combinations were evaluated during the two-year experiment. Twenty-seven of these combinations were maintained in both years.

Table 3 presents a description of the in-

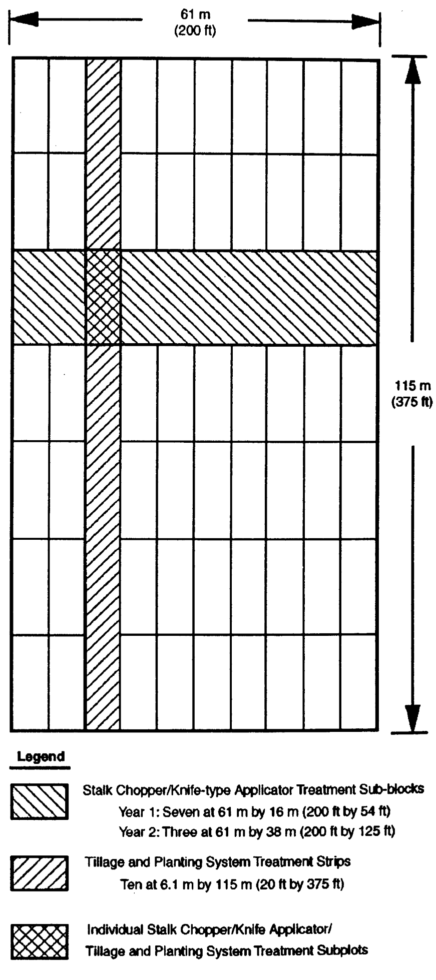

Figure 1. Schematic of main blocks, sub-blocks, tillage treatment strips, and individual stalk chopper/knife applicator/tillage system treatment subplots

dividual implements used, as well as the implement speeds and operating depths. The implements were either owned by the University of Nebraska or loaned by local farmers, a fertilizer/chemical dealership, and an implement dealer. All field operations were conducted in a manner and at times typical for our area. Thus, some time often elapsed between individual operations in a given stalk chopper/knife applicator/tillage and planting system treatment sequence.

It should be noted that, although there were similarities, the till-plant system used in this study differed from a ridge-plant or ridge-till system as described by Dickey et al. (1992) and Jasa et al., in that the planting operation was not done on established ridges. The residue cover data, however, should be representative for the first year of a ridge system, prior to ridge formation.

It should also be noted that the objective of this experiment was to evaluate residue cover remaining after the conduct of the treatment combinations. Thus, no fertilizer was applied during the knifing operation and the planters were operated without seed.

Color photographic slides were used to document residue cover. Photographs were taken along a line across the center of each individual stalk chopper/knife applicator/tillage system subplot, perpendicular to the row direction. An area approximately 1.22 m (4.0 ft) wide by 0.76 m (2.5 ft) long was represented by each slide. Five slides were taken across each subplot, thus covering the entire 6.1 m (20 ft) subplot width.

Photographs to determine percent residue cover after harvest were taken on December 3, 1986, on two selected tillage system treatments in two of the stalk chopper/knife applicator treatments during Year 1; and on November 5, 1987, on four selected tillage system treatments for each of the three stalk chopper/knife applicator treatments in Year 2. A final set of photographs was taken each spring on each of the individual stalk chopper/knife applicator/tillage system treatment subplots immediately after the planting operation.

Percent residue cover was determined from the photographic slides using the photographic grid method described by Laflen et al. (1981). For each slide, 117 grid intersect points were observed to determine if residue covered the point. Any points that were covered by living vegetation were not counted. The number of residue-covered intersections was divided by the total observed intersections to give percent cover. Two observers independently read most of the slides, and these observations were averaged to give a single value for each slide. In the data analysis, the percent cover values from each of the five slides taken across each tillage system subplot were treated as individual subsamples for that treatment subplot.

The data were analyzed using a mixed model. The model included random effects associated with main blocks, subblocks, subplots, and a residual. Random effects were also added to account for the differential effects of tillage and planting systems in the two years and the differential effects of the treatment combinations in the two years. A random effect for year was not included because of the small overall differences between the two years of the study. The model included fixed effects associated with tillage and planting system, and stalk chopper and knife applicator operations, along with their interac-

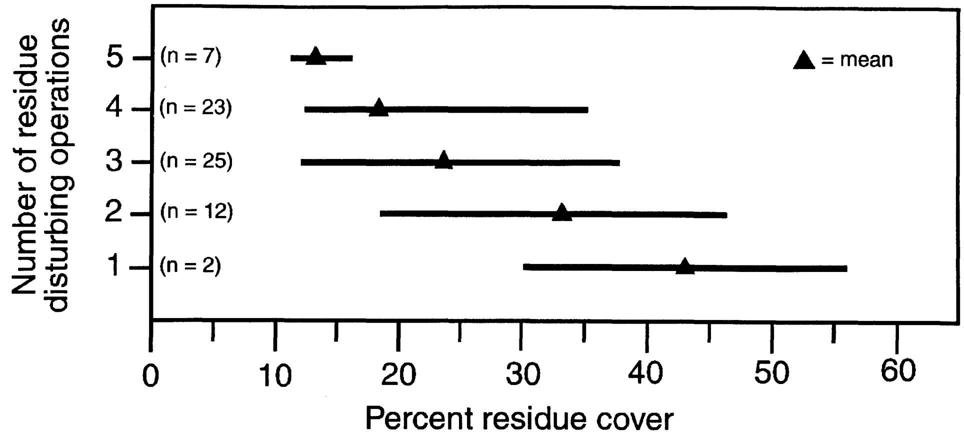

Figure 2. Percent residue cover after planting for stalk chopper/knife applicator/tillage system treatment combinations having 1, 2, 3, 4, and 5 residue-disturbing operations

Table 3. Implement descriptions, field speeds, and operating depths

Implement	Description*	Speed km/h	Speed (mph)	Depth cm	Depth (in)
Stalk chopper	Brady Model 180 Multi Crop Chopper; PTO powered flail-type, 4.6 m (15 ft) width.	5	(3)	-	-
Knife applicator	Blue Jet toolbar anhydrous ammonia applicator; 6.1 m (20 ft) wide, eight 76 cm (30 in) spaced curved coil shanks with replaceable ACRA-PLANT tips approximately 5 cm (2 in) wide, no coulters in front of knife shanks.	6	(4)	20	(8)
Disk	John Deere Model BW-F; 5.9 m (19.5 ft) wide, 50 cm (19.5 in) diameter disk blades with 22 cm (8.5 in) spacing, notched blades on front gangs.	8	(5)	13	(5)
Field cultivator	Sunflower Model 5230-23; 3.0 m (10 ft) operating width, 23 cm (9 in) wide sweeps with 18 cm (7 in) spacing and 5 cm (2 in) wide shanks, spring tooth harrow attached.	8	(5)	10	(4)
Chisel plow	Shop made; 3.0 m (10 ft) wide, Allis Chalmers 5 cm (2 in) wide straight points with 30 cm (12 in) spacing, no coulters in front of shanks.	8	(5)	20	(8)
Blade plow	Flex King Model KM-14; 4.6 m (15 ft) wide, three 1.5 m (5 ft) wide sweeps with 5 cm (2 in) wide shanks and a 56 cm (22 in) diameter coulter in front of each sweep, rotary hoe type harrow attached.	6	(4)	13	(5)
Planter	John Deere Max-Emerge Model 7100; eight 76 cm (30 in) spaced rows, double disk seed furrow openers, 41 cm (16 in) diameter smooth-edge bubble coulters.	6	(4)	4	(1.5)
Till-planter	Buffalo All-Flex Till-Planter Model 4500; four 76 cm (30 in) spaced rows, 25 cm (10 in) wide sweeps, smooth drive coulters, slot shoe seed furrow openers.	6	(4)	5	(2)

*Mention of brand names is for descriptive purposes only. Endorsement or exclusion is not intended or implied.

tions. Analyses were carried out using the GLMM program (Blouin and Saxton).

Results and discussion

Despite the sizeable difference in yield, residue covers after harvest were similar, averaging 77.3% and 78.9% for Year 1 and Year 2, respectively. We did not expect this lack of difference, since residue cover is often assumed to be a direct function of crop yield (Reinsch; Soil and Water Conservation Society 1993; Stott). The 2-year average after-harvest residue cover of less than 80% in this experiment was comparable to the after-harvest cover of 70% given by Fee and the 2-year average cover before spring tillage operations of 77% reported by Erbach. It was, however, substantially less than the 95% after-harvest corn residue cover given by Dickey et. al. (1986), although this value was suggested for irrigated conditions. These results illustrate some of the variability of residue cover that can occur; and that tabulated values of residue cover (Dickey et al. 1986; Reinsch; Soil Conservation Service and the Equipment Manufacturers Institute) and computer programs that predict residue cover (Soil and Water Conservation Society 1993; Stott) should be used with a degree of caution.

Averaged across the 27 stalk chopper/knife applicator/tillage system treatment combinations that were common in both years, there was no significant difference between years in percent residue cover after planting (P=0.85). Therefore, the data presented for these treatments are 2-year averages.

Except for no-till planting, all tillage and planting systems had some stalk chopper/knife applicator treatment combinations that resulted in significantly less than 40% cover (Table 4), the value used in a field study conducted by the Soil and Water Conservation Society to assess conservation plans. Significantly less cover remained when no-till planting was preceded by a stalk chopper and/or knife applicator operation, compared to no-till planting alone (P<0.1).

When a stalk chopper but no knife applicator was included in a complete tillage and planting system, as much as 38% less cover remained following planting (N/N/BTP vs. F/N/BTP treatments, Table 4). Averaged across stalk chopper/knife applicator/tillage system treatments, including a stalk chopper operation resulted in 24% less cover compared to the same treatments where the residue was not chopped (P<0.001). These results were somewhat unexpected, since the stalk chopping operation initially redistributed the residue and percent cover appeared to increase. However, we later observed that the chopped residue was more prone to movement by the wind than unchopped residue. Also, we believe that the smaller pieces of chopped residue may have been more susceptible to deterioration by weathering and burial by subsequent soil-disturbing operations. Evidence that this may have been the case is given by Soil Conservation Service and Equipment Manufacturers Institute. For small grains, information in the SCS/EMI publication indicates that if the straw is cut into small pieces during harvest, then the residue should be considered fragile, and less cover will remain after a subsequent operation than for the same operation conducted in residue that is considered nonfragile. Results from our study indicate that a classification of fragile may also be appropriate if corn residue is chopped.

When a knife applicator but no stalk

Table 4. Percent residue cover remaining on the soil surface after planting

Stalk chopper/ knife applicator/ tillage system treatment	Residue cover (percent)*		
No-till plant			
N/N/NT**	56.0	†	a
S/N/NT	46.5	‡	b
N/S/NT**	45.7	‡	b
N/F/NT	45.5	‡	bc
F/N/NT	42.7	#	bcd
F/F/NT**	37.8	#	bcde
S/S/NT	34.5	#	def
Blade plow, Plant			
N/N/BP**	41.3	#	bcd
S/S/BP	35.3	#	cdef
N/S/BP**	34.8	††	def
N/F/BP	31.5	††	defgh
S/N/BP	28.0	††	efghijkl
F/F/BP**	26.7	††	fghijkl
F/N/BP	26.3	††	fghijklm
Field cultivate, plant			
N/N/FP**	32.7	††	defg
N/S/FP**	31.3	††	efgh
N/F/FP	30.1	††	efghi
S/S/FP	28.8	††	efghijk
S/N/FP	24.7	††	fghijklmn
F/N/FP	22.7	‡‡	hijklmno
F/F/FP**	21.8	‡‡	hijklmno
Till plant			
N/N/TP**	30.1	††	efghi
N/S/TP**	29.7	††	efghi
S/S/TP	28.9	††	efghij
N/F/TP	28.1	††	efghijkl
F/N/TP	19.8	‡‡	ijklmnop
S/N/TP	18.6	‡‡	jklmnop
F/F/TP**	16.3	‡‡	mnop
Disk, Plant			
N/N/DP**	28.2	††	efghijk
N/F/DP	23.0	‡‡	ghijklmno
S/N/DP	22.2	‡‡	hijklmno
N/S/DP**	21.4	‡‡	hijklmno
S/S/DP	19.2	‡‡	ijklmnop
F/N/DP	18.1	‡‡	jklmnop
F/F/DP**	16.9	‡‡	mnop

Stalk chopper/ knife applicator/ tillage system treatment	Residue Cover (percent)*		
Disk, Field cultivate, Plant			
N/S/DFP	21.3	‡‡	hijklmnop
N/N/DFP	20.1	‡‡	hijklmnop
F/F/DFP	13.9	‡‡	nop
Blade plow, Till-plant			
N/S/BTP**	20.3	‡‡	hijklmnop
N/N/BTP**	19.7	‡‡	ijklmnop
S/S/BTP	19.5	‡‡	ijklmnop
NS/N/BTP	17.7	‡‡	klmnop
N/F/BTP	17.1	‡‡	lmnop
F/F/BTP**	13.2	##	op
FN/NBTP	12.1	##	op
Chisel plow, Disk, Plant			
N/S/CDP**	19.5	‡‡	ijklmnop
N/N/CDP**	19.1	‡‡	jklmnop
N/F/CDP	17.9	‡‡	jklmnop
S/N/CDP	16.5	‡‡	mnop
S/S/CDP	16.1	‡‡	mnop
F/N/CDP	14.9	‡‡	mnop
F/F/CDP**	12.9	##	op
Chisel plow (fall), Disk, Plant			
N/N/C(f)DP	19.3	‡‡	ijklmnop
N/F/C(f)DP	18.0	‡‡	jklmnop
F/N/C(f)DP	15.1	‡‡	mnop
F/F/C(f)DP	14.9	‡‡	mnop
N/S/C(f)DP	12.4	##	op
Disk, Disk, Plant			
N/N/DDP**	17.5	‡‡	lmnop
S/N/DDP	16.7	‡‡	mnop
N/S/DDP**	14.3	##	nop
N/F/DDP	13.4	##	op
F/N/DDP	12.3	##	op
S/S/DDP	12.2	##	op
F/F/DDP**	11.5	##	p
Disk(fall), Disk, Plant			
N/F/D(f)DP	17.7	‡‡	jklmnop
N/N/D(f)DP**	17.1	‡‡	mnop
F/N/D(f)DP	16.6	‡‡	mnop
N/S/D(f)DP**	14.2	##	nop
F/F/D(f)DP**	11.2	##	p

*Treatment means followed by the same letter (a, b, c, etc.) are not significantly different by t test (P>0.1).
Treatment means followed by † are significantly less than 70% cover (P<0.1).
Treatment means followed by ‡ are significantly less than 60% cover (P<0.1).
Treatment means followed by # are significantly less than 50% cover (P<0.1).
Treatment means followed by †† are significantly less than 40% cover (P<0.1).
Treatment means followed by ‡‡ are significantly less than 30% cover (P<0.1).
Treatment means followed by ## are significantly less than 20% cover (P<0.1).
**Stalk chopper/knife applicator/tillage system treatment conducted in both years 1 and 2. Percent residue cover values for these treatments are two-year means.

chopper was included in a complete tillage and planting system, as much as 36% less cover remained following planting (N/N/C(f)DP vs. N/S/C(f)DP treatments, Table 4). Using a knife applicator resulted in an average of 13% and 16% less cover when this operation was conducted in the spring and fall, respectively, for treatments where the residue was not chopped, compared to no knifing operation ($P<0.05$). Averaged across stalk chopper/knife applicator/tillage system treatments, including a knife applicator operation resulted in 11% less cover compared to treatments that did not include a knifing operation ($P<0.05$). These results were generally in agreement with the percent residue remaining values given by SCS and EMI for anhydrous ammonia applicators used in non-fragile crop residue.

When a stalk chopper and a knife applicator were both included in a complete tillage system, residue cover remaining after planting was as much as 46% less than not including either of these implements (N/N/TP vs. F/F/TP treatments, Table 4). Averaged across tillage systems, using both a stalk chopper and a knife applicator in the fall resulted in 35% less cover than not including either operation in a complete tillage and planting system ($P<0.05$).

Timing of the stalk chopping and/or knife applicator operation influenced the amount of cover remaining. The trend was for more cover to remain when these operations were conducted in the spring as opposed to the fall (Table 4). Averaged across tillage systems, there was 17% less cover when both the stalk chopping and knife applicator operations were conducted in the fall, compared to conducting these two operations in the spring ($P<0.05$). Averaged across the stalk chopper/knife applicator/tillage system treatments, 14% greater cover resulted for spring stalk chopping and/or knife applicator operations as compared to the conduct of these operations in the fall ($P<0.05$). Apparently, when residue is disturbed in the fall, it becomes more fragile. This change results in more extensive reduction of the cover by subsequent residue-disturbing operations. Also, decomposition by weathering may be accelerated. Some evidence of this is given by the decomposition coefficients used in the Revised Universal Soil Loss Equation software (Soil and Water Conservation Society 1993) which would predict more than 50% greater cover losses for soybean residue (fragile) than for corn residue (non-fragile) when exposed to the weather during the same time period.

Forty-five of the 69 stalk chopper/knife applicator/tillage system treatment combinations resulted in significantly less than 30% cover (Table 4), and thus did not meet the criterion established by the Conservation Technology Information Center (formerly the Conservation Tillage Information Center) to be classified as conservation tillage. Only the NT and BP tillage and planting systems met this criterion for all stalk chopper/knife applicator treatments.

Although field cultivating followed by planting would generally be thought of as a conservation tillage system, when the stalks were chopped in the fall, the FP system had residue cover levels that were significantly less than 30% (F/N/FP and F/F/FP treatments, Table 4). Similarly, if a stalk chopper and/or a knife applicator operation was included, the DP system had residue cover levels that were significantly less than 30%. With the exception of the N/N/DP treatment, any complete tillage and planting system that included a disking operation had a residue cover that was significantly less than 30%. In all cases, tillage and planting systems that had two tillage operations resulted in residue cover levels that were significantly less than 30%.

Eleven of the stalk chopper/knife applicator/tillage system treatment combinations had residue cover levels that were significantly less than 20% (Table 4). Nearly all of these combinations included at least one residue-disturbing operation that was conducted in the fall.

Stalk chopper/knife applicator/tillage system treatments that had only one or two residue-disturbing operations generally resulted in residue covers that were not significantly less than 30% (Table 4). (In this study, stalk chopping, use of a knife applicator, tillage, and planting were considered as residue-disturbing operations.) Residue cover for complete tillage and planting systems that had only two residue-disturbing operations ranged from 18.6% to 46.5%, and averaged 33.2% (Figure 2). The range of residue cover was very similar for complete tillage and planting systems having either three or four residue-disturbing operations, although the average cover was less when four operations were used. Of the 23 stalk chopper/knife applicator/tillage system treatments that had four residue-disturbing operations, 20 produced residue covers that were significantly less than 30%, whereas 15 of the 25 complete systems with only three residue-disturbing operations produced covers that were significantly less than 30% (Table 4). All complete tillage and planting systems with five residue-disturbing operations produced residue cover levels that were significantly less than 30%.

Summary and conclusions

Percent residue cover was measured after planting during two crop years for tillage and planting systems that included combinations of stalk chopping and the use of a knife-type fertilizer applicator in corn residue.

Despite sizeable differences in crop yield for each of the two years, after-harvest residue covers were similar, averaging slightly less than 80%. These results did not follow the assumption that residue cover is a direct function of crop yield. In addition, for the crop yields in this study, after-harvest residue covers were less than those predicted by two computer programs (Soil and Water Conservation Society 1993; Stott) used for crop residue management and/or soil erosion control decisions. Although computer programs or tabulated values of residue cover can be useful for general planning and comparison purposes, these should be used with some caution; measurements taken under actual field conditions are still the most reliable means of determining percent residue cover.

When a stalk chopper and/or a knife applicator was used, residue cover was significantly reduced. Overall, including knife applicator and stalk chopper operations in a complete tillage and planting system resulted in approximately 11% and 24% less residue cover after planting, respectively, compared to not performing these operations. Thus, these residue-disturbing operations must be accounted for when evaluating or estimating residue cover for soil erosion control potential or conservation plan compliance. Immediately after the stalks were chopped, because the residue was cut into smaller pieces and redistributed, percent cover appeared to increase. However, with subsequent residue-disturbing operations, the chopped corn residue behaved more like a fragile residue, and cover was reduced more than for corn residue that was not chopped.

Conducting stalk chopping and/or knife applicator operations in the fall resulted in an average of 12% less residue cover after planting, compared to conducting these operations in the spring. Timing of residue-disturbing operations is a management decision that needs to be considered.

With only one exception, any stalk chopper/knife applicator/tillage system treatment combination that included a disk resulted in residue cover levels after planting that were significantly less than 30%. When two tillage operations were conducted, residue cover was consistently less than 30%. Treatment combinations that had three or more residue-disturbing operations frequently resulted in residue covers that were less than 30%. Therefore, these combinations did not meet the established criterion to be classified as conservation tillage. Only the no-till and blade plow plant systems consistently resulted in at least 30% cover for all combinations of stalk chopper and knife applicator operations. No-till was the only system that consistently resulted in residue covers that were significantly greater than 30%.

Results of this study further support the inappropriateness of equating conservation tillage with a specific tillage implement, tillage and planting system, or even the number of residue-disturbing operations that are conducted. In addition, these results strongly support a Soil and Water Conservation Society task force conclusion that residue levels in many conservation plans may be too optimistic, especially those plans specifying covers in excess of 40% (Soil and Water Conservation Society 1989). Of the 69 stalk chopper/knife applicator/tillage system combinations evaluated, 60 resulted in residue covers that were significantly less than 40%, and only four had residue covers that were not significantly less than 50% under the conditions of this study.

Until newer implements that may leave greater amounts of residue cover become more widely used, tillage and planting system options appear to be limited for those producers with conservation plans specifying large amounts of residue cover, at least under conditions comparable to those of this study. The need for each operation in a tillage and planting system must carefully evaluated. Eliminating residue-disturbing operations is the primary means of increasing the amount of residue cover that remains on the soil surface for erosion control.

REFERENCES CITED

Blouin, D.C., and A.M. Saxton. 1990. General linear mixed models GLMM (version 1.0) user's manual. Louisiana State Univeristy Baton Rouge.

Conservation Technology Information Center (formerly Conservation Tillage Information Center). 1986. 1985 National survey, conservation tillage practices. CTIC. West Lafayette, Indiana (formerly Ft. Wayne, Indiana).

Dickey, E.C., C.R. Fenster, J.M. Laflen, and R.H. Mickelson. 1983. Effects of tillage on soil erosion in a wheat-fallow rotation. Trans. ASAE. 26(3): 814–820.

Dickey, E.C., P.J. Jasa, B.J. Dolesh, L.A. Brown, and S.K. Rockwell. 1987. Conservation tillage: perceived and actual use. J. Soil and Water Cons. 42(6): 431–434.

Dickey, E.C., P.J. Jasa, and D.P. Shelton. 1986. Estimating residue cover. NebGuide G86-793. Cooperative Extension. Uniersit. of Nebraska. Lincoln. 4 p.

Dickey, E.C., D.P. Shelton, P.J. Jasa, and T.R. Peterson. 1984. Tillage, residue and erosion on moderately sloping soils. Trans. ASAE. 27(4): 1093–1099.

Dickey, E.C., D.P. Shelton, P.J. Jasa, and T.R. Peterson. 1985. Soil erosion from tillage systems used in soybean and corn residues. Trans. ASAE. 28(4): 1124–1129, 1140.

Dickey, E.C., J.C. Siemens, P.J. Jasa, V.L. Hofman, and D.P. Shelton. 1992. Tillage system definitions. Conservation Tillage Systems and Management—Crop Residue Management with No-till, Ridge-till, Mulch-till. MWPS-45. Midwest Plan Service. Ames, Iowa. pp. 5–7.

Dickey, E.C., G.A. Wicks, D.E. Eisenhauer, and L.E. Lucas. 1989. Agricultural energy conservation project: impacts of a five-year educational program. Final Report to the Nebraska State Energy Office. Cooperative Extension. Univ. of Nebraska. Lincoln, NE.

Erbach, D.C. 1982. Tillage for continuous corn and corn-soybean rotation. Trans. ASAE. 25(4): 906–911, 918.

Fee, R. 1989. Crop residue—going, going, gone. Successful Farming. 87(12): 24–27.

Jasa, P.J., D.P. Shelton, A.J. Jones, and E.C. Dickey. 1991. Conservation tillage and planting systems. NebGuide G91-1046. Cooperative Extension. University of Nebraska. Lincoln. 4 p.

Laflen, J.M., M. Amemiya, and E.A. Hintz. 1981. Measuring crop residue cover. J. Soil and Water Cons. 36(6): 341–343.

Laflen, J.M,. and T.S. Colvin. 1981. Effect of crop residue on soil loss from continuous row cropping. Trans. ASAE. 24(3): 605–609.

Laflen, J.M., W.C. Moldenhauer, and T.S. Colvin. 1980. Conservation tillage and soil erosion on continuously row-cropped land. Crop Production with Conservation in the 80s. ASAE. St. Joseph, Missouri. p. 121–133.

Nebraska Agricultural Statistics Service. 1989. 1988 Nebraska Agricultural Statistics. Nebraska Department of Agriculture Lincoln, Nebraska.

Nebraska Agricultural Statistics Service. 1990. 1989 Nebraska Agricultural Statistics. Nebraska Department of Agricuture Lincoln, Nebraska.

Reinsch, W.A. 1986. Managing crop residue. Agronomy Technical Note No. 99. USDA-SCS. Lincoln, Nebraska. 4p.

Shelton, D.P., P.J. Jasa, and E.C. Dickey. 1986. Soil erosion from tillage and planting systems used in soybean residue: part I—influences of row spacing. Trans. ASAE. 29(3): 756–760.

Soil Conservation Service (SCS). 1978. Soil Survey of Dixon County, Nebraska. USDA-SCS.

Soil Conservation Service and the Equipment Manufacturers Institute (SCS and EMI). 1992. Estimates of residue cover remaining after single operation of selected tillage machines. USDA-SCS. 2 p.

Soil and Water Conservation Society (SWCS). 1989. Implementing the Conservation Title of the Food Security Act—a field oriented assessment . SWCS. Ankeny, Iowa. 74 p.

Soil and Water Conservation Society (SWCS). 1993. Revised universal soil loss equation user's guide. Version 1.0. SWCS. Ankeny, Iowa. 61 p.

Stott, D.E. 1991. RESMAN—a residue management decision support program. Version 1.31. USDA Agricultural Research Service. Software distributed by Ciba-Geigy. Greensboro, North Carolina.