1994

Tillage And Planting System, Stalk Chopper, And Knife Applicator Influences On Corn Residue Cover

David P. Shelton  
*University of Nebraska-Lincoln, dshelton2@unl.edu*

Stephen D. Kachman  
*University of Nebraska-Lincoln, steve.kachman@unl.edu*

Elbert C. Dickey  
*University of Nebraska at Lincoln, edickey1@unl.edu*

K.T. Fairbanks  
*University of Nebraska-Lincoln*

Paul J. Jasa  
*University of Nebraska at Lincoln, pjasa1@unl.edu*

Follow this and additional works at: [https://digitalcommons.unl.edu/biosysengfacpub](https://digitalcommons.unl.edu/biosysengfacpub)

Part of the [Biological Engineering Commons](https://digitalcommons.unl.edu/biosysengfacpub)


[https://digitalcommons.unl.edu/biosysengfacpub/283](https://digitalcommons.unl.edu/biosysengfacpub/283)

This Article is brought to you for free and open access by the Biological Systems Engineering at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Biological Systems Engineering: Papers and Publications by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.
Tillage and Planting System, Stalk Chopper, and Knife Applicator Influences on Corn Residue Cover

D. P. Shelton, S. D. Kachman, E. C. Dickey, K. T. Fairbanks, P. J. Jasa

ABSTRACT. Percent corn (Zea mays L.) residue cover remaining on the soil surface after planting was measured for 11 tillage and planting systems that included combinations of the use, and timing, of a stalk chopper and/or a knife-type fertilizer applicator. Tillage, as well as use of a stalk chopper or knife applicator, significantly reduced residue cover. Only 27 of the 69 stalk chopper/knife applicator/tillage and planting system treatment combinations that were evaluated could be classified as conservation tillage by having at least 30% residue cover remaining after planting.

Keywords. Residue cover, Tillage, Stalk chopper, Knife applicator.

Tillage and planting systems that leave a protective cover of crop residue on the soil surface have been shown to reduce soil losses, and are among the most cost-effective erosion control practices. Leaving as little as 20% of the soil surface covered with corn (Zea mays L.) or soybean (Glycine max L. Merr.) residue reduced erosion by 50% of that which occurred from a cleanly tilled, residue-free surface (Dickey et al., 1984; 1985). Similarly, a no-till planting system that left a 95% cover of wheat residue reduced erosion by 99.8% of that which occurred from a moldboard plow system (Dickey et al., 1983). Further, these researchers and others (Laflen et al., 1980; Laflen and Colvin, 1981; Shelton et al., 1986) have demonstrated that soil erosion from a rainfall event is inversely related to percent residue cover on the soil surface.

The erosion reducing benefits of crop residue cover are well recognized and promoted by the Soil Conservation Service, Cooperative Extension, and other agencies and organizations. Nationally, over 65% of the Conservation Plans that have been developed to comply with the conservation provisions of the 1985 Food Security Act (Farm Bill) use some form of crop residue management as a primary method of reducing soil erosion (Soil and Water Conservation Society, 1989). In Nebraska, nearly all Conservation Plans specify that a certain percent residue cover, sometimes as great as 85%, must remain on the soil surface following planting (Soil Conservation Service, 1990).

Farmers often do not relate well to the concept of percent residue cover, tending instead to relate more to a specific tillage and planting system or a given sequence of field operations. Evidence of this is given by Dickey et al. (1989) who found that farmers, when visually estimating percent residue cover, tended to overestimate by more than a factor of two. A perception also exists among some farmers that because moldboard plowing is no longer practiced, conservation tillage or crop residue management has been adopted (Dickey et al., 1987). Further, the residue cover reducing effects of a soil-engaging knife, such as for fertilizer application, and/or the effects of stalk chopping, may be overlooked by farmers when estimating the percent residue cover that will remain for a given tillage and planting system.

OBJECTIVE

The overall objective of this research was to measure and compare percent corn residue cover remaining on the soil surface following the conduct of selected tillage and planting systems in conjunction with combinations of the use, and timing, of stalk chopper and knife-type fertilizer applicator operations.

METHODOLOGY

Research was conducted at the University of Nebraska Northeast Research and Extension Center in Dixon County, near Concord, Nebraska. Predominate soils were a Baltic silty clay and Colo silty clay loam (Soil Conservation Service, 1978), with a 1% slope. Percent residue cover was evaluated during two crop years; 1986 through 1987 (Year 1) and 1987 through 1988 (Year 2). Each year, a field which had produced soybeans the previous year was cleanly tilled (disked at least three
times) prior to planting the corn to be used for the residue study. A short-season (105 day maturity group) corn variety, DeKalb 524, was planted in 76-cm (30-in.) spaced rows at approximately 44,200 seeds/ha (17,900 seeds/acre), a seeding rate typical in northeast Nebraska for nonirrigated corn production. Planting occurred on 22 May 1986, and on 9 June 1987 for Years 1 and 2 of the study, respectively, using a John Deere Max-Emerge 7100 eight-row planter. The corn crop was not irrigated or cultivated.

Corn was harvested on 3 November 1986, for Year 1 of the residue cover measurements, using a John Deere 7720 combine equipped with an eight-row corn header and factory-installed straw chopper. Harvest occurred on 27 October 1987, for Year 2, using an Avco New Idea Model 708 UNI SYSTEM equipped with a four-row corn header and a UNI SHELLER.

After harvest each year, an area of the field was divided into four main blocks, each 61-m (200-ft) wide x 115-m (375-ft) long, providing four replicated plot areas. Each main block was divided into sub-blocks for the stalk chopper and/or knife applicator treatments. Seven sub-blocks, each 61-m (200-ft) wide x 16-m (54-ft) long, were established in each main block during Year 1; and three sub-blocks, each 61-m (200-ft) wide x 38-m (125-ft) long, were used in Year 2. Combinations of the use, and timing, of a stalk chopper and/or knife applicator operation 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 divided into 6.1-m (20-ft) wide by 115-m (375-ft) long 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 and planting system treatment subplots during Year 1 and Year 2, respectively (fig. 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 and planting system treatments as the columns.

Nine tillage and planting systems were evaluated during both years of the experiment. Each year, an additional system was also used, for a total of 11 tillage and planting systems that were evaluated in the two-year study. Tillage and planting systems that include a disk, field cultivator, or chisel plow are common in central and eastern Nebraska (Dickey and Rider, 1980). Ridge-till and no-till planting systems are becoming more widely used as they leave more residue on the surface and have reduced fuel and labor costs. Two blade plow systems were also included because the blade plow provides some tillage but should leave comparatively more residue on the soil surface. A moldboard plow system was not used in this study because its use has declined substantially due to the large fuel requirement and nearly complete burial of surface residue cover.

The field operations that comprised each individual tillage and planting system are listed in table 2. Table 3 presents a description of the individual implements used,
as well as the implement speeds and operating depths. 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 Jasa et al. (1991) and Dickey et al. (1992), in that planting was not done on established ridges. The data, however, should be representative for the first year of a ridge system, prior to cultivation for ridge formation.

<table>
<thead>
<tr>
<th>Table 2. Tillage and planting systems used</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Description*</td>
</tr>
<tr>
<td>Chisel plow (fall), Disk, Plant†</td>
</tr>
<tr>
<td>Chisel plow, Disk, Plant</td>
</tr>
<tr>
<td>Disk (fall), Disk, Plant</td>
</tr>
<tr>
<td>Disk, Disk, Plant</td>
</tr>
<tr>
<td>Disk, Field cultivate, Plant‡</td>
</tr>
<tr>
<td>Disk, Plant</td>
</tr>
<tr>
<td>Field cultivate, Plant</td>
</tr>
<tr>
<td>Blade plow, Till-plant</td>
</tr>
<tr>
<td>Blade plow, Plant</td>
</tr>
<tr>
<td>Till-plant</td>
</tr>
<tr>
<td>No-till plant</td>
</tr>
</tbody>
</table>

* Unless otherwise noted, all tillage and planting operations were conducted in the spring.
† Only used in Year 1.
‡ Only used in Year 2.

All field 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, planting was centered on the old rows. The implements used were either owned by the University of Nebraska or loaned by local farmers, a fertilizer/chemical dealership, and an implement dealer.

For those treatment combinations that included a stalk chopper, this was the first field operation following harvest in the fall, or the first spring field operation. However, if fall tillage [C(f)DP and D(f)DP 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 combinations of stalk chopper/knife applicator/tillage and planting system were evaluated. Twenty-seven of these treatments were common to both years.

Color photographic slides were used to document residue cover. Slide film used was Kodak Kodachrome ASA 64. Photographs were taken along a line across the center of each individual stalk chopper/knife applicator/tillage and planting system subplot, perpendicular to the row direction. A tripod-mounted 35-mm camera, equipped with a 28-mm f2.8 wide angle lens was used. Camera height was approximately 1-m (40-in.) above the soil surface. This camera/lens combination allowed an area approximately 1.22-m (4.0-ft) wide x 0.76-m (30-in.) long to be recorded on each photographic slide. Five slides were taken across each subplot, thus covering the entire 6.1-m (20-ft) subplot width. The camera was equipped with a data back which imprinted each slide with a six-digit code that was used for identification.

Whenever the natural lighting conditions were such that even minor shadows could be discerned on a light-colored horizontal surface, a hand-held vinyl fabric shade was used to cast a shadow over the entire area being photographed. This procedure provided essentially uniform lighting conditions, regardless of sunlight and cloud condition.

Photographs to determine percent residue cover after harvest were taken on 3 December 1986, on two selected tillage and planting system treatments in two of the stalk chopper/knife applicator/tillage and planting system subplots, perpendicular to the row direction. A tripod-mounted 35-mm camera, equipped with a 28-mm f2.8 wide angle lens was used. Camera height was approximately 1-m (40-in.) above the soil surface. This camera/lens combination allowed an area approximately 1.22-m (4.0-ft) wide x 0.76-m (30-in.) long to be recorded on each photographic slide. Five slides were taken across each subplot, thus covering the entire 6.1-m (20-ft) subplot width. The camera was equipped with a data back which imprinted each slide with a six-digit code that was used for identification.

Percent residue cover was determined from the photographic slides using the photographic grid method described by Laflen et al. (1981). With this method, the slide image was projected onto a grid comprised of 9 horizontal and 13 vertical lines. For each slide, the 117 intersect points were observed to determine if residue appeared at the point. Any points that showed 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 and planting 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, sub-blocks, 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 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 interactions. Analyses were carried out using the GLMM program (Blouin and Saxton, 1990).

RESULTS AND DISCUSSION

Although not an explicit part of this experiment, mean harvested corn grain yields were 8100 and 6210 kg/ha (129 and 99 bu/acre) for Years 1 and 2, respectively. This yield difference was not unexpected, since during Year 2 the crop was planted later and, following a frost, was harvested somewhat earlier than for Year 1. The lower yield in 1987 (Year 2) also followed the trend for reduced yield of nonirrigated corn production both in northeast Nebraska and for the state, compared to 1986 production. Average 1986 nonirrigated corn yields in northeast Nebraska and for the state were 6090 and 6340 kg/ha (97 and 101 bu/acre), respectively; whereas in 1987, average nonirrigated corn yields were 5710 and 5840 kg/ha (91 and 93 bu/acre), respectively. For comparison, 1986 irrigated corn yields averaged 8540 kg/ha (136 bu/acre) in northeast Nebraska and 8850 (141 bu/acre) for the entire state. Similarly, in 1987, the average yield was 8470 and 9290 kg/ha (135 and 148 bu/acre), respectively, for irrigated corn in northeast Nebraska and in the state (Nebraska Agricultural Statistics Service, 1989, 1990).

Despite the sizeable difference in yield, residue covers after harvest were comparable, averaging 77% and 79% for Year 1 and Year 2, respectively. This lack of difference was not expected, since residue cover is often assumed to be a direct function of crop yield (Reinsch, 1986; Stott, 1991; Soil and Water Conservation Society, 1993). Based on this assumption, Year 1, having the greater yield, should have had a correspondingly greater residue cover. There was some difference in the time interval between harvest and when the photographs to determine after-harvest cover were taken. In Year 1 approximately one month elapsed, whereas in Year 2 only slightly over a week elapsed. However, it is not likely that the additional exposure to the weather was a major factor in the lack of difference in after-harvest covers for the two years. In a companion study of soybean residue at the same site, Burr et al. (1986) reported no significant differences between percent cover measured after harvest and cover measured four months later in the following spring. Based on the decomposition coefficients used for Revised Universal Soil Loss Equation calculations (Soil and Water Conservation Society, 1993), cover losses would be expected to be approximately 56% greater for soybean residue than for corn residue when exposed to the weather for a given period of time.

The two-year average after-harvest residue cover of less than 80% was similar to the after-harvest cover of 70% given by Fee (1989) and the two-year average cover before spring tillage operations of 73% reported by Erbach (1982). 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. After-harvest covers were also substantially less than the residue covers of 96% and 98% predicted using the RESMAN residue management program (Stott, 1991) and the 88% and 94% residue covers predicted using the Revised Universal Soil Loss Equation computer software (Soil and Water Conservation Society, 1993) for corn grain yields of 6210 and 8100 kg/ha (99 and 129 bu/acre), respectively.

There was no significant difference (P = 0.85) between years in percent residue cover after all tillage and planting operations had been completed (table 4). Averaged across tillage and planting system, inclusion of a stalk chopper and/or a knife applicator operation significantly reduced residue cover. When the stalk chopper and knife applicator were both used in the fall, residue cover averaged 36% less than when neither operation was performed (F/F vs. N/N, table 4).

Overall, inclusion of a knife applicator in a tillage and planting system reduced residue cover by 11% (P = 0.042) compared to no knife operation (table 4). Conducting the knife applicator operation in the fall resulted in 16% less residue cover compared to leaving the residue undisturbed (N/F vs. N/N, table 4). These results were somewhat less than the 20% reduction suggested by Dickey et al. (1986) for irrigated corn residue, but were generally in agreement with the percent residue remaining values given by the Soil Conservation Service and Equipment Manufacturers Institute (1992) for anhydrous ammonia applicators used in nonfragile residue.

Chopping the stalks had a significant effect on residue cover after planting, with differences as great as 32% occurring (F/N vs. N/N, table 4). Overall, stalk chopping resulted in 24% less cover compared to treatments where the residue was not chopped (P < 0.001). These results were somewhat unexpected, because chopping initially redistributed the residue and percent cover seemed to increase. However, the chopped residue was later observed to be much more prone to movement by the wind. Also, the smaller pieces of residue resulting from chopping may have been more susceptible to deterioration by weathering and burial by subsequent soil-disturbing operations.

Timing of the stalk chopper and/or knife applicator operation also influenced the amount of cover remaining. The trend was for less cover reduction to occur when these operations were conducted in the spring compared to the fall (table 4). When both the stalk chopper and knife applicator operations were conducted in the fall, there was 17% less cover compared to conducting these two operations in the spring (F/F vs. S/S, table 4). Overall, 12% less cover (P = 0.025) resulted when the stalk chopper and/or knife applicator operations were conducted in the fall, as compared to the conduct of these operations in the spring. Apparently, when residue is disturbed in the fall, decomposition by weathering is accelerated and/or the
Timing of Stalk Chopper

Factor                      Level                      Residue Cover (%)
---------------------------------------------------------------
Year†                      Year 1                        25 a
                        Year 2                        24 a
Knife applicator‡        Not included                  27 a
                        Included                       24 b
Stalk chopper‡           Not included                  29 a
                        Included                       22 b
Timing of Stalk chopper and/or Knife applicator‡
                        Fall                         22 a
                        Spring                        25 b
Stalk chopper/ Knife applicator‡
                        N/N                           31 a
                        N/S                           27 b
                        N/F§                          26 b
                        S/S§                          24 bc
                        S/N§                          24 bc
                        P/N§                          21 cd
                        P/F                           20 d
Tillage and planting system (P < 0.001)
                        No-till plant                  NT 47 a
                        Blade plow, Plant             BP 34 b
                        Field cultivate, Plant       FP 29 bc
                        Till-plant                    TP 25 cd
                        Disk, Plant                   DP 22 cde
                        Disk, Field cultivate, Plant  DFP 18 def
                        Blade plow, Till-plant        BTP 18 ef
                        Chisel plow, Disk, Plant      CDP 17 ef
                        Chisel plow (fall), Disk, Plant§ C(t)DP 16 ef
                        Disk, Disk, Plant             DFP 14 f
                        Disk (fall), Disk, Plant      D(f)DP 14 f

* Values within each factor followed by a different letter are significantly different (P < 0.05).
† Only includes the stalk chopper/knife applicator/tillage and planting system treatments that were common in both years.
‡ Only includes the eight tillage and planting systems that were common among all seven stalk chopper/knife applicator treatments (C(t)DP, D(t)DP, and DFP systems excluded).
§ Year 1 only.
¶ Only includes the three stalk chopper/knife applicator treatments (N/N, N/S, and F/F) that were common among all 11 tillage and planting system treatments.

Eliminate from a tillage and planting system treatment combinations (table 7) met the criterion that was established by the Conservation Districts Program (CDP) and the overall field comparison and decision process (ODP) system. This indicated that the field cultivator eliminated approximately 25% more residue than the disk, and significantly less than the tillage system. Similarly, the field cultivator tended to reduce residue cover less than the disk. This is illustrated by the trend for greater cover for the DFP system as compared to the DDP system. The relative rankings in final cover for the CFP, DFP, and DDP systems (table 4), indicate that the blade plow reduced residue cover less than the field cultivator and significantly less than the disk. Similarly, adopting no-till planting by eliminating one or more tillage operations from a tillage and planting system resulted in differences in final residue cover. The effects of six such substitutions are illustrated in table 5. The most significant increases were changing from a till-planter to a conventional planter, which resulted in residue cover increases averaging 19 percentage points.

The effects of eliminating a single tillage operation are illustrated in table 5. Adopting no-till planting by eliminating one or more tillage operations from a tillage and planting system resulted in a cover increase of 25 percentage points. Similarly, adopting no-till by eliminating the blade plow or field cultivator increased the residue cover by approximately 13 and 18 percentage points, respectively.

The relative rankings in final cover for the CFP, DFP, and DDP systems (table 4), indicate that the blade plow reduced residue cover less than the field cultivator and significantly less than the disk. Similarly, adopting no-till planting by eliminating a single tillage operation increased residue cover by approximately 25 percentage points. Similarly, adopting no-till by eliminating the blade plow or field cultivator increased the residue cover by approximately 13 and 18 percentage points, respectively.

The relative rankings in final cover for the CFP, DFP, and DDP systems (table 4), indicate that the blade plow reduced residue cover less than the field cultivator and significantly less than the disk. Similarly, adopting no-till planting by eliminating a single tillage operation increased residue cover by approximately 25 percentage points. Similarly, adopting no-till by eliminating the blade plow or field cultivator increased the residue cover by approximately 13 and 18 percentage points, respectively.

The relative rankings in final cover for the CFP, DFP, and DDP systems (table 4), indicate that the blade plow reduced residue cover less than the field cultivator and significantly less than the disk. Similarly, adopting no-till planting by eliminating a single tillage operation increased residue cover by approximately 25 percentage points. Similarly, adopting no-till by eliminating the blade plow or field cultivator increased the residue cover by approximately 13 and 18 percentage points, respectively.

Substituting one implement for another in a tillage and planting system also resulted in differences in final residue cover. The effects of six such substitutions are illustrated in table 5. The most significant increases were changing from a till-planter to a conventional planter, which resulted in residue cover increases averaging 19 percentage points.

A comparison of the aggressiveness of certain tillage implements in reducing residue cover can also be made. The relative rankings in final cover for the BT, DFP, and DDP systems (table 4), indicate that the blade plow reduced residue cover less than the field cultivator and significantly less than the disk. Similarly, the field cultivator tended to be less aggressive than the disk. This is further illustrated by the trend for greater cover for the DFP system as compared to the DDP system. The primary actions of a disk are downward cutting, inversion, and horizontal soil displacement which tends to incorporate residue below the soil surface. By contrast, the sweeps on either a blade plow or field cultivator produce a horizontal soil shearing or cutting force as well as vertical lifting as soil and residue pass over the sweep blades. The field cultivator sweeps were wider than the shank spacing, thus part of the soil was disturbed by two sweeps, in contrast to the blade plow where sweep width was essentially equal to the horizontal spacing. Further, for a given width of implement, the field cultivator had approximately four times more shank width than the blade plow, which served to disturb the soil comparably to more residue on the surface.

Only 27 of the 69 stalk chopper/knife applicator/tillage and planting system treatment combinations (table 7) met the criterion that was established by the Conservation Distinctive Program (CDP) and the overall field comparison and decision process (ODP) system. This indicated that the field cultivator eliminated approximately 25% more residue than the disk, and significantly less than the disk. Similarly, adopting no-till planting by eliminating a single tillage operation increased residue cover by approximately 25 percentage points. Similarly, adopting no-till by eliminating the blade plow or field cultivator increased the residue cover by approximately 13 and 18 percentage points, respectively.

Table 5. Effects of eliminating a tillage operation from a tillage and planting system

<table>
<thead>
<tr>
<th>Eliminate</th>
<th>From System</th>
<th>To Give System</th>
<th>Increase in Residue Cover (Percentage Points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disk</td>
<td>DFP</td>
<td>NT</td>
<td>25 *</td>
</tr>
<tr>
<td>Disk</td>
<td>DFP</td>
<td>FP</td>
<td>11 *</td>
</tr>
<tr>
<td>Disk</td>
<td>DFP</td>
<td>DP</td>
<td>8 *</td>
</tr>
<tr>
<td>Chisel plow</td>
<td>CDP</td>
<td>DP</td>
<td>5 *</td>
</tr>
<tr>
<td>Field cultivator</td>
<td>FP</td>
<td>NT</td>
<td>18 *</td>
</tr>
<tr>
<td>Field cultivator</td>
<td>DFP</td>
<td>DP</td>
<td>4 *</td>
</tr>
<tr>
<td>Blade plow</td>
<td>BP</td>
<td>NT</td>
<td>13 *</td>
</tr>
<tr>
<td>Blade plow</td>
<td>BTP</td>
<td>TP</td>
<td>7 *</td>
</tr>
</tbody>
</table>

* P < 0.05

*The effects of eliminating a single tillage operation are illustrated in table 5. Adopting no-till planting by eliminating one or more tillage operations from a tillage and planting system resulted in a cover increase of 25 percentage points. Similarly, adopting no-till by eliminating the blade plow or field cultivator increased the residue cover by approximately 13 and 18 percentage points, respectively.

Substituting one implement for another in a tillage and planting system also resulted in differences in final residue cover. The effects of six such substitutions are illustrated in table 5. The most significant increases were changing from a till-planter to a conventional planter, which resulted in residue cover increases averaging 19 percentage points.

A comparison of the aggressiveness of certain tillage implements in reducing residue cover can also be made. The relative rankings in final cover for the BP, FP, and DFP systems (table 4), indicate that the blade plow reduced residue cover less than the field cultivator and significantly less than the disk. Similarly, the field cultivator tended to be less aggressive than the disk. This is further illustrated by the trend for greater cover for the DFP system as compared to the DDP system. The primary actions of a disk are downward cutting, inversion, and horizontal soil displacement which tends to incorporate residue below the soil surface. By contrast, the sweeps on either a blade plow or field cultivator produce a horizontal soil shearing or cutting force as well as vertical lifting as soil and residue pass over the sweep blades. The field cultivator sweeps were wider than the shank spacing, thus part of the soil was disturbed by two sweeps, in contrast to the blade plow where sweep width was essentially equal to the horizontal spacing. Further, for a given width of implement, the field cultivator had approximately four times more shank width than the blade plow, which served to disturb the soil comparably more residue on the surface.

Only 27 of the 69 stalk chopper/knife applicator/tillage and planting system treatment combinations (table 7) met the criterion that was established by the Conservation Distinctive Program (CDP) and the overall field comparison and decision process (ODP) system. This indicated that the field cultivator eliminated approximately 25% more residue than the disk, and significantly less than the disk. Similarly, adopting no-till planting by eliminating a single tillage operation increased residue cover by approximately 25 percentage points. Similarly, adopting no-till by eliminating the blade plow or field cultivator increased the residue cover by approximately 13 and 18 percentage points, respectively.
Tillage Information Center (1986) of a 30% or greater cover following planting to be classified as conservation tillage. Only the NT and BP systems met this criterion for all seven stalk chopper/knife applicator treatments. Although field cultivating followed by planting would generally be thought of as a conservation tillage system, when both the stalk chopper and knife applicator were used in the fall, the FP system had residue cover that was significantly less than 30%. Similarly, the DP and TP systems had residue cover levels that were sometimes significantly less than 30%, depending on the specific stalk chopper/knife applicator treatment. In all cases, tillage and planting systems that had two tillage operations resulted in residue cover levels that were significantly less than 30%.

Five stalk chopper/knife applicator/tillage and planting system treatment combinations had residue cover levels that were significantly less than 20% (Table 7). All of these combinations included at least one residue-disturbing operation that was conducted in the fall.

Results of this study further support the inappropriateness of equating conservation tillage with a specific tillage implement or tillage and planting system, rather than with a specific level of residue cover. In addition, these results strongly support a conclusion of a Soil and Water Conservation Society task force that residue levels in many Conservation Plans may be too optimistic, especially those plans that call for covers in excess of 40% (Soil and Water Conservation Society, 1989). Only no-till planting consistently left residue cover levels that were significantly greater than or equal to 40% under the conditions in this study (Table 7).

Until newer implements that may leave greater amounts of residue cover become more widely used, tillage and planting system options may be limited for producers with Conservation Plans specifying large amounts of residue cover to meet conservation compliance provisions of the 1985 Food Security Act and the 1990 Food, Agriculture, Conservation, and Trade Act.

### SUMMARY AND CONCLUSIONS

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

Despite sizeable differences in crop yield for each of the two years, after-harvest residue covers were comparable, averaging slightly less than 80%.

When a stalk chopper and/or a knife applicator was used, residue cover after planting was significantly reduced, compared to not performing either of these operations. Overall, the knife applicator and stalk chopper operations resulted in approximately 11 and 24% less residue cover, 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.

Timing of the stalk chopper and/or knife applicator operations also influenced residue cover remaining after planting. Conducting these operations in the spring, rather than in the fall, resulted in an average of 14% greater cover.

Significantly more residue could generally be left on the soil surface by eliminating one or more tillage operations from a tillage and planting system. Eliminating both primary and secondary tillage resulted in an increase in residue cover of 31 percentage points, from an average of 16% cover to 47% cover. Eliminating the disking operation from the disk, plant system resulted in a cover increase of 24 percentage points, from 22% cover to 46% cover. Similarly, substituting the blade plow for the disk left significantly more residue cover.

Almost without exception, any stalk chopper/knife applicator/tillage and planting system treatment combination that had more than three residue-disturbing operations resulted in residue covers that were significantly less than 30%. Similarly, if both primary and secondary tillage operations were conducted, residue cover after planting was less than 30%. Therefore, these combinations

---

**Table 7. Percent residue cover remaining on the soil surface after planting for the individual stalk chopper/knife applicator/tillage and planting system treatments**

<table>
<thead>
<tr>
<th>Stalk Chopper/ Knife Applicator/ Tillage System</th>
<th>Residue Cover (%)</th>
<th>Stalk Chopper/ Knife Applicator/ Tillage System</th>
<th>Residue Cover (%)</th>
<th>Stalk Chopper/ Knife Applicator/ Tillage System</th>
<th>Residue Cover (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/N/NT† 56a</td>
<td>S/N/FP 25b</td>
<td>N/N/FP 17c</td>
<td>S/N/FP 17c</td>
<td>S/N/FP 17c</td>
<td>S/N/FP 17c</td>
</tr>
<tr>
<td>S/N/NT 47a</td>
<td>N/F/DP 23b</td>
<td>F/F/DP 16d</td>
<td>N/F/DP 16d</td>
<td>N/F/DP 16d</td>
<td>N/F/DP 16d</td>
</tr>
<tr>
<td>N/S/NT† 46a</td>
<td>F/N/FP 23b</td>
<td>F/F/DP 16d</td>
<td>F/F/DP 16d</td>
<td>F/F/DP 16d</td>
<td>F/F/DP 16d</td>
</tr>
<tr>
<td>N/F/NT 46a</td>
<td>S/N/DP 22b</td>
<td>F/F/DFP 16d</td>
<td>F/F/DFP 16d</td>
<td>F/F/DFP 16d</td>
<td>F/F/DFP 16d</td>
</tr>
<tr>
<td>N/F/BP† 41a</td>
<td>F/F/DFP 22c</td>
<td>F/F/DFP 16d</td>
<td>F/F/DFP 16d</td>
<td>F/F/DFP 16d</td>
<td>F/F/DFP 16d</td>
</tr>
<tr>
<td>F/F/NT† 38a</td>
<td>N/S/DPP 21c</td>
<td>F/F/DFP 16d</td>
<td>F/F/DFP 16d</td>
<td>F/F/DFP 16d</td>
<td>F/F/DFP 16d</td>
</tr>
<tr>
<td>N/S/FP† 35a</td>
<td>S/N/SBP 20c</td>
<td>S/N/SBP 16d</td>
<td>S/N/SBP 16d</td>
<td>S/N/SBP 16d</td>
<td>S/N/SBP 16d</td>
</tr>
<tr>
<td>S/N/BP† 35a</td>
<td>N/S/DPP 20c</td>
<td>N/S/DPP 16d</td>
<td>N/S/DPP 16d</td>
<td>N/S/DPP 16d</td>
<td>N/S/DPP 16d</td>
</tr>
<tr>
<td>S/N/NT 34a</td>
<td>F/N/FP 20c</td>
<td>F/N/FP 15e</td>
<td>F/N/FP 15e</td>
<td>F/N/FP 15e</td>
<td>F/N/FP 15e</td>
</tr>
<tr>
<td>N/N/BP† 33b</td>
<td>N/N/FP 20c</td>
<td>N/N/FP 15e</td>
<td>N/N/FP 15e</td>
<td>N/N/FP 15e</td>
<td>N/N/FP 15e</td>
</tr>
<tr>
<td>N/F/BP 32b</td>
<td>S/B/FP 19c</td>
<td>S/B/FP 15e</td>
<td>S/B/FP 15e</td>
<td>S/B/FP 15e</td>
<td>S/B/FP 15e</td>
</tr>
<tr>
<td>N/S/FP† 31b</td>
<td>N/S/CDFP 19c</td>
<td>N/S/CDFP 14f</td>
<td>N/S/CDFP 14f</td>
<td>N/S/CDFP 14f</td>
<td>N/S/CDFP 14f</td>
</tr>
<tr>
<td>N/F/BP 30b</td>
<td>N/N/FDFP 19c</td>
<td>N/N/FDFP 14f</td>
<td>N/N/FDFP 14f</td>
<td>N/N/FDFP 14f</td>
<td>N/N/FDFP 14f</td>
</tr>
<tr>
<td>N/F/NT 30a</td>
<td>N/F/DFP 19c</td>
<td>N/F/DFP 14f</td>
<td>N/F/DFP 14f</td>
<td>N/F/DFP 14f</td>
<td>N/F/DFP 14f</td>
</tr>
<tr>
<td>N/N/FPP† 30b</td>
<td>N/N/DFP 19c</td>
<td>N/N/DFP 14f</td>
<td>N/N/DFP 14f</td>
<td>N/N/DFP 14f</td>
<td>N/N/DFP 14f</td>
</tr>
<tr>
<td>S/S/FP 29b</td>
<td>N/S/FDFP 19c</td>
<td>N/S/FDFP 13g</td>
<td>N/S/FDFP 13g</td>
<td>N/S/FDFP 13g</td>
<td>N/S/FDFP 13g</td>
</tr>
<tr>
<td>S/N/NT 28b</td>
<td>N/N/FDFP 19c</td>
<td>N/N/FDFP 13g</td>
<td>N/N/FDFP 13g</td>
<td>N/N/FDFP 13g</td>
<td>N/N/FDFP 13g</td>
</tr>
<tr>
<td>N/N/FP† 27b</td>
<td>N/S/DFP 18b</td>
<td>N/S/DFP 13g</td>
<td>N/S/DFP 13g</td>
<td>N/S/DFP 13g</td>
<td>N/S/DFP 13g</td>
</tr>
<tr>
<td>F/F/BP† 27b</td>
<td>N/F/DFP 18b</td>
<td>N/F/DFP 13g</td>
<td>N/F/DFP 13g</td>
<td>N/F/DFP 13g</td>
<td>N/F/DFP 13g</td>
</tr>
<tr>
<td>N/F/BP 26b</td>
<td>S/N/BP 18c</td>
<td>S/N/BP 11d</td>
<td>S/N/BP 11d</td>
<td>S/N/BP 11d</td>
<td>S/N/BP 11d</td>
</tr>
</tbody>
</table>

* P < 0.05

15 percentage points equals the largest minimum difference in percent residue cover for significant differences between individual treatments (P < 0.05).

a Value statistically equal to or greater than 40% cover (P < 0.05).

b Value statistically equal to or greater than 30% cover (P < 0.05).

c Value significantly less than 30% cover (P < 0.05).

d Value significantly less than 20% cover (P < 0.05).

† Stalk chopper/knife applicator/tillage and planting system treatment conducted in both years 1 and 2.

---

APPLIED ENGINEERING IN AGRICULTURE
could not be classified as conservation tillage. Only the no-till planting and blade plow, plant systems consistently met the 30% criterion for all combinations of stalk chopper and knife applicator operations. No-till was the only system which consistently resulted in residue covers equal to or greater than 40%.

REFERENCES


———. 1990. Personal communications with SCS field personnel.


