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The Influence of Implement Type and Tillage Depth on Residue Burial

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Abstract

The ability of tillage implements to maintain surface residue coverage are largely dependent upon the implement's main active component. Two categories of tillage implements were compared to determine their ability to maintain surface residue coverage when operating at different tillage depths. Chisel-type implements were found to bury substantially less crop residue than disc-type implements. Disc-type implements were also found to be highly dependent upon tillage depth. A more thorough understanding of the ability of tillage implements to maintain adequate amounts of surface residue coverage should enable producers to select appropriate implements to maximize production while minimizing erosion.
Keywords. Tillage, Implement, Residue, Chisel, Disc.

Introduction

Many tractor operators have learned from experience that increasing their tillage depth results in reduced amounts of residue present on the soil surface. For many years, this mattered little since residue was largely considered 'trash.' However, since researchers began to recognize the significance of crop residue and the erosion control that can be associated with residue's presence, more credence has been attributed to maintaining adequate surface coverage.

A vast number of implements have been constructed for tilling the soil and many leave significant residue coverage. However, many operational parameters can affect the effectiveness of tillage tools to maintain surface residue. Woodruff and Chepil (1958) first reported that an offset disc would leave varying amounts of residue on the soil surface based on its depth of operation, speed, and angle of offset. A full discussion of all implements and the effect of these operational parameters for each under varying soil and climatic conditions is beyond the scope of any intended research. However, some assumptions about similarities in tillage action can be made about the varying types of implements and their effect on residue and soil.

Two large groups of tillage implements can generally be constructed: (1) those that till the entire area of the field and (2) those that only till within the row zone. The first tillage grouping consists of systems that uniformly treat the entire soil surface without considering the location of row or wheel tracks. This is largely the system that historically has been used in conventional tillage systems where the entire soil surface was plowed, chiseled, disced and prepared so that planters could place the seed anywhere in the field and it would have the same chance of germination and productivity. Four broad categories of various tillage tools can be identified for all tillage tools that have been developed for soil preparation:

Chisel-type implements - implements consisting primarily of shanks that are dragged through the soil and have no active, moving components.

Disc-type implements - implements consisting primarily of rotating discs that cut and move the soil.

Rotary-tillage-type implements - implements consisting primarily of a powered, rotating, shaft with attached tillage blades.

Inversion-type implements - implements consisting primarily of shares/discs that invert the soil down to the depth of tillage, mainly consisting of moldboard plows.

It is widely recognized that these implement types vary broadly and overlap significantly. This overlap results from the fact that many tillage tools have components from several of the above categories. Therefore, this categorization will allow broad assumptions to be made about the effect of operational parameters on their performance relating to residue burial.

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One of the operational parameters that tends to have the largest effect on residue burial by tillage implements is depth of tillage. Other than the previous reference to Woodruff and Chepil's research (1958), few researchers have addressed this operational variance. Fewer still have reported complete data about their tillage operations in residue, including depth of tillage, residue coverage, and amount of residue originally present. Johnson (1987 and 1988) found that when tillage depth was reduced from 25 to 10 cm with a chisel plow, 20% less surface residue was buried. Hanna et al. (1992) found that reducing tillage depth from 10.4 to 5.1 cm with a disc harrow buried 4% less residue. Further research is proposed to study the implement types and issues raised in this paper.

Methods and Materials

The study was conducted near Shorter, AL at the E.V. Smith Research Center on a Norfolk loamy sandy soil. Grain sorghum was sown in 1998 with plots being harvested for grain yield. Glyphosate was used to control weeds during winter months. Two commercial implements were evaluated: (1) John Deere[2] 210 Disc and (2) DMI Tiger-Mate II High Residue Field Cultivator. One of these implements could be classified as a disc-type implement and the other a chisel-type implement. Two depths of tillage were conducted in the fall and spring of the year, 7.6 cm and 15.2 cm. A no-till plot was also used for comparison purposes. The speed of operation was maintained constant at 5 km/hr. All operations were conducted with a JD 8300 tractor (8402 kg, 149 kW).

Line-transect measurements of residue on the soil surface were taken to determine percent residue cover for all tillage treatments. Measurements of residue mass were also obtained. All residue remaining on the soil surface was split into standing and flat categories. Four 0.25m x 0.25m plots within each treatment were harvested and the residue washed, dried, bagged, and weighed.

Results and Discussion

Only a small portion of the results will be presented due to space limitations. In the fall of the year, the no-till plot was found to have 74% residue coverage according to the line-transect method (Table 1). This was significantly greater than either of the four tillage treatments with shallow chiseling having 54% residue coverage, shallow discing having 42% residue coverage, and deep discing having 22% residue coverage. In the following spring of the year, the no-till residue coverage had decreased to 34% which was still statistically the largest amount exceeding all other treatments.

Table 1. Percent residue cover remaining after tillage treatments were applied in Fall of 1998 and Spring of 1999

	Fall Sampling		Spring Sampling	
Treatments	Percent Residue Cover	Percent Cover Compared to No-till	Percent Residue Cover	Percent Cover Compared to No-till
No-Tillage	74 a	-----	34 a	-----
Fall-Chisel-Shallow	54 b	74 a	25 b	73 a
Fall-Chisel-Deep	39 c	54 b	18 cd	56 bc
Spring-Chisel-Shallow			22 bc	64 ab
Spring-Chisel-Deep			22 bc	64 ab
Fall-Disc-Shallow	42 c	59 b	22 bc	67 ab
Fall-Disc-Deep	22 d	30 c	14 de	38 de
Spring-Disc-Shallow			16 d	47 cd
Spring-Disc-Deep			10 e	31 e
LSD $_{(0.10)}$	*10*	*11*	*5*	*15*

No differences were found in the mass of residue left flat on the soil surface in the fall after tillage (Table 2). However, statistically significant differences were found in the mass of residue left standing. The largest amount of standing residue was in the no-till plot (2030 kg/ha) with similar values being found in the shallow chiseling plot (1915 kg/ha). The total amount of residue left on the soil surface was greatest in the no-till plot

[2] The use of companies, tradenames, or company names does not imply endorsement by USDA-ARS.

Table 2. Mass of residue remaining after tillage treatments were applied in Fall of 1998 and Spring of 1999

	Fall Sampling				Spring Sampling			
	---------- kg ha^{-1} ----------			- % -	---------- kg ha^{-1} ----------			- % -
Treatments	Flat	Standing	Total	Mass Remaining	Flat	Standing	Total	Mass Remaining
No-Tillage	1095	2030 a	3125 a	-----	1890 a	750 a	2640 a	-----
Fall-Chisel-Shallow	970	1915 ab	2885 a	95 a	1390 b	120 c	1510 b	60 a
Fall-Chisel-Deep	800	1305 c	2105 b	70 b	1145 bc	535 ab	1680 b	63 a
Spring-Chisel-Shallow					1120 bc	510 ab	1630 b	62 a
Spring-Chisel-Deep					1090 bc	700 a	1790 b	70 a
Fall-Disc-Shallow	960	1507 bc	2470 ab	85 ab	1325 b	270 bc	1595 b	61 a
Fall-Disc-Deep	635	665 d	1300 c	44 c	675 cd	35 c	710 c	28 b
Spring-Disc-Shallow					1200 b	105 c	1305 b	53 a
Spring-Disc-Deep					400 d	40 c	440 c	16 b
LSD $_{(0.10)}$	*ns*	*404*	*738*	*17*	*485*	*296*	*521*	*21*

(3125 kg/ha) and the shallow chiseling plot (2885 kg/ha) with slightly less being found in the shallow discing plot (2470 kg/ha).

Measurements of percent soil surface coverage taken after tillage treatments were applied the following spring showed great reductions even in the no-till plots which still maintained the highest percentage of residue cover (34%) and total amount of mass residue remaining on the soil surface (2640 kg/ha). This significant decrease in residue coverage from 74% in the fall to 34% in the spring is probably due to the degradation of the grain sorghum leaves which left only stalks for soil protection. One interesting natural transition that occurred due to the wintering process was the marked increase in flat residue from 1095 kg/ha in fall to 1890 kg/ha in spring (Table 2). This increase came at the expense of standing residue which declined from 2030 kg/ha to 750 kg/ha.

Chiseling operations conducted either in spring or fall showed similar values of residue cover (Table 1) and total residue mass remaining on the soil surface (Table 2) the following spring. Virtually no difference in either measurement was found due to depth of tillage or timing of tillage. However, large differences were seen due to depth of tillage for the discing operation, particularly for residue mass left on the soil surface after deep discing in fall (710 kg/ha) and spring (440 kg/ha) as compared to shallow discing in fall (1595 kg/ha) and spring (1305 kg/ha).

Data plotted from published sources that reported tillage depths (Hanna et al.,1995; Johnson, 1987; McCool et al., 1989; Wagner and Nelson, 1995) are shown in Figure 1. A linear regression was fitted to the reported data for the 'chisel-type' and 'disc-type' implements. Depth of tillage was found to have a more pronounced effect on 'disc-type implements' over 'chisel-type implements' with a steeper line being projected. This result was verified by the data from the current study that was presented in Tables 1 and 2 and plotted in Figure 1 which showed small differences in residue mass or cover remaining after chiseling due to differences in tillage depth, but large differences resulting from differences in depth of discing.

Summary

Broad classifications of tillage tools were created to assist in making general determinations about their varying effectiveness in reducing residue burial. Two commonly used implement types (chisel and disc) were compared to determine their ability to retain surface residue as a function of tillage depth. Published data and data resulting from this experiment showed that disc-type implements buried an increased amount of crop residue as depth of tillage increased. Chisel-type implements, however, buried lesser amounts of crop residue and were not as dependent upon tillage depth.

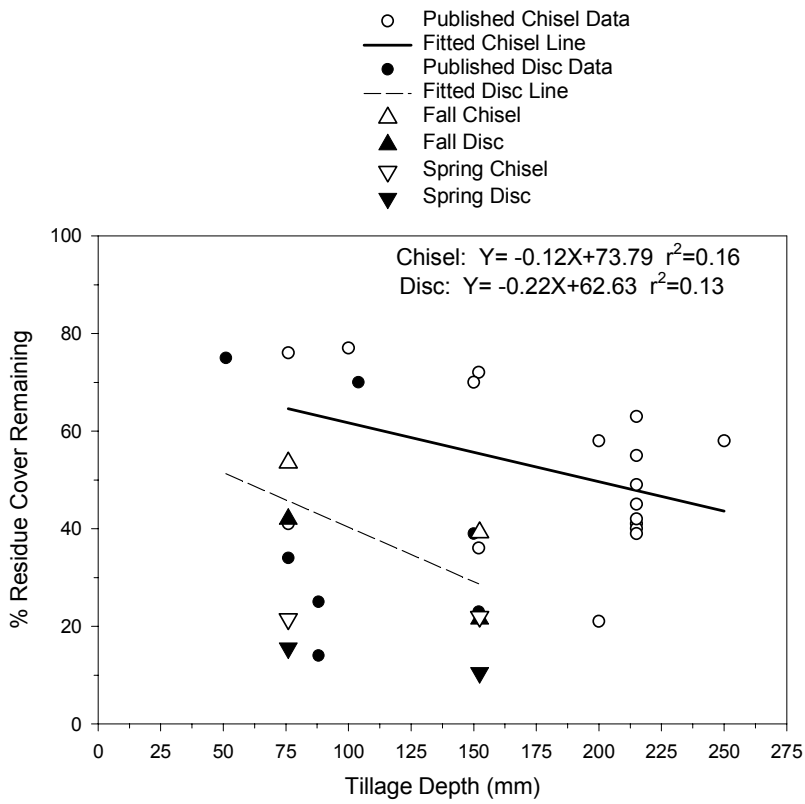

Figure 1. Selected published data of percent residue cover remaining after tillage for two classes of tillage implements shown with current research results.

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