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# Crop Residue Cover and Manure Incorporation — Part I: Reduction of Cover

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## Summary and Implications

*Manure incorporation represents a compromise between best management practices for soil erosion control and manure management. Manure should be incorporated into the soil for odor control, increased availability of nutrients and control of potential manure runoff. However, soil and crop residue disturbance should be minimized for soil erosion control. This field study was conducted to: 1) determine the influence that commercially available soil-engaging components used to simultaneously apply and incorporate manure have on the reduction of crop residue cover [Part I - this article]; and 2) determine and evaluate some of the factors that may influence the amount of residue cover reduction that occurs with these components [Part II - companion article]. Seven different configurations of manure injectors/applicators were operated in residue from irrigated and non-irrigated corn, soybeans and oats in the fall and/or spring of three different crop years. Averaged across crop, year and season, residue cover reduction was significantly less for coulter-type applicators than for disk-type applicators (P<0.001), disk-type applicators reduced residue cover significantly less than chisel and sweep injectors (P<0.001), and chisel and sweep injectors reduced residue cover similar to a tandem disk (P=0.398). Ranges of values to estimate the percentage of the initial amount of corn (non-fragile) residue cover that will remain following the use of manure application/incorporation components are: chisel and sweep injectors, 30 to 65 percent; disk-type applicators, 40 to 65 percent; and coulter-type applicators, 80 to 95 percent. Similarly, for soybean or oat (fragile) residue, estimates of the initial residue cover remaining are: chisel and sweep injectors, 5 to 15 percent; disk-type applicators, 15 to 40 percent; and coulter-type applicators, 65 to 80 percent. These values can be used for estimation or planning purposes when site-specific data are not available. Results of this research indicate that certain configurations of manure application/incorporation equipment may leave adequate residue cover for acceptable soil erosion control, particularly in non-fragile residue. However, the equipment must be selected, adjusted and operated with the dual objectives of residue and manure management, rather than used simply as a means of manure disposal.*

## Background and Introduction

Effective management of manure has become an increased focus of many swine producers due to environmental concerns such as water quality and odor control, and to better capitalize on the fertilizer value of the manure. A best management practice (BMP) is to incorporate manure into the soil to maximize nutrient availability, especially nitrogen, and to minimize odors and potential degradation of surface water quality through manure runoff.

Maintaining crop residue on the soil surface is one of the most cost-effective soil erosion control practices. Erosion can be reduced by 50 percent of that occurring from a cleanly tilled field when just 20 percent of the soil surface is cov-

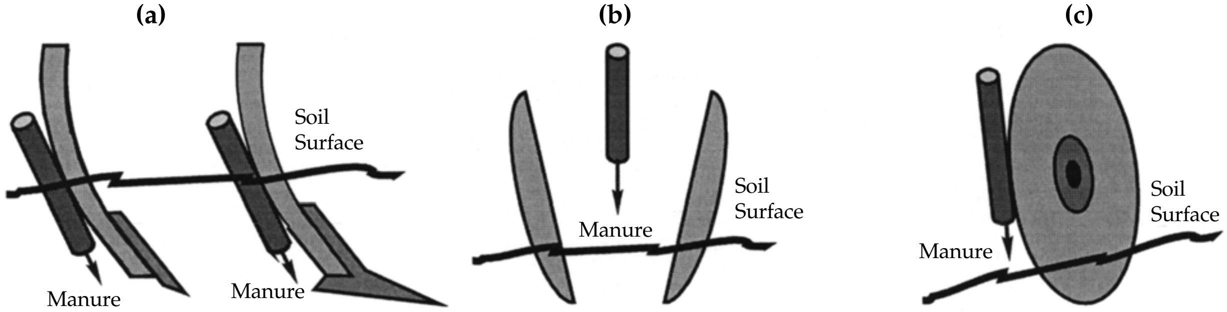


**Figure 1. Schematic of typical soil-engaging components used for simultaneous application and incorporation of manure: (a) chisel and sweep injectors; (b) disk-type applicator; and (c) coulter-type applicator.**

**Table 1. Summary of injection/application equipment used.[a]**

**Chisel and sweep injectors**
- Balzer 20.5 in. wide sweeps with integral 2.25 in. wide straight chisel points; 30 in. spacing on toolbar
- Balzer 20.5 in. wide sweeps with integral 2.25 in. wide straight chisel points and 17.5 in. diameter ripple coulter in front of each injector; 30 in. spacing on toolbar
- Calumet 2 in. wide straight chisel points; 30 in. spacing on toolbar
- Calumet 14 in. wide sweeps; 30 in. spacing on toolbar

**Disk-type applicators**
- Calumet Disk Applicators; 16 in. diameter disks spaced 16 in. at their centers; 30 in. spacing on toolbar
- Vittetoe Disk Applicators; 22 in. diameter disks spaced 31 in. at their centers; 60 in. spacing on toolbar

**Coulter-type applicator**
- Sukup Manufacturing 25 in. diameter coulter applicators; 30 in. spacing on toolbar

**Knife-type anhydrous ammonia applicator**
- Blue Jet 0.5 in. wide rigid C-shaped knife shanks with 20 in. diameter smooth coulters in front of knives; 30 in. spacing on toolbar

**Tandem disk**
- John Deere model TO210; spring tooth harrow attachment

[a]Mention of brand names is for descriptive purposes only. Endorsement or exclusion of others is not intended or implied.

ered with residue. A soil erosion control BMP is to minimize soil and crop residue disturbance, thus leaving greater amounts of crop residue on the soil surface.

These two BMPs are in conflict since disturbance of the soil and residue for manure incorporation, either with conventional tillage implements or with equipment specifically designed for manure application/incorporation, will reduce the amount of residue cover remaining on the soil surface for erosion control.

Although estimates of residue cover reduction by tillage and other soil-engaging implements are available in tabulated form and computer programs, estimates of residue cover reduction by manure application/incorporation equipment are not well documented. Therefore, a research project was conducted to: 1) determine the influence that commercially available soil-engaging components used to simultaneously apply and incorporate manure have on the reduction of crop residue cover [Part I - this article]; and 2) determine and evaluate some of the factors that may influence the amount of residue cover reduction that occurs with these components [Part II - companion article].

## Procedures

*Soil-Engaging Components*

Three general configurations of soil-engaging components are typically used with tank spreaders and towed hose systems to simultaneously apply and incorporate either liquid or slurry manure. These are:

**Chisels and sweeps** (Figure 1a) are the most common components for manure application/incorporation. These generally consist of a C-shaped shank, 2-3 inches wide, with either a chisel or sweep point bolted to it. Shank spacing on the toolbar usually ranges from 20 to 60 inches. Chisel points are typically 2-3 inches wide, and can be either straight or twisted. Sweeps are typically 7-24 inches wide. At least one manufacturer offers a combination chisel point and sweep as a single unit. Most manufacturers also offer coulters that can be mounted in front of the shanks to help cut the crop residue, which improves residue flow between and around the shanks. Operating depth of chisels and sweeps is usually 4-8 inches. Manure exits the supply tube below the soil surface, making these units true manure injectors.

**Disk-type applicators** (Figure 1b) consist of two opposed concave disks, typically 14-22 inches in diameter, mounted on an angled shaft. Spacing between the centers of the individual disks is generally 12-32 inches. Because of the angled shaft, the disks are skewed relative to the direction of travel, giving a wider spacing between the disks at the front edges than at the rear. Manure exits slightly above the soil surface through the supply tube between the disks. Operating depth of the disks is generally 3-6 inches. As the applicator moves through the field, the disks throw loosened soil and crop residue inward and upward, mixing the soil and residue with the manure flowing from the supply tubes. Following application, the field often appears as strips of essentially undisturbed residue and soil alternated with strips of mixed soil, residue, and manure. The width of the undisturbed strip is dependent on both the spacing between the two opposing disks, and the spacing of the disk units along the toolbar, which is typically 15-60 inches.

**Coulter-type applicators** (Figure 1c) consist of a large rolling coulter, typically 22-25 inches in diameter, a manure supply tube, and a closing or press wheel. The coulter is angled approximately 5 degrees compared to both the direction of travel and to vertical. As the applicator moves through the field, the soil and residue is cut by the coulter and a slot is wedged open. Manure is applied in this slot, and the press wheel then forces the slot closed. Operating depth of the coulters is usually 4-8 inches. Coulter applicators are typically operated in pairs, with one skewed to the right and one skewed to the left, to eliminate implement side-draft.

Seven configurations of commercially available manure injection/application components were evaluated in this research (Table 1). A tandem disk and a knife-type anhydrous ammonia applicator

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were also included for comparison purposes. Evaluations were made in both irrigated and dryland corn residue (non-fragile residue) and in soybean and oat residue (fragile residue). Trials were conducted at the University of Nebraska Haskell Agricultural Laboratory near Concord in the spring and fall of 1996 and 1997. Partial funding was provided by the Nebraska Pork Producers Association.

## Results and Discussion

*Residue Cover Reduction by the Components*

Residue cover reductions as great as 98 percent occurred in soybean and oat residues for some of the chisel and sweep injector treatments. In all cases, when chisel and sweep injectors were used in either soybean or oat residue, cover reductions of 70 percent or greater occurred. Taken across year, season and specific equipment, the mean residue cover reduction was 92 percent when chisel and sweep injectors were used in soybean and oat residues. Likewise, the mean residue cover reduction was 52 percent when chisel and sweep injectors were used in corn residue, with reductions ranging from 25 to 87 percent. Mean cover reductions by chisel and sweep injectors were not significantly different ($P \geq 0.110$) from the reductions by the tandem disk in any of the four types of residue.

Mean residue cover reduction by the disk applicators taken across year and season was 72 percent for soybean and oat residues and 45 percent for corn residue. Residue cover reduction by the disk applicators was not significantly different ($P \geq 0.130$) compared with the tandem disk in either irrigated or non-irrigated corn residue, but was significantly less ($P<0.001$) in soybean and oat residues.

Residue cover reductions by the coulter-type applicator were significantly less ($P<0.005$) than the reductions by chisel and sweep injectors, disk applicators and the tandem disk for each of the four residue types. Taken across year and season, mean residue cover reduction for the coulter applicator was 37 percent for soybean and oat residues, and 11 percent for corn residue.

**Table 2. Percentage of initial residue cover remaining following manure application/incorporation.**

| Application/Incorporation Component | Percentage of Initial Residue Cover Retained: Soybean and Oat Residue (Fragile) | Corn Residue (Non-fragile) |
|---|---|---|
| Chisel and Sweep Injectors | 5-15 | 30-65 |
| Disk-Type Applicators | 15-40 | 40-65 |
| Coulter-Type Applicators | 65-80 | 80-95 |
| Tandem Disk | 5-25 | 35-60 |

*Estimating Percent Residue Cover Remaining*

One objective of this research was to determine values similar to those available for many tillage and other residue-disturbing operations that could be used to estimate the amount of residue cover expected to remain for soil erosion control following operation of manure application/incorporation equipment. Suggested ranges of values for both fragile and non-fragile residues are presented in Table 2. These data can be used for planning purposes if site and equipment-specific values are not available. [Note: the values in Table 2 are percentage of initial residue cover remaining, not percent reduction as previously discussed; percentage cover remaining = (100 - percent reduction).]

The values in Table 2 can be multiplied by the percent residue cover present before manure application/incorporation to obtain an estimate of the amount of cover that will remain following manure incorporation. For example, assume that a coulter-type applicator is used to apply manure in a recently combined soybean field having an average residue cover of 70%. Multiply 70% (after harvest cover) by 0.7 (estimated percentage of cover remaining for a coulter-type applicator used in soybean residue, expressed as a decimal) which gives about 50% residue cover following manure application. In contrast, if a chisel or sweep injector was used in the same soybean field, less than 10% cover would likely remain (70% x 0.1 = 7%). Likewise, in an irrigated corn field having an average residue cover of 95%, the expected percent cover following manure application/incorporation would be approximately 40% (95% x 0.45) if a chisel or sweep injector is used; slightly over 50% (95% x 0.55) if a disk-type applicator is used; and about 80% (95% x 0.85) if a coulter-type applicator is used.

As with tillage operations, the amount of residue cover remaining after manure incorporation is influenced by many factors including: component design, shank spacing on the toolbar, adjustments, field speed, depth of soil disturbance, previous residue disturbance, soil and residue condition and others. Thus, the best procedure is to operate the manure incorporation equipment in a small, representative area of the field, and then measure the amount of residue cover remaining (refer to University of Nebraska Cooperation Extension NebGuide G93-1133, *Estimating Percent Residue Cover Using the Line-Transect Method*.) Also, manure incorporation is only one operation within a series or system of operations that are performed in a field between harvest of one crop and planting of the next crop in that field. Each soil and residue-disturbing operation must be considered when evaluating the amount of residue that will remain for erosion control. (For a more complete listing of implements and residue amounts remaining, as well as more information about the influence of various factors on residue cover, refer to University of Nebraska Cooperation Extension NebGuide G93-1135, *Estimating Percent Residue Cover Using the Calculation Method*.)

**Conclusions**

Results of this research project indicate that adequate residue cover can remain for effective erosion control with some configurations of manure injectors and applicators, particularly in corn or other non-fragile residue. However, the equipment must be selected, adjusted and operated with the dual objectives of manure and residue management, rather than the objective of simply disposing of the manure. The companion article titled *"Crop Residue Cover and Manure Incorporation — Part II: "Fine-Tuning" the System"* discusses some of these considerations. With this information, swine producers should be better able to select a manure management system that is also compatible with their soil erosion control objectives.

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