January 2004

Crop Residue Cover and Manure Incorporation — Part II: "Fine-Tuning" the System

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

Crop Residue Cover and Manure Incorporation — Part II: "Fine-Tuning" the System

David P. Shelton[1]

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. Values to estimate the amount of residue cover that will remain following the use of common manure application/incorporation components have been presented in the article titled "Crop Residue Cover and Manure Incorporation — Part I: Reduction of Cover." This article discusses some of the influence that injector/applicator spacing, tire spacing, field speed and several other factors can have on residue cover reduction. Much of this information is based on field observations which may help swine producers in the selection and operation of manure incorporation components, especially when trying to maximize the residue cover that remains for erosion control.

Background and Introduction

Manure incorporation represents a conflict between best management practices (BMPs) for soil erosion control and manure management. Manure should be incorporated into the soil for odor control, maximum availability of nutrients, and control of potential manure runoff. But, for maximum soil erosion control, the soil and crop residue should remain undisturbed. These two BMPs must be balanced since disturbing the soil and residue for manure incorporation, either with conventional tillage implements or with equipment specifically designed for manure application/incorporation, reduces the amount of residue cover remaining for erosion control.

The companion article titled "*Crop Residue Cover and Manure Incorporation — Part I: Reduction of Cover*" presents results from a research project conducted at the University of Nebraska Haskell Agricultural Laboratory that evaluated the residue cover reduction caused by various soil-engaging components typically used with tank spreaders and towed hose systems to simultaneously apply and incorporate either liquid or slurry manure. Ranges of values are given for the percentage of the initial residue cover that could be expected to remain following the operation of chisel and sweep manure injectors, disk-type applicators, coulter-type applicators and a tandem disk.

This article discusses some of the influence that injector/applicator spacing, tire spacing, field speed and several other factors can

(Continued on next page)

have on residue cover reduction. Much of this information is based on field observations and related experiences, and is intended to help swine producers in the selection and operation of manure application/incorporation components, especially when trying to maximize the residue cover that remains for erosion control.

"Fine-Tuning" the System for Residue Management

The type of soil-engaging component (chisel or sweep injector, disk-type applicator, coulter-type applicator, etc.) is the predominant factor affecting residue cover reduction during manure incorporation. However, adjustments, operating conditions and many other factors can influence the amount of cover reduction that occurs. Following is a discussion of some of these factors.

- **Applicator Spacing and Width.** Spacing of the injectors/applicators on the toolbar can have a major influence on residue cover reduction. Decreasing the spacing between these components generally will increase the amount of residue disturbance (i.e. less cover remains). There is, however, a minimum spacing where the soil surface area disturbed by one applicator overlaps the area impacted by the adjacent applicator, and the result is essentially full width disturbance.

  To evaluate the degree of disturbance caused by individual injectors/applicators, passes in soybean residue were made with single injector or applicator units. The width of the disturbance (defined as loose soil on the surface) was measured perpendicular to the direction of travel in 50 places over a distance of 200 feet. The average disturbed width ranged from 7 inches for the coulter applicator to 57 inches for one of the disk-type applicators, Table 1. In general, as the width of the soil-engaging component increased, the width of disturbance also increased. For example, the coulter-type applicator consists of a 25 inch diameter coulter that is angled approximately 5 degrees relative to both the direction of travel and to vertical. The maximum profile width of this component perpendicular to the direction of travel is approximately 2 inches. At the soil surface, however, this width is on the order of 1 inch or less, depending on the operating depth. Also, soil-opening is with a cutting action, rather than a lifting or inverting action. Hence the disturbed width would be expected to be the least. Much of the disturbance that did occur was the result of soil that adhered to the coulter blade, and then fell or was thrown to the side as the implement moved through the field. For the other components, the width at the soil surface perpendicular to the direction of travel was approximately: 0.5 inch for the knife-type anhydrous ammonia applicator; 2 inches for both the Calumet chisel and sweep (width of shank); 15 inches for the Calumet disk applicator; and 30 inches for the Vittetoe disk applicator. Also, with the exception of the coulter-type applicator and knife-type ammonia applicator, the soil-engaging components evaluated are designed to loosen and lift or throw the soil, and mix the manure with it. As such, a wider area of disturbance would be expected as the width of the soil-engaging component increased.

  Results from the Vittetoe disk applicators (22 in. diameter disks with 31 in. spacing between disks) also illustrate the influence of applicator spacing. Because of the wide spacing between the two disks, these applicators were spaced 60 inches apart on the tank toolbar, rather than the 30-inch spacing used for all other injectors/applicators. This configuration resulted in strips of disturbed soil and residue between the disks, alternated with strips of essentially undisturbed soil and resi-

Table 1. Average width of soil disturbance for single injectors or applicators.

Description of Injector or Applicator[a]	Disturbed Width (inches)[b]
Sukup Coulter Applicator (25 in. diameter blade, 5 mph)	7 a
Knife-type Fertilizer Applicator (0.5 in. wide knife with smooth coulter, 5 mph)	17 b
Calumet Chisel Injector (2 in. wide straight chisel, 5 mph)	36 c
Calumet Disk Applicator (16 in. disks, 16 in. apart, 7 mph)	36 c
Calumet Sweep Injector (14 in. wide sweep, 5 mph)	42 d
Calumet Disk Applicator (16 in. disks, 16 in. apart, 10.5 mph)	45 d
Vittetoe Disk Applicator (22 in. disks, 31 in. apart, 7 mph)	57 e

[a]Mention of brand names is for descriptive purposes only. Endorsement or exclusion of others is not intended or implied.
[b]Means followed by a different letter are significantly different ($P<0.001$).

Table 2. Average residue cover reduction for disk applicators with 22 inch diameter disks, 31 inch spacing between disks, and 60 inch spacing of applicators on tank toolbar.

Area	Residue Cover Reduction (percent)[a]	
	Soybean Residue	Corn Residue
Between individual disks	89 a	57 a
Between adjacent applicators	47 b	29 b
Overall	68	43

[a]Within residue type, means followed by a different letter are significantly different ($P<0.001$).

due in the area between adjacent applicators. Both strips were approximately 30 inches wide. Residue cover was measured in both areas. Average residue cover reductions are shown in Table 2.

As expected, significantly ($P<0.001$) more reduction occurred between the individual disks than between adjacent applicator units. The reduction between adjacent applicators was due primarily to soil that was thrown by the disks and fell in the area between the applicators. If the applicators were spaced closer together on the toolbar, proportionately more of the total area would be disturbed directly by the individual disks, and the overall reduction would be greater. Conversely, for a given applicator unit spacing, if the individual disks were spaced closer together, less of the total area would be disturbed directly by the disks, and overall residue cover reduction would be less. Thus, to minimize residue cover reduction, the width of the applicator unit should be as narrow as possible and applicator spacing on the toolbar should be as wide as possible.

For both disk-type applicators used in this study, the spacing between the disks of each individual unit was approximately 50% of the applicator unit spacing on the tank toolbar. The values presented in Part I to estimate residue cover reduction by disk-type applicators are based on this spacing. However, field observations and manufacturer's sales literature indicate that disk-type applicators are sometimes mounted on the tank toolbar such that the spacing between the disks of adjacent applicator units is minimal (i.e. the disks are nearly hub-to-hub). In these cases, the overall reduction would likely be close to the values in Table 2 for the area between individual disks, or similar to the reductions that would be expected from chisel and sweep injectors.

- **Chisels vs. Sweeps.** More residue cover remained when chisel points were used as compared to sweeps. In corn residue, chisel points reduced residue cover by an average of 51 percent, whereas sweeps reduced the cover by 63 percent ($P<0.001$). The width of disturbance was also significantly greater for sweeps than for chisels, Table 1.

- **Straight vs. Twisted Chisel Points.** Twisted chisel points will reduce residue cover more than straight chisel points. (Straight points were used in this study.)

- **Coulters.** Coulters are sometimes added to tillage implements or planters to cut the residue and improve residue flow around or through the equipment. Adding a coulter to the combination chisel/sweep injector in this study did not have an effect on the amount of residue cover that remained. A Canadian researcher, however, reported that the addition of a coulter in front of a sweep manure injector increased draft force by 27% and caused greater soil surface roughness compared with the sweep alone. Thus, it appears that adding a coulter to manure injection equipment should be considered only for specific situations, such as with exceptionally heavy or tough residue, not on a routine basis.

- **Disk-Type Applicators.** Residue and soil disturbance by the disk-type applicators varied considerably depending on soil conditions. Under relatively dry and/or non-cohesive soil conditions, virtually all disturbance was confined to the area between the two disks of each individual applicator unit, and the area between adjacent units remained essentially free of loose soil. Under other conditions, such as when the soil was relatively damp, a considerable amount of soil was thrown by the disks onto the area between adjacent applicators, reducing the percent cover of this area. Also, damp/wet soil tended to stick and pack on the inside of the disks. This sometimes caused the disks to stop turning, resulting in a scraping or plowing action which left bare strips with large piles of residue at the ends. Scraper blades, similar to those often used to clean disk harrow blades, might help reduce this problem.

  Disk-type applicators might fit well in a ridge-plant system. When operated on a flat field (no ridges), disk applicators leave a ridge about four to eight inches high that is a mixture of soil, residue, and manure. These ridges could be used as the start of a ridge-plant system. If manure application was done in the fall, the loose soil/residue/manure mixture would have time to settle and consolidate prior to planting on the ridge top the following spring. Similarly, if the applicators were centered on an existing ridge, some rebuilding of the ridge would occur, and manure would be applied in the area where the next year's crop would be planted. In either case, manure application rates should be carefully controlled to avoid potential seedling injury. However, a possible drawback is the potential to concentrate weed seeds, coming either from the manure itself or from the soil surface, directly in the crop row.

- **Coulter-Type Applicators.** Coulter-type applicators left the most residue cover of any of the manure injectors and applicators evaluated in this study. As such, they are the most compatible with no-till planting systems. At least one manufacturer markets a coulter applicator unit as a "No-Till Injector," although this is somewhat of a misnomer in that the manure exits the supply tube above the soil surface, and

(Continued on next page)

some disturbance of the soil and residue does occur.

It appears that coulter-type applicators might offer the opportunity to apply manure into a growing crop or pasture, a practice that has been used for some time in the United Kingdom. One UK researcher concluded that shallow injection of manure slurry into a growing cereal crop allowed manure application when crop nutrient requirements were at their maximum; provided a much larger window of time for manure application; and had no detrimental influence on crop yield. Further investigation of this manure management alternative is warranted.

- **Field Speed.** More cover generally will remain when equipment is operated at slower speeds. For example, operating one of the disk applicators at 7 mph resulted in an average width of soil disturbance of 36 inches, whereas the disturbance increased to 45 inches at 10.5 mph, Table 1.

Manure application rate (volume per unit area) is primarily controlled by field speed for some manure tanks, with faster speeds required to achieve lower application rates. Also, a speed about 10 mph was recommended by the factory representative for the Calumet disk applicator to achieve thorough mixing of the loosened soil, residue and manure being applied. Thus, in certain cases, the operator may have only limited ability to reduce field speed in an effort to leave more residue cover. This suggests that the ability to control flow rates from the manure tank, and hence control application rates independent of field speed, may be beneficial for lessening residue cover reduction and improving manure nutrient utilization. Some manufacturers are now offering this option.

- **Manure application rates.** There may be differences in the amount of manure that can be applied by the different types of injectors/applicators. It appears that as the degree of soil and residue disturbance increases, the amount of manure that can be applied while still achieving thorough incorporation also increases. For example, the coulter applicator opens a relatively small slot or channel in the soil which may overflow if large volumes of manure are applied, particularly if the soil has a low infiltration rate. In contrast, large volumes of manure can be applied with chisel and sweep injectors since, by design, a sizable volume of soil is loosened during their operation, and the manure is applied below the soil surface.

Manure application rates also may be controlled by component design. For example, manure supply tubes on the chisels, sweeps, and disk applicators used in this study were all 3 inches in diameter, whereas the coulter applicators were equipped with 2 inch supply tubes. This should not be a factor, however, if manure is applied at agronomic rates to meet crop nutrient needs.

- **Tire Spacing.** Particularly when operating in row-crop residue, tire spacing on the axles (both on the manure tank and tractor) should be adjusted to conform to plant row spacing, and the tires should be centered in the row middles. If this is not the case, standing residue can be knocked down by the tires and covered by the injectors/applicators. (Tire spacing that matches the row spacing is imperative if manure will be side-dressed into growing crops or applied in a ridged field.)

If tire spacing does not match row spacing, injectors/applicators mounted on the front of the tank (as opposed to the rear) may leave somewhat greater amounts of residue cover. With this configuration, standing residue that was knocked down by the tank tires would be knocked down onto the area that had already been disturbed, rather than in front of the injectors/applicators. Situations similar to this have been observed when no-till planting into corn residue. Standing corn stalks were knocked down by the planter components, slightly increasing the amount of residue cover compared to the cover prior to the planting operation. However, judging from sales literature, only a very limited number of manure equipment manufacturers offer a front-mount option. Also, front-mounting may substantially limit the use of different types of injectors/applicators since clearance below the tank is usually quite limited.

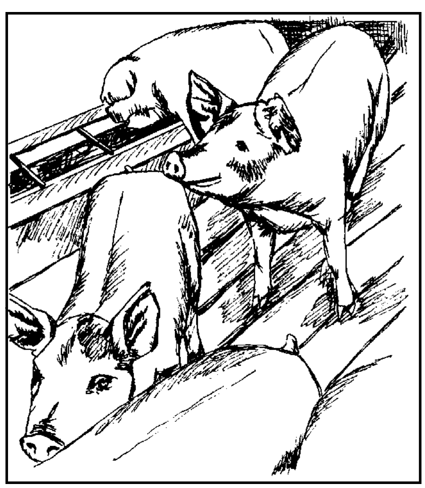
- **Soil surface following application/incorporation.** All of the injectors/applicators to some extent left ridges and/or valleys in the field. These were most pronounced for the chisel and sweep injectors and the disk applicators. In the case of the chisel and sweep injectors, some type of subsequent tillage would likely be needed to smooth and level the surface prior to planting. This, as well as the planting operation, would further reduce the residue cover remaining for erosion control. For the disk applicators, subsequent tillage might not be necessary, provided that the plant row spacing matched the applicator spacing. Planting could be done either on top of the ridge as previously discussed, or in the essentially undisturbed area between adjacent applicator units. Planting in a field where coulter applicators had been used could be performed at nearly any location, although planting directly in the applicator track should be avoided to prevent seedling injury from contact with the applied manure.

- **Apply on the contour.** Manure application/incorporation equipment should be operated on the contour, rather than up-and-down hill, to help reduce potential soil erosion and manure runoff. For example, the disk applicators tended to leave channels at both edges of the applicator track which could serve as areas for concentrated water flow. Likewise, the slot left by the coulter applicator could also serve as a water flow channel, potentially washing out the applied manure during a heavy rain. When operated on the contour, the ridges and valleys may act as mini-terraces or small dams which slow water runoff from rainfall or snow melt, thus increasing infiltration into the soil and reducing erosion potential.

- **Fall vs. Spring Application.** If manure is applied and incorporated in the fall or if the residue is disturbed in the fall by grazing, tillage, stalk chopping, or knifing-in fertilizer, subsequent spring operations reduce cover more than if all operations are conducted in the spring. These operations cut or break the residue into smaller pieces, mix soil and residue, and speed over-winter weathering, thus making the residue more susceptible to decomposition and burial in the spring. Another University of Nebraska research project showed that for the same sequence of field operations used in corn residue, residue cover measured after planting averaged 12 percent less ($P<0.05$) when at least one operation was conducted in the fall, compared to performing all operations in the spring.

  If possible, apply and incorporate manure in the spring, rather than the fall, to maximize the amount of residue cover remaining. This also more closely matches crop nutrient needs, and may reduce nutrient leaching. Also, greater amounts of residue cover would remain on the soil surface during the winter and early spring for increased erosion protection during this period. However, manure application only in the spring is not always feasible due to limitations in manure storage capacity. Also, field access and compaction may be more of a concern since the soil is usually wetter in the spring than in the fall. As mentioned previously, manure application into a growing crop or pasture may be a manure management alternative that could overcome some of these issues.

- **Oat Residue.** Oat (and possibly other small grain) residue may offer some unique opportunities for manure/residue management. With harvest typically in late summer, the window of time available for manure application is greater than with fall-harvested crops. Also, there is often re-growth of the oat plants and/or oat seed that remains in the field due to harvest losses. For example, during one year of this study, 12 to 16 inches of new growth occurred between harvest and the first killing frost. If manure is applied/incorporated shortly after harvest, this new growth may add some residue cover to the bare areas caused by the application/incorporation operation, thus reducing the erosion potential. Additionally, vegetative growth from oat harvest losses or from a seeded cover crop may help stabilize nutrients from the manure by using plant uptake to store nutrients in the residue.



Conclusions

Results of this research project indicate that adequate residue cover can be maintained for effective erosion control with some configurations of manure injectors/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. With careful planning, swine producers should be able to select a manure management system that is also compatible with their soil erosion control objectives.

---

[1]David P. Shelton is professor, Department of Biological Systems Engineering and extension agricultural engineer, at the Haskell Agricultural Laboratory, Concord, Neb.