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Do Cover Crop Residue and No-Till Increase Poultry Litter Runoff?

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Introduction

Manure and litter produced during broiler production are an environmental issue in Kentucky. The most common and practical disposal method is to apply the poultry wastes to pasture and crop land. If the wastes are incorporated by tillage immediately after application to crop land, nitrogen that might otherwise be lost by ammonia volatilization is conserved. However, incorporating wastes is not possible in no-till, which is a best management practice (BMP) used by 51% of Kentucky's farmers to control soil erosion. One question is whether surface application of poultry wastes onto no-till fields could increase fecal bacteria contamination of surrounding waterways if surface runoff occurs.

Because no-till is extensively used by Kentucky farmers, we felt it was important to examine: (1) the cumulative runoff of soil and fecal contaminants after applying unincorporated poultry litter to no-till soil and (2) the effect of such surface application on the trapping efficiency of grass filter strips, a currently recommended BMP for controlling manure and fecal bacteria runoff. We also wanted to see whether varying the amount of surface residue on no-till soils affected subsequent runoff water quality from litter-amended no-till soil and filter strips capturing any potential runoff.

Methods

We prepared research plots on Maury silt loam soil in Lexington KY that was being no-tilled. The plots were 58 feet long and had an average slope of 9%. The previous year, each plot had been chisel plowed to a depth of 8 inches and then disked. We surface applied poultry litter at 10 tons per acre wet weight and used a rain simulator to create surface water runoff on the first and third days after application. We analyzed the runoff water from the waste-amended plots when four different amounts of surface residue were present : (1) a minimum cover (weedy fallow that was removed before rainfall); (2) a weedy cover (weedy fallow that was killed but not removed from the plots); (3) a managed ryegrass cover (annual ryegrass cover removed prior to rain simulation); (4) an unmanaged ryegrass (ryegrass cover left intact and in excess of normal farming practice). Each residue treatment was replicated three times. We killed the cover with paraquat 11 days prior to each rain simulation and removed the residue by mowing and collecting the clippings in appropriate treatments. Surface runoff water samples were collected from gutters at the bottom of the waste-amended plots and at the bottom of 15-foot-long grass filter strips that received surface water runoff from these amended plots. The grass filter strips, a mixed tall fescue and Kentucky bluegrass sod, were mowed to a height of 1 5/8 inches before the rain simulations. We analyzed the runoff samples for fecal coliforms, sediment, and nutrients.

Results

In 1996 and 1997 we evaluated how the four different types of residue management affected the runoff of poultry litter components after surface application onto no-till soils. We also evaluated whether subsequent trapping of these components by grass filter strips was affected. Litter application increased the fecal coliform content in the underlying no-till soil approximately 100-fold in 1996 and 1000-fold in 1997 to concentrations of 2.1×10^3 and 6.4×10^4 cells per gram of soil, respectively (Figure 1). For the short period we sampled after litter application, fecal coliform concentrations in the soil increased rather than decreased (Figure 1) because of favorable moisture and temperature conditions for bacterial growth (Figure 2).

There was a large difference in the amount of sediment loss in runoff water when some residue was present compared to when that residue was absent. In 1996, for example, 78% more sediment was lost in runoff when the weedy cover was removed before the first rain simulation compared to when it was left intact. The two ryegrass cover treatments examined in 1997, which contained much more residue than the weedy cover treatments, were not significantly different from each other in terms of sediment runoff.

Removing the surface residue of the cover crop (weeds or ryegrass) did not significantly affect either the cumulative nutrient or fecal coliforms in runoff from the waste-amended plots either year. The average fecal coliform concentration was 8.9×10^5 CFU/100 mL in runoff from the first rain and 3.8×10^5 CFU/100 mL in the second rain. Likewise, the surface residue treatment did not affect the fecal coliform concentrations leaving the filter strips. In 1996 the fecal coliform concentrations in runoff leaving the filter strips ranged from 3.4 to 5.8×10^4 CFU/100 mL, and in 1997 they ranged from 7.6 to 23.0×10^4 CFU/100 mL. For comparison, the water quality standard for recreational use in Kentucky is 2×10^3 CFU /100 mL.

The filter strips below the minimum cover and the weedy cover treatments had trapping efficiencies comparable to the ryegrass cover treatments for most parameters except fecal coliforms. However, it is worth noting that the plots were drier in 1996 than 1997 (Figure 2) and the wetter soils apparently promoted greater runoff. Although there was an advantage to having some weedy cover rather than no cover in the eventual trapping of fecal coliforms by the filter strip, the relationship of the two residue treatments was inconsistent for other runoff parameters. The overall trapping efficiency of the grass filter strips was greatest for sediment (80%) and least for fecal coliforms (44%) (Table 1).

Previous studies on these plots indicated that when poultry litter was incorporated, fecal coliform trapping by adjoining grass filter strips was 74%. Although incorporation appears to improve fecal coliform trapping efficiency in filter strips, total fecal coliforms entering and leaving the filter strips were 10 to 1000 times higher when the soil above the filter strip was tilled and the litter was incorporated in those previous studies. Although incorporating litter may improve filter strip trapping efficiency, it does not necessarily decrease fecal coliform concentrations in runoff, nor does it decrease the total number of fecal coliforms eroded from soil. Besides, litter incorporation and soil tillage results in greater soil erosion and nutrient loss than from no-till fields.

In minimum cover and weedy cover treatments, filter strip trapping efficiencies declined in the second rain. In contrast, ryegrass cover treatments consistently had higher filter strip trapping efficiencies during the second rain for all parameters (sediment, fecal coliforms, and nutrients). Too much cover appeared to be detrimental to trapping efficiency by grass filters. There was always higher filter strip trapping efficiency in managed ryegrass cover plots compared to unmanaged ryegrass cover (Table 1). This is probably because the excessive residue reduced infiltration thus causing a higher velocity of surface runoff. In addition, higher runoff contributed to channelized flow in which much of the runoff from the waste-amended plots was channeled through just a few locations in the filter strips.

Conclusions

Surface applying poultry litter to no-till fields was a more effective management practice than incorporating the litter by tillage, in terms of what was contained in the surface runoff water. Although the trapping efficiency of adjoining filter strips declined slightly when the litter was not incorporated, the overall quality of surface runoff from filter strips improved in terms of cumulative sediment and fecal coliform loss. Within limits, increasing the surface residue in no-till was beneficial to decreasing the bacteriological content of surface water leaving the filter strips. Increasing the amount of residue from minimal cover to some weedy residue greatly reduced runoff and increased sediment and fecal coliform trapping by grass filters. A managed ryegrass cover crop did not initially increase filter strip trapping efficiency compared to a weedy cover, while excessive residue was actually detrimental. However, the filter strip performance in managed cover treatments consistently outperformed weedy cover treatments when successive rains occurred.

The optimal situation is one in which poultry litter is applied several days before rain occurs and fields are managed by no-till (for surface residue benefits), or a cover crop is planted and managed without leaving excessive residue. Filter strips should be used for sediment, nutrient, and fecal coliform reduction with the knowledge that any runoff escaping the filter strips may easily exceed water quality standards for fecal coliforms when poultry litter is applied. However, filter strips are an effective best management practice for protecting overall water quality.

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Figure 1. Fecal Coliform Concentration Before and After Litter Application

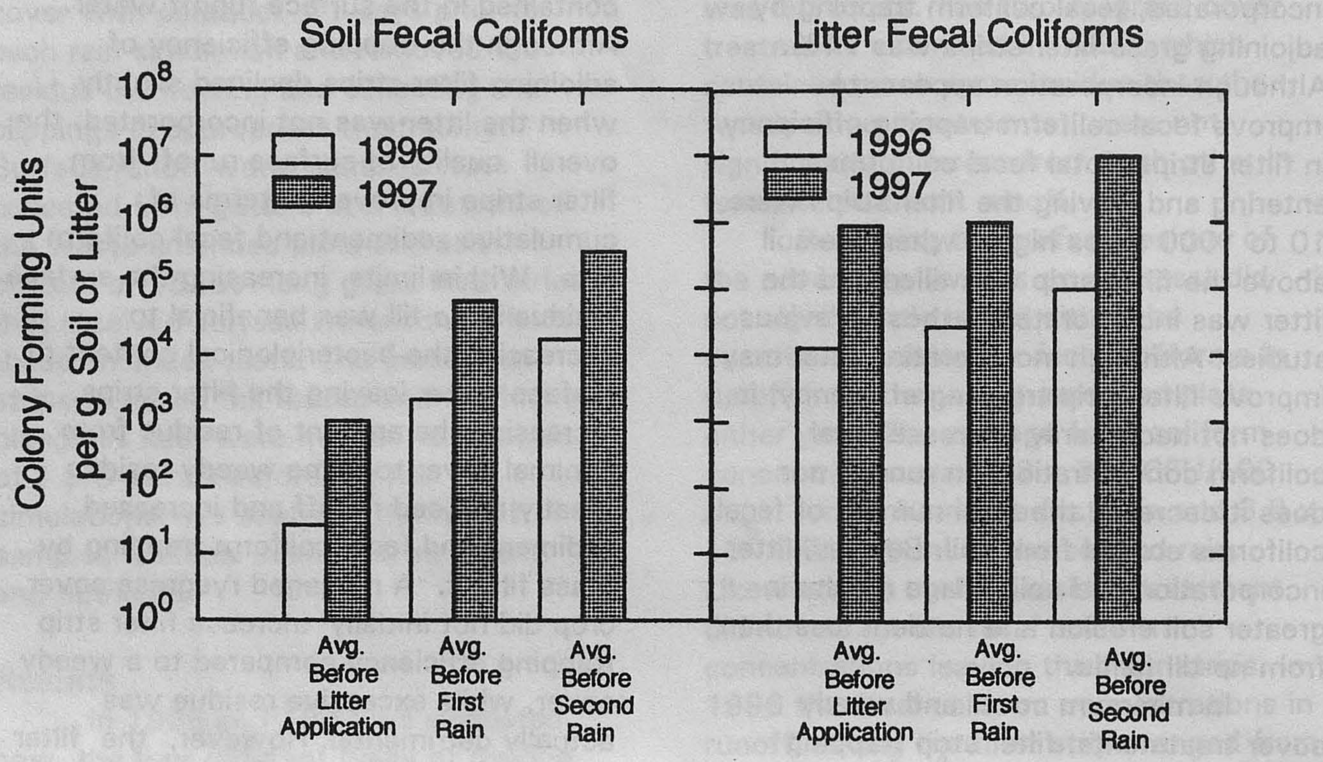

Figure 2. Soil Moisture Before and After Litter Application

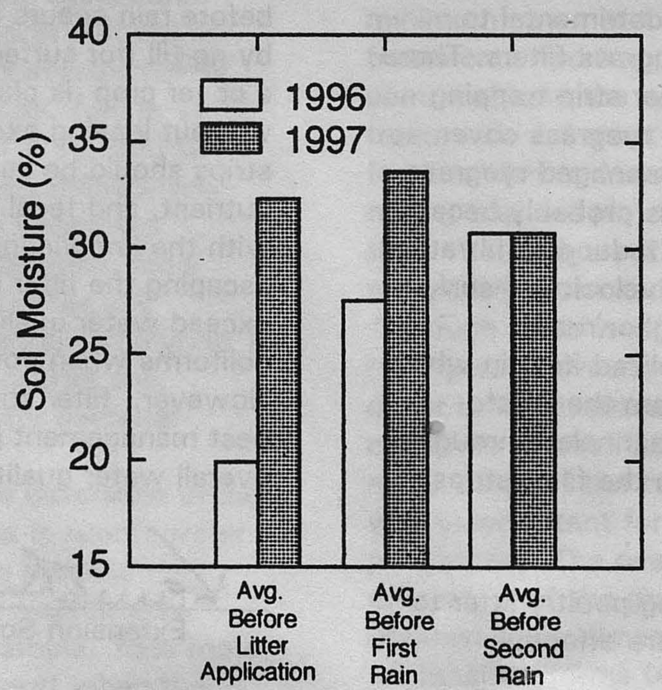

Table 1. Trapping efficiency of grass filter strips for runoff from poultry litter applied to no-tillage plots with different amounts of surface residue (values represent the average of three plots within a cover treatment.

Runoff Constituent		% Trapping Efficiency by Cover Treatment				Overall Trapping Efficiency
		Minimum Cover	Weedy Cover	Managed Ryegrass	Unmanaged Ryegrass	
		------- 1996 --------		------- 1997 ---------		
Sediment	Rain 1	95.6a	92.8a	83.9b	50.1a	80%
	Rain 2	91.9a	72.8b	89.1b	65.8a	
Fecal coliforms	Rain 1	26.5b	63.5a	68.1	32.7	44%
	Rain 2	0.0d	43.2c	69.7	45.8	
Total N	Rain 1	89.2	93.0	75.0b	38.2a	73%
	Rain 2	84.4	77.7	75.5b	49.9a	
Total P	Rain 1	91.6	91.8	77.2b	40.2a	73%
	Rain 2	82.4	71.0	78.1b	50.8a	
NO_3^--N	Rain 1	88.9	43.8	67.5b	9.5a	55%
	Rain 2	73.6	41.1	71.1b	40.9c	
NH_4^+	Rain 1	89.5	91.9	76.6b	43.1a	71%
	Rain 2	68.4	73.4	79.2b	48.4a	
PO_4^{3-}-P	Rain 1	87.2	90.4	76.5b	39.3a	67%
	Rain 2	56.4	70.0	75.3b	40.2a	

Trapping efficiencies for the same runoff constituent in the the same year that are followed by a different letter are significantly different.

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