MECHANICAL AERATION TO REDUCE P EXPORT FROM MANURED GRASSLANDS

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REFERENCE: *Proceedings of the 2007 Georgia Water Resources Conference*, held March 27–29, 2007, at the University of Georgia.

Abstract. The poultry industry is an important component of agricultural production in the Southern Piedmont of Georgia. Associated manures are typically surface-applied to pastures as a fertilizer for forages. However, this surface application of manures allows phosphorus (P) to accumulate at the soil surface and runoff to become contaminated with P and to transport it to surface waters. As such, a study was conducted to examine the conservation potential of mechanical aeration of grasslands. Mechanical aeration has potential to reduce P transport by partially incorporating applied manures, allowing for more P adsorption by the soil, increasing infiltration by breaking the soil surface, and by slowing runoff flow by increasing the roughness of the landscape. We examined the effects of four aeration treatments (aeration with cores, "no-till" disk aeration perpendicular to the slope, aeration with spikes, and no aeration treatment) on the export of dissolved reactive P (DRP) in surface runoff from grasslands with two nutrient treatments (broiler litter and a control of no manure). Plots (0.75 x 2 m) were established on a Cecil soil series with mixed tall fescue/bermudagrass vegetation on 8 to 12% slopes. Plots were then aerated and manures applied at a rate of 30 kg P ha^{-1}, prior to simulated rainfall at a rate of 75 mm h^{-1}. While aeration had minimal impact on volume of runoff, core aeration decreased DRP loads ($P < 0.05$) from applied broiler litter by 61%. Given that Cecil soil is common in pastures receiving broiler litter in the Southern Piedmont, these results suggest that core aeration could have a widespread impact on water quality in the Southern Piedmont region.

INTRODUCTION

Agricultural nonpoint pollution from surface-applied manures has the potential to contribute to eutrophication of surface waters. In freshwaters, controlling inputs of DRP, a measure of the fraction of P most available for uptake by aquatic algae and bacteria, can be a critical aspect of controlling eutrophication (McDowell et al., 2004). Agricultural professionals have developed several strategies to reduce the amount of available P transported to surface waters. One strategy is incorporation of manures into the soil in order to facilitate binding of P with soil minerals. However, as any depth of incorporation may negatively impact forage production, incorporation is generally not practical in perennial grassland systems. As such, one solution is the injection of liquid manures, but this method requires the use of heavy injection equipment which could severely compact the soil and is generally only used with liquid manures. Aeration of grasslands, such as aeration by spikes (Pote et al. 2003; Franklin et al., 2004; Shah et al., 2004), disking perpendicular to the slope, or aeration by cylindrical cores has potential to partially incorporate applied manures, to allow for more P adsorption by the soil, increase infiltration by breaking the soil surface, and to slow runoff flow by increasing the roughness of the landscape. While past grassland research on mechanical aeration of the soil surface to reduce P losses is limited, it offers an experimental basis for analyzing various aeration treatments, which in turn will allow for utilization of available nutrients while sustaining environmental quality.

MATERIALS AND METHODS

Plots (0.75 x 2 m) were established on a Cecil soil series (fine, kaolinitic, thermic, Typic Kanhapludults) with mixed tall fescue-bermudagrass vegetation on 8 to 12% slopes. Simulated rainfall was applied at a rate of 75 mm h^{-1} according to the National P Protocol (National Phosphorus Research Project, 2003) in order to evaluate baseline conditions of runoff from plots. Plots were classified into four blocks according to runoff volume, after which four aeration treatments (aeration with cores, no-till disk aeration perpendicular to the slope, aeration with spikes, and no aeration treatment) were combined with two nutrient treatments (broiler litter and no manure) and randomly applied to plots within each block.

Immediately following aeration, plots were fertilized with manure treatments at a rate of 30 kg P ha^{-1} prior to rainfall simulation in January 2005. Runoff samples were collected at 5-min intervals until 30 min of runoff had occurred. All runoff during 30-min of runoff was collected

to determine runoff volumes between each sampling time. In June 2005, plots were compacted using methods described by Clary (1995) to simulate compaction resulting from cattle hoof action in grazed pastures. Following compaction, plots were again aerated and nutrient treatments applied before the final rainfall simulation in June 2005, using the same methods as in January 2005.

Filtered samples were analyzed for DRP by the molybdate blue method (Murphy and Riley, 1962). Samples collected at 5-min intervals represent point estimates of concentrations and were plotted versus cumulative runoff volume. The points were joined and the area under the curve integrated to determine cumulative mass of DRP lost at each collection time.

Runoff volume and export DRP were examined using the PROC GLM procedure (SAS institute, 1994) with baseline runoff volume used a covariate in the analysis.

RESULTS AND DISCUSSION

Given the lack of interaction between aeration and manure application events, results reported here are averaged over both the January and June events.

Runoff volume

Though there was a trend toward lower runoff volume with core aeration as compared to the control of no aeration under all nutrient treatments, there were no significant differences (P<0.05) in mean runoff volume from either core, no-till disk, or spike aeration compared to the control of no aeration treatment (Table 1). Localized soil compaction in the aeration slits, caused by the aeration implements entering the soil (most notably the spike and disk aeration), may have prevented an increase in infiltration with aeration.

Table 1. Mean runoff volume as affected by aeration type

	Broiler litter	None
---Aeration type---	Runoff volume (% of rainfall applied)	
Core	17.7 a†	17.7 a
No-till disk	24.0 a	26.2 a
Spike	22.5 a	21.0 a
None (control)	23.1 a	20.0 a

† within nutrient application groups, means represented by the same letter are not significantly different (P>0.05)

Dissolved reactive P

With applied broiler litter, core aeration decreased DRP mass export by 61% compared to the control of no aeration (Table 2). The effectiveness of core aeration may be in part due to the greater surface area of soil exposed by the practice, allowing more soil surface area for binding of P with clay minerals, thus reducing the concentration of P in runoff. When combined with the trend toward reduction in runoff volume with core aeration, there was a significant reduction in DRP mass export with core aeration.

Table 2. Mean export of dissolved reactive phosphorus (DRP) as affected by aeration type

	Broiler litter	None
---Aeration type---	--------DRP export (kg P ha^{-1})--------	
Core	0.755 b†	0.055 a
No-till disk	1.809 a	0.066 a
Spike	1.560 a	0.056 a
None (control)	1.925 a	0.055 a

† within nutrient application groups, means represented by the same letter are not significantly different (P>0.05)

CONCLUSIONS

Results presented here suggest that aeration, specifically core aeration, has potential to reduce DRP export from surface-applied manures. Given that Cecil soil is common in pastures receiving broiler litter in the Southern Piedmont, core aeration could have a widespread impact on water quality in the Southern Piedmont region.

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