KNIFE AERATION TO REDUCE CONCENTRATIONS OF SEX HORMONES IN SURFACE RUNOFF FROM PASTURES FERTILIZED WITH BROILER LITTER

Miguel Cabrera[1], Sayed Hassan[1], John Rema[1], and Vaughn Calvert II[2]

AUTHORS: [1]Crop & Soil Sciences, University of Georgia, Athens, Georgia 30602; [2]Central Research and Education Center, 1508 N. Godfrey Rd. NW., Eatonton, Georgia 31024.
REFERENCE: *Proceedings of the 2011 Georgia Water Resources Conference*, held April 11–13, 2011, at the University of Georgia.

Abstract. Broiler litter contains the naturally-excreted hormones testosterone and 17-β estradiol, which can contaminate surface runoff when litter is applied to pastures. This study was conducted to evaluate the effect of knife aeration of pastures receiving broiler litter on hormone concentrations in surface runoff. Six 0.8-ha paddocks on tall fescue and bermudagrass were fertilized with 5 Mg ha^{-1} in March and November 2008, and in March 2009. Three paddocks were aerated immediately after application and three paddocks were left non-aerated as controls. Surface runoff samples were collected with automated samplers and analyzed for the sex hormones with GC/MS. Knife aeration reduced concentrations of hormones in surface runoff occurring soon after litter application and aeration. These results suggest that knife aeration may be a useful management practice to reduce contamination of surface waters with sex hormones derived from broiler litter.

INTRODUCTION

Broiler litter, a mixture of chicken (*Gallus gallus domesticus*) excreta and bedding material, contains naturally-excreted sex hormones testosterone and 17-β estradiol. Because broiler litter is commonly surface applied to pastures as fertilizer, these hormones may contaminate surface waters via surface runoff (Finlay-Moore et al., 2000; Velicu and Suri, 2009). Thus, management practices are needed to minimize surface runoff contamination. Mechanical aeration, which consists of disturbing the soil surface by making vertical slits (Franklin et al., 2007) or cylindrical holes (Kraft et al., 2004), has been effective at reducing phosphorus (P) losses from grasslands fertilized with broiler litter (Franklin et al., 2007; Butler et al., 2008). This reduction in P loss has been attributed in part to strong binding of P to soil surfaces exposed by mechanical aeration. Because testosterone and 17-β estradiol also bind strongly to soil (Sangsupan et al., 2006), mechanical aeration may be effective at reducing their concentrations in surface runoff. The objective of this study was to evaluate the effect of knife aeration on concentrations of testosterone and 17-β estradiol in surface runoff from grasslands fertilized with broiler litter.

MATERIALS AND METHODS

Six 0.8-ha paddocks located at the Central Georgia Research and Education Center (39°24' N, 83°29' W, elevation 150 m) were used to evaluate the impact of knife aeration under grazed conditions. The dominant species on the paddocks were tall fescue (*Lolium arundinacea* Schreb.) and bermudagrasss (*Cynodon dactylon* L.), and the main soils were classified as Altavista (fine-loamy, mixed, semiactive, thermic Aquic Hapludults), Cecil (fine, kaolinitic, thermic, Typic Kanhapludults), Helena (fine, mixed, semiactive, thermic Aquic Hapludults), and Sedgefield (fine, mixed, active, thermic Aquic Hapludults). All paddocks received 5 Mg ha^{-1} broiler litter in March and November 2008, and in March 2009. Three paddocks were aerated immediately after litter application and three paddocks were left non-aerated as controls. Aeration was carried out with 1.5-cm-wide ammonia-injection knives (Universal NH3 knife, Shoup Manufacturing Co., Kankakee, IL) mounted on a chisel-plow frame. This implement made continuous slits (10 cm deep and 27 cm apart) perpendicular to the field slope. Earthen berms (0.6 m high, 1.5 m wide) surrounding each paddock directed surface runoff to a 0.45-m H-flume equipped with a Coshocton wheel, which sampled surface runoff. At pre-determined runoff volumes, composite water samples were automatically collected from the Coshocton wheel pan and stored in a 10-L bottle inside an ISCO 3700FR refrigerated sampler (ISCO Corporation, Lincoln, NE). Testosterone and 17-β estradiol in runoff samples were extracted with dichoromethane in a separatory funnel, evaporated to dryness and redissolved in methanol, and analyzed with a Varian 4000 GC/MS (Varian Inc., Walnut Creek, CA). Statistical analysis was carried out with PROC MIXED in SAS (SAS Institute Inc., 2008), with sampling dates as repeated measures.

RESULTS AND DISCUSSION

IN 2008, there were no major runoff events (<5 mm) between the first litter application in March and the second litter application in November, but there were ten major runoff events after that (Figs. 1 and 2). The statistical analysis conducted with PROC MIXED

indicated a significant ($p<0.05$) interaction between aeration treatment and runoff date. In most cases, mechanical aeration reduced the concentration of both hormones when runoff events occurred within two weeks after litter application and aeration treatment (Figs. 1 and 2). This time-limited effect of aeration may have been due to 1) closing of aeration slits with time due to cattle activity, and 2) binding of hormones with recalcitrant humic fractions in soil. Fan et al. (2007) found that after a 5-d incubation at room temperature, 85% of the non-mineralized hormones (testosterone and 17-β estradiol) was associated with humin as well as fulvic and humic acids. Hormones associated with these humic fractions are not water soluble and therefore not susceptible to solubilization by surface runoff.

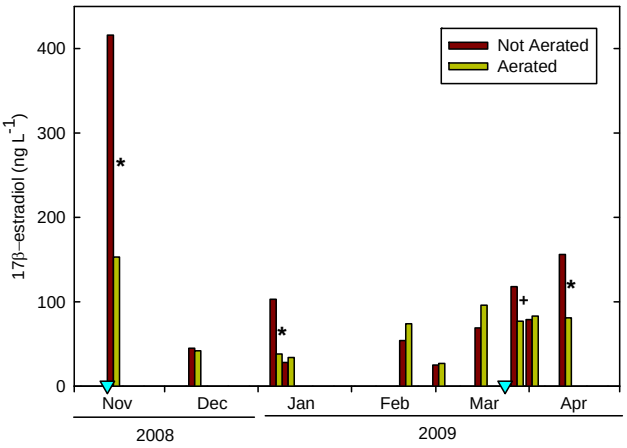

Figure 1. Concentration of 17-β estradiol in surface runoff from paddocks from paddocks fertilized with broiler litter with and without knife aeration (triangles indicate date of litter application and aeration treatment;* and + indicate significance at p=0.05 and p=0.12, respectively).

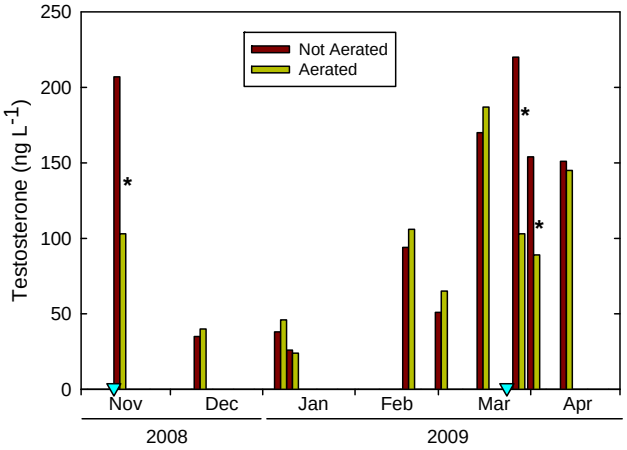

Figure 2. Concentration of testosterone in surface runoff from paddocks fertilized with broiler litter with and without knife aeration (triangles indicate date of litter application and aeration treatment;* indicates significance at p=0.05).

Concentrations of sex hormones in surface runoff are usually largest in runoff events occurring soon after broiler litter application (Nichols et al., 1997; Finlay-Moore et al., 2000). Thus, the reduction in concentration achieved with knife aeration during the first two weeks after treatment may result in a significant reduction in the overall annual loss of hormones from pastures receiving broiler litter.

CONCLUSIONS

Our results suggest that knife aeration of pastures immediately after broiler litter application may be a useful management practice to reduce contamination of surface runoff with sex hormones derived from the litter.

REFERENCES

Butler, D.M., D.H. Franklin, M.L. Cabrera, A.S. Tasistro, K. Xia, and L.T. West. 2008. Evaluating aeration techniques for decreasing phosphorus export from grasslands receiving manure. J. Environ. Qual. 37:1279-1287.

Finlay-Moore, O., P.G. Hartel, and M.L. Cabrera. 2000. 17-β estradiol and testosterone in soil and runoff from grasslands fertilized with broiler litter. J. Environ. Qual. 29:1604-1611.

Fan Z.S., Casey F.X.M., Hakk H., Larsen G.L. 2007b. Persistence and fate of 17 beta-estradiol and testosterone in agricultural soils. Chemosphere 67:886-895.

Franklin, D.H., M.L. Cabrera, L.T. West, V.H. Calvert, and J.A. Rema.2007. Aerating grasslands: Effects on runoff and phosphorus losses from applied broiler litter. J. Environ. Qual. 36:208–215.

Kraft, R.W., S.J. Keeley, and K. Su. 2004. Conversion of fairway-height perennial ryegrass turf to Kentucky bluegrass without nonselective herbicides. Agron. J. 96:576–579.

Nichols, D.J., T.C. Daniel, P.A. Moore, Jr., D.R. Edwards, and D.H. Pote. 1997. Runoff of estrogen hormone 17β-estradiol from poultry litter applied to pasture. J. Environ. Qual. 26:1002-1006.

Sangsupan H.A., Radcliffe D.E., Hartel P.G., Jenkins M.B., Vencill W.K., Cabrera M.L. 2006. Sorption and transport of 17 beta-estradiol and testosterone in undisturbed soil columns. J. Environ. Qual. 35:2261-2272.

SAS Institute. 2008. SAS/STAT 9.2 user's guide. SAS Inst., Cary, NC.

Velicu, M., and R. Suri. 2009. Presence of steroid hormones and antibiotics in surface water of

agricultural, suburban, and mixed-use areas. Environ. Monit. Asses. 154:349-359.